virtual mathpsych/iccm 2022

55th annual meeting of the society for mathematical psychology (virtual edition)

20th international conference on cognitive modeling (virtual edition)

july 11–15, 2022
only on
mathpsych.org

Welcome

Dear Members of the SMP/ICCM Community,

It is my pleasure to welcome you to another virtual joint meeting of the Society for Mathematical Psychology and the International Conference on Cognitive Modeling. Thanks to the Society's investments in response to COVID-19, we have an excellent system in place for the conference this year. While we are also able to host a separate, in-person conference this year in Toronto, the advantages of a virtual conference were significant enough to continue holding the virtual meeting this year, and hopefully in perpetuity. Particularly, the virtual conference allows a much wider range of researchers to present their work, connect with one another, and learn from others because of the reduced cost and the dramatically reduced environmental impact. Additionally, recorded talks give interested community members to view materials at their own convenience.

Highlights of our virtual meeting this year include talks by a wide range of researchers from the SMP and ICCM research communities across the globe, a welcome mixer on July 11th, a poster meetup session on July 12th, and a meetup of the Women of MathPsych on July 13th.

Before getting to updates for SMP, I would like to congratulate ICCM, our partners in this conference, for formalizing their society. Thanks to our partnership, we continue to be the premier conference for cognitive modeling. We look forward to sharing our research between the communities this year and hopefully for many years to come.

This year SMP will recognize the 2021 Estes Early Career Award Winner, Daniel Heck, and Senior Fellow Award winner, A.A.J. "Tony" Marley. Sadly, Tony passed away before he was notified of the award. During the in-person conference this year, at the SMP business meeting, we will also announce the Estes Early Career Award winner and Senior Fellow Award winners for 2022 along with the best paper award winners from SMP's two journals, the R. Duncan Luce Outstanding Paper Award from the *Journal of Mathematical Psychology*, and the Outstanding Paper Award from *Computational Brain & Behavior*.

In closing, I would like to thank Joachim Vandekerckhove for organizing and implementing the virtual meeting almost entirely on his own as well as for his fundamental role in developing the infrastructure for hosting virtual conferences.

Kind Regards,

Joe Houpt
President of the Society for Mathematical Psychology

mathpsych.org

About virtual MathPsych/ICCM 2022

Due to the popularity of the online format of the previous years, the 2022 edition of the annual joint meeting of the Society for Mathematical Psychology and the International Conference on Cognitive Modeling was split into two completely separate events: a virtual conference followed by an in-person conference. Virtual MathPsych/ICCM 2022 will be hosted fully on mathpsych.org.

The underlying philosophy to the schedule of this virtual conference is that it is **asynchronous** and relatively **low-commitment**. Attendees all over the world should be able to enjoy a virtual conference equally. Furthermore, we wanted to make it possible to participate, at least partially, even without a fast internet connection, and without the need to commit the majority of one's time.

Virtual MathPsych/ICCM 2022 is intended to be welcoming and accessible to all. It is hoped that a slow-moving, measured schedule will allow everyone to participate, regardless of geographical location, and in a way that can be combined with other responsibilities.

Much of the conference will be and remain visible to the public for non-interactive viewing. Certain research presentations and recordings of live sessions will be accessible to registered participants only.

MathPsych

The Society for Mathematical Psychology promotes the advancement and communication of research in mathematical psychology and related disciplines. Mathematical psychology is broadly defined to include work of a theoretical character that uses mathematical methods, formal logic, or computer simulation. The official journals of the society are the *Journal of Mathematical Psychology* and *Computational Brain & Behavior*.

ICCM

The International Conference on Cognitive Modeling (ICCM) is the premier conference for research on computational models and computation-based theories of human behavior. ICCM is a forum for presenting, discussing, and evaluating the complete spectrum of cognitive modeling approaches, including connectionism, symbolic modeling, dynamical systems, Bayesian modeling, and cognitive architectures. ICCM includes basic and applied research, across a wide variety of domains, ranging from low-level perception and attention to higher-level problem-solving and learning.

Contents

Code of conduct

The Society for Mathematical Psychology (SMP) is committed to the highest standards of diversity, equity, inclusion, and the free expression of ideas. We seek to provide an environment in which diverse participants may learn, network, and enjoy the company of colleagues. We recognize a shared responsibility to create and sustain that environment for the benefit of all. This Code of Conduct sets forth our commitment to providing a harassment-free and inclusive environment at SMP sponsored events (including all scientific meetings) as well as for all individuals engaged in SMP related business. All forms of harassment are prohibited. Specific prohibited behaviors include but are not limited to the following:

- Harassment or intimidation based on gender, gender identity, gender expression, age, sexual orientation, disability, appearance, body size, race, ethnicity, political orientation and views, religion (or lack thereof), or other group status
- Unwelcome behavior as well as verbal or written comments (including online comments) related to the above categories that create a hostile meeting environment (e.g., sexist or racist jokes)
- Sexual harassment or intimidation, including unwelcome sexual attention
- Unwelcome physical contact
- Harassing photography or recording
- Stalking or following (physical or virtual)
- Sustained disruption or threatening of conference presenters
- Cyberbullying (i.e., the use of computers, cell phones or other devices to send or post emails, text messages or images intended to harass another person) and social media abuse
- Advocating for, or encouraging, any of the above behavior
- This code of conduct is not intended to limit the terms of open and respectful scientific inquiry or discussion. Critical examination, debate, and robust disagreement regarding beliefs and viewpoints, germane to the topic of discussion and presented respectfully do not, in themselves, constitute harassment.

We expect individuals to follow this code of conduct at all SMP scientific meetings and in all other SMP related business.

Enforcement

Individuals asked to stop any harassing behavior are expected to comply immediately. If an individual engages in harassing behavior, the SMP executive board retains the right to take any actions to keep SMP a welcoming

environment for all individuals. These actions include simply warning the offender, expulsion from a scientific meeting with no refund of registration or other attendance-related costs, expulsion from the society, and/or banishment from all future SMP meetings. Appeals for any of these actions will be handled by the executive board.

Reporting

If you are being harassed, notice that someone else is being harassed, or have any other concerns, please report it to us immediately. We value your involvement in SMP, and will make every effort to ensure that you feel safe and welcome in our society.

