Australian Mathematical Psychology Conference 2016

Key Information

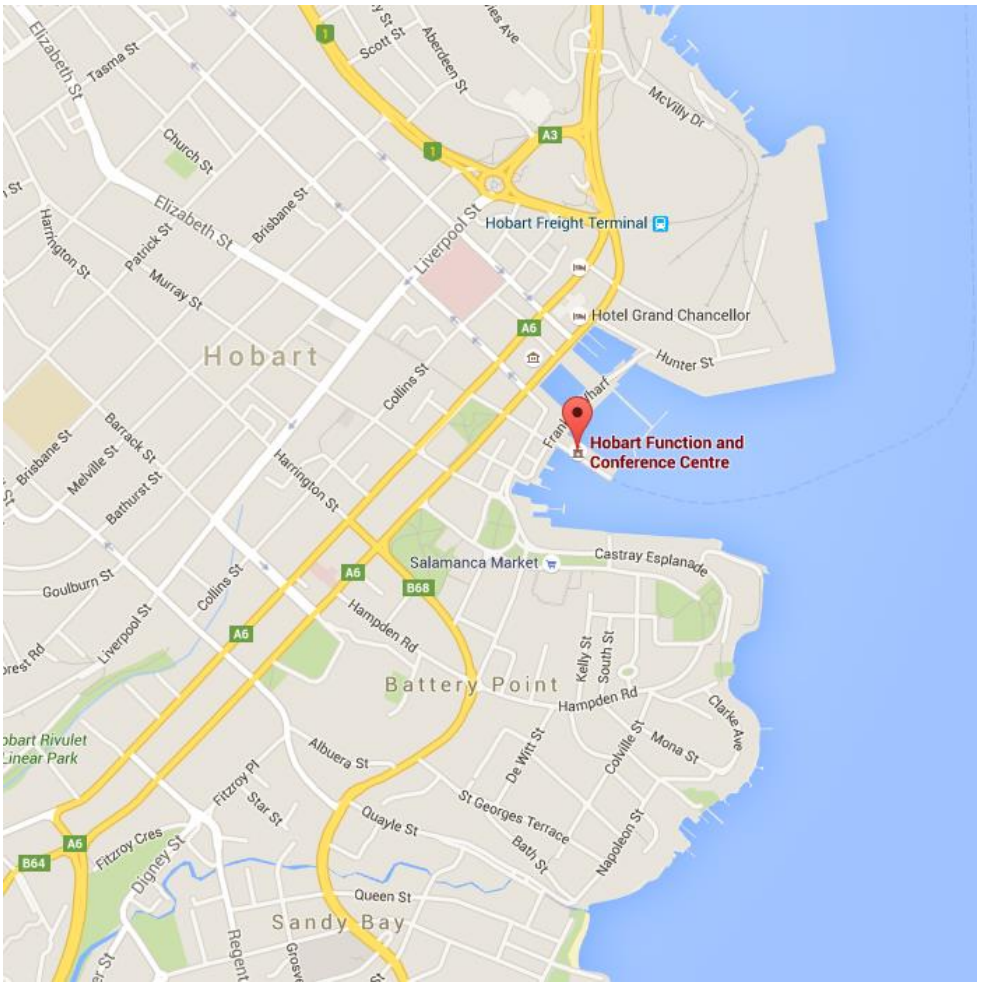
Conference Dates:

- Main Conference: Wednesday 10th, Thursday 11th and Friday 12th of February 2016 (Conference will finish at lunchtime on the Friday, to enable flights back to the mainland)

Conference Venue

Location:

- Hobart Function and Conference Centre, Sovereign Room - 1 Elizabeth Street Pier, Hobart http://hfcc.com.au/



Registering for the Conference

- **Registration to the conference and dinner is now closed**

Conference Dinner

- Thursday the 11th of February 7.30pm for 8pm sit down
- Customs House – 1 Murray Street, Hobart

Extra Activities

We will have the traditional cricket game before the conference dinner on Thursday. Transport will be provided at 5:15pm outside the conference venue to Nutgrove sports grounds, returning at 7pm. You can also go for a swim at the beaches next to the sports grounds.

For those of you interested in staying longer to do the tourist thing some of the locals will lead an expedition out to Mona for lunch and a look at the museum. Arrive at the Mona ferry terminal at 1:00pm for the departure at 1:15pm sharp. Tickets should be pre-purchased from http://www.mona.net.au/visit/getting-here/. Return ferries can be caught every hour after that until early evening.

On Saturday morning there is the popular Salamanca Market (it is right outside the conference hotel). Some potential day trips could be to Port Arthur and on the way you could visit the Tasmanian Devil Park or the Hasting Caves State Reserve; both are scenic drives.

Conference Timetable at a Glance

Abstracts ordered alphabetically by first authors name at the end of this document.

WEDNESDAY

Time	Event	Authors
9:15-9:30	Welcome	Andrew Heathcote
	Session 1: Chair Jeromy Anglim	
9:30-9:45	A Bayesian perspective on the Reproducibility Project	*Joachim Vandekerckhove, Alexander Etz
9:45-10:00	Bayesian Hierarchical Models of Dynamic Ability–Performance Relationships	*Jeromy Anglim
10:00-10:15	Examining the Relationship Between Practice and Strategy Use: Hierarchical Bayesian Models of Composite and Component Strategy Use	*Sarah Wynton, Jeromy K. Anglim
10:15-10:30	How credible are Bayesian Credible Intervals?	*Lauren Kennedy, Daniel Navarro, Amy Prefors, Nancy Briggs
10:30:10:45	Stuck in the Gates: Bayesian Modelling of Trigger Failure in the Stop Signal Task	*Patrick Skippen, Dora Matzke, Andrew Heathcote, William R Fulham, Patricia T. Michie, and Frini Karayanidis
10:45-11:15	**Coffee**	
	Session 2: Chair Don Van Ravenzwaaij	
11:15-11:30	Geometric morphometric analysis for quantifying and categorizing brain structure shape in diabetic and non-diabetic populations	*Erin Walsh, Marnie Shaw, Mark Fraiser, Kaarin Anstey & Nicolas Cherbuin
11:30-11:45	One Approach for Integrating Neural and Behavioral Data into a Single Model	*Don Van Ravenzwaaij, Alexander Provost, Scott D. Brown

11:45-12:00	Informing cognitive models of visual decision making with EEG measures of attention	*Michael Nunez, Ramesh Srinivasan, Joachim Vandekerckhove
12:00-12:15	Looking at it from a different angle	*Max Keuken, B.U. Forstmann1, L. van Maanen
12:15-12:30	Ranking Choices in Context Effect Tasks	*Shi Xian Liew, Piers D. L. Howe, Daniel R. Little
12:30-2:00	**Lunch**	
	Session 3: Chair Sally Andrews	
2:00-2:15	Diffusion vs. linear ballistic accumulation: Different models, different conclusions about the slope of the zROC in recognition memory	*Adam Osth, Beatrice Bora, Simon Dennis, Andrew Heathcote
2:15-2:30	Cognitive models in the extreme	*Melissa Humphries, Barbara Holland, Angus Reynolds, Raimondo Bruno
2:30-2:45	Expectancy Valence Insight Learning (EVIL): A computational model of confidence in experiential choice	*Emmanouil Konstantinidis, Maarten Speekenbrink, David R. Shanks
2:45-3:00	The Mechanisms of Semantic Priming: Insights from Individual Differences	*Sally Andrews, Melissa Prince, Aaron Veldre
3:00-3:15	Disentangling Stimulus-Driven and Strategic Effects in Lexical Decision	*Melissa Prince, Andrew Heathcote, Colin J. Davis, Sally Andrews
3:15-3:45	**Coffee**	
	Session 4: Chair Michael Smithson	
3:45-4:00	Comparing the performance of several proposed models of risky inter-temporal choice	*Ash Luckman, Chris Donkin, Ben R. Newell
4:00-4:15	Better than Beta? Modelling Random Variables on the Unit Interval with CDF-Quantile Distributions	*Yiyun Shou, Michael Smithson
4:15-4:30	Conflict and Ambiguity: Described versus Experienced	*Daniel Priest, Michael Smithson
4:30-4:45	Does Experiencing Uncertainty Make People More Pessimistic?	*Michael Smithson, Daniel Priest
4:45-5:00	Experiencing Ambiguity through Missing Information	*Ben Newell, Şule Güney

THURSDAY

Time	Event	Authors
	Session 5: Chair Philip Smith	
9:15-9:30	Using an experience sampling approach to distinguish distance versus location based strategies in memory for when	*Simon Dennis, Vishnu Sreekumar, Nathan Evans
9:30-9:45	Resources masquerading as slots: Flexible allocation of visual working memory	*Chris Donkin, Arthur Kary, Fatima Tahir, Robert Taylor
9:45-10:00	Individual Differences in the Removal of Outdated Information from Working Memory	*Ullrich Ecker, Kris Singh, Gilles Gignac,
10:00-10:15	Diffusion modelling reveals evidence for unequal variance signal detection models of the lexical decision task	*Gabriel Tillman, Adam Osth
10:15-10:30	Diffusion model analysis of the focus of attention in visual working memory: Access costs, interference, and retrieval failure.	*David Sewell, Simon D. Lilburna, Philip L. Smith
10:30:10:45	The Attention Weighted Sample Size Model of Visual Short-Term Memory: Signal Detection and Diffusion Model Analysis	*Philip Smith, Simon D. Lilburn, Elaine A. Corbett, David K. Sewell
10:45-11:15	**Coffee**	
	Session 6: Chair Dan Little	
11:15-11:30	Recency effects and response times in perceptual categorization: Comparing exemplar and rule-based accounts in a modified Garner task	*Daniel Little, Tony Wang, Robert M. Nosofsky
11:30-11:45	Overcoming the curse of dimensionality: how category structure affects the learning of complex categories	*Wai Keen Vong, Amy Perfors
11:45-12:00	On testing core assumptions of signal detection theory	*John Dunn, Laura Anderson
12:00-12:15	Testing dual-process theories of reasoning using logic training and believability	*Rachel G. Stephens, John C. Dunn, Brett K. Hayes, Michael L. Kalish
12:15-12:30	Using iterated Learning to Uncover Inductive Biases in Multiple Cue Judgment	*Arthur Kary, Ben Newell, Chris Donkin
12:30-2:00	**Lunch**	

