Conference Abstracts
35th Annual Meeting of the Society for Mathematical Psychology
July 25-28, 2002, Miami University, Oxford, OH

Sensory Processing and Perception--

Spike Timing Variability Limits Motion Discrimination   **Friday 8:30 a.m**.

 Joe Lappin, Duje Tadin, Vanderbilt University, Bart Borghuis, Martin Lankheet, Wim van de Grind, Utrecht University

The visible structure of moving stimulus patterns must be fully represented by responses of retinal neurons. (Entropy cannot be reduced by later cortical mechanisms and cognitive processes.) Because motion perception depends on correlations between multiple input signals, discriminations of moving images should be limited by the temporal reliability of spike trains at the first stages of vision. To study the temporal limits of early visual information, we have (a) developed a method to describe the timing variability of spike trains, (b) evaluated the spike timing variability of cat retinal ganglion and LGN cells in response to moving gratings of varied contrast and temporal frequency, (c) analyzed these temporal effects on a simple correlational model of motion discrimination, and (d) compared these effects with temporal thresholds for human motion discrimination. We find that human motion discriminations are temporally limited in the same manner as the spike trains of early visual neurons. These and other recent results indicate that limits on the statistical information for motion discrimination are primarily temporal. Evidently, visually effective motion information is not determined solely by 'motion energy'.

Dominance times for binocular rivalry and ambiguous motion   **Friday 8:55 a.m.**
 rivalry share individual diffferences

Keith D. White, University of Florida, John D. Pettigrew, University of Queensland

Binocular rivalry can be produced by stimulating the left eye with a small patch of drifting vertical lines while stimulating the right eye with a patch of drifting horizontal lines (or vice versa). Typically these do not fuse perceptually into a plaid; rather, one pattern dominates perception for a few seconds then the other pattern dominates for a few seconds. Perceptual alternation can also occur absent dichoptic stimulation when viewing an ambiguous figure or ambiguous motion stimuli. It is theoretically important to establish whether binocular rivalry is closely related to the latter perceptual alternations because in them the conditions do not exist to support competition between monocular neural channels, an explanation proposed for binocular rivalry. Thirty-one undergraduates participated in two 20 min sessions of binocular rivalry and two 20 min sessions of observing Bonneh's reversible sphere, non-dichoptic ambiguous depth from motion stimulus.   Mean dominance times were correlated across subjects (motion dominance period $= 3.2 *$ rivalry dominance period, r = .43, p = .01). For most subjects, the individual's histogram of motion dominance periods was similar in shape to his/her own histogram of rivalry dominance periods (average r^2 = .39), about 75% as good a predictor as the test-retest reliability between sessions with the same stimuli (average r^2 = .52), and a better predictor than any other subjects' histograms (average r^2 = .27). These covariations within individuals in binocular rivalry and in non-dichoptic ambiguous motion rivalry cannot be explained by competition between monocular neural channels.

Perspicuity without depth: 'mental rotation' as correlation   **Friday 9:20 a.m.**

Keith K. Niall, Defence R&D Canada (Toronto)

In some typical judgments on perspective pictures in psychological experiments, response times may have less to do with angular orientation in depth than with properties measured in the picture plane itself. Degree of compression, not depicted angular difference, accounts for changes in comparison response times for planar shapes in perspective. This degree of compression can be evaluated by an operation in the picture plane. The degree of compression is given by the cosine of the angle of the shape to the picture plane; an elementary operation on the shape's silhouette can be applied to compute that value squared. The operation is the autocorrelation of the silhouette, and the mean value of that autocorrelation is the desired value. The same rule predicts response times in a very different situation, when untrained observers identify photographs of aircraft models as F-15 or F-16 jets. A simple rule is found to fit

observers' response times: the rule is expressed in terms of the mean of the autocorrelation of black and white silhouette images of the aircraft. This pattern of response times is stronger for observers who are more accurate in identifying the aircraft. The squared area of those silhouettes represents a variable that fits response times despite auxiliary variations in aircraft type, standoff distance, and the spatial orientation of the aircraft. Loosely stated, one can account for response times in these two tasks by the relative area of the splotch that an aircraft - or an abstract plane shape - makes on the display screen.

A new look at the perception of relative mass in colliding balls: Friday 9:45 a.m. Invariants, similarity, and rules

Andrew L. Cohen, Indiana University

The mass of an object cannot be seen. In certain circumstances, however, observers are good at identifying the heavier of two colliding balls. The theory of direct perception maintains that observers are able to detect mathematically complex patterns in the visual field that accurately specify relative mass without invoking high-level processing (Runeson, et al, 2000). In contrast, constructivists argue that observers use imperfect, rudimentary cues that must be augmented through cognitive processes (Gilden & Proffitt, 1989). This research explores a number of new models of relative mass perception that speak to the larger issue of what type of information organisms can utilize to perform complex tasks. First, high-level optical patterns consistent with the direct perception approach are considered. Each pattern is sufficient to accurately determine mass judgments and is embedded in a simple perceptual model. Second, a more constructivist, similarity-based model is developed in which the detection of relative mass is viewed as a categorization task. Each collision resides in a multidimensional space, the dimensions of which represent perceptual aspects of the collisions. Similarity between collisions is a decreasing function of distance in the space. Relative mass judgments are based on the similarity of the test collision to all learned collisions in which Ball 1 or Ball 2 was heavier. Experiments contrasting these models will be discussed.

Analysis of Response Time and Accuracy Models of Psychophysics and Decision------

Adaptive Techniques for Response Latencies Friday 8:30 a.m.

Ragnar Steingrimsson, UC Irvine

Using adaptive procedures to estimate selective points on a psychometric curve rather than the often more complex task of modeling the entire function has become a common practice in psychophysical studies. In many cases, having estimates for these points provides sufficient information for the researcher and hence represents savings in time and other resources. Research using latency variables does not readily lend itself to this methodology since response time is regarded as an inherently dependent variable. However, using a well-established inverse relationship that obtains between response times and stimulus intensity, a formal argument is developed showing that it is possible to determine the stimulus intensity that gives rise to a fixed median response time—or that of any fixed percentile. A proposed method employs adaptive techniques to estimate this intensity for a fixed response time and percentile. In addition to the formal development, the feasibility of using any of three adaptive techniques—transformed Up-Down, Robbins- Monroe process, and PEST—are evaluated using extensive computer simulations. The results of the simulations demonstrate that acceptable results can be obtained in reasonable time and that a particular application of the transformed Up-Down procedure produces the best results. Finally, this method is used in a simple empirical situation, the results of which are consistent with both theoretically predicted outcomes and the results of the simulations.

Testing Capacity Hypotheses: Applying Proportional Friday 8:55 a.m. Hazards and Frailty Models

Michael J. Wenger, Christof Schuster, University of Notre Dame, James T. Townsend, Indiana University

Proportional hazards (Cox) regression models were introduced by Sir David Cox in 1972. The basic approach has become widely used in survival analysis, due in part to the limited and weak assumptions required in order to apply the models. In spite of their wide-spread use, to our knowledge, these models and related developments (known as frailty models) have not been applied to the analysis of response time (RT) data. We examine the robustness of these models in the face of the common

characteristics of RT distributions, for both single-observer and aggregate data, and illustrate how these models can be used to frame and test hypotheses regarding capacity in perceptual and cognitive tasks.

Bayesian Analysis of Response Times   **Friday 9:20 a.m.**

Van Zandt, T., Peruggia, M., & Chen, M., Ohio State University

      Response time (RT) data present unique problems for statistical nalysis, including non-normality, and short and long-term sequential dependencies which make the assumption of i.i.d. observations untenable. We consider Bayesian hierarchical models in which the RTsare described as conditionally independent Weibull random variables given the parameters of the Weibull distribution. The sequential dependencies, as well as the effects of response accuracy, stimulus characteristics, and subject specific learning processes are incorporated via a linear regression model for the logarithm of the scale parameter of the Weibull distribution. We compare the inferences from our analysis with those obtained by a standard ANOVA of the mean RTs. We show that the Bayesian analysis can detect effects that are hidden by standard procedures, and emphasize the potential for incorporating established RT models into statistical analyses.