You can make a report by emailing info@mathpsych.org. This email is directly monitored by the secretary/treasurer and the president. Any reports made by email will be accessible by the executive board. You may also make a report in person to any member of the executive board.

The conference will take place primarily on mathpsych.org (the *conference venue*). Some parts of the conference are accessible only to registered participants, so you need to log in using the 'Member login' button at the top right.

The conference will be held mostly asynchronously, over a period starting on **July 11, 2022**, and concluding on **July 15, 2022**. Shortly before the beginning of this period, all prerecorded presentations will be published on the conference venue.

Venue and rooms

The venue is divided into different sections, which we are calling **rooms**. Once you are logged in at mathpsych.org, joining the conference is as easy as clicking a colorful link at the top of the page or tapping in a navigation menu on your mobile device.

Simultaneously released, sequentially featured presentations

While all presentations will be made available at the same time on or about **July 4, 2022**, and remain available throughout, we will publish **recommended viewing times**. Every weekday, a set of approximately 15 virtual talks will be "featured." Presentations will remain featured for two days, giving everyone in all time zones the opportunity to view them. With about 15 talks being recommended each day, and each talk taking no more than 15 minutes, the time commitment to view every talk in the conference is about four hours per weekday. Eventually each talk will be featured once.

Discussion boards for constant engagement

While (and after) a presentation is featured, we encourage all conference attendees to participate in the **discussion board** to post questions about the presentation or engage in in-depth group discussions. A lengthy exchange on a public discussion board forms a potentially very useful resource for the audience's deeper understanding of a topic.

Live Q&A follow-up

Near the end of the period of time in which a presentation is featured, selected speakers will participate as panelists in a moderated live Q&A

session. In these sessions, panelists will answer questions about the work they presented. Participation in a Q&A session (both as a panelist and as an audience member) is by invitation only. Panelists will be asked to kick off the Q&A session by briefly summarizing their presentation and by answering selected questions from the **discussion board**.

Live events

While much of the conference will be accessible to the public, all interactive (live) events will be tightly secured. Access to live Q&A sessions will require users to log in with a verified account. Access to all social events will be restricted to verified, registered attendees who reserved a virtual seat ahead of time.

Live events will make use of two third-party services: Zoom (zoom.us) and GatherTown (gather.town). These services will be free to use and work inside a regular browser. Zoom also works as an app on most smartphones; GatherTown requires a desktop or laptop. These services all require a camera and a microphone, although we also support dialing in to Zoom sessions by phone. Access will be protected by private access links and passwords, which will be disseminated via the conference venue — typically the login information will become available 30 minutes before a session starts.

Finally, note that we can make no guarantees that live events will happen as planned. A lot can happen to make live events impossible without notice. In the unlikely case that an ongoing event is abruptly interrupted, updates will be published on the session page or via email.

Certificate of attendance

A certificate of attendance can be obtained from the conference venue. Log in to your user account, go to your profile by clicking your user name at the top right, and go to Certificates of Attendance.

Presenting at virtual MathPsych/ICCM 2022

The 2022 conference will be the third annual MathPsych/ICCM meeting to be held online. Since the mechanics of such a conference will still be new to many, we have designed a small set of guidelines that all presenters should take into account. **Please read this entire chapter.**

Part of these guidelines are informed by our belief that our research should be, to the fullest extent possible, accessible to all. As a result, when authors submit a presentation to MathPsych/ICCM, we believe it should be considered **publicly accessible by default**. Submitters will be given the choice to opt out of the immediate publication of their presentation. Instead they can choose to embargo their work for any amount of time, even permanently, during which the presentation will be accessible to authenticated users only.

To learn more about embargoing or about submitting your presentation without making it public (or, more generally, without using YouTube), be sure to read the section titled "If you have concerns about publication…" on page 16.

Record your presentation

All presentations should be recorded using **screen capture software with voice-over**. This tends to produce higher quality sound and video than camera recordings of slide projections. (An inset showing the speaker is allowed but not required.) Software to record your screen and audio is relatively easy to come by. Zoom is currently a popular option at many universities. Current versions of all major computer operating systems have built-in screen recorders that also allow for recording audio from the microphone and allow the presenter to use the mouse as one would a laser pointer. The main hardware requirement is a microphone that can be placed close to you.

When you record the voice-over, please keep in mind that there is essentially no distance between you and the audience's ear. Speak in a clear, "inside voice." Also be mindful of the international character of the audience: Just as you should avoid unnecessary jargon, it is best to avoid slang and expressions that might be unfamiliar to non-native speakers of English.

Finally, also keep in mind that your talk will be visible to a large and diverse audience, and the Code of Conduct applies here, too.

Publish your presentation

If at all possible, presentations should be uploaded to YouTube. This has a number of advantages, including free storage, high bandwidth, and automatic closed captioning. To upload a video to YouTube, you need a Google or GSuite account (many institutional email addresses are GSuite accounts; personal Google accounts are free and easy to make).

1. Go to studio.youtube.com
2. Log in with your Google or GSuite account
3. Click the CREATE button
4. Choose "Upload videos" and select your recording
5. Enter a title
6. Enter the following description:

> This presentation is part of virtual MathPsych/ICCM 2022.
> See more via https://mathpsych.org/conferences/vmp2022

7. Make note of the **Video link** on the right side of the window (this is what you will need to submit at the conference venue)
8. Answer the required questions (e.g., this video is not targeted at children; this video has never appeared on television)
9. When asked about privacy settings, choose either **Public** or **Unlisted**

Publishing via YouTube is currently free and allows users to upload an unlimited number of videos (videos longer than 15 minutes require account verification; but no presentation format at MathPsych/ICCM is longer than 15 minutes). Among other things, this means that presenters who have trouble using YouTube can ask any friend or colleague to upload a video to their account. If you are not able to upload a video to YouTube, you may also contact the MathPsych Conference Chair (see p. 85) who can do it on your behalf.

Closed captioning

All prerecorded videos **must** have captions available. This is an accessibility requirement of the conference. Fortunately, YouTube makes this very easy — once you upload a video, an automatic speech-to-text engine will generate closed captions for your video. They are added to your video a few minutes after uploading. While the automatically generated captions are generally good, they do need to be checked and often edited manually. To do so, take the following steps.