	Session 7: Chair Andrew Neal	
2:00-2:15	Accumulating evidence for the delay theory of prospective memory costs	*Luke Strickland, Shayne Loft, Roger W. Remington, Andrew Heathcote
2:15-2:30	The Effects of Time Pressure on Evidence Accumulation in a Complex Multi-Stimulus Environment.	*Hector Palada, Andrew Neal, Rachel Tay, Russell Martin, Andrew Heathcote
2:30-2:45	Quantifying the psychological value of goal achievement	*Timothy Ballard, Andrew Neal
2:45-3:00	Development of a general model of multiple-goal pursuit	*Andrew Neal, Timothy Ballard
3:00-3:15	Multiple information sources in perceptual similarity	*Andrew Hendrickson, Daniel Navarro, Chris Donkin
3:15-3:45	**Coffee**	
	Session 8: Chair Amy Perfors	
3:45-4:00	Do people use feature correlations when judging similarity?	*Steven Langsford, Andrew Hendrickson, Amy Perfors, Daniel Navarro
4:00-4:15	Knowledge partitioning in person-perception	*Robert de Lisle, Daniel Little, Yoshi Kashima
4:15-4:30	Selecting an Optimal Subgroup of Experts	*Marcellin Martinie, Piers Howe, Tom Wilkening
4:30-4:45	Formation of joint judgements by dyads: Weighted averaging vs mixture of strategies	*Simon Farrell, Rebecca Floyd, David Leslie, Roland Baddeley
4:45-5:00	Social, not statistical, and not irrational? The Monty Hall Problem revisited	*Amy Prefors, Daniel Navarro, Titia Benders, Chris Donkin
5:15	**Cricket** (bus will depart from conference venue)	
8:00	**Conference Dinner**	

FRIDAY

Time	Event	Authors
	Session 9: Chair Scott Brown	
9:15-9:30	Information transfer and aural comprehension	*David Allingham
9:30-9:45	The influence of practice and overall feedback on achieving reward rate optimality	*Nathan Evans, Scott Brown
9:45-10:00	Target proportion manipulations selectively influence response bias	*Yishin Lin, Andrew Heathcote
10:00-10:15	Retest Reliability of the Parameters of the Ratcliff Diffusion Model	*Veronika Lerche, Voss, Andreas
10:15-10:30	Diffusion Modeling of the Approximate Number System	*Roger Radcliff, Gail McKoon
10:30:10:45	Flexibility of Evidence-Accumulation Models	*Matt Jones, Ehtibar Dzhafarov,
10:45-11:15	**Coffee**	
	Session 10: Chair Ami Eidels	
11:15-11:30	Are You Being Serial? Cognitive Processing Systems of Enumeration	*Paul Garrett, Ami Eidels
11:30-11:45	A pre-accumulator inhibitory parallel model of decision making with multiple same-feature luminance stimuli	*Anthea Blunden, Daniel R. Little, Daniel R. Little
11:45-12:00	The Capacity of Opaque and Transparent Chinese Words	*Xue Jun Cheng, Daniel Little
12:00-12:15	What Do Cows Drink? Investigating the Intersection of Memory Cues Using Systems Factorial Technology	*Zach Howard, Neralie Stuart, Ami Eidels, Simon Dennis
12:15-12:30	A Systems Factorial Technology Analysis of the Effect of Feature-to-Feature Distance on the Processing of Separable Dimensions	*Sarah Moneer, Daniel R. Little
12:30-1:00	**Business Meeting**	
1:15	**Ferry to MONA (arrive at ferry terminal by 1pm at the latest)**	
5:00	**Ferry to Hobart**	

Information transfer and aural comprehension

David Allingham

University of Newcastle

This talk is one part background, one part supposition and one part request. I will talk about neural response modelling work undertaken in a former life, which resulted in a complete multi-channel cochlear implant model, from auditory processing to nerve response to brain processing (in a relatively theoretical sense). Results obtained from that model demonstrated the enhancement of information transfer due to the addition of noise at an optimal amplitude.

In building this model we made two important assumptions. The first is of optimal reconstruction of the neural response spike-train (an argument made by appeal to the plasticity of mental processing). The second is that ``information transfer'' through this system, as measured in a formal information-theoretic manner, is positively correlated with ``aural comprehension'' (measured in some way) for cochlear implant users.

With reference to existing results in this area, I am seeking ways in which these assumptions could be tested through cognitive experiments, and will describe the desired outcomes of such experiments.

The Mechanisms of Semantic Priming: Insights from Individual Differences

Sally Andrews*[1], Melissa Prince[2] & Aaron Veldre[1]
University of Sydney[1]
Flinders University[2]

This research used an experimental psychometric approach to compare semantic priming effects from masked 50 ms primes with brief (200 ms) visible, unmasked primes in a large sample (n=99) of skilled readers who had been assessed on vocabulary and spelling ability. To distinguish between prospective and retrospective contributions to semantic priming, symmetrically associated words (eg *answer-question*), were compared with pairs that were asymmetrically associated in either the forward (eg *panda bear*) or backward (eg *ball-catch*) direction. Linear mixed effect regression models and reaction time (RT) distribution analysis were used to assess how masked and unmasked priming differ in their sensitivity to differences between both the form of semantic similarity, and individual differences in lexical proficiency.

Delta plots for the complete sample showed that the small, but significant masked semantic priming effect was due to a relatively constant shift across the RT distribution, while the priming from unmasked primes increased across the RT distribution. This pattern is consistent with the qualitative differences implied by Gomez, Perea & Ratcliff's (2013) diffusion modeling of masked and unmasked priming which showed that masked priming was best captured by the T_{er} parameter while unmasked priming affected drift rate as well as T_{er} . Gomez et al. interpreted these findings as confirming the distinction between an initial perceptual encoding stage and a subsequent evidence accumulation process.

The present data qualify this conclusion by showing that the average patterns of priming were significantly modulated by individual differences in lexical proficiency, assessed by a composite of vocabulary and spelling ability. Higher proficiency participants showed stronger masked priming, but weaker unmasked priming than low proficiency participants. The differential delta plots for masked and unmasked priming were driven by the lower proficiency participants. High proficiency participants showed very similar distributional patterns of priming for masked and unmasked primes. The implications of these findings for models of lexical retrieval and semantic priming will be discussed.

Bayesian Hierarchical Models of Dynamic Ability–Performance Relationships

Jeromy Anglim
Deakin University

There is a long history of research on how the relationship between stable traits (e.g., cognitive ability, personality, etc.) and task performance changes with practice, experience, or time (Ghiselli, 1956; Humphreys, 1960; Fleishman and Hempel, 1954; Ackerman, 1988; Keil & Cortina 2001). A related line of research has studied the relationship between practice and performance, commonly operationalised as task completion time. Much of this research has focused on group-level trends, although there is increasing awareness of the importance of studying the relationship between practice and performance at the individual-level (e.g., Heathcote, Brown, & Mewhort, 2000; Anglim & Wynton, 2015). A wide range of analytic approaches have been adopted to examine dynamic ability–performance relationships (for a review see, Sturman, 2007). These approaches have a range of shortcomings, including (a) using simplistic polynomial functions to model the relationship between practice and performance, (b) failing to capture distributional characteristics of performance, (c) treating ability–performance correlations at a given time point as sufficient statistics, and (d) exploring a limited range of interaction effects between practice and ability on performance.

A Bayesian hierarchical approach provides several advantages over these traditional approaches (Anglim & Wynton, 2015): (1) non-linear functions can be used to model the relationship between practice and performance that better reflect the core features of learning curves—monotonic deceleration of rate of learning and the approach to an asymptote; (2) the models provide a complete description of the data generating process; (3) a broader range of interaction effects between ability and practice can be incorporated; and (4) using factor analytic representations, the latent structure of ability can be incorporated into the model.

The present study aimed to refine models of the relationship between practice, ability, and performance using Bayesian hierarchical modelling. Data was drawn from a study of 154 adults who completed a battery of ability tests that measured cognitive, perceptual speed, and psychomotor ability. Participants then completed 30 blocks of trials on a text editing task where performance was measured as the average time to complete various text editing actions such as deleting text, changing a word, and cutting and pasting text. The talk will present alternative models of these interaction effects and discuss implications for integrating theories of stable individual differences with individual differences in skill acquisition.

Quantifying the psychological value of goal achievement

Timothy Ballard[*1], Andrew Neal[1] & Simon Farrell[2]
[1]University of Queensland
[2]University of Western Australia

When pursuing competing goals, people often adopt a "putting out fires" strategy by prioritising whichever goal is furthest from achievement (Schmidt & DeShon, 2007). This strategy often increases the likelihood of achieving more than one goal, but also increases the risk of failing to achieve any goals. Previous work has suggested that the putting out fires strategy can be attributed to people undervaluing the rewards associated with achieving some, but not all of their goals (Ballard, Yeo, Neal, & Farrell, in press).