On Implications of Near Equivalent Models for Signal   **Friday 9:45 a.m.**
Detection Theory and Memory Research

Lawrence T. DeCarlo, Ph.D., Columbia University

  Examples are discussed where, for a given set of psychological data, it is possible to find several models that describe the data. For example, in research that applies signal detection theory (SDT), a traditional explanation of normal receiver operating characteristic (ROC) curves with slopes other than unity is that the variances of the signal and noise distributions are not equal. There are, however, other explanations for non-unit slope normal curves. One possibility is that the underlying distributions are not normal; it has been shown, for example, that SDT with extreme value distributions can account for some non-unit slope normal curves. Another possibility considers the role of an additional process in SDT; the process is viewed as giving rise to latent classes of events (e.g., attended and non-attended items) and so responses arise from a mixture of distributions. ROC plots and fit statistics show that models associated with the different accounts are often near equivalent with respect to describing the data, and so the choice between them cannot be, and should not be, made on the basis of statistical evidence alone; other evidence that bears on the validity (or lack of validity) of a model is needed. It is also noted that, even in situations where different models can be distinguished with respect to fit, near equivalent models still arise when simple generalizations are considered. It is important to recognize the implications of near equivalent models for theory and to consider how general a model the data can support.

Categorization--

A Biologically Plausible Model of Rule-Based   **Friday 10:35 a.m.**
Category Learning

Shawn W. Ell, F. Gregory Ashby, Vivian Valentin, Michael Casale, Emily Waterhouse, University of California, Santa Barbara

      Rule-based tasks are those in which subjects can learn the category structures via some explicit reasoning process. In the most common applications, only one stimulus dimension is relevant, and the observer's task is to discover this relevant dimension and then to map the different dimensional values to the relevant categories. A critical component of this class of category learning tasks is that the observer maintains a representation of the rule (or relevant dimension) in working memory across trials. Many studies have implicated lateral prefrontal cortex in working memory. Recent results reinforce this idea and provide evidence that various subcortical structures may also help mediate working memory function (e.g., head of the caudate nucleus, globus pallidus, medial dorsal nucleus of the thalamus). We describe a computational model in which working memory, and in turn rule-based category learning, is mediated by parallel, prefrontal cortical-thalamic loops. The "cells" in the model are described by a system of first order differential equations designed to mimic the behavior of real cells at the same time that the entire network effectively mimics human spatial working memory behavior. In addition, applications of the model to more traditional category learning tasks will be discussed.

False Prototype Enhancement Effects in Perceptual   **Friday 11:00 a.m.**
Categorization

Robert M. Nosofsky, Indiana University, Safa R. Zaki, Indiana University

        Nosofsky and Zaki (1988) demonstrated that a single-system exemplar model accounted for the categorization-recognition dissociation observed for normals and amnesics in dot-pattern classification tasks reported by Knowlton and Squire (1993). Smith and Minda (2001) criticized Nosofsky and Zaki's (1998) account by arguing that if one used physical distances between dots as a measure of similarity, then a prototype model provided better fits to the categorization data than did an exemplar model. The main qualitative result supporting the prototype model is that it predicted a steeper typicality gradient than did the exemplar model. In this research we point to shortcomings in Smith and Minda's modeling analyses. They assumed arbitrary correspondences between dots instead of psychologically plausible correspondences when computing similarities to a critical subset of the patterns. They also fitted a psychologically implausib e version of the prototype model. When these shortcomings are corrected, we find that there is no difference in the ability of exemplar and prototype models to account for the categorization data. Finally, in empirical work, we discover bases for "false" prototype enhancement effects that go beyond the ability of either current model to explain. These false prototype enhancement effects do not arise from prototype abstraction during learning but rather from artifacts involving the testing procedure.

A Test of the Optimal Classifier's Independence Assumption   **Friday 11:25 a.m.**
in Perceptual Categorization

Corey J. Bohil, W. Todd Maddox, University of Texas at Austin

        Observers completed perceptual categorization tasks that included separate base-rate/payoff manipulations,corresponding simultaneous base-rate/payoff manipulations, and conflicting simultaneous base-rate/payoff manipulations. Performance was (a) closer to optimal for 2:1 than 3:1 base-rate/payoff ratios, and when base-rates, as opposed to payoffs were manipulated, and (b) was more in line with the predictions from the flat-maxima hypothesis than the independence assumption of the optimal classifier in corresponding and conflicting simultaneous base-rate/payoff conditions. A hybrid model that instantiated simultaneously the flat-maxima and COBRA hypotheses was applied to the data. The hybrid model was superior to a model that incorporated the independence assumption suggesting that violations of the independenc eassumption are to be expected, and are well captured by the flat-maxima hypothesis without requiring any additional assumptions. The parameters indicated that observers? reward-maximizing decision criterion rapidly approaches the optimal value, and that more weight is placed on accuracy maximization in separate and corresponding simultaneous base-rate/payoff conditions, than in conflicting simultaneous base-rate/payoff conditions.

Model Selection and Issues in Statistics---

Information Matrix Goodness-of-Fit Tests for   **Friday 10:35 a.m.**
 Explanatory Logistic Regression and Neural Net Models

Richard Golden, University of Texas at Dallas, Steven Henley, Martingale Research Corporation, Michael Kashner, UT Southwestern Medical Center, Robert Katz, Martingale Research Corporation

        This paper presents new theoretical and simulation results on the important issue of the development of statistical tests for evaluating the fit of a particular model to the underlying data generating process. Existing goodness-of-fit tests (e.g., the chi-square goodness-of-fit test) often focus upon the "predictive" aspects of the model through direct comparison of observed relative frequencies and predicted probabilities. Moreover, the degrees of freedom for many goodness-of-fit tests can be quite large for models of complex behavioral phenomena even in situations where the probability model has a relatively small number of free parameters. These two major limitations have been partially addressed by White's (1982, 1994) Information Matrix Test (IMT) Methodology. Unlike popular methods (e.g., chi-square goodness-of-fit test), the IMT indirectly evaluates goodness-of-fit by directly examining the integrity of the asymptotic covariance matrix of the parameter estimates. Such statistics are typically the basis for most types of statistical inferences associated with "explanatory" as opposed to "predictive" data analyses. In this paper, four new unpublished variations of the IMT for logistic regression modeling (or equivalently

single layer feedforward neural networks whose parameters are estimated using maximum likelihood estimation) are presented and simulation studies designed to illustrate the appropriateness of the large sample sample approximations are presented.

Flexibility versus Generalizability in Model Selection   Friday 11:00 a.m.
Mark A. Pitt, Woojae Kim, In Jae Myung, Ohio State University.

Which quantitative method should be used to choose among competing mathematical models of cognition? Massaro, Cohen, Campbell, and Rodriguez (2001) favor Root Mean Squared Deviation (RMSD), choosing the model that provides the best fit to the data. Their simulation results appear to legitimize its use for comparing two models of information integration because it performed just as well as Bayesian Model Selection (BMS), which had previously been shown by Myung and Pitt (1997) to be a superior alternative selection method because it considers a model's complexity in addition to its fit. After contrasting the theoretical approaches to model selection espoused by Massaro et al and Myung and Pitt, the present study investigated the cause of the inconsistencies by expanding on the simulations of Massaro et al. Findings demonstrate that the results from model recovery simulations can be misleading if not interpreted relative to the data on which they were evaluated, and that BMS is a more robust selection method.

Testing simple taxonomic hypotheses   Friday 11:25 a.m.
Bruce Oddson, Bloorview MacMillan Children's Centre

Taxonomic disputes - whether data is best represented as a continuum or by separate groups - have been central to many debates in psychology. Waller and Meehl (1998) developed a method for descriptively determining the existence of two groups from three or more correlated variables. Based on the general covariance mixture theorem (GCMT), the method does not depend upon departures from multi-variate normality and is suitable for some situations where the assumptions of DA and cluster analysis cannot be met. Their method considers the distribution of covariance (cov) between two random normal variables (x,y) each sensitive to group membership. This presentation will describe progress towards a method for making an inferential test of taxonomic hypotheses of two groups on three variables. This is accomplished by testing the distribution of co-variances using selected components of a smooth test of uniformity suggested by Neyman. Alternately, a Bayesian comparison of continuum (described by probability of uniform covxy distribution) and taxonomic hypotheses can be created. Power decreases rapidly as the difference between within group. It also decreases as 1) the number of groups increase, 2) the groups increase the range in which they overlap, 3) the variance of either group increases, and 4) the number of observations becomes unbalanced between groups. The method is applied to the question of whether the severity of childhood head injuries is better represented as a continuum or in the traditional groupings of mild, moderate, and severe.