1. Go to studio.youtube.com
2. Log in with your Google or GSuite account
3. In the left bar menu, click "Subtitles" to see a list of videos you have uploaded
4. Click the downward arrow under "Languages," next to your video
5. Click the line that reads "English (automatic)" that has appeared

This will bring you to a relatively intuitive subtitle editor that allows you to edit the generated captions while listening to the audio.

It sometimes happens that YouTube fails to generate automated captions even after many hours of waiting. To generate captions yourself, a high-quality option is sonix.ai. The first 30 minutes on sonix.ai are free to you, and the generated captions can be added to your presentation using the same steps as above.

Submitting your recorded presentation to the conference

All presenters at the conference should make sure they are registered as participants (via mathpsych.org). There, the details of your presentation can be found under Profile → My submissions, and the YouTube **Video link** can be added.

The deadline for submitting the recording is **June 30, 2022**. Note that the recordings will be reviewed before they are published. It is important that the instructions above as well as the specific instructions (on p. 16 and beyond) are closely followed.

Copyright information; intellectual property

Before you record

Since materials submitted to the conference will by default be made available to the public, we have to consider whose intellectual property is involved. Please make sure that everything in your recorded presentation is either in the public domain, or that it is your own intellectual property, or that you have the permission of the copyright holder to publish the material and to transfer the right to publish. In particular, if you use figures, clip art, or other audiovisual material that was previously published (by anyone, anywhere; not just an academic publisher), those may not be permitted.

When you submit the recording

At the time you submit your recording, you will be asked to give the Society for Mathematical Psychology the right to publish your presentation. Specifically, you will have to confirm the following statement:

> I hereby give the Society for Mathematical Psychology a non-exclusive, non-transferable, non-revocable license to make this content publicly available.

You will also be able to specify an embargo if you so desire.

If you have concerns about publication or about using YouTube

If you are unable or unwilling to make your recording available to the general public, or unable or unwilling to use YouTube, you may contact the MathPsych Conference Chair for instructions on how to make your presentation available to the conference attendees only. We are able to store recordings on a private server and make them visible only to users who are logged in and who have confirmed their identity. However, please keep in mind that this confers essentially no guarantees in practice. With hundreds of people with the ability to log in, we have no practical way to contain the illicit dissemination of digital materials.

Additionally, if you choose this option, it would be your responsibility to add closed captions for your presentation.

Specific instructions for presenters

Virtual MathPsych Talk

Virtual MathPsych Talks are spoken presentations accompanied by a slide deck. The maximum duration of a Virtual MathPsych Talk presentation is **15 minutes and 0 seconds**, but shorter presentations are welcome.

Because these presentations will be published by the Society for Mathematical Psychology, we have added minor rules regarding the format and style of the presentation:

1. Talks should be recorded as screencasts, showing only slides with voiceover (not, e.g., a camera recording of a presenter and a projection; an inset of the speaker is allowed but not required).
2. Talks should use the opening slide that is provided by us (see an example in Figure 1). The slide can be downloaded from the conference website in your profile → My submissions → title slide.
3. Presenters should start the recording by introducing themselves by name ("Hello, my name is…") and stating that "this is a prerecorded presentation for the 2022 Meeting of the Society for Mathematical Psychology."

To submit a presentation, go to the conference venue mathpsych.org, log in, and select Profile → My submissions. You will need the YouTube **Video link**.

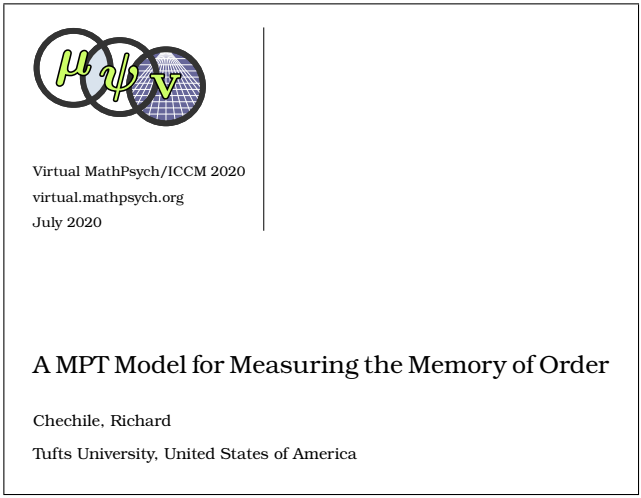

Figure 1: An example opening slide for the Virtual MathPsych Talk format.

Virtual MathPsych Fast Talk

Virtual MathPsych Fast Talks are spoken presentations accompanied by a slide deck. The maximum duration of a Virtual MathPsych Fast Talk presentation is **5 minutes and 0 seconds**, but shorter presentations are encouraged. Virtual MathPsych Fast Talk should have no more than 4 slides (not including the provided title slide). The underlying idea is that this recording is the equivalent to the short pitch that poster presenters give to passers-by.

Because these presentations will be published by the Society for Mathematical Psychology, we have added minor rules regarding the format and style of the presentation:

1. Talks should be recorded as screencasts, showing only slides with voiceover (not, e.g., a camera recording of a presenter and a projection; an inset of the speaker is allowed but not required).
2. Talks should use the opening slide that is provided by us (see an example in Figure 1). The slide can be downloaded from the conference website in your profile → My submissions → title slide.
3. Presenters should start the recording by introducing themselves by name ("Hello, my name is…") and stating that "this is a prerecorded presentation for the 2022 Meeting of the Society for Mathematical Psychology."

To submit a presentation, go to the conference venue mathpsych.org, log in, and select Profile → My submissions. You will need the YouTube **Video link**.

Figure 2: An example opening slide for the Virtual ICCM Paper format.

Virtual ICCM Paper

Virtual ICCM Papers are spoken presentations accompanied by a slide deck. The maximum duration of a Virtual ICCM Papers presentation is **15 minutes and 0 seconds**, but shorter presentations are welcome.