In this talk, we examine the psychological value of various goal achievement outcomes. We present an experiment in which participants made repeated prioritisation decisions whilst pursuing either two approach or two avoidance goals.

They were rewarded $10 if they achieved both goals, and either $0, $2.50, $5, $7.50, or $10 if they achieved only one.

The results showed that the tendency to use the putting out fires strategy decreased as the reward for achieving only one goal increased, and was generally higher when people were pursuing avoidance goals compared to approach goals. On average, participants used the putting out fires strategy more often than the reward-maximising model. This difference was most pronounced when there was no additional reward associated with achieving the second goal. In this condition, participants still strived to achieve both goals even when doing so decreased the expected reward.

Model comparisons revealed that a model which assumed that the subjective value of achieving one goal departed from the objective value provided a better account of the data than a model with an objective value function and a noisy decision process. According to the parameter estimates, people behaved as if they were placing more value on achieving both goals and less value on achieving only one goal than the reward-maximising model. These findings suggest that there is added value in achieving multiple goals over and above the financial incentive associated with doing so, which can often lead to compromises in performance and objective reward.

References

Ballard, T., Yeo, G., Neal, A., & Farrell, S. (in press). Departures from Optimality When Pursuing Multiple Approach or Avoidance Goals. *Journal of Applied Psychology*.

Schmidt, A. M., & DeShon, R. P. (2007). What to do? The effects of discrepancies, incentives, and time on dynamic goal prioritization. *Journal of Applied Psychology*, *92*, 928–941. doi:10.1037/0021-9010.92.4.928

A pre-accumulator inhibitory parallel model of decision making with multiple same-feature luminance stimuli

Ms. Anthea G. Blunden*, Dr. Daniel R. Little, Dr. Piers D. L. Howe
University of Melbourne.

Current models of categorisation tend to assume that decision making using multidimensional visual stimuli is driven by a fixed similarity relationship between features. For example, exemplar-based models assume that once the initial similarity relationship is determined (e.g. via multidimensional scaling), decision making occurs in a predictable way via similarity-based comparisons to stored exemplars. Similar assumptions underlie rule-based models based on general recognition theory. Using Systems Factorial Technology and the Logical Rule models, which generalise modern categorisation models to allow for different processing architectures, but still assume a fixed representation, we provide a diagnosis of information processing (i.e., whether processing is serial, parallel or coactive) when feature information is not categorically different and is presented in multiple locations. That is, we examine categorisation and response time when separate discs of differing levels of luminance are presented in different spatial locations. Our results show that processing occurs coactively (i.e., is pooled into a single decision process). However, capacity is best described as limited. This finding is atypical because under standard assumptions, coactive models (including exemplar-based models and GRT-based models) predict super capacity. Hence, our results cannot be accounted for using any of the standard processing architectures. Rather, processing can be described using a multi-stage model account of decision making. This account assumes an early pre-accumulator inhibitory interaction which alters the nature of the inputs when there is more than one dimension. This model can predict both coactivity and limited capacity. We conclude that models of categorisation need to account for early interactions between stimulus dimensions; we further highlight the need for a closer connection between models of perceptual processes and models of categorisation decisions.

The Capacity of Opaque and Transparent Chinese Words

Xue Jun Cheng*[1], Daniel Little[1]
[1]School of Psychological Sciences, The University of Melbourne

Stimuli that we have a high level of experience with such as faces and words are special in that they seem to be processed holistically (i.e., represented according to their whole and not their constituent parts). Studies comparing the processing of words and non-words have shown that words show the hallmarks of holistic processing more than non-words, especially for native readers. However, it is uncertain which aspect of experience drives this difference in processing. A study by Han et al. (2014) investigating semantic transparency (i.e., the relationship between the meaning of the whole word compared to the meaning of its constituents) found that opaque words (e.g., hogwash) were more often and more accurately recognized compared to their transparent counterparts (e.g., rosebud). In the current study, we aim to use the same opaque and transparent two-character Chinese words used in Han et al. (2014), but examine response time (RT) data, which allow us to obtain a more rigorous definition and measurement of holistic processing. We adapted the redundant target paradigm used by Houpt et al. (2014) to examine capacity in the detection of opaque and transparent words. Both fluent readers and readers with no experience were tested. Results show more limited capacity for transparent compared to opaque words. These results indicate that we may be more inclined to memorize opaque words as individual character meanings do not help us arrive at the meaning of the whole. In contrast, as the meaning of a whole transparent word can be derived from its constituents, we are more likely to process each character in a serial, additive manner to arrive at the whole.

Keywords: words, holistic, perception, capacity

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Knowledge partitioning in person-perception

Robert de Lisle*, Dr Daniel Little, Prof Yoshi Kashima
University of Melbourne

People use *knowledge partitioning* to decompose complex rules into simple, local strategies, bound to values of a categorical *context* variable. It may be a generally adaptive strategy, but can lead to idiosyncratic errors. It has been observed in function-learning and categorisation studies with expert and non-expert participants, but never with socially meaningful stimuli. In our experiments, we have reproduced function-learning and knowledge partitioning in the social domain using the fundamental dimensions of personality perception, *warmth* and *competence*, as learned predictor variables and race as a context variable. The subjective component of these ratings not only makes them more variable, but also introduces an additional source of variation

Using an experience sampling approach to distinguish distance versus location based strategies in memory for when

Simon Dennis*
University of Newcastle
Unforgettable Technologies Inc

Vishnu Sreekumar
National Institutes of Health

Nathan Evans
University of Newcastle

Friedman (1993, 2004) argued that people typically use direct retrieval, order-based, location-based or distance-based strategies to isolate the time at which an event occurred, with the later two being most common. Location-based processes rely on the retrieval of information associated with the cues that can be used to draw inferences about the timing of an event. Distance-based strategies rely on some quality of the memory that changes as a function of time such as strength. Strong memories would be judged as having occurred more recently.

In the current experiment, participants wore a smartphone in a pouch around their necks for a period of two weeks. The phone collected image, audio, GPS and accelerometry data. After a retention interval of one week, they were asked to judge the specific day on which each of a selection of images was taken.

We reasoned that when participants were employing distance based strategies their errors would predominantly fall on adjacent days to the actual day on which the image was taken. When they were employing location-based strategies, however, one might expect errors to occur more often on days with similar schedules - in particular on the equivalent day in the incorrect week. The proportion of location-based errors was significantly above chance and numerically above the proportion of distance based errors.

Participants in this experiment were also asked to provide confidence ratings and valence judgements. Confidence ratings were generally accurate, a result that is at odds with much of the ecological memory literature. The intensity of valence affected performance, but the polarity did not.

Using the image, audio, accelerometry and GPS data, we can also build a representation of the experience of the participant when they were encoding the event. Audio and GPS were found to be significant predictors of participants memory judgements, while images and accelerometry were not.

A hierarchical Bayesian model is developed that is capable of estimating the contributions of the distance-based and location-based strategies to memory decisions.

Resources masquerading as slots: Flexible allocation of visual working memory

Chris Donkin*, Arthur Kary, Fatima Tahir & Robert Taylor

University of New South Wales, Australia

Whether the capacity of visual working memory is better characterized by an item-based or a resource-based account continues to be keenly debated. Here, we propose that visual working memory is a flexible resource that is sometimes deployed in a slot-like manner. We develop a computational model that can either encode all items in a memory set, or encode only a subset of those items. A fixed-capacity mnemonic resource is divided among the items in memory. When fewer items are encoded, they are each remembered with higher fidelity, but at the cost of having to rely on an explicit guessing process when probed about an item that is not in memory. We use the new model to test the prediction that participants will more often encode the entire set of items when the demands on memory are predictable.

On testing core assumptions of signal detection theory

John C. Dunn*
University of Adelaide

Laura Anderson
Binghamton University

Consider the following experiment. Participants are required to detect the presence of a defined signal across a number of trials under *n* different conditions that are presumed to affect discriminability. They rate their confidence of observing such a signal on a *k*-point scale. The following recognition memory experiment is an example of this kind of experiment. Words are studied under divided or focused attention and in each word may be studied on one, two or four different trials. This defines $n = 6$ different conditions of interest. Subsequently, memory is tested in a yes-no recognition test using a 6-point confidence scale. The result is a 6 × 5 matrix of hit rates (suppressing the row of false alarm rates and the final column of 1s).

Let h_{ij} be the hit rate for the *i*th condition at the *j*th confidence level. We want to model these data with an appropriate signal detection model. That is,

$$h_{ij} = F(z_{ij})$$

$$z_{ij} = (d_i - c_j)/s_i,\ s_i \approx 1$$

where, d_i and s_i are the location and scale, respectively, of the evidence distribution for the *i*th condition, and c_j is the *j*th response criterion.

The problem is that we don't know what the form of the cumulative distribution function, *F*. We can, of course, assume it to have a particular form, e.g., Normal, and, if this fits the data, to be happy with that. But, if it doesn't fit the data, is that because the core assumption of the signal detection model is wrong or because we have made a bad choice for *F*? The aim of this talk is to outline an approach that can be used, in principle, to test the signal detection model without specifying the form of *F*.