Mathematics for the Cognitive Sciences   Friday 11:50 a.m.
John Miyamoto, University of Washington

Probably most members of the Society would agree that the standard quantitative curriculum in most graduate psychology programs is poorly suited to the needs of modern research psychologists. The current curriculum emphasizes statistical methodology and data analysis with primary emphasis on multiple regression, analysis of variance, and multivariate techniques that build upon this basis. Other statistical methods, mathematical modeling and computer simulation are also taught, but generally not as part of the required curriculum. The weakness of this approach is that little effort is devoted to teaching the basic mathematical concepts and problem solving skills that are needed for a real understanding of statistical methods and mathematical modeling. Most instructors attempt to give intuitive explanations that minimize the mathematical demands on students, and the occasional hardnosed instructor insists that students already have a strong mathematical background before undertaking his or her course. What instructors do not attempt to do is to develop mathematical competence in a population of psychology students who have high intelligence but weak mathematical training. Consequently, psychology students generally find it difficult to think flexibly and creatively about mathematical models of psychological processes. I will argue that the needs of modern research psychologists are better served if they are trained in basic mathematics, including logic, set theory, algebra, probability theory, and elementary calculus, with applications of these disciplines in statistical theory, data analysis, and the modeling of psychological phenomena. I will outline a revised quantitative curriculum that teaches basic mathematical concepts and

reasoning skills without shortchanging the methodological applications that are taught in the current curriculum.

Symposium: Quantitative Models of Visual Processing---

A hybrid approach to quantitative modeling of sensory systems.   Friday 1:45 p.m.

Lynn A. Olzak , Miami University, Thomas D. Wickens, James P. Thomas, University of California, Los Angeles

I describe the application of a signal-detection approach to investigating the nature and independence of sensory mechanisms that underlie the ability to make fine sensory discriminations. The approach was developed at UCLA together with James P. Thomas and Thomas D. Wickens over a period of more than 20 years, and we have applied it over the last 12 years to attempt to understand interactions among mechanisms of spatial pattern perception. Loosely, the approach involves setting up predictions for single or double-judgment discrimination rating experiments that involve two or more stimulus components or dimensions. We set up a "null" hypothesis of independence and assume ideal-observer behavior to predict expected performance under these conditions. We make the explicit assumption that decision criteria are fixed (unlike General Recognition Theory) and that differences in performance **d'** values from predicted values are due to interactions among sensory pathways that process the two stimulus dimensions or components. I present data illustrating dramatic and selective interactions among pathways tuned to very different spatial frequencies or orientations, which suggest that the spatial visual system is organized to optimally provide information about) the orientation of edges and 2) the contrast and textural grain of object surfaces.

Feature vs. conjunction search and cue-validity effects explained   Friday 2:15 p.m.
within a common signal detection framework

Miquel P. Eckstein, University of California Santa Barbara

Two important results in the study of visual attention are: 1) the larger set-size effects for feature vs. conjunction search; 2) the cue-validity effect. These two results have been traditionally explained in terms of two different theories/metaphors of visual attention. The feature vs. conjunction dichotomy is accounted for in terms of visual attention acting as a temporally serially mechanism needed to bind information across feature dimensions (Treisman & Gelade, 1980). The cue-validity results are explained in terms of a limited attentional resource that when deployed to one location increases the efficiency of perceptual processing at the attended location (Posner, 1980). In contrast, extending previous work (Shaw; Kinchla,; Graham; Palmer), human visual accuracy in these two distinct paradigms can be compared to a signal detection model (and sometimes the optimal Bayesian observer) that takes in account the stochastic and independent processing of visual information for each feature and the prior probability of target appearance at each location. In the signal detection model (SDT), the lower performance with conjunction search arises from the combination of information across two noisy feature processors, only one of which is informative in distinguishing target from distrctors, while the cue-validity effect arises due to the larger weighting given to the cued location. Most importantly, the SDT model quantitatively predicts human accuracy without resorting to either a temporally serial or a limited capacity attentional mechanism. In the SDT framework (and for both paradigms), visual attention has a unique function/interpretation that is simply to select or differentially increase the weight given to relevant information and to ignore or differentially decrease the weight given irrelevant noisy sources.

Spike train analysis reveals cooperation between Area 17   Friday 2:45 p.m.
neuron pairs that enhances spatial discrimination

A.B. Bonds, J.M. Samonds, J.D. Allison, Vanderbilt University

We examined 22 pairs of neurons in Area 17 of cats that were paralyzed and anesthetized. We studied changes in ensemble responses for small (<10deg, 0.1c/deg) and large (>10deg, 0.1c/deg) differences in orientation (OR) and spatial frequency (SF). Examination of temporal resolution and discharge history revealed advantages in discrimination from both dependent (connectivity) and independent (bursting) interspike interval properties. For 12 pairs with at least moderate connectivity, we found the average synergy (information greater than that summed from individual neurons) was 50% for fine discrimination of OR and 20% for SF; and <10% for gross discrimination of both OR and SF.

Dependency (Kullback-Leibler "distance" between the actual responses and two wholly independent responses) was measured between pairs of neurons while varying OR (10 pairs), SF (10 pairs) and contrast (9 pairs). Dependency was more selective to spatial parameters than was firing rate. Variation of dependence against SF corresponded to variation of burst rate, and was even narrower than burst rate tuning for OR (suggesting that burst length also influences dependency). Since there is no differential modulation of burst rate and average firing rate with contrast, dependency strength matched average firing rate. The results suggest that salient information is more strongly represented in bursts, but that isolated spikes also have a role in transferring this information between neurons. The dramatic influence of burst length modulation on both synaptic efficacy and dependency around the peak OR (where firing rate remains relatively constant) leads to significant cooperation that improves orientation discrimination.

Hue, Saturation and Brightness: Nonlinear Dynamic Model of Human Color Vision Fundamentals. Friday 3:15 p.m.

Vincent A. Billock, Northrop Brumman Information Technology, Brian H. Tsou U.S. Air Force Research Laboratory.

How are fundamental color percepts like hue, saturation, and brightness synthesized from information available in early cortical units? We explored two kinds of nonlinear dynamic interactions between such cells: competition and synchronization. We modeled hue opponency with winner-take-all competitive interactions between relatively narrowband wavelength selective cortical units. Some poorly understood aspects of color opponency are better modeled in this nonlinear dynamic framework than by traditional subtractive opponency. We find experimentally that competitive opponency can be disabled by combining equiluminance and retinal stabilization (e.g., subjects perceive forbidden colors like reddish-green; Billock et al., JOSA A, 2001). Another nonlinear dynamic interaction between neurons is synchronization; spiking neurons are oscillators, and coupled oscillators tend to synchronize the phase and frequency of their firing patterns. Since sensory neurons carry information in the timing and frequency of spike trains, synchronization results in sensory transformations. The nature of the transformation depends on the type of the coupling and on nonlinearities in the system. Assuming a simple rate coding model, with two mechanisms whose uncoupled frequencies are monotonic transforms of activity in hue and luminance mechanisms, we identify conditions that lead to coupled frequencies that are like vector summation of hue and luminance, which we use model chromatic brightness. Similarly, we identify conditions that lead to power laws of hue/brightness, which we use to model chromatic saturation

Plenary I: Dynamics of Visual Oscillations and Waves: Evidence for a Competitive Hierarchy. Friday 4:00p.m.

Hugh R. Wilson, York University

Poster Session--------Heritage Room, Shriver Center, Friday 5:30pm----------------------------------

1. Minding TRACS: On dealing with dynamic odds in a probabilistic card game

Kevin Burns, The MITRE Corporation

TRACS (Tool for Research on Adaptive Cognitive Strategies) is a family of games played with a special deck of two-sided cards (see www.tracsgame.com). TRACS has the advantage of being both mathematically tractable to theoretical analysis and psychologically relevant to practical applications. The simplest game, called Straight TRACS, is a series of choices where the player must turn over one of two cards to match a third card. The object is to make the most matches on a trip through the deck. The challenge is to track the changing odds in order to make the best choices. We performed experiments and simulations to measure cognitive performance against normative standards in this probabilistic and dynamic task. Our experiments show that people are surprisingly limited in concurrent counting of card sets and in normalizing numbers to convert counts to odds. In concurrent counting, the observed limit of reliable performance is about 3 cards per set. This is an interesting result because it corresponds to the well-known subitizing limit of human visual perception. Experiments also show that most people deal with this limit by counting only the rarest sets. This is an interesting result because simulations show that more effective strategies can be implemented with the same memory requirements. We close by offering a

rational explanation for the apparently irrational card-counting strategy adopted by most players. Our explanation considers the benefits of this strategy in another version of the game, called Wild TRACS, that more closely replicates the practical challenges of naturalistic decision making.