Because these presentations will be published by the Society for Mathematical Psychology, we have added minor rules regarding the format and style of the presentation:

1. Talks should be recorded as screencasts, showing only slides with voiceover (not, e.g., a camera recording of a presenter and a projection; an inset of the speaker is allowed but not required).
2. Talks should use the opening slide that is provided by us (see an example in Figure 1). The slide can be downloaded from the conference website in your profile → My submissions → title slide.
3. Presenters should start the recording by introducing themselves by name ("Hello, my name is..") and stating that "this is a prerecorded presentation for the 2022 International Conference on Cognitive Modeling."

To submit a presentation, go to the conference venue mathpsych.org, log in, and select Profile → My submissions. You will need the YouTube **Video link**.

Virtual ICCM Extended Abstract

Virtual ICCM Extended Abstracts are also spoken presentations accompanied by a slide deck. The maximum duration of a Virtual ICCM Extended Abstract presentation is **5 minutes and 0 seconds**, but shorter presentations are encouraged.

Because these presentations will be published by the Society for Mathematical Psychology, we have added minor rules regarding the format and style of the presentation:

1. Talks should be recorded as screencasts, showing only slides with voiceover (not, e.g., a camera recording of a presenter and a projection; an inset of the speaker is allowed but not required).
2. Talks should use the opening slide that is provided by us (see an example in Figure 1). The slide can be downloaded from the conference website in your profile → My submissions → title slide.
3. Presenters should start the recording by introducing themselves by name ("Hello, my name is…") and stating that "this is a prerecorded presentation for the 2022 International Conference on Cognitive Modeling."

An option that is perhaps slightly more challenging is for presenters to use a single slide that contains an entire poster, and then zoom in/out and pan over the poster as they narrate the presentation. This may be useful for presenters who already have a poster prepared. Note that the screen recording should still begin with the provided title slide.

To submit a presentation, go to the conference venue mathpsych.org, log in, and select Profile → My submissions. You will need the YouTube **Video link**.

Live Q&A instructions

Symposium speakers and presenters of **contributed talks** will be invited to participate in a live Q&A session on the last day the session is featured.

In these sessions, panelists will answer questions about the work they presented. Panelists will be asked to kick off the Q&A session by answering selected questions from the **discussion board**. Each panelist will also be asked to introduce themselves and provide the audience with a short (one minute) refresher on the topic of their presentation.

Q&A sessions will be moderated by one or two conference staff members and will be accessible only to authenticated users. They will not be live-streamed in any public venue. After the session, a recording of a Q&A session will be made public only if no panelists in that session object.

Presenters of **Fast Talks** (MathPsych) or **posters** (ICCM) will be invited to join a social event in which all participants can mingle and join the conversation.

A note on timing of the live Q&A sessions

All MathPsych live sessions are scheduled between 15:00 and 18:00, Eastern Daylight Time. We are aware that this is not an ideal time for all presenters and audience members. The decision to hold live sessions in this time slot is based on a combination of considerations: That the majority of presenters (and therefore the likely majority of the audience) at the conference are in North America; That the selected time slot is merely in the evening (rather than in the middle of the night) in Central European Summer Time and in the early morning in Australian Eastern Standard Time, which together account for the majority of the remaining presenters; and that our tech support is based in the Pacific Time zone.

By similar reasoning, the ICCM live sessions will typically be held from 13:00 to 14:00, Eastern Daylight Time. ICCM's membership leans more toward Europe than to Australia by a significant margin.

Virtual ICCM I Q&A

July 11, 2022, from 14:00 EDT to 15:00 EDT

Invited panelists:

- **Fisher**, Christopher — *A comparison of quantum and multinomial processing tree models of the interference effect*
- **Brand**, Daniel — *Do models of syllogistic reasoning extend to generalized quantifiers?*
- **Nagashima**, Kazuma — *Modeling optimal arousal by integrating basic cognitive components*
- **Yang**, Cher — *A model of motivation and effort allocation in the ACT-R cognitive architecture*

Memory and learning Q&A

July 11, 2022, from 15:00 EDT to 16:00 EDT

Invited panelists:

- **Bhui**, Rahul — *Ambiguity and confirmation bias in reward learning*
- **Zhang**, Lyulei — *Incorporating orthographic representations in recognition memory through global matching models*
- **Chen**, Yiyang — *Mutual interference in working memory updating: A hierarchical Bayesian model*
- **Spektor**, Mikhail — *A validation study of paired-word recognition models*
- **Paron**, Madison — *A context-based model of recall and decisions*
- **Paron**, James — *A context-based model of recall and decisions*
- **Nosofsky**, Robert M. — *Hybrid-similarity exemplar model for predicting individual-item recognition in a high-dimensional category domain*

Dimension reduction Q&A

July 11, 2022, from 16:00 EDT to 17:00 EDT

Invited panelists:

- **Mayer**, Maren — *Cultural Consensus Theory for two-dimensional location judgments*
- **Innes**, Reilly — *Honey, I shrunk the parameter space: Dimensionality reduction for hierarchical models.*
- **Stevenson**, Niek — *Honey, I shrunk the parameter space: Dimensionality reduction for hierarchical models.*
- **Tan**, Nicole Yuen — *Specificity of the jumping-to-conclusion bias in social anxiety: An account using the Bayesian computational modeling approach*
- **Chávez De la Peña**, Adriana Felisa — *Principal-component exploration of individual differences in the general-speed component of response times.*
- **Arora**, Nipun — *Using machine learning to make interdisciplinary studies tractable - Agency as a case study*
- **Pedersen**, Arthur Paul — *Measurement theory sans Archimedes or order, with applications to logic, probability, and choice*

Welcome mixer

July 11, 2022, from 17:00 EDT to 18:00 EDT

Virtual ICCM II Q&A

July 12, 2022, from 14:00 EDT to 15:00 EDT

Invited panelists:

- **Fincham**, Jon — *Combining EEG and a cognitive model to infer the time course of game play*
- **Borghetti**, Lorraine — *Towards a method for evaluating convergence across modeling frameworks*
- **Du**, Yinuo — *Modeling of multi-defender collaboration in a cyber-security scenario*
- **Nishikawa**, Jumpei — *Estimating phonological awareness with interactive cognitive models: Feasibility study manipulating participants' auditory characteristics*