The approach we outline combines two central concepts – *oriented matroid (OM) theory* and the principle of *exchangeability*. We first consider the case of $s_i = 1$ and write, $h = F(z)$, where *h* is the set of predicted hit rates re-arranged as an *nk*-vector, and $z = Ax$, where *A* is an appropriate design matrix, and *x* is a vector of (unknown) parameter values. OM theory provides a representation of *A* in terms of a set of sign vectors (called *covectors*) that are preserved under any monotonic transformation (such as *F*). In this representation, each predicted value may be a different (monotonic) function of *z*. Exchangeability follows from the additional constraint that each value is the *same* (monotonic) function of *z*. This results in a *test* of the core assumptions of the signal detection model avoiding any attempt at parameter estimation. We note that this test is equivalent to the independence and cancellation tests of additive conjoint measurement although derived in a different way.

Individual differences in the removal of outdated information from working memory

Ullrich Ecker*, Kris Singh, & Gilles Gignac

University of Western Australia

The ability to keep working memory content up to date is important for a number of higher cognitive functions such as reasoning, but it is also crucial for the effective operation of working memory itself. We argue that an active item-wise removal process lies at the heart of working memory updating. Removing outdated or irrelevant information allows focused processing of relevant information, and minimizes interference. We recently introduced a new memory updating paradigm to measure a person's removal efficiency. In this talk, I will present data from individual differences studies exploring the co-variation of removal efficiency with working memory capacity and fluid intelligence through structural equation modelling.

The influence of practice and overall feedback on achieving reward rate optimality

Nathan Evans*, Scott Brown
University of Newcastle

Research into performance optimality, and more specifically reward rate optimality, has had mixed findings on the ability of humans to adopt a strategy that can achieve optimal performance. Although the findings of Starns and Ratcliff (2012) suggested strong evidence for the inability of humans to achieve reward rate optimality, two theoretically meaningful factors were not considered in their experiment: the time spent on the task, and the amount of overall task feedback given to participants. Our study extends upon Starns and Ratcliff (2012), looking at the differences in achieved reward rate, and distance from the optimal strategy, over blocks in a random dot motion task with a range of different feedback groups. Our findings indicate that participants both increase in reward rate with more task practice, and those with more feedback achieve a higher reward rate than those without. In addition, those with adequate feedback appear to closely approach, and even achieve, the optimal strategy with increasing time on the task, showing that humans may in fact be able to achieve reward rate optimality.

Formation of joint judgements by dyads: Weighted averaging vs mixture of strategies

Rebecca Floyd[1], David Leslie[2], Roland Baddeley[1] and Simon Farrell[3*]

[1]University of Bristol
[2]University of Lancaster
[3]University of Western Australia

How does a group combine information from different members in order to arrive at a consensual judgement? One suggestion is that groups combine information in a Bayes optimal fashion: the group calculates a weighted average of individuals' estimates, with the weightings being proportional to the quality of the information each individual possesses (Sorkin et al., 2001; Bahrami et al., 2010). Alternatively, other research suggests that formation of judgements in small groups is relatively simple (Koriat, 2012). In a series of studies, we asked members of a dyad to make private estimates of a continuous quantity (the direction of movement of a coherent motion stimulus), and to then share their estimates in order to arrive at a joint judgement. In contrast to previous studies, the examination of continuous judgements allowed us to examine how dyads combined their estimates on a trial-by-trial basis. In keeping with the previous work, we observed an overall improvement in accuracy of judgements in dyad's joint judgements (compared to the individual judgements). Examination of the histograms of responses suggests that dyads did not calculate a weighted average of estimates, but instead were selecting their answers from near one of their individual answers or a point between the two. Logistic regression on the category of joint response (determined using Gaussian Mixture Modelling) showed that a greater disparity in individual judgements predicted a greater likelihood of returning one of those individual judgements as the joint response (as opposed to averaging responses), and the relative trial-by-trial accuracy of dyad members predicted which individual response was returned as the joint judgement. Removing feedback about dyad member's individual answers and incentivising accurate performance did not change the overall pattern of results. The results are consistent with a strategy mixture model, in which dyads use one of several simple rules to combine their individual estimates. Nonetheless, we note that the results are also compatible with a Bayesian model (Lindley, 1983) that makes some more realistic assumptions about the task, particularly a) that dyad members have some uncertainty about each others' precision, and b) that the dyad samples from the joint posterior, rather than taking the expected value of that distribution.

Are you being serial? Cognitive processing systems of enumeration

Paul Garrett & Ami Eidels
University of Newcastle

The operation of quantifying, or enumeration a small group of items is usually achieved through one of two processes. The innate form of enumeration is termed *subitizing* and is believed to underlie the rapid and effortless enumeration of items between one to four. The learned form of enumeration is termed *counting* and refers to the accumulative enumeration of larger item sets. We investigated how these two forms of enumeration are integrated by the human brain. Using an advanced mathematical-modelling framework termed *Systems Factorial Technology*, we assessed three fundamental properties within the processing systems of enumeration: Architecture (parallel vs. serial), stopping rule (exhaustive vs. minimum time processing) and workload capacity. Our findings show unexpected applications of counting in item sets less than four, the use of parallel subitizing, and the implementation of task-inappropriate stopping rules. These findings provide insight into how the human brain integrates numerical information, and shed light on the disparity between the evolutionary-adaptive enumeration process of subitizing, compared to the learned enumeration process of counting.

Target proportion manipulations selectively influence response bias

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Selective influence is an important tool in the development of models of decision making for establishing a causal link between experimental manipulation and cognitive processes. Recently, the widely held the assumption that response caution selectively influences evidence thresholds has been rejected, with effects on the rate of evidence accumulation being found (Heathcote & Love, 2012; Rae, Heathcote, Donkin, Averell & Brown, 2014; Starns, Ratcliff, & McKoon, 2012). We conducted a model-selection study using the linear ballistic model (Brown & Heathcote, 2008) and the diffusion model (Ratcliff & Tuerlinckx, 2002) to examine whether target proportion manipulations selectively influence response thresholds in perceptual, the lexical decision, and the recognition memory tasks (Forstmann, Brown, Dutilh, Neumann, & Wagenmakers, 2010; Starns, Ratcliff, & McKoon, 2012; Wagenmakers, Ratcliff, Gomez, & McKoon, 2008). In all three tasks we found no effects of target proportion on the rate of evidence accumulation but strong effects on response bias mediated by distance from the starting point to thresholds for each response. This result suggests unambiguously that the target proportion manipulations are an effective and widely applicable selective influence variable.

Multiple information sources in perceptual similarity

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Previous research has proposed that perceptual similarity arises from at least two processes that contribute information to judgments at different speeds (Goldstone & Medin, 1994). In the current work we extend the original Goldstone & Medin framework and replicate their results in a speeded same-difference perceptual discrimination task. We account for these results with a set of Linear Ballistic Accumulator models that utilize perceptual information sources in different combinations and time delays. Model comparisons show the best account of these results is a model with two independently-processed sources of similarity information: raw featural information and relational information. The implications for computational models of similarity will be discussed.

What do cows drink? Investigating the intersection of memory cues using Systems Factorial Technology

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What do cows drink? If you first answered 'milk', you are not alone; this is a commonly cited trick of the mind. But what process leads to this common mistake? One explanation is that the two 'cues' (cow, drink) have an 'associative intersection' point; both cues are independently associated with 'milk'. Thus when both cues are probed simultaneously, the resultant search process incorrectly identifies 'milk' as the answer. Despite the failure in the above example, in everyday life identifying such 'intersections' is extremely useful. Consider the following scenario; you are trying to decide on a holiday location with a friend who is interested in hiking, whilst you are interested in swimming. The intersection of these two different activities (swimming, hiking) might be Hobart, a location that satisfies both constraints. Smith, Huber and Vul (2013) note that we seem to effortlessly solve problems of this manner every day. However, such problems are actually computationally complex, and the process through which alternatives are selected is not fully understood. Those authors, using a modified Remote Associates Test, suggested that cues are considered one-at-a-time, implying a serial search process. However, the cow-drink example above, and other similar problems, lend themselves more naturally to a parallel search process. In this presentation we discuss an ongoing attempt to identify the processing architecture (serial or parallel) in a two-cue paradigm, using the powerful, non-parametric Systems Factorial Technology.

Cognitive models in the extreme

Melissa Humphries*, Barbara Holland, Angus Reynolds, Raimondo Bruno

University of Tasmania

Imagine a scenario: *A client comes in to your office. Let's say they are rehabilitating from a drug addiction. You want to ascertain if impulsivity is a problem for this client so that you can tailor their treatment to effectively suit their needs. So you give them a quick game to play; the Balloon analogue response task (BART). You use a cognitive model to analyse the data and the results suggest a highly impulsive individual.* With estimates of impulsivity much higher than we would normally expect, this individual is an extreme performer. So how should you interpret these results? Should you trust the results? The answer to these questions may not be as straight forward as we think. We present parameter recovery simulations for a popular model of behaviour on the BART and raise the question whether individuals can be effectively modelled in the extreme.

Flexibility of evidence-accumulation models

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Evidence-accumulation models of decision making, in particular the diffusion model (DM) and linear ballistic accumulator (LBA), become unfalsifiable without constraints on intertrial variability of growth rates (Jones & Dzhafarov, 2014). The proof of this theorem allows for variants of the models that are arguably quite different from those found in fits to real data, including complex multimodal growth-rate distributions, violation of the selective-influence assumption that growth-rate distributions are invariant across experimental conditions, and negligible levels of diffusion in the DM. Here we explore the flexibility of the models under these additional restrictions: unimodal growth-rate distributions, selective influence, and a lower bound on the DM's diffusion rate. We report three results demonstrating that, even under these restrictions, growth-rate variability is flexible enough to mimic the effects of startpoint variability, a theoretical assumption that has been held as essential to fitting data. First, we demonstrate analytically that the standard LBA is formally equivalent to a generalized LBA with no startpoint variability, using unimodal growth-rate distributions that obey selective influence. Second, we show that the same holds for the DM in the limit of negligible diffusion. Third, we show by example with real data that this mimicry problem applies to the DM even with large levels of diffusion. In conclusion, these three restrictions still leave the models excessively flexible, in that the theoretical question of startpoint variability remains unidentifiable.