2. Modeling the effects of prime duration and location in perceptual identification

Christoph T. Weidemann, Richard M. Shiffrin, Indiana University, David E. Huber, University of Colorado

We present the results of several forced-choice perceptual identification studies. On each trial, a masked target presentation followed one or two sequentially presented primes. Each prime presentation consisted of a single word presented both above and below fixation. We separately manipulated prime duration and vertical eccentricity between the primes. Neither, one, or both of the choice words repeated a prime word. In keeping with the result of Huber, Shiffrin, Quach, and Lyle (in press), short prime presentations produced a preference for repeated words whereas longer prime presentations produced a small preference against repeated words. In some cases these effects were modulated by eccentricity, with more centrally fixated primes producing larger preference effects. In one experiment, the same prime word was first presented for a long duration with a large eccentricity, followed by a brief, near threshold, more central presentation. Surprisingly, there was a strong preference to choose such a prime, despite the overall extended prime duration. All conditions were quantitatively handled with the ROUSE model of Huber, Shiffrin, Lyle, and Ruys (2001), which includes the offsetting components of source confusion and discounting. In particular, the sequential prime presentation result was explained by assuming the brief central presentation resulted in additional source confusion, but not additional discounting.

3. An analysis of the recognition-recall relation in four distributed memory models

Michael Kahana, Dan Rizzuto, Abraham Schneider, Brandeis University

Many process models of episodic memory can now simultaneously account for performance in both recognition and recall tasks. In most applications, the modeling of different tasks is done across experiments, where the variation in multiple parameters allows models to capture the many differences in experimental procedures. To better evaluate these models, we assess their ability to fit data on successive recognition and recall tests given after a single study phase. This method provides data not only on mean levels of performance, but also on the contingency relations between the outcomes on the two tests. Under a wide range of experimental conditions, ones that influence both recognition and recall probability, the correlation remains at a moderate level, typically between 0.45 and 0.65. We analytically derive the theoretical correlation between recognition and recall predicted by each of four distributed memory models: local and global match versions of both matrix and convolution-correlation models. The local-match matrix model produces a substantial correlation between item recognition and cued recall whereas the other classes of models predict modest correlations. In all four models, variability in goodness of encoding increases the correlation between successive tests, and variability in the encoding of the test cue decreases the correlation. In the local match models, output encoding increases the correlation, whereas output encoding has no effect on the correlation in the global match models. None of the models adequately fits the experimental data. The local-match matrix model generates correlations that are too high, whereas the other models tend to generate correlations that are too low.

4. A lag-recency effect in item recognition

Greg Schwartz, Michael Kahana, Brandeis University

Interitem associative effects are not only seen when subjects attempt to learn novel pairings of familiar items. In the free recall task, items from nearby list positions tend to be recalled together, a finding refered to as the lag-recency effect (Kahana, 1996, Howard & Kahana, 1999). We examined whether such associative effects might also appear in item recognition. Twenty one subjects each participated in eight sessions of a continuous item recognition task. When probed successively for recognition of two old items, correct RTs for the second probe were significantly faster when the first and second probe appeared in adjacent study positions than when they appeared in remote positions. This lag-recency effect is not predicted by models of recognition memory that consider the probe item to be the sole retrieval cue (e.g., global matching models). In contrast, this effect may be seen as consistent with the retrieved context view of item recognition (e.g., Dennis & Humphreys, 2001). If the context retrieved by the preceding cue item enters the current memory comparison, performance will be enhanced for items that share similar contextual codes.

5. Isolation: a unifying account of paired-associates and serial learning

Jeremy B. Caplan, Brandeis University

Providing further evidence for Asch & Ebenholtz's (1962) associative symmetry hypothesis (ASH), Rizzuto and Kahana (2001) found that the correlation between successive forward and backward probed recall of word pairs was near unity. We tested whether this finding extended to probed recall of serial lists. Unlike pairs, the correlation is significantly below unity, though still positive. This finding, along with the advantage of forward over backward probed recall observed in serial lists (Kahana & Caplan, in press) shows that ASH fails to generalize to serial lists. We argue that this seemingly categorical difference between pairs and sequences reflects an underlying continuum. In a paired-associates task, paired items are relatively isolated from other pairs, with the effect that forward and backward cueing are susceptible to correlated interference from other list items. In contrast, item pairs in serial lists are not isolated; consequently, interference from other list items will differ depending on cueing direction. We show that this isolation principle can be implemented in associative models by varying the ratio of within-pair associative strength to between-pair associative strength. Similarly, one can implement isolation in positional models by varying the similarity of positional codes within versus between pairs. The isolation principle provides a way for various models to account for both paired associates and serial learning.

6. Microlevel analysis constrains models of serial learning

Kelly M. Addis, Michael J. Kahana, Brandeis University

Models of sequence memory typically rely on either item-to-item associations, or position-to-item associations with a rule for how positions are retrieved and updated. Both classes of models can account for the changes in serial position curves across trials. Serial position curves, however, do not show the behavior of individual items over the course of multiple study-test trials. Extending Tulving's (1964) analysis of free recall, we present an analysis of sequence learning that tracks the acquisition and forgetting of item and order information at the level of individual items across serial positions. Applying this analysis to a large serial learning data set, we show that while a basic implementation of the positional coding model fits the data fairly well, the associative chaining model fails to make the appropriate types of errors. Yet both models produce reasonable serial position curves, even when fitting to the more detailed analysis. We followed up with an experiment that disrupted the acquisition of item-to-position associations by requiring subjects to learn lists with varied starting positions (e.g., Ebenholtz, 1963). Although a pure positional model could not learn these lists, subjects were only moderately impaired. These findings point to the development of hybrid models that incorporate both elements of positional and associative coding.

7. Assessing significance in linear oscillator models

Eric S. Covey, Dr. Steven M. Boker, University of Notre Dame

Dynamical systems have emerged as useful mathematical methods for the analysis of behavioral data. In particular, linear oscillator models can describe and predict behavior in settings as varied as posture control and mood regulation. When fitting dynamical models to data, it is important to have objective criteria for determining the likelihood that an estimated oscillation parameter is due to chance alone. Methods are described for fitting a linear oscillator model to
observed data, and assessing inferrentially whether a true signal exists.

8. Emotional expressions as Gestalt

Ase Innes-Ker, James T. Townsend, Indiana University

Gestalt perception of emotional expressions was investigated using a search paradigm. Using stochastic process models as a theoretical basis, evidence for parallel architecture, super-capacity, exhaustive stopping rule and positive dependence between channels can be considered as evidence for gestalt processing. The features consisted of the eyes nose and mouth extracted from photographs of the same individual expressing different emotions (target and foil face). The arrays consisted of 2, 3 or 4 features, with between 0 and 4 features drawn from the foil expression resulting in 3 types of stimuli: Source consistent target (SCT) Source consistent foil (SCF) and Source Inconsistent (SI). Features were placed in a biologically correct configuration (Gestalt, G) or a scrambled (S) configuration. Decisions about the arrays were made either under exhaustive instruction (respond yes if all features are from the

target expression) or a self-terminating instruction (respond yes if any feature is from the target expression). Processing architecture appears parallel, with participants using a self-terminating stopping rule whenever diagnostic features are present (target features in Self-Terminating condition, foil features in Exhaustive). Exhaustive processing is evident when no diagnostic features are present. G shows evidence for super-capacity as compared to S for SC stimuli. Comparing 2 feature to 4 feature stimuli capacity is limited when processing is self-Terminating, especially when one of the 2 feature arrays consist of the face-half dominant in expression signaling, suggesting that adding features interferes with processing. In exhaustive conditions, there is some evidence for super-capacity for Gestalt.

9. Cognitive style, generalization, and implicit learning
Kristin Christy, John Parker , Mark Hammerly & Robin Thomas, Miami University

This study exlores generalization within an implicit categorization task and its relation to measures of cognitive style. All participants completed several inventories of cognitive style (field independence/dependence, impulsivity/reflexivity, visual/verbal, etc.). One group trained on an information integration categorization task while a control group performed a rule-governed task using the same stimuli. Both groups performed another information integration task that used a different set of stimuli however the task had the same underlying category structure as the training task of the implicit group. It was found that some measures of cognitive style were related to categorization accuracy in the training task and that these participants tended to learn the transfer task faster.