Evidence accumulation Q&A

July 12, 2022, from 15:00 EDT to 16:00 EDT

Invited panelists:

- **Chen**, Haomin — *Linear ballistic accumulator models of confidence and response time.*
- **Qarehdaghi**, Hasan — *EZ-CDM: easy estimation of circular diffusion model parameters*
- **Epping**, Gunnar — *Open system model of choice and response time*
- **Stuchlý**, Erik — *Defining one's boundaries: Exploration of the decision threshold parameter space during a reward maximisation task.*
- **Hadian Rasanan**, Amir Hosein — *Race Levy-Brownian model: An evidence accumulation model with both Levy flight and diffusion properties*
- **Foster**, Kendal — *fddm: an R package for fitting the Ratcliff diffusion decision model*
- **Zwicker**, Jason — *Timing during gaps in the stimulus: A drift-diffusion analysis*

Neurocognitive modeling Q&A

July 12, 2022, from 16:00 EDT to 17:00 EDT

Invited panelists:

- **Ghaderi-Kangavari**, Amin — *Novel neuro-cognitive models can explore spatial attention's effect on perceptual decision making*
- **Ma**, Si — *A neural index of resource availability: Unifying subsequent memory effect, primacy serial position effect, and word frequency effect*
- **Gronau**, Quentin Frederik — *A Bayesian hierarchical model for EMG data*
- **Sun**, Jie — *Incorporating exogenous and endogenous sources of evidence in recognition memory to explain trial-by-trial drift rate variability in the diffusion decision model*

Poster and Fast Talk meetup session

July 12, 2022, from 17:00 EDT to 18:00 EDT

Invited panelists:

- **Seow**, Roderick — *Discontinuities in function learning*
- **Ismail**, Hadeel — *Using GOMS to model individual differences in a competence assessment task*
- **Huang**, Adam — *A quantum walk framework for multialternative decision making*
- **Todorovikj**, Sara — *Predicting algorithmic complexity for individuals*
- **Kettner**, Felix — *Reverse-engineering of Boolean concepts: A benchmark analysis*
- **Mannhardt**, Johannes — *How do humans revise spatial beliefs?*
- **Truong**, Nhut — *Using deep neural networks for modeling representational spaces: the prevalence and impact of rarely-firing nodes*
- **Saad**, Laura — *Does memory noise follow Weber's Law? An investigation in one temporal binding dataset*
- **Le**, Evelyn — *A comparison of retrofitting multiple knowledge structures to a cognitive diagnostic assessment*
- **Somasundaram**, Ashwin — *A comparison of retrofitting multiple knowledge structures to a cognitive diagnostic assessment*
- **Ricupero**, Sarah — *Testing the KRK predictions: Testing knowledge too much leads to learning*
- **Conway**, Sean — *Categorization with multiple items: Empirical and modeling results*
- **Ortmann**, Alexandra — *Modeling asymmetric human exploratory choice behavior across the gain and loss domains*
- **Izydorczyk**, David — *What is more democratic, a stone or a feather? Predicting nonsensical choices using high-dimensional vector representations obtained from a semantic space model*
- **Sloman**, Sabina J. — *How to know what you should know: Implications of the choice of prior distribution on the behavior of adaptive design optimization*
- **Thorpe**, Alexander — *Keep your eyes on the sky: task prioritisation under high workload in aviation*
- **Farahani**, Hojjatollah — *Using the association rule mining in psychological research: A case study of trauma data*
- **Yang**, Hang — *Separating the roles of orthographic and semantic information in the neural correlates of evidence accumulation for lexical decision-making*
- **Fang**, Jun — *Analogical transfer in multi-attribute decision making*
- **Vigo**, Ronaldo — *Determining natural prototypes with a mathematical theory of subjective information*
- **Wimsatt**, Jay — *Determining natural prototypes with a mathematical theory of subjective information*
- **Soto**, Fabian — *Extending signal detection theory to the analysis of generalization and other tasks using continuous responses to multiple items*
- **Baribault**, Beth — *matstanlib: A MATLAB library for visualization, processing, and analysis of output from Bayesian models in Stan*
- **Collins**, Allan — *Capacity predictions of nested architectures: application to visual perception across the hemispheres*

Women of Mathematical Psychology virtual meetup

July 13, 2022, from 12:00 EDT to 14:00 EDT

Virtual ICCM III Q&A

July 13, 2022, from 14:00 EDT to 15:00 EDT

Invited panelists:

- **Fisher**, Christopher — *On the limits of spreading activation in ACT-R: Predictions and testability*
- **Bugbee**, Erin — *Leveraging cognitive models for the wisdom of crowds in sequential decision tasks*
- **Bartlett**, Madeleine — *Fast online reinforcement learning with biologically-based state representations*
- **Grennan**, Gillian — *Estimating ACT-R declarative memory parameters using a drift diffusion model*
- **Conway-Smith**, Brendan — *Clarifying system 1 & 2 through the common model of cognition*

Reasoning and metacognition Q&A

July 13, 2022, from 15:00 EDT to 16:00 EDT

Invited panelists:

- **Jiwa**, Matthew — *Hedonism in information search – biased information-seeking leads to biased beliefs*
- **Cruz**, Nicole — *Measuring coherence in reasoning*
- **McCormick**, Erin — *Decision strategy adaptation to time constraints*
- **Alaukik**, Abhay — *Polarization & extremism when sampling qualitative information: Choosing between options worse than estimating relative preferability or independent ratings*
- **Markant**, Doug — *Learning the order of things: Modeling encoding- and retrieval-based strategies for transitive inference*

Attention and perception Q&A

July 13, 2022, from 16:00 EDT to 17:00 EDT

Invited panelists:

- **Zilker**, Veronika — *Stronger attentional biases can be linked to higher reward rate in preferential choice*
- **Gillespie**, Nathan — *A scaling study of novel auditory stimuli for creating artificial events*
- **Bahg**, Giwon — *The effects of personalization on category learning: An empirical investigation*
- **Chung**, Ching Hui — *The effects of value and probability on the utilization of the perceptual decision strategy*
- **Zhang**, Hanshu — *Holistic processing for Chinese characters and English words*
- **Fific**, Mario — *Modular serial-parallel network for hierarchical facial representations*