Using iterated Learning to Uncover Inductive Biases in Multiple Cue Judgment

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Understanding how people integrate information about multiple cues to predict an outcome is a fundamental problem of judgment and decision making research. The topic touches on the rule vs. exemplar debates, as well as debates about the extent to which people ignore information. We use an "iterated learning" procedure, in which the data produced by one participant is used to generate the stimuli for the next participant, to recover the inductive biases that participants rely on when making multiple cue judgments. We trained an initial participant with stimuli generated from a positive linear function with four binary cues, and took their test responses as the training stimuli for the next participant. We repeated this procedure using five initial participants to create five "families" of learners, with data passed along up to ten participants in each family. Our initial results suggest a complex picture of multiple biases, with two families converging to a positive one cue rule, one family converging to a positive linear two cue rule and, surprisingly, two families converging to rules containing interactions between cues.

How credible are Bayesian Credible Intervals?

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All statistical tests and models make assumptions, including assump- tions about how ”clean” the data is - whether (and how) it is contam- inated, and what is the nature of any random error. One method for dealing with this problem is the use of robust statistics, which are less sensitive to violations in assumptions than other methods. Many such statistics have been developed as modifications to frequentist methodolo- gies. Bayesian statistics have more freedom in model specification, but even these rely on having a model that is well-specified for the problem. In this discussion we use simulations to compare how trustworthy some common Bayesian and frequentist models are when sample data violate the generative assumptions of the model. The results demonstrate that whilst not all models are trustworthy in the face of violations, some are considerably more trustworthy than others.

Looking at it from a different angle

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A common phenomenon observed in perceptual decision-making tasks is that an increase of the similarity between choice alternatives leads to prolonged response times (RT) and decreased accuracy. One explanation for these detrimental effects on behavior is that task difficulty increases with increased similarity of choice alternatives. A popular way to manipulate the similarity of choice options in simple 2 forced-choice tasks such as the Random Dot Motion (RDM) task is to change the angular distance between choice alternatives[1-3]. Previous work has, however, shown that cognitive process models which only incorporate the angular distance might be too simplistic[3,4]. We therefore set out to test the effects of choice similarity using an RDM task with six angles of target separation.

In line with previous findings and process models[5], the behavioral results revealed shorter RTs and increased accuracy with less similar choice options. Importantly this decrease was found up to 90° of target separation. However, once the separation between the choice alternatives exceeded 90°, the predictions and the observed behavior diverged. As the similarity between the alternatives further decreased, the RTs increased and accuracy decreased. These unexpected results were replicated and extended in two additional experiments with a coherence manipulation (Exp 2) and a speed-emphasize manipulation (Exp 3).

The results will be discussed in light of current process models, their limitations to capture the present findings, and future experiments to shed light on the underlying mechanisms driving the observed behavior.

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Expectancy Valence Insight Learning (EVIL): A computational model of confidence in experiential choice

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The relationship between decision accuracy and confidence has been extensively investigated since the early days of psychological research. Most of these studies examined psychological effects and decision processes in the domain of perceptual decision-making. However, little is known about the interplay of decision accuracy and confidence in consequential economic decisions as in the case of experience-based decision-making. The purpose of this talk is twofold: First, to examine the progression of choice and confidence judgments in the context of a typical experience-based task, the Iowa Gambling Task. Second, to provide a formal description of confidence judgments and their relationship to choice mechanisms. In our task, participants select cards from four different decks with different monetary payoffs and their goal is to maximize overall gains. After each card selection, they are asked to provide a confidence judgment on having selected an advantageous option. The results show that learning to choose the most profitable options is accompanied by accurate reports of confidence. We developed a computational model (Expectancy Valence Insight Learning - EVIL) to unfold the cognitive processes that give rise to choice and confidence based on the principles of Reinforcement-Learning and Signal Detection Theory. Our model can accurately account for choice selections and confidence ratings across all trials of the task and provides an explanatory framework of metacognitive judgments in the context of experience-based decision-making.

Do people use feature correlations when judging similarity?

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In our richly structured world, features are often related to each other. Some almost always co-occur (like legs and feet), some are mutually exclusive (like having gills and playing the piano), and many are statistically related (like having fur and a tail). It seems intuitively sensible that people must notice and track these kind of feature correlations, but what is less obvious is whether and to what extent they shape our judgments of overall similarity. Some theories of similarity suggest that feature co-occurrence should have a large impact on similarity (Kemp, 2005), others make no reference at all to co-occurrences when calculating similarity (Markman & Gentner, 1993), and still others predict that co-occurrence information should play a constrained role of some sort (Tenenbaum & Griffiths, 2001; Pothos et al., 2013). This study investigates this issue empirically: how do people use co-occurrence information when evaluating similarity? We presented participants with stimuli containing features that varied in their internal correlational structure, and found that people do track and use such correlations. Implications for theories of similarity and category construction will be discussed.

Retest reliability of the parameters of the Ratcliff Diffusion Model

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With the application of the Ratcliff Diffusion Model (1978) different cognitive components involved in binary classification tasks can be separated (e.g., the speed with which information is accumulated from a speed-accuracy trade-off). The validity of the diffusion model parameters has been successfully demonstrated for different paradigms and by means of both experimental validation and correlational studies. However, the reliability of the model parameters has been scarcely investigated. We analyzed the retest reliability of the parameters of the Ratcliff Diffusion Model in two different experimental paradigms: a lexical decision task and a recognition memory task. Reliability coefficients are presented for different trial numbers and different optimization criteria. Besides, for each paradigm, we executed a simulation study based on the parameter ranges observed in the empirical data. This allows the disentangling of parameter estimation error from trait and state proportions.

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Ranking choices in context effect tasks

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Decision-making involving a set of options can involve preferential choice – where the most-preferred option is chosen – or the rank-ordering of all available options. Studies of context effects – the phenomena where an option's choice probability depends not only on its utility, but also its context in relation to other options – have mostly involved preferential choice tasks. Across two experiments, we investigated the generalisability of these context effects to rank-ordering tasks. Similar to a number of previous experiments, our results showed no evidence for context effects when data is averaged across the whole sample. Instead, we found clear groups of individual differences that demonstrate strong biases towards specific dimensions. Current models of context effects are fit to this data, and their implications are discussed.

Keywords: rank-ordering, context effects, averaging, individual differences

Recency effects and response times in perceptual categorization: Comparing exemplar and rule-based accounts in a modified Garner task

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A number of converging operations suggest that, unlike separable dimensions, integral dimensions are processed holistically. Garner's classic tasks (e.g., Garner, 1974) convincingly demonstrate these differences by showing that integral dimensions, but not separable dimensions, tend to interfere with each other if one of the dimensions must be ignored but facilitate one another if the dimensions are varied in a correlated manner. One key aspect of Garner's results is that item and response repetitions result in faster response times. Here we report an experiment in which we increased variation on the relevant stimulus dimension (by increasing the number of stimuli) to reduce stimulus repetitions. Nonetheless, we find a clear recency effects in both response time and accuracy. We tested three models of category choice response times including both exemplar-based and General Recognition Theory (GRT) models including a modern version of the distance-from-boundary theory which utilizes an integrated array of linear ballistic accumulators. The standard versions of these models are insensitive to sequence effects and are ruled out by our data; hence, we also tested novel sequence sensitive versions of the models. Qualitative and quantitative model comparison supported the exemplar-based account by highlighting the need for item-specific representations. The standard GRT-based account of modelling category regions is insufficient, but we suggest modifications that would allow the GRT-based theory to account for our data.

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Comparing the performance of several proposed models of risky inter-temporal choice

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The focus of this talk is the development of models of choices that involve both risks and temporal delays. In the current literature three models have been proposed to deal with these choice types; the Probability and Time Trade-off model, (Baucells & Heukamp, 2010) the multiplicative Hyperboloid discounting model (Vanderveldt, Green & Myerson, 2015) and a modified Hyperbolic Discounting model (Yi et al., 2006). Each of these models has been constructed to explain a subset of behaviors observed in the risky inter-temporal literature, but they have never been systematically tested against each other. In two experiments we compare the performance of these three models, as well as several additional models derived from common models of risky and inter-temporal choices, by focusing on the predictions that they make. In experiment one we test the ability of each model to predict what people will do when faced with a choice between a risky outcome and a delayed outcome, based on their behavior in choices that involve only risks or only delays. In experiment two we focus on the predictions the models make about three common effects in the risky and inter-temporal choice literature, namely the magnitude (multiplying outcomes by a constant), common ratio (multiply probabilities by a constant) and common difference (increase temporal delays by a constant) effects. We look both at the effects of these manipulations, and the predictions of each model, across 6 different types of choices that combine risks and delays.