Judgment, Decision, & Choice I---

Reconsidering the Testing of the Generic Utility Theory   Saturday 8:30 a.m.
Richard A. Chechile, Susan F. Butler, Tufts University

Miyamoto (1988) provided a framework for a wide class of utility models that he called the generic utility theory (GUT). Chechile and Cooke (1997), Chechile and Luce (1999) and Chechile and Butler (2000) have assessed the GUT class of models by means of a regression-based methodology. In this paper, the methodology used by Chechile and associates is critiqued and an improved procedure advanced. This new procedure also has undercovered a model overfit problem in the earlier work. Data from the Chechile and Butler (2000) experiment and data from a new experiment are examined with the new assessment method. Although most participants still are not well described by the GUT model, there are considerable individual differences, and some participants are now recognized as behaving as described by GUT.

Representing behavioral discontinuities in simple gambles   Saturday 8:55 a.m.
R. Duncan Luce, University of California, Irvine

Strong empirical evidence exists for some form of discontinuity when the smallest positive consequence of a gamble is replaced by 0. Indeed, if lotteries (x,p;y) and (x,p;0), x=y>0, are compared, then for p sufficiently large many people prefer (x,p;0) to (x,p;y), a clear violation of monotonicity (M. H. Birnbaum, 1997). The talk describes a way of accommodating this within the framework of linked preferences, gambles, and their joint receipt (Luce, 2000). The obvious solution is to use different weighting functions in the two cases. But with segregation, on which earlier theories were based, this degenerates to the same weighting function. Thus, segregation has to be replaced by something not involving 0 consequences. So, the mathematical issue is how to axiomatize the general representation excluding 0 consequences. I propose using right distributivity, which follows from the original theory based on (right) segregation, that avoids 0. A dual theory holds for left distributivity. For commutative joint receipts, the usual rank-dependent utility representation arises. In addition a new general family arises: if V is additive over joint receipts and C denotes a chance event, the form is

$$V(x,C;y)=V(y)+M[V(x)-V(y),C],$$

where M is strictly increasing in the first variable. For non-commutative joint receipts, nothing changes, which is relevant to global psychophysics. Issues of generalizing the theory beyond binary gambles are mentioned.

Modeling the effects of uncertainty and delay in making choices   **Saturday 9:20 a.m.**

Rahul M. Dodhia, NASA Ames Research Center, David H. Krantz, Karen Burhans, Columbia University

We propose a goal-based, constructive choice framework as an alternative to multiplicative models of intertemporal and risky choice. In this framework, making a choice is viewed as finding a solution to a design problem (in which constraints are set by a person's goals) rather than maximizing some utility function. We briefly discuss the activation and adoption of goals in risky and intertemporal choice situations. The framework predicts a dissociation between the effects of uncertainty and the effects of delay that allows for a measurement free test of joint independence of the multiplicative model. People are likely to be more sensitive to uncertainty, but less sensitive to delay, for important, long term goals than for less important, short term goals. We show using multiplicative conjoint measurement that the multiplicative model fails the test of joint independence. The conjoint measurement analysis also suggests an experimental design to directly demonstrate and test the uncertainty and delay effects predicted by the goal-based framework. Two experiments based on this design are reported. In Experiment 1, we manipulate the magnitude of the prospects in intertemporal and risky choices. Using monetary and non-monetary prospects, and two different methods of eliciting choices from subjects, we show that joint independence does not hold. The goal-based framework also predicts conditions in which subjects' patterns of choices observed in Experiment 1 can be changed. We implement these conditions in Experiment 2 and show that the subjects' choices do change in the expected direction.

Information Processing I---

For visual search, the details of the task reverse the ordering   **Saturday 8:55 a.m.**
of the set-size effect for localization and identification

Tom Busey, Indiana University, John Palmer, University of Washington

The effect of divided attention is different for identification and localization. We ask whether this difference is due to perceptual processing capacity or to the decision process. Using visual search, we measured set-size effects for finding a target grating (left-leaning) among distractor gratings (right-leaning). The identification task was yes-no detection and the localization task was to specify the target location. The observed set-size effects were larger for localization than for identification. This difference was shown for several spatial and temporal frequencies and controls ruled out explanations based on task difficulty, sensory factors, and response measures. The different decision requirements for the two tasks was modeled using signal detection theory and by assuming unlimited capacity for both tasks. This model predicted much of the observed difference between tasks. Thus, the observed difference may be due to the differences in the decision process.

Parallel vs Serial Processing and Individual Differences in   **Saturday 9:20 a.m.**
High-Speed Scanning in Human Memory

James T. Townsend , Mario Fific, Indiana University

Many mental tasks that involve operations on a number of items take place within a few hundred milliseconds. In such tasks, it has long been of interest to psychologists as to whether the items were processed simultaneously (i.e., in parallel) or sequentially (i.e., serially). Although certain types of parallel and serial models have been ruled out, it has not been possible to entirely separate serial and parallel models in typical data. Recent advances in theory-driven methodology now permit strong tests of serial vs. parallel processing in rapid scanning for a target in short-term memory. Methodology involving factorial variation in order to determine mental architecture and to assess processing capacity has been greatly expanded over the past several decades. We challenge previous ideas using double factorial paradigm designed to test architectural properties of short-term memory processing. Three variables were manipulated in this experiment: number of processing elements (n=2 and 4), phonemic dissimilarity of a target to the particular memorized element (high, low) and duration between memorized set and a target (short-long ISI). We employ the recent results involving the distribution properties, such as survivor interaction contrast, rather than means alone. Our results suggest that some observers are serial whereas others are strongly parallel when set size is small (n=2). However for larger set size (n=4) findings for several subjects showed possible mixture of serial and parallel processing. Contrary to typical previous

hybrid models parallel processing is more likely to be identified at the beginning of the memorized list (old items), while serial processing is more likely to be associated with new items in the list.

New Investigator: *David Huber (University of Colorado)*   **Saturday 10:00 a.m.**

Judgment, Decision, & Choice II   ---

A Thurstonian Model for Sophisticated Approval Voting   **Saturday 11:05 a.m.**

Moon-Ho Ringo Ho, Michel Regenwetter, University of Illinois at Urbana-Champaign, Ilia Tsetlin, Duke University

Approval Voting is a voting method where each voter approves of any subset of the available candidates. Merrill (1981) and later Brams and Fishburn (1983) have argued that a sophisticated voter should establish his/her expected utility for each candidate and that the voter should vote for those candidates that have above average expected utility. We present and discuss a Thurstonian random utility model for sophisticated approval voting in which the expected utilities of the candidates are modeled by a multivariate normal distribution. This model accounts for the idea that different voters attach different expected utilities to the candidates (i.e., they evaluate differently each candidate's chance of being elected as well as the utility of having that candidate elected) and it accommodates the idea that voters experience uncertainty in their evaluation of candidates' utilities and probabilities of being elected.

Social Choice and Aggregation of Utility: A Topological   **Saturday 11:30 a.m.**
Characterization

Matt Jones, Jun Zhang, Gilberto Simpson, University of Michigan

We study the topological properties of aggregation maps f that combine individual voters' preferences over k candidates, with preference expressed by a real-valued, k-dimensional utility vector u defined on interval scale. Since any such utility vector is specified only up to arbitrary affine transformation, the space of utility vectors R^k may be partitioned into equivalence classes $\{a \cdot u + b \mid a \in R^+, b \in R\}$. The quotient space is shown to be the union of S^{k-2}, the k-2 dimensional sphere, and the singleton $\{0\}$ (corresponding to indifference or null preference), with a non-Hausdorff topology. Suppress k and denote $T = S \cup \{0\}$. An aggregation map in general is then $f: T^N = T \times T \times ... \times T \rightarrow T$ (where N denotes the number of voters). Restricting the domain to S^N and/or range to S, and assuming continuity of the aggregation map, we investigate the four scenarios (of allowing or disallowing null preference in individual and/or social choice): (i) $T^N \rightarrow S$: f must be a constant map; (ii) $T^N \rightarrow T$: each voter either has the power to null the social choice (by choosing 0) or has no power at all; (iii) $S^N \rightarrow S$: it has been established (Chichilnisky and Heal, 1983; Baryshinikov, 1994) that there does not exist a continuous map that is anonymous and unanimous, and that any continuous map satisfying the Pareto condition is homotopically equivalent to a dictatorial map; (iv) $S^N \rightarrow T$: in contrast to (iii), there exist examples of aggregation maps which are continuous, anonymous, unanimous, and Pareto. Furthermore, all continuous maps are homotopic to one another, and this homotopy can be made to respect the sub-classification of maps according to anonymity, unanimity, weak Pareto, and an appropriately defined stability condition (i.e. the subclass of maps satisfying any combination of these constraints is connected in the homotopy topology)

On a general concept of scoring rules: model and empirical   **Saturday 11:55 a.m.**
data analysis

.E. Rykhlevskaia, M. Regenwetter, University of Illinois at Urbana-Champaign

In the theory of decision-making and social choice, individual preferences can be aggregated with a variety of competing methods (including so-called "scoring rules"). We consider a mixture model of group choice, characterized by a joint probability distribution over a collection of asymmetric binary relations (on the set of possible alternatives). We do not require individual preferences to be linear orders, rather the model encompasses preferences expressed as weak orders or partial orders (such as semiorders, interval orders, etc.). We define a general concept of scoring rules in terms of mixtures over asymmetric binary relations (and equivalent random utility models), and discuss the special cases of plurality, antiplurality, and the Borda score. We show how, in an empirical analysis of National Election Study data, different scoring rules may lead to different outcomes. More importantly, we also show how the

conclusions based on the preference aggregation crucially depend not only on the data themselves (voter responses), but also on the representation of individual preferences, as, say, weak, semi- or interval orders. The proposed definition of scoring rules in a mixture model context generalizes a broad class of methods of preference aggregation.