Virtual ICCM IV Q&A

July 14, 2022, from 14:00 EDT to 15:00 EDT

Invited panelists:

- **Swan**, Garrett — *Exploring multitasking strategies in an ACT-R model of a complex piloting task*
- **Khemlani**, Sunny — *A computational cognitive theory of temporal reasoning*
- **Patil**, Umesh — *Modeling prominence constraints for German pronouns as weighted retrieval cues*
- **Cranford**, Edward — *Combining machine learning and cognitive models for adaptive phishing training*

Formal analysis Q&A

July 14, 2022, from 15:00 EDT to 16:00 EDT

Invited panelists:

- **Smithson**, Michael — *Flexible cdf-quantile distributions on the closed unit interval*
- **Schweickert**, Richard — *Constructing an unobservable critical path network from observable slacks*
- **Gondan**, Matthias — *rolog: Querying Prolog from R*
- **Xu**, Robin — *Modeling pilot flight performance on take-off task with QN-ACTR*
- **Castillo**, Lucas — *Using sampling algorithms to explain human random generation*
- **Golden**, Richard — *Estimating parameter confidence intervals in possibly misspecified parameter redundant models*
- **Altay**, Ayca — *Attacker behavior detection in critical infrastructure*

Decision making Q&A

July 14, 2022, from 16:00 EDT to 17:00 EDT

Invited panelists:

- **Glautier**, Steven — *In search of the preference reversal zone*
- **Cooper**, Gavin — *Discriminating between models of processing in multi-attribute choice*
- **Liu**, Yanjun — *The impact of experience on preference formation and context effects in multi-alternative, multi-attribute choice*
- **Hélie**, Sébastien — *Using Bayesian modeling to assess the similarity between cognitive and physical effort discounting*
- **Spektor**, Mikhail — *Cognitive modeling of multi-attribute preferential and perceptual choices*
- **Akrenius**, Mikaela — *The role of entropy in probability weighting*

Virtual ICCM V Q&A

July 15, 2022, from 14:00 EDT to 15:00 EDT

Invited panelists:

- **Curley**, Taylor — *Modeling short-term fatigue decrements in the successive/simultaneous discrimination task*
- **Lane**, Peter — *Evolving understandable cognitive models*
- **Tan**, Nicole Yuen — *Specificity of the jumping-to-conclusion bias in social anxiety: An account using the Bayesian computational modelling approach*
- **Dietz**, Emmanuelle — *Argumentation-based reasoning guided by chunk activation in ACT-R*

VMP 2022 afterparty

July 15, 2022, from 15:00 EDT to 16:00 EDT

Hybrid-similarity exemplar model for predicting individual-item recognition in a high-dimensional category domain

Nosofsky, Robert M.
Indiana University

Meagher, Brian
Indiana University Bloomington

Session:
Memory and learning – live on Monday, July 11, at 15:00 EDT

Participants learned to classify a set of rock images into geologically-defined science categories. We then investigated the nature of their category-based memory representations by collecting old-new recognition data in a subsequent transfer phase. An exemplar model provided better qualitative accounts of the old-new recognition data than did a prototype or clustering model. However, to account for the variability in recognition probabilities among the old training items themselves, a hybrid-similarity exemplar model was needed that took account of distinctive features present in the items. The study is among the first to use computational models for making detailed quantitative predictions of old-new recognition probabilities for individual items embedded in complex, high-dimensional similarity spaces.

A validation study of paired-word recognition models

Voormann, Anne

Spektor, Mikhail
University of Warwick

Klauer, Christoph
University of Freiburg, Germany

Session:
Memory and learning – live on Monday, July 11, at 15:00 EDT

How do people recognize objects they have encountered previously? Cognitive models of recognition memory aim to explain overt behavior (e.g., recognizing an object) using latent psychological processes (e.g., true recognition and pure guessing). Validation studies assess whether the mechanisms underlying cognitive models properly reflect the psychological processes they aim to explain. The present study provides such a validation study for models describing paired-word recognition using selective-influence manipulations.
In a paired-word recognition task, people have to provide a simultaneous categorization of randomly paired words as either both being previously studied, only one word being previously studied, or both words being new. To selectively manipulate mnemonic processes, we implemented a strength manipulation (Experiment 1) in which certain words were presented more often during study. To influence decisional processes, we relied on two different base-rate manipulation, one of response categories (Experiment 2), in which certain pair types more frequent during the test phase, and one of overall target and lure frequencies (Experiment 3). We assessed the validity of general recognition theory, a multidimensional signal detection theory model, and the paired two-high threshold model, a discrete-state model.
In line with the literature on single-word recognition, both models captured the strength manipulation using parameters associated with mnemonic processes. Surprisingly, both of the base-rate manipulations were captured by mnemonic parameters as well, even though the extant literature would suggest a selectively influence on parameters associated with decisional processes. We discuss implications for model validity and future directions in paired-word recognition.

A context-based model of recall and decisions

Paron, Madison
University of Pennsylvania

Paron, James
University of Pennsylvania

Kahana, Mike
University of Pennsylvania

Session:
Memory and learning – live on Monday, July 11, at 15:00 EDT

Existing models of memory posit separate processes for encoding and retrieval: the study of items is an endogenous process of item- and context-reinstatement, while retrieval occurs through an exogenous drift-diffusion procedure. We argue that the same iterative memory process underlying encoding also underlies recall and decision-making, and propose a new model of endogenous, context-based recall decisions. The simulated model explains documented empirical facts about accuracy and inter-response times (IRTs) in free-recall experiments. These facts include the distribution of IRTs, the increase in average IRTs over successive retrievals, and the negative relation between accuracy and IRTs. The model is isomorphic to a large class of drift-diffusion models, implying a memory-based microfoundation for these common decision models and their use in theories of free recall. We demonstrate the theory's broad implications by applying it to more general decision problems.