Selecting an optimal subgroup of experts

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The observation that aggregates such as the mean or median of forecasts of a group of individuals tend to outperform individual forecasts has been described as the Wisdom of Crowds (WOC) effect (Surowiecki, 2004). Mannes, Soll, and Larrick (2014) showed that aggregating the predictions of a properly selected subgroup of experts can achieve better predictions than aggregating the predictions of the entire pool of forecasters. Budescu and Chen (2015) developed a principled method of selecting this subgroup by selecting the top contributors of the crowd, a method they called the contribution weighted model (CWM). However, other ways of identifying and combining expert forecasts may result in still more accurate forecasts. Our study compared the accuracy of CWM to a selection of other aggregation and weighting models for the dataset of the Forecasting ACE project. This project investigated the degree to which volunteers could predict global events such as "Will the US deploy troops to the Congo in 2011". Although we were able to replicate the finding of Budescu and Chen that CWM generated more accurate predictions than averaging over all forecasters, we were also able to identify other prediction models that performed as well and possibly even better than CWM.

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A Systems Factorial Technology Analysis of the effect of feature-to-feature distance on the processing of separable dimensions

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Recent studies have demonstrated that separable dimensions are processed serially when presented in separate spatial locations (Fifić, Little, & Nosofsky, 2010; Little, Nosofsky, & Denton, 2011), but in a mixture of serial and parallel processes when the dimensions overlap (Little, Nosofsky, & Denton, 2011; Moneer, Wang, Little, 2015). These results suggest that decreased distance between separable dimensions drives a shift from serial to parallel processing architectures. The present study tests this hypothesis using a logical-rules design (Fifić et al., 2010) and systems factorial technology analyses (Townsend & Nozawa, 1995). Stimuli were comprised of two semi-circles that varied on the saturation of a red hue in one and the orientation of a radial line in the other, and the distance between them was varied between conditions. Our results show that when the dimensions were presented with a gap in between them, processing was mostly serial. By contrast, when no gap was present (i.e., the semi-circles came together to form a whole circle), processing was mostly parallel. These results are consistent with our hypothesis and indicate that separable dimensions do not need to overlap in space to be processed in parallel, but perhaps need only fit into the same attentional window. However, when these dimensions were overlapped, a consistent failure of selective influence was observed across all participants, suggesting decreased distance can also result in early perceptual interaction between dimensions.

Development of a general model of multiple-goal pursuit

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We describe the ongoing development of a formal model that explains the mechanisms by which people make choices amongst competing goals in a dynamic environment ("multiple goal pursuit"). The model, referred to as the extended multiple-goal pursuit model (MGPM*), is an integration of the multiple-goal pursuit model (Vancouver, Weinhardt, & Schmidt, 2010), and decision field theory (Busemeyer & Townsend, 1993).

In this talk, we present an experiment examining the effects of distance to goal and time to deadline on choice probability, and assess the ability of the MGPM* to account for these effects. Participants performed a task requiring them to manage two crops. The goal was to ensure that each crop grew to a certain height by a certain time. Participants had to repeatedly choose which crop to irrigate as the task progressed.

The results suggest that participants prioritised the goal with the shorter deadline or the greatest distance remaining, provided that goal was achievable. If one of the goals was not achievable, participants tended to prioritise the goal that was achievable (i.e., the goal with the longer deadline or shorter distance remaining). The MGPM* was able to account for the results using a nonmontonic, discontinuous value function (Vancouver, More, & Yoder, 2008). The model assumes that the value of acting on a goal increases as the expectancy of achieving that goal decreases, but falls to zero when expectancy falls below a threshold. We discuss the ability of the model to account for the effects observed in existing empirical studies of multiple-goal pursuit, including the effects of goal framing, incentives and uncertainty on prioritization, in addition to related phenomena observed in the decision making and motivation literature, including goal gradient effects and time discounting.

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Experiencing Ambiguity through Missing Information

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Recent studies show that sampling from gamble distributions prior to choice reduces ambiguity aversion dramatically. We aimed to test whether aversion is still reduced when people experience the most essential component of ambiguity – that is, missing/imprecise information regarding outcomes and probabilities – through sampling. Prior to making a final choice in an Ellsberg-Type gamble task, participants sampled either single outcomes or outcome distributions which provided them with either precise (i.e., "outcome = win", "probability of winning = 0.6", respectively) or imprecise information (i.e., "outcome = unknown", "probability of winning = between 0.4 and 0.6") respectively. While we replicated previous findings with reduced levels of ambiguity aversion when the sampled information was precise, we found ambiguity-averse patterns in conditions with imprecise information. Our results also demonstrated that the higher the degree of imprecision (i.e., the more frequently "unknown" outcomes were observed across sampling trials), the higher the level of ambiguity aversion. A follow-up study, with additional manipulation-check components, confirmed these main findings indicating that experienced ambiguity does not reduce ambiguity aversion if the information observed by participants during sampling is ambiguous/imprecise.

Informing cognitive models of visual decision making with EEG measures of attention

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Our goal was to explore how attention differentially affects psychological processes of perceptual decision making. Joint reaction time (RT) and accuracy data from two-alternative forced choice tasks are well fit by diffusion models, a class of models that assume a continuous accumulation of evidence before a decision is made. One benefit of diffusion models is that they yield parameter estimates that have psychological interpretations, e.g. correct evidence accumulation rate, within-trial accumulation variance, evidence threshold, and non-decision time (a mix of preprocessing time and motor response time). Using hierarchical Bayesian forms of diffusion models we show that attention, as measured by cortical electrical activity on the surface of the scalp (EEG) in response to visual stimuli, affects different components of subjects' reaction time. Individual differences in suppression of visual noise leads to faster non-decision time and more accurate decision making. Also, trial-to-trial delays in response to the visual signal were positively correlated with trial-specific non-decision times suggesting that some early single-trial EEG measures reflect preprocessing time within subjects. Preprocessing time was then separated from motor response time, traditionally unidentifiable, using external EEG measures as data in a hierarchical diffusion model fit. Integrating EEG attention measures in hierarchical Bayesian diffusion models yields better prediction for known and new subjects' accuracies and reaction time distributions than Bayesian hierarchical fits of diffusion models without EEG measures. Future applications of using neural data to constrain cognitive models are discussed.

Keywords: Diffusion models, Hierarchical Bayesian, Perceptual decision making, Electroencephalography (EEG), Visual attention

Diffusion vs. linear ballistic accumulation: Different models, different conclusions about the slope of the zROC in recognition memory

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The relative amount of variability for targets vs. foils items in recognition memory is commonly measured using the receiver operating characteristic (ROC) procedure, in which participants are given either a bias manipulation or are instructed to give confidence ratings to probe items. A near universal finding is that targets have 1.25 times the variability of foil items. Ratcliff and Starns (2009) questioned the conclusions of the ROC procedure by demonstrating that accounting for decision and criterion noise within a response time model yields different conclusions about relative memory evidence than the ROC procedure yields. In this work we examined how conclusions differ depending on the choice of response time model. In the first study, we employ a procedure where participants give yes/no ratings followed by a high/low confidence rating. In the second study, we re-examine data from a yes/no recognition experiment with five different bias levels conducted by Dube et al. (2013). All datasets were fit with the drift diffusion model (DDM), the linear ballistic accumulator (LBA) model, and signal detection theory (SDT) using hierarchical Bayesian analyses. The fits revealed a close correspondence between the magnitude of relative evidence variability between the DDM and SDT models, whereas the LBA model produced estimates that were quite close to equal variance between targets and foils. Implications for models of memory will be discussed.

The effects of time pressure on evidence accumulation in a complex multi-stimulus environment.

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We investigated the strategies adopted in response to time pressure within a complex multi-stimulus environment. Participants completed a simulated unmanned aerial vehicle target detection task. In Study 1 we manipulated classification complexity and the number of stimuli in a trial. In Study 2 we replaced classification complexity with a deadline manipulation. We modeled observed choices and response times using the LBA model (Brown & Heathcote, 2008). The rate of evidence accumulation (i.e., drift rate) mediated the effects of deadline. Response caution (i.e., threshold) mediated the effects of number of stimuli. In Study 1, non-decision times increased with number of stimuli, whereas in Study 2, non-decision times decreased with deadline. Classification complexity affected the difference in drift rates between the matching and mismatching accumulators, though only for target stimuli. Our results provide evidence that individuals are sensitive to distinct predictors of time pressure, and adopt alternative strategies in response to these factors. Additionally, the studies provide further support for the application of the LBA to decision-making in complex applied settings.

Social, not statistical, and not irrational? The Monty Hall Problem revisited

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The Monty Hall problem has been studied for decades, often within the context of demonstrating that people are irrational or poor statistical reasoners. Here we consider another reason that people make the choices they do: they interpret it as a social problem rather than a statistical one. We demonstrate mathematically that if one makes different assumptions about the data-generating process involved -- assumptions that map onto different social scenarios -- then the rational action to take changes. Moreover, we show that people given cover stories that capture these different assumptions change their actions as predicted by a rational statistical model.

Conflict and ambiguity: Described versus experienced

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Previous research has found a decrease in ambiguity-aversion when information is "experienced" rather than "described". We argue that this finding is an artefact of researchers operationalizing ambiguity in terms of second-order probability distributions of outcomes sampled from an environment rather than in terms of the outcomes themselves. In two studies we operationalized experienced uncertainty as uncertain outcomes rather than indeterminate probabilities. Moreover, we included both ambiguity and conflict as distinct types of uncertainty.

In Study 1, we established that ambiguity and conflict aversion are prevalent under experienced outcomes. Additionally, we replicated the finding from described conflict vs ambiguity studies that ambiguity is preferred to conflict.