Information Processing II --

Dimensional Consistency Effects: A Dynamic Cross-Correlational Modeling Approach
Saturday 11:05 a.m.

Angelina M. Copeland, Michael J. Wenger, University of Notre Dame

Over the past three years we have examined the perception of complex visual forms using experimental paradigms that allow us to disentangle perceptual and decisional influences. We have consistently obtained evidence of dimensional consistency effects, in which forms with consistent dimensions are perceived more efficiently than forms with inconsistent dimensions. Analysis of response probabilities (using multidimensional signal detection analyses and fits of parametric models) and response latencies (at the level of the hazard function of the response time distribution) has implicated both a perceptual and decisional source for the dimensional consistency effects. We are now using this large body of data to begin work on a stochastic dynamic modeling framework, capable of representing hypotheses regarding both perceptual and decisional influences. In this talk, we will present the initial developments and applications of this modeling approach. The perceptual representation of the complex form, as well as the representation of a set of forms stored in memory are modeled by noisy dynamic linear channels. The psychological evidence used to support a response decision is modeled using spatial cross-correlation, evolving in time, allowing predictions of both response probabilities and response latencies.

A strong test of the dual-mode hypothesis
Saturday 11:30 a.m

Erin M. Ingvalson, Michael J. Wenger, University of Notre Dame

One account of facial cognition, the dual mode hypothesis, maintains there are two sources of information in a human face, featural and configural, and these sources are processed simultaneously and independently of one another. Processing and identification of upright faces relies primarily on configural information and this information is disrupted to such an extent upon inversion as to result in a reliance on featural information (e.g., Searcy & Bartlett, 1996). The dual mode hypothesis can be interpreted in terms of a parallel self-terminating processing architecture architecture with a self-terminating stopping rule, super-capacity (at the level of overall system performance), and a preservation of channel independence. Townsend and Nozawa's (1995) double-factorial paradigm is used to provide a simultaneous test of these predictions, using upright and inverted faces and face-like schematic images.

Strength-based and time-based supervised networks: Theory and comparisons.
Saturday 11:55 a.m.

Denis Cousineau, Université de Montréal

In the recent years, connectionist networks became more and more popular and supplanted the more traditional models of cognitive psychology such as the accumulator models, the race models, etc. However, I showed recently that the accumulator models can be transformed easily into a network of channels and that this network can solve the same problems than the connectionist networks. In addition, I showed that a simple learning rule exists for networks based on the accumulation of evidence. Whereas the former kind of networks can be seen as strength-based network, the latter are better defined as time-based network. I will present a new synthesis of the supervised learning networks encompassing both strength-based and time-based networks. To do so, I will expand the matrix algebra so that the inner product can be modified to take into account which type of network is modeled. Because the aim of both types of network is identical, we proceed to a comparison of the two. The manipulated dimensions are 1) the presence of noise and its amplitude; 2) the presence of redundant channels. Results shows that strength-based networks fare better in the presence of noise whereas time-based networks are better in presence of redundancy. However, when both are manipulated, only the time-based networks can learn in the presence of high noise and high level of redundancy.

Plenary II: Discrimination, Dissimilarity,   **Saturday 1:50 p.m**
and Perceptual Mapping.
Ehtibar Dzhafarov (Purdue University)

Scaling and Measurement---

Techniques for scaling directional data   **Saturday 3:00 p.m.**
David Waller, Miami University
      A common way for researchers to model or graphically portray people's spatial knowledge of a large environment is by applying multidimensional scaling (MDS) to a set of pairwise distance estimations. I describe two MDS-like techniques that incorporate people's knowledge of directions instead of (or in addition to) their knowledge of distances. Maps of a familiar environment derived from these procedures were more veridical, and were rated by participants as being more accurate, than those derived from nonmetric MDS. By incorporating people's relatively accurate knowledge of directions, these methods may offer spatial cognition researchers and behavioral geographers a sharper analytical tool than MDS for investigating cognitive maps.

Title Tests for Curvature in Psychological Spaces   **Saturday 3:25 p.m.**
Jesse Spencer-Smith, University of Illinois Urbana-Champaign, James Townsend, Indiana University
      In multidimensional scaling, measures of similarity or dissimilarity are treated as proximity data (ordinal scaling), or distances (ratio scaling). An early step in preparing data for scaling is the addition of a constant to each distance measurement to ensure the data can be represented in a Euclidean space of minimal dimensionality. We demonstrate that the optimal choice of additive constant also minimizes curvature that may be present in the data, and therefore the derived configuration must be distorted. We discuss three tests for uncovering curvature in psychological proximity data prior to scaling. In the first test, data are assumed to lie on a ratio scale, and can be applied to any such data. In the second test, data are assumed to lie on a ratio scale and it is assumed that some subset of points are collinear and between pairs of points. In the third test, data are assumed to lie on an ordinal scale, with additional assumptions concerning the configuration of points. Results of the application of the tests to dissimilarity judgments of facial expressions and artificial stimuli are also discussed.

Developing the notion of dimensions of a psychological variable   **Saturday 3:50 p.m.**
 by means of reversed dimensional analysis
S. Alex Marinov, Applied Linguistics Centre†, Julia Boon, David Laurence, Sam Research
      The developing of the notion of dimensions of psychological variables is of paramount importance in quantitative psychology [1]. Such a developing is largely viewed as a problem of establishing a link of the sort found in physics between the "psychological" and the "physical" realms [2]. A major obstacle in this approach appears to be the fact that the "psychological" is not defined in terms of any dimensions which appear in the "physical" [3]. We argue that the notion of dimensions in psychology can be developed independently of the "physical", provided the dimensions of psychological variables are interpreted in the sense of phenomenological dimensions. Such dimensions are similar in nature to fractal dimensions [4] and can be obtained from data by the method of Reversed Dimensional Analysis [5]. A procedure for uncovering dimension-like structures in data sets and, if found, assigning dimensions to the variables involved, is proposed. The procedure is independent of the kind of variables involved and therefore is applicable in both cases: (i) a set of non-physical variables only; and (ii) a set consisting of both non-physical and physical variables. Illustrative examples are discussed.
References: [1] Ward (1992) in Algom (Ed.) Psychophysical approaches to cognition., Amsterdam: North Holland, 187-249; [2] Luce & Krumhansl (1988), in Atkinson (Ed), Stevens' Handbook of Experimental Psychology, New York: Wiley, 3-74; [3] Van Brakel (1993) , Behavioral and Brain Sciences, 16, 163-164; [4] Mandelbrot (1983) The fractal geometry of nature, San Francisco: Freeman; [5] Marinov & Panov (2000) in 16-th ISP Proceedings, 257-262.