Mutual interference in working memory updating: A hierarchical Bayesian model

Chen, Yiyang
University of Kansas

Peruggia, Mario
The Ohio State University, United States of America

Van Zandt, Trisha
Ohio State University

Session:
Memory and learning – live on Monday, July 11, at 15:00 EDT

We built a hierarchical Bayesian model for the working memory updating task. This model jointly accounts for both responses and reaction times in the memory updating paradigm, which is a commonly used paradigm to measure working memory capacity. To model responses, we adopted a mutual interference framework from Oberauer & Kliegl (2006) that characterized activation levels of working memory items, and extended this framework into a Markov chain structure to characterize a wider range of responses. To model reaction times, we adopted a Wald diffusion framework where the Wald parameters were associated with activation levels of working memory items. This model allows us to investigate the mechanism underlying participant performance in the memory updating task under a joint theoretical framework. We applied this model to an empirical data set investigating the effects of working memory training. Modeling results revealed that training might not improve overall working memory capacity, but may lead to a general improvement in the speed of processing.

Ambiguity and confirmation bias in reward learning

Bhui, Rahul
Massachusetts Institute of Technology

Dorfman, Hayley

Gershman, Samuel J.
Harvard University

Session:
Memory and learning – live on Monday, July 11, at 15:00 EDT

We tend to interpret feedback in ways that confirm our pre-existing beliefs. This confirmation bias is often treated as irrational, but may have adaptive foundations. In this project, we propose a new Bayesian computational model of confirmation bias and a novel experimental paradigm to study its impact on learning. When faced with an ambiguous outcome, we must form the most accurate interpretation we can by making use of all available information, which includes our pre-existing beliefs. Confirmation bias may thus constitute an inductive bias that speeds up learning, analogous to missing data imputation. We test this theory using a reward learning task in which participants are only provided partial information about outcomes, allowing more leeway for subjective interpretation. We find that our Bayesian model better explains the dynamics of behavior and stated beliefs compared to more traditional learning models, supporting an adaptive basis for confirmation biased learning from repeated feedback.

Incorporating orthographic representations in recognition memory through global matching models

Zhang, Lyulei
The University of Melbourne

Osth, Adam
The University of Melbourne

Session:
Memory and learning – live on Monday, July 11, at 15:00 EDT

Global matching is a key concept in many models of recognition memory which posits retrieval as a process of matching test probe against every stored memory representation to produce a measure of global similarity. However, to date many models have not adopted principled representations of words. While some memory models have advanced through adopting realistic semantic representations, little work has explored the consequence of integrating perceptual representation. A variety of orthographic representations of words has been proposed in the psycholinguistics literature to account for several orthographic similarity effects between word pairs, however, little contact has been made to recognition memory. The study aimed to firstly establish three key orthographic similarity effects in recognition memory, namely the replacement effect, exterior-letter effect and transposition effect, and secondly to compare four orthographic representations (i.e. slot-coding, closed-bigram, open-bigram, and the overlap model) in their ability to capture recognition memory data in a global matching framework. 162 participants completed a recognition memory study of words using unrelated lists where targets were paired with lures of different orthographic similarity types. Different orthographic representations were used to calculate a global similarity value for each test probe, which was then used to model recognition accuracy via Luce's choice rule in a hierarchical Bayesian framework. Results showed clear replacement effect, adjacent and non-adjacent transposition effects and start-letter importance in recognition memory. Model selection results support the open-bigram coding being the best orthographic representation in recognition memory.

Honey, I shrunk the parameter space: Dimensionality reduction for hierarchical models.

Joint modelling of behaviour and neural activation poses the potential for a significant advance to methods of linking brain and behaviour. However, methods of joint modelling have been limited by difficulties in estimation, often due to high dimensionality and simultaneous estimation challenges. In this talk, we present a method of model estimation which allows for a significant dimensionality reduction using factor analysis at the group level in a Bayesian hierarchical model based estimation framework. The method is based on the particle metropolis within Gibbs sampling algorithm (Gunawan, Hawkins, Tran, Kohn, & Brown, 2020) - which is robust and reliable - with changes implemented to the standard 'pmwg' R package. Additionally, we briefly highlight several alternate solutions to the dimensionality problem. Although we focus on joint modelling methods, this model based estimation approach could be used for any high dimensional modelling problem. We provide open source code and accompanying tutorial documentation to make the method accessible to any researchers.

Innes, Reilly
University of Newcastle

Stevenson, Niek
University of Amsterdam

Gronau, Quentin Frederik
University of Newcastle

Heathcote, Andrew
University of Tasmania

Forstmann, Birte
University of Amsterdam

Brown, Scott
University of Newcastle

Miletić, Steven
University of Amsterdam

Session:
Dimension reduction – live on Monday, July 11, at 16:00 EDT

Specificity of the jumping-to-conclusion bias in social anxiety: An account using the Bayesian computational modeling approach

To date, little is known about the role of social anxiety in the assignment of evidence weights which could contribute to the jumping-to-conclusion bias. The present study used a Bayesian computational method to understand the mechanism of jumping-to-conclusion bias in social anxiety, specifically through the assignment of weights to information sampled. The present study also investigated the specificity of the jumping-to-conclusion bias in social anxiety using three variations of beads tasks that consisted of neutral and socially threatening situations. A sample of 210 participants was recruited from online communities to complete the beads tasks and a set of questionnaires measuring the trait variables including social anxiety and the fears of positive and negative evaluation. The Bayesian model estimations indicated that social anxiety and fears of evaluation did not significantly bias the assignment of evidence weights to information received, except when mostly positive feedback was shown. Our results did not support a significant association between the jumping-to-conclusion bias and social anxiety/ fears of evaluation.

Tan, Nicole Yuen
The Australian National University

Shou, Yiyun
The Australian National University, Australia

Chen, Junwen
The Australian National University

Christensen, Bruce
The Australian National University, Australia

Session:
Dimension reduction – live on Monday, July 11, at 16:00 EDT

Using machine learning to make interdisciplinary studies tractable - Agency as a case study

Hemmer, Pernille
Rutgers University

Musolino, Julien
Rutgers University, United States of America

Arora, Nipun
Rutgers University, New Brunswick

Session:
Dimension reduction – live on Monday, July 11, at 16:00 EDT

Researchers are often faced with novel and complex problems requiring interdisciplinary solutions. However, interdisciplinary research requires integrating previously unrelated concepts across different fields—a task that involves discovering and processing very large quantities of information. Given the nature of the challenge, big data and machine learning tools naturally come to mind as potential solutions. Here, we present an approach that automates the discovery of relevant literature and uses machine intelligence to identify fine-grained semantic relationships embedded within thousands of articles. Specifically, we apply this technique to the case of human agency. In doing so, we aim to fill a critical gap in that broader literature, namely the absence of an account of agency that integrates the sociological and psychological natures of the phenomenon.