In Study 2, preferences for information sources and "best" estimates of the utility of options under risky, ambiguous and conflicting information conditions were elicited, for both experienced and described information presentations. Contrary to the earlier research reports regarding ambiguity-aversion, preference for risk over ambiguity was not lower when information was experienced rather than described. Likewise, no significant difference was found for preferences of risk over conflict. However, the preference for ambiguity over conflict was found to decrease when information was experienced.

Disentangling stimulus-driven and strategic effects in lexical decision

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Recent research has aimed to disentangle the cognitive mechanisms underlying lexical decision performance, rather than assuming it provides a veridical reflection of the ease of lexical access. In this study we simultaneously examine two manipulations widely used to probe lexical processing; namely using a masked repetition priming paradigm and varying (between-lists) the nature of the nonword distractors. In particular, we use the Linear Ballistic Accumulator (LBA) model to tease apart whether these effects are stimulus-driven or mediated by strategic decisional processes. If the facilitatory effect of an identity compared to unrelated prime is driven by the stimulus properties being encoded more easily (e.g., a 'savings effect'), this effect should manifest on the LBA's nondecision time parameter (t0). In contrast, if the relative ease of making a word/nonword response is influenced by the difficulty of the list environment, this effect should manifest on parameters relating to the decision threshold and quality of evidence obtained from a stimulus. We also explore if these effects are related to individual differences in reading and spelling proficiency. Results and their implications for current models of lexical access will be discussed.

Diffusion modeling of the approximate number system

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Models that have been developed to represent the numerosity of non-symbolic displays (e.g., arrays of blue and yellow disks) have assumed a representation in which integer values are represented as distributions on a number line around their mean values (termed the approximate number system). In one of the models, the mean of the distribution and its standard deviation increase linearly with numerosity. In the other model, the standard deviation is constant but the mean increases logarithmically. Both models account for the finding that discriminability between numerosities is reduced as numerosity increases. The models are not distinguishable when applied to accuracy data but if the distributions they produce in response to stimuli are used to define drift rate in the diffusion model (a sequential sampling decision model), then the models are identifiable. We report experiments in which arrays of blue and yellow disks are displayed and participants report which color has the higher number. The model with standard deviation in drift rate increasing with numerosity predicts decreasing response times and accuracy as a function of numerosity for constant differences between the two disk colors, whereas the logarithmic model predicts increasing response times and decreasing accuracy. We found that the diffusion model with the standard deviation increasing with numerosity best fit the data.

Diffusion model analysis of the focus of attention in visual working memory: Access costs, interference, and retrieval failure

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The focus of attention is a central pillar of contemporary theories of working memory, often identified with the current contents of conscious awareness. Despite broad acceptance and recognition of the utility of the construct, there is ongoing debate about many of its fundamental properties. Key issues include whether the focus of attention can hold one or up to around four items, as well as the effects of memory load on the quality and time course of selection of information in the focus of attention. We investigate some of the properties of the focus of attention in the context of a probed visual working memory task in which people judged the orientation of Gabor patch stimuli embedded in dynamic noise. Analysis of diffusion model parameters showed that increases in memory load produced three key effects: (1) Reductions in the quality of the underlying stimulus representations that were well-characterized by a sample size model of the information capacity of visual working memory; (2) Increases in the time needed to selectively access a probed representation in memory and initiate a decision; (3) Increases in the rate of retrieval failure, which result in guessing. The results are consistent with theories that assume only one item can be held in the focus of attention. With additional assumptions, the results can also be reconciled with theories that assume a multi-item focus of attention. We discuss the implications of our results in both theoretical contexts and how they further our understanding of some of the fundamental properties of the working memory system.

Better than beta? Modelling random variables on the unit interval with CDF-quantile distributions

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Smithson and Shou (2015) introduce a two-parameter family of distributions for modeling random variables on the (0, 1) interval by applying the cumulative distribution function (cdf) of one parent distribution to the quantile function of another. Family members have explicit pdfs, cdfs and quantiles in a location parameter and a dispersion parameter. They are amenable to likelihood inference, and enable a wide variety of quantile regression models, with predictors for both the location and dispersion pa- rameters. These distributions can capture shapes not obtainable by the beta distribution, but how well do they perform when fitted to real data? We present some examples where they out-perform the beta distribution, but also describe some instances where the beta distribution performs better. We also briefly describe an R package 'cdfquantreg' for estimating models with these distributions.

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Stuck in the gates: Bayesian modelling of trigger failure in the stop signal task

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Response inhibition is a facet of cognitive control utilised to cancel or supress prepotent responses that are no longer appropriate within the current environment. For example, halting after seeing an approaching car as you cross the road. The Stop-Signal Task (SST) is a paradigm in which models of response inhibition can be represented in the laboratory. The SST pits two independent processes (Go vs. Stop) against each other to determine the underlying latency of the inhibitory process (Stop-Signal Reaction Time; SSRT). However, the estimation of SSRT is fraught with numerous difficulties, such as the inability to predict and control for trials on which the inhibitory process fails to trigger (i.e., trigger failure, TF). We utilise Bayesian parameter estimation to quantify both the probability of TF and full distribution of SSRT within a large healthy cohort (*n* = 180, mean age = 21, 56% Female). We provide support for the inclusion of TF within current models of response inhibition through behavioural, electrophysiological, and model selection analysis. As expected, larger rates of TF was related to poorer adherence to task goals. Attention to the Stop task was also reduced in participants with higher percentages of TF, but the same effect was not present for the Go task. Furthermore, model selection provided substantial evidence favouring the inclusion of TF in the estimation of SST parameters. Among other parameters, the mean and variance of SSRT was significantly reduced with the inclusion of TF. We discuss these results in relation to the current models of response inhibition and provide suggestions for future experiments utilising the SST.

The attention weighted sample size model of visual short-term memory: Signal detection and diffusion model analysis

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We investigated the capacity of visual short-term memory (VSTM) in a phase discrimination task that required judgments about the configural relations between pairs of black and white features. Sewell et al. (2014) found that VSTM capacity in an orientation discrimination task was well described by a sample size model for both simultaneously and sequentially presented stimuli for displays of up to four items. The sample size model views VSTM as a resource comprised of a finite number of stimulus samples and predicts the invariance of $\sum_{i=1}^{m}(d_i')^2$, the sum of squared sensitivities across items, for displays of different sizes, *m*. For phase discrimination, the display size effect significantly exceeded that predicted by the sample size model for both simultaneous and sequential displays. With sequential presentation, the display size effect and the serial position curves were predicted by an attention weighted sample size model, which assumes that the first presented item captures attention and receives a disproportionate share of resources. The choice probabilities and response time distributions from the task were well described by a diffusion process model in which the drift rates embodied the assumptions of the attention weighted sample size model.

Does Experiencing Uncertainty Make People More Pessimistic?

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Previous research has found a decrease in ambiguity-aversion when information is "experienced" rather than "described". We argue that this finding is an artefact of researchers operationalizing ambiguity in terms of second-order probability distributions of outcomes sampled from an environment rather than in terms of the outcomes themselves. We operationalized experienced uncertainty as uncertain outcomes rather than indeterminate probabilities. Moreover, we included both ambiguity and conflict as distinct types of uncertainty.

As described in Priest and Smithson (AMPC2016), preference for risk over ambiguity was not lower when information was experienced rather than described. Likewise, no significant difference was found for preferences of risk over conflict. The preference for ambiguity over conflict decreased somewhat when information was experienced. This effect turns out to be explained by the impact of experience vs description on participants' frequency estimates.

When asked to estimate the true frequency of the event of interest, the responses were strongly multi-modal. Most participants chose either the midpoint, the lower bound of the frequency interval, or a value midway between these two. Here, description versus experience and type of uncertainty had strong effects. Participants were less likely to choose the midpoint in the experienced-information scenarios than in the described-information scenarios. Likewise, they were less likely to choose the midpoint under conflict and ambiguity than under risk. This effect was much stronger in the experienced than in the described scenarios.

Thus, differences between responses to experienced and described uncertainties may arise primarily in judgements rather than in utilities.

Testing dual-process theories of reasoning using logic training and believability

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Dual-process theories posit that separate intuitive and reflective processes contribute to reasoning. Under this view, inductive judgments are more heavily influenced by the fast intuitive processes that use background knowledge or associative information. In contrast, deductive judgments are more strongly influenced by the slower reflective processes that are more deliberate and rule-based. However, our recent meta-analysis of existing research showed there is limited evidence that this complex account is required. Rather, a simpler single-process theory can account for both inductive and deductive judgments. Guided by our meta-analysis and state-trace analysis, we conducted two new experiments in search of evidence of the dual-process account. Crucially, two factors were manipulated that might be expected to differentially affect intuitive and reflective processes. Participants judged the strength of written valid and invalid arguments, with separate groups using either inductive or deductive criteria. We factorially manipulated whether the arguments were believable according to background knowledge (which should have a greater influence on intuitive processes), and whether participants had received training on how to correctly assess logical validity for the difficult argument forms (which should have a greater influence on reflective processes). We found that both factors indeed influenced people's inductive or deductive judgments. However, there was still no evidence that the single-process account should be rejected in favor of the dual-process account.