Dual Scaling Between Comparison and Reference Stimuli in   **Saturday 4:15 p.m.**
Multidimensional Psychological Space

Jun Zhang, University of Michigan

         In the theory of Fechnerian scaling of psychological space (Dzhafarov and Colonius, 1999; 2000), discrimination probability plays a key role in the construction of psychometric differential which, after a global transformation, becomes the metric ("indicatrix") of the underlying Finsler space. This construction invoked only minimal assumptions on the shape of discrimination probability, among which two are central (i) regular minimality, i.e., for the pair of stimulus values involved in comparative judgment, each minimizes the discrimination probability when the other is held fixed (treated as the reference stimulus); and (ii) non-constant similarity, i.e., the value of the discrimination probability at its minimum is a non-constant function of the reference stimulus value. These two conditions were shown to preclude a large class of well-behaved Thurstonian scaling (Dzhafarov, SMP'2001). Here I study the general form of discrimination function that satisfy these two conditions, using the tools of convex analysis. Noting that regular minimality and non-constant similarity express precisely the notion of conjugacy under Fenchel-Legendre transformation, a 1-to-1 mapping between the comparison stimulus space and the reference stimulus space can be naturally constructed. Expressed in terms of the comparison and reference stimulus values, the resultant psychometric differential is shown to take the form of an asymmetric divergence measure originally proposed in differential geometry of probability manifold (Amari, 1985). This divergence measure, which is non-negative and asymmetric at large, actually induces a Riemannian metric in the small, with psychometric order (defined in Dzhafarov and Colonius, 2000) equal 2.

Information Processing III---

A Model of the "go/no-go" Lexical Decision Task   **Saturday 3:00 p.m.**

Pablo Gomez, Northwestern University, Manuel Perea. Universitat de Valencia, Roger Ratcliff, Northwestern University

         The go/no-go task is an alternative experimental technique to the yes/no dual choice task. Although most researchers find better accuracy in the go/no-go task, the task effects on RTs are not consistent. If the go/no-go task is to be used extensively, it is necessary to understand what are the processes that differ from the yes/no to the go/no-go task. We examined several assumptions about what these processes might be by implementing them in the diffusion model. The different implementations of the model were applied to data from five lexical decision task experiments. The implementation that provided the most satisfactory account for all dependent variables (accuracy, correct and error RTs and their distributions) was one in which we assumed that: (1) there is an implicit negative decision boundary associated with the no-go trials; (2) the response preparation stage in go/no-go is shorter than in yes/no; and (3), subjects can change the decision criteria across tasks. This implementation differs from previous formulations that assumed that the go/no-go task could be accounted for with single-boundary diffusion or random walk models. In addition, it provides an explanation for the typical task effects on response probability and latency.

Theories of Function Learning: The Diagnosticity of   **Saturday 3:25 p.m.**
Multi-Modality.

Stephan Lewandowsky, Mike Kalish, University of Western Australia

         Kalish, Lewandowsky and Kruschke recently reported three function learning experiments in which people had to associate a single continuous stimulus variable with a continuous response variable. In all experiments, the to-be-learned functions were characterized by regions of uncertainty about the correct response (e.g., because outlying responses were required for some stimulus values during training). At transfer, people were found to respond multi-modally to
stimuli within the region of uncertainty. That is, responses clustered either around the value suggested by the primary function or around the values of the outlying responses. No responses of intermediate magnitudes were observed. We show that this pattern of responding is compatible with the predictions of a mixture-of-experts model presented by Kalish, Lewandowsky, and Kruschke. We also show that the multimodal pattern of responding cannot be accommodated by another computational model of function learning, EXAM, which was proposed by Delosh, Busemeyer and McDaniel (1997).

Problem solving without search   Saturday 3:50 p.m.

Zygmunt Pizlo, Zheng Li, Purdue University

It has been commonly assumed, since the seminal work of Newell & Simon (1972) that human problem solving involves search through the set of possible operators in order to find a sequence which minimizes the length (cost) of the solution. Our study was motivated by examples of solving problems (visual navigation, traveling salesman) where humans do not seem to perform any search or to use distances (costs). We tested subjects in 5, 8, 15 and 35 puzzles, which belong to the class of NP-complete problems. We measured the number of moves and time it takes to solve a problem. Our results show that the time of solving the problem is directly proportional to the number of moves and is approximately a linear function of the problem size. These results suggest the absence of search in solving the problems. From the solutions to the 15 puzzle we designed further tests to measure the subject's ability to judge distances among the states of his solutions as well as direction from one state to another. A "direction" from state A to B is defined as the path from A to B. We found that subjects can reliably judge directions but not distances. We conclude that: (i) direction, rather than distance, is the fundamental element of human problem solving, and (ii) direction can account for producing good solutions to difficult problems, without performing search.

Judgement, Decision, & Choice III ---

Beyond Statistical Artifact: A Critical Examination for Effects   Sunday 8:30 a.m.
of Random Error on Choice and Confidence Judgment

Hongbin Gu, University of North Carolina-Chapel Hill, Thomas S. Wallsten, University of Maryland

An important theoretical development in the study of confidence and calibration concerns the critical role of random error in findings of miscalibration (Erev, Wallsten & Budescu, 1994; Soll(1996); Suantak, Bolger, & Ferrell, 1996). Recently, Juslin, Winman & Olsson (2000) dismissed many regularities as artifacts associated with the experimental setting and the statistical analyses (end-of-scale effects, linear dependence and regression to the mean). This study presents a critical review of the effects of random error on calibration. A rigorous analysis shows the conditions under which different calibration patterns are expected. They depend on the relationship between underlying psychological structures, as well as the size of the error components associated with each structure. Simulation studies demonstrate the major calibration findings under various conditions, and provide an opportunity to test the artifact claim of Juslin et al (2000). An analysis using a data set from Juslin (1998) refutes the artifact claim. The results thus far offer confirmative support for distinctive psychological algorithms for choice and confidence.

Confidence Modeling in Perceptual Tasks   Sunday 8:55 a.m.

Ed Merkle, Trisha Van Zandt, Ohio State University

The issue of confidence calibration is concerned with a person's ability to accurately predict his or her level of performance on atask. A typical finding is that of overconfidence: people tend to believe that they are correct more often than they actually are. We examine confidence calibration in a simple choice RT task. Our experiments are motivated by an accumulator model in which confidence is modeled using Vickers' (1977) balance-of-evidence hypothesis. This model proposes that information supporting each alternative accumulates on separate counters. The observer responds in favor of whichever alternative's counter first hits a designated threshold level. Confidence can then be scaled from the difference between the counters at the time that the observer makes a response. We examine the overconfidence result in general, hard-easy effects, and a new finding: people are less well calibrated under response bias.

Sequential Sampling Models of Human Text Classification   Sunday 9:20 a.m.

Michael D. Lee, University of Adelaide

Text classification involves deciding whether or not a document is about a given topic. It is an important problem in machine learning, because automated text classifiers have enormous potential for application in information retrieval systems. It is also an interesting problem for mathematical psychology, because it involves real world human decision making with complicated stimuli. This paper develops two models of human text document classification based on random walk and accumulator sequential sampling processes. We evaluate the models using data from an experiment where participants classify text documents presented one word at a time under task instructions that emphasize either speed or accuracy,

and rate their confidence in their decisions. Fitting the random walk and accumulator models to these data shows that the accumulator provides a better account of the decisions made, and a balance of evidence measure provides the best account of confidence. Both models are also evaluated in the applied information retrieval context, by comparing their performance to established machine learning techniques on the standard Reuters-21578 corpus. It is found that they are almost as accurate as the benchmarks, and make decisions much more quickly because they only need to examine a small proportion of the words in the document. In addition, the ability of the accumulator model to produce useful confidence measures is shown to have application in prioritizing the results of classification decisions.

Cognitive Neuroscience---

How Acuity Is Conserved in Convergent-Divergent Networks: Only One Way?

Sunday 8:30 a.m.

Thomy Nilsson, University of Prince Edward Island

Afferent sensory pathways must be convergent. Otherwise, there would not be enough room in the brain. What prevents a huge loss of acuity when all that information gets squeezed through relatively few nerve fibres? Once the information gets into the brain, acuity is restored by a corresponding divergence to as many neurons as the original number of receptors or more, depending on where one draws the line between 'input' and 'processing'. As branch diagrams, convergent-divergent schematas look good and make intuitive sense. But have you ever tried to make one actually work? By work, I mean as a simple linear system without fancy coding mechanisms or handwaving. The first time I drew such a system, it worked. Some years later, I drew another, but it didn't work. Puzzling. I had thought that any divergent pattern which mirrored the convergent pattern would restore acuity. Not so. After dozens of diagrams, I concluded that there was only one basic way to design a linear convergent- divergent system that conserved acuity. That basic schema is presented along with a model in MicroSaint. Also shown is a multiple version which achieves higher rates of convergence and divergence. Question: Is there a formal way to determine if this is only basic way to achieve linear spatial multiplexing?

A model of neurotransmitter habituation and dishabituation in autism.

Sunday 8:55 a.m.

Don Loritz, Eleni Koutsomitopoulou, LexisNexis Corporation and Georgetown University.