Accumulating evidence for the delay theory of prospective memory costs

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Event-based prospective memory (PM) tasks require participants to substitute an atypical PM response for a routine ongoing task response when presented with PM targets. Responses to ongoing tasks are often slower when participants have PM demands compared to when participants perform the ongoing task alone, an effect referred to as the PM 'cost', which particularly occurs when the target feature is 'nonfocal' (does not need to be processed to complete the ongoing task). In tasks where nonfocal targets were defined in terms of shallow features Heathcote et al. (2015) found that two decision models [the Linear Ballistic Accumulator (LBA) and Drift Diffusion Model (DDM))] accounted for costs through cautious responding, rather than changes in the quality of ongoing task processing, challenging capacitysharing theories. We extended their research by modelling the costs in a lexical decision task with PM targets defined by semantic categories (requiring deep nonfocal processing), as well as focal PM targets that induce smaller costs. The LBA provided a substantially better fit of the data than the DDM. The LBA attributed both nonfocal and focal costs to increased caution in making word responses, suggesting that even deep nonfocal PM target semantic processing does not cause capacity-sharing. The stimulus-specific caution effects found are consistent with the delay theory of costs, which proposes that participants specifically slow ongoing-task responses that could potentially pre-empt PM responses. There was also evidence of more global increase in caution (increase in non-word caution) in non-focal PM, likely reflecting a change in perceived task difficulty.

Keywords: prospective memory, costs, delay theory, linear ballistic accumulator model, diffusion model

Diffusion modelling reveals evidence for unequal variance signal detection models of the lexical decision task

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The lexical decision task is among the most commonly used paradigms in psycholinguistics. In both the signal detection and diffusion model frameworks, lexical decisions are based on a continuous source of evidence for both words and non-words. Letter stings that are more word like increase the speed of processing, which is quantified by the drift rate parameter in the diffusion model. Previous applications of the diffusion model to the lexical decision task assumed that the between trial variation in drift rate is equal across words and non-words. We fit both an equal variance and a model with separate variance parameters for words and nonwords to multiple lexical decision datasets. The equal and unequal variance models were compared using Savage-Dickey Bayes Factors and the Deviance Information Criterion. Our results suggest that the unequal variance model provides a better account of the lexical decision data. Our results are consistent with the REM-LD model.

Keywords: lexical decision task, diffusion model, unequal variance

A Bayesian perspective on the Reproducibility Project

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We revisit the results of the recent Reproducibility Project: Psychology by the Open Science Collaboration. We compute Bayes factors---a quantity that can be used to express comparative evidence for an hypothesis but also for the null hypothesis - for a large subset (N=72) of the original papers and their corresponding replication attempts. In our computation, we take into account the likely scenario that publication bias had distorted the originally published results.

Overall, 75% of studies gave qualitatively similar results in terms of the amount of evidence provided. However, the evidence was often weak.

The majority of the studies (64%) did not provide strong evidence for either the null or the alternative hypothesis in either the original or the replication, and no replication attempts provided strong evidence in favor of the null.

In all cases where the original paper provided strong evidence but the replication did not (15%), the sample size in the replication was smaller than the original. Where the replication provided strong evidence but the original did not (10%), the replication sample size was larger.

We conclude that the apparent failure of the Reproducibility Project to replicate many target effects can be adequately explained by overestimation of effect sizes (or overestimation of evidence against the null hypothesis) due to small sample sizes and publication bias in the psychological literature.
We further conclude that traditional sample sizes are insufficient and that a more widespread adoption of Bayesian methods is desirable.

One approach for integrating neural and behavioral data into a single model

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Recent decades have witnessed amazing advances in both mathematical models of cognition and in the field of cognitive neuroscience. These developments were initially independent of one another, but recently the fields have started to become interested in joining forces. The resulting joint modeling of behavioral and neural data can be difficult, but has proved fruitful. We briefly review different approaches used in decision-making research for linking behavioral and neural data, and also provide an example. Our example provides a tight link between behavioral data and evoked scalp potentials measured during mental rotation. The example model illustrates a powerful way of linking such data sets. We demonstrate the use of such a model, provide a model comparison against interesting alternatives, and discuss the conclusions that follow from applying such a joint model.

Keywords: joint modeling; cognitive neuroscience; response time data; ERP.

Overcoming the curse of dimensionality: how category structure affects the learning of complex categories

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How does the number of features impact category learning? One view suggests that additional features creates a "curse of dimensionality" - where having more features causes the size of the search space to grow so quickly that discovering good classification rules becomes increasingly challenging. The opposing view suggests that additional features provide a wealth of additional information, so learners should be able to use this information to improve their classification performance. Several studies have explored this issue before, but appear to have generated opposing results: some finding that learning improves with additional features (Hoffman & Murphy, 2006) while others find that it does not (Minda & Smith, 2001; Edgell et al., 1996). Here we investigate the possibility that category structure may explain this apparent discrepancy -- that more features are useful in categories with family resemblance structure, but are not (and may even be harmful) in more rule-based categories. We find while the impact of having many features varies across the different category structures, and that these results can be explained by a unified model that attends to a limited number of features on any given trial but incorporates information across all features to make classification judgements.

Geometric morphometric analysis for quantifying and categorizing brain structure shape in diabetic and non-diabetic populations

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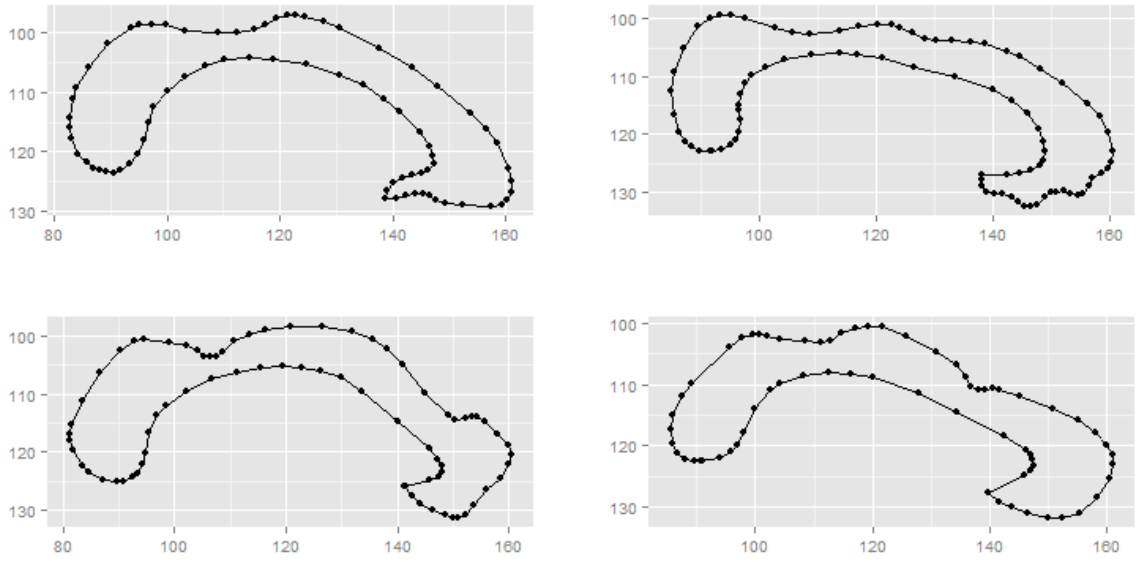
Brain scans are highly complex. They are typically converted into analysable form by researchers (or software) tracing contours to describe the boundaries of selected neural structures. These are used to calculate surface area, volume, and thickness, which are subsequently used in analyses. This focus on size and volume has proven very fruitful, but is insensitive to structural changes that may impact on brain functioning, such as twisting or bowing. Just as volume or surface area gives parsimonious insight into neural structures, investigation of shape requires dimension reduction to facilitate manageable analysis.

This talk explores different analytical approaches that quantify and meaningfully summarise the shape of neural structures, using simulated and real-world two-dimensional contours of the corpus callosum (the structure that connects the left and right brain hemispheres). It includes discussion of the techniques themselves, and also the approaches that can be used to quantify and evaluate their success in meaningfully summarising shape. Each approach will be discussed in terms of the difference in area and outline between the original (known) shape, and the shape reconstructed from analysis. The most promising method (efourier) will be used to show how shape analysis can provide information about potentially significant differences in brain structure in clinical groups, such as diabetics.



(The image depicts example corpus callosum contours traced from MRI scans of healthy middle-aged volunteers)

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Examining the relationship between practice and strategy use: Hierarchical bayesian models of composite and component strategy use

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Introduction: Research into how individuals acquire new skills has often examined changes in how they complete the task or changes in strategy use. This previous research has often utilized aggregated data to examine changes in single strategies on simple tasks. This study will expand on previous research by examining models of individual level strategy use on a complex computer based task where changes in memory retrieval, amount of irrelevant information processing, and method of task execution, can be observed. Our aim was to examine whether these changes occur abruptly and, if so, whether these abrupt changes are smoothed over when different types of strategy change are aggregated into a global measure of strategy efficiency.

Method: 163 participants completed 15 three-minute blocks of the Wynton Anglim Booking (WAB) Task. The task requires participants to make swimming class bookings by asking questions of the parent and selecting the right class on the timetable. Not asking irrelevant questions, retrieving class rules from memory and using filters to reduce the options shown on the timetable could reduce task completion time. Strategy use was measured as the proportion of trials a strategy was utilized within a block and aggregated measures were calculated as the average of the components. We used Bayesian methods to fit abrupt and power functions to strategy use data within a hierarchical framework and evaluated them using deviance estimates, plots of model fits and posterior predictive checks.

Results: Plots of the data indicated that the component level strategies generally changed abruptly while the aggregated measures changed gradually. Although the power function was quite flexible and able to mimic the abrupt function, model evaluation generally supported the findings from the plots.

Discussion: We theorize that a possible reason we see gradual performance improvements resulting from abrupt changes in strategy use is because the abrupt changes occur at different points in practice for different types of strategy change.

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