Adaptive Resonance Theory (ART, Grossberg 1976 *et seq.*) describes a "rebound" mechanism of neurotransmitter habituation and dishabituation which simultaneously activates new learning sites in long-term memory and protects sites of established memory against adventitious recoding under Hebbian dynamics. Grossberg and Gray independently proposed that the role of the hippocampus in new memory formation is that of a "comparator" (Gray and Rawlings 1986) with Grossberg 1982 more specifically suggesting that such a comparator is implemented by neurotransmitter rebounds and evidenced by a P300 of hippocampal origin. Loritz (1999) extrapolates these and other ART mechanisms to language learning and performance. A computer simulation of these mechanisms in limbic system/hippocampus and neocortex will be presented. In conjunction with recent findings of hippocampal abnormalities in autism (Bauman and Kemper, 1994), it will then be argued that general cognitive characteristics of autism and specific characteristics of autistic language disorder (*e.g.* negative/non-negative echolalia, pronominal reversal, "asocial"conversational disorder) can be most concisely described by a failure of the modeled comparator mechanism. In conclusion, the paper will discuss more recent research (Brown, Bullock, and Grossberg 1999) which suggests that the epicenter (or at least one dopaminergic epicenter) of this mechanism might instead be located slightly off the hippocampus-Papez circuit in the ventral striatum.

A Functional Model of the Effect of Midazolam on the Hippocampus And Recognition Memory

Sunday 9:20 a.m.

Kenneth J. Malmberg (presenter), Rene Zeelenberg, and Richard M. Shiffrin
Indiana University

The pharmaceutical Midazolam causes dense, but temporary, antereograde amnesia in patients. Because Midazolam can be used to impair memory in otherwise normal populations, its use as a research tool could potentially have a large impact on the human memory research. The question that we ask is at the function level: How does Midazolam harm memory? We consider two hypotheses: The effect of

Midazolam is to cause the hippocampus region to store less information in memory, and/or Midazolam causes the hippocampus region to store episodic information less accurately in memory. The Retrieving Effectively from Memory model (REM, Shiffrin & Steyvers, 1997) can predict the effects of Midazolam, study time, and normative word-frequency on both yes-no and remember-know recognition memory (Hirshman, Fisher, Henthorn, Arndt, and Passannante, in press). According to the current REM model, storing information less accurately is necessary and sufficient to predict the data, but storing less information is neither necessary nor sufficient.

Judgment, Decision, & Choice IV ---

Comparing decision making models for the   Sunday 10:10 a.m..
Bechara Gambling Task: An application of the generalization criterion
Anli Lin, Jerome Busemeyer, Peter Finn, Indiana University

　　　The Bechara gambling task has frequently been used by Cognitive and Clinical Neuroscientists as a method for assessing decision making deficits in special populations including brain damaged patients and drug abuse populations. We developed several different mathematical models for this learning and decision task, and we have conducted extensive model comparisons at the individual level of analysis. This paper presents the results of model comparisons based on the generalization criterion proposed by Busemeyer and Wang (Journal of Mathematical Psychology, 2000, 44, 171-189).

A unified framework for comparing models of individual   Sunday 10:35 a.m.
preferential choice
Joseph G. Johnson, Indiana University, Max Planck Institute for Human Development

　　　My work explores the use of a single mathematical framework, with the use of psychologically meaningful parameter interpretations, to derive and compare different preferential choice models. These models are usually evaluated in terms of their normative and/or descriptive plausibility. Because individual preference is inherently subjective, I would argue that it is not possible to use a benchmark (e.g. weighted additive models) or other normative criteria to evaluate these models-however, measures such as parsimony and generalization can be used to compare models. Instead, independent appraisal of models of preferential choice should be performed in terms of their ability to account for individual behavior that is demonstrated in realistic environments. The major elements of the behavior under examination are response measures (e.g. choice and response time), process measures (e.g. strategy employed), and choice properties (e.g. transitivity, dominance, independence). Not only should models under serious consideration accurately describe these characteristics, but they should also be able to portray individual differences. I propose the use of appropriate parameter restriction and specification to achieve this latter goal. I will review the essential characteristics of Decision Field Theory (DFT, Busemeyer & Townsend, 1993; Diederich, 1997; Roe, Busemeyer & Townsend, 2001), and how this theory can be utilized as a mathematical framework for representing a wide variety of preferential choice models. Then, I will introduce a procedure that allows for the modeling of a large number of different weighting schemes, initial biases, memory assumptions, computation processes, thresholds, constraints, and other individual characteristics within this framework.

Predictions of Decision Field Theory based on prior outcomes   Sunday 11:00 a.m.
Robert M. Roe, Rachel F. Barkan & Keith D. Markman, Ohio University
One well documented phenomenon in the literature of decision making regards the effect of prior outcomes. The common finding is that prior gain leads to risk aversion while prior loss leads to risk seeking (e.g. Kahneman and Tversky, 1979). Some conflicting effects were also found. For example, the "gambling with the house-money effect" (Thaler and Johnson, 1990), which shows prior gain leads to risk seeking rather than to risk aversion. We use Decision Field Theory(DFT) to predict the effects of prior outcomes on choices of gambles. This model reproduces risk aversion after prior gain and
risk seeking after prior loss as well as gambling with the house money, and risk aversion after prior losses. In the past, the conflicting effects were attributed to different mechanisms of segregating or integrating prior outcomes. DFT assumes that prior outcomes are integrated into the experienced utility of the reference point. Whether those prior outcomes lead to risk aversion or to risk seeking depend on the individual utility function of the DM, the threshold he/she uses and the level of general inconsistency in his/her preferences.

Memory---

A dual process REM model for registration with/without   **Sunday 10:10 a.m.**
learning.

Kenneth J. Malmberg, Jocelyn E. Holden, Richard M. Shiffrin, Indiana University,

High and low frequency words were studied 0, 1, 3, 6, or 12 times each, each in either plural or singular form. At test participants gave judgments of frequency of a word in its exact plurality (0 representing a judgment of 'new'). This is a variant of the 'registration without learning' effect first studied by Hintzman, Curran, and Oppy (1992). The REM model of recognition memory (Shiffrin & Steyvers, 1997) applied to this paradigm predicts a performance advantage for low frequency words, a mirror effect for dissimilar foils, but a change in the mirror effect for similar foils (foils differing only in plurality from studied words). These predictions were upheld qualitatively, but a good quantitative fit required an extension of the single process REM model to include a dual process in which recall could be used to reject similar foils.

Modeling interlist repetition effects in free recall   **Sunday 10:35 a.m.**

Michael J. Kahana, Gene Sirotin, Emily Dolan, Brandeis University, Marc Howard, Suracuse University

A prediction that follows from both retrieved context and inter-item associative models of free recall is that interlist repetitions should impair memory retrieval, inducing prior list intrusions (PLIs) and making it difficult to distinguish items in the target list from those presented in earlier lists. We conducted two large-scale free recall studies in which some items in a given list also appeared on earlier lists. In all cases, subjects were instructed to recall the items from the most recently presented list. Repetition greatly enhanced recall of list items, and associative tendencies following once-presented and repeated items were nearly identical. However, after recalling repeated items subjects were significantly more likely to make PLIs (although the overall level of PLIs was very low). We fit these data using two different models of free recall: Both models assume that context changes both within and between lists, but in one model, contextual retrieval is used to form interitem associations (e.g., Howard & Kahana, in press), and in the other model, interitem associations are formed by rehearsal in a short-term store (e.g., Raaijmakers & Shiffrin, 1980).

Modelling error latencies in serial recall   **Sunday 11:00 a.m.**

Simon Farrell, Northwestern University, Stephan Lewandowsky, University of Western Australia

Empirical regularities in response probabilities in serial recall have been well established, and have been shown to imply specific mechanisms in models of serial recall. However, these empirical and theoretical advances have not been accompanied by research on latencies, data which have been found to neatly constrain models in other areas. We present some new regularities in error latencies from several experiments, and show that these data mandate specific assumptions about serial recall processes using modelling in a generic competitor network. Specifically, we show that perseveration errors are faster than anticipation errors, and suggest that primacy gradient, in combination with response suppression, most ably accounts for this pattern of latencies.

EICL and TODAM   **Sunday 11:25 a.m.**

Bennet Murdock, University of Toronto

A computational model (EICL) based on excitation, inhibition, a closed-loop learning algorithm, and a toy lexicon can explain the two puzzling memory phenomena, the mirror effect and the spacing effect. I shall report on my attempts to implement EICL in TODAM, a process model which so far has not been able to provide a satisfactory account of these two effects.