We programmatically scanned 6 databases using the keywords 'human agency'. The automated method mined 2700+ full papers across 9 different disciplines. We then used Latent Dirichlet Allocation—a Bayesian machine learning technique—to identify 54 topics present in this corpus. PCA was used to distribute the topics on the semantic space to visualize the lay of the land. Rendering these in a networked representation allowed us to locate specific cross-disciplinary relationships from a haystack of literature without having to manually read nearly 3,000 papers. Finally, the trained model was used to quantify intersectionality within each paper that helped us identify key articles.

Our method enables researchers to discover a broad and exhaustive corpus of relevant literature, quickly develop a big-picture understanding from it, and discover deep, interdisciplinary connections. Being automated, the approach ameliorates selection biases. The approach is also sensitive to different conceptualizations of the same word which makes it particularly suited to process interdisciplinary literature. Finally, the method is topic-neutral, and therefore broadly applicable. We have published its codebase on Github for the wider community.

Principal-component exploration of individual differences in the general-speed component of response times.

Chávez De la Peña, Adriana Felisa
University of California, Irvine

Rouder, Jeffrey
University of California, Irvine

Vandekerckhove, Joachim
University of California, Irvine

Session:
Dimension reduction – live on Monday, July 11, at 16:00 EDT

A common method to localize cognitive processes is Donders' subtractive method. For example, to localize inhibition in the Stroop task, performance in a congruent condition is subtracted from that in an incongruent condition. Many cognitive tasks purport to measure inhibition this way. A critical question is whether individual difference scores correlate across these tasks. We find that they do not. Inhibition response time difference scores correlate weakly at best, often below .1 in value.

We revisit three large-scale data sets and find that overall task response times do correlate at over .5 in value. This result implies that participants are consistently fast or slow to respond across these tasks. The main source of individual variation is not inhibition, but rather overall or general speed.

We explore the dimensionality and structure of general speed across individuals and tasks in extended data sets. With several tasks per set, it is possible to ask whether there is a unified general speed versus several varieties of general speed. A principal component analysis (PCA) revealed a strong first factor in all sets, consistent with a unidimensional, unified construct of general speed.

One way of contextualizing these results is to compare them to human anthropometrics. While human bodies are similar in many ways, they seemingly vary on a "size" factor. We analyze a publicly available set of 93 body measurements collected across 6,068 US military personnel. Indeed, a strong first factor of size emerges, but so does a second factor that captures how heavy people are for their height. Perhaps surprisingly, the first-factor solution for general speed is comparable to or even stronger than it is for anthropometrics. Moreover, we were unable to identify a coherent second factor for general speed. We conclude that general speed is likely unidimensional.

Cultural Consensus Theory for two-dimensional location judgments

Mayer, Maren
University of Mannheim

Heck, Daniel
University of Marburg

Session:
Dimension reduction – live on Monday, July 11, at 16:00 EDT

Cultural Consensus Theory (CCT) is a statistical approach for aggregating subjective judgments or ratings for which correct answers are not known. In a typical CCT setting, several informants provide judgments for items from a certain knowledge domain (e.g., cultural norms). However, both the correct answers and informants' competence are unknown. Batchelder and Romney (1986) developed CCT to identify the latent "cultural truth" based only on the observed judgments while accounting for differences in informants' competence. Here, we extend CCT to two-dimensional continuous data such as geographical coordinates (longitude and latitude) of subjective location judgments on maps. For instance, when asking a group of informants to locate a set of unknown sites (e.g., capital cities), the new CCT-2D model provides estimates of the inferred locations and the informants' abilities. For this purpose, we develop a joint model of longitude and latitude judgments (i.e., x- and y-coordinates) which assumes a common cultural truth of item locations and accounts for correlated errors with respect to the x- and y-coordinates. The CCT-2D model is tested using both simulated and empirical data, showing that the resulting aggregate location estimates are more accurate than those obtained by unweighted averaging.

Measurement theory sans Archimedes or order, with applications to logic, probability, and choice

Alexander, Sam
US Securities and Exchange Commission

Moss, Lawrence S.
Indiana University Bloomington

Stecher, Jack
University of Alberta

Pedersen, Arthur Paul
City University of New York

Session:
Dimension reduction – live on Monday, July 11, at 16:00 EDT

This talk reports two mathematical results in measurement theory and illustrates the power and scope of their application to problems in judgment, inference, and decision making. The first result characterizes conditions under which an algebraic system admits a fully ordered extension, while the second result is a representation theorem for ordered algebraic systems. More specifically, expressed in the language of preference, the first result asserts that any system of preferences over a family of gambles can be extended to a completely ordered system of preferences, provided it satisfies a certain coherence requirement analogous to the one de Finetti advanced for his foundations of probability. Unlike de Finetti's criterion, this coherence criterion requires neither transitivity, Archimedeanness, boundedness, nor continuity of preference. The second result asserts that any completely ordered system of preferences satisfying the proposed coherence requirement admits a representation by linear utility in an associated ordered field extension of the reals. This result is a corollary of what is at once an extension of Hölder's Theorem, a cornerstone of the modern theory of measurement, and Hahn's Embedding Theorem, itself fundamental to the modern theory of ordered algebraic systems. Unlike a hyperreal field, the associated ordered field extension consists of formal power series which tightly trace the location of non-Archimedeanness (if any) in the underlying system of preferences, or as special case of the corollary, system of probability judgments. These results are applied to obtain representation results in probability and decision theory under uncertainty as well as logical characterization results in natural language inference for syllogistic logics of assertions "Most X are Y" and "X is more probable than not."

Novel neuro-cognitive models can explore spatial attention's effect on perceptual decision making

Ghaderi-Kangavari, Amin
Shahid Beheshti University

Amani Rad, Jamal
Shahid Beheshti University

Nunez, Michael D.
University of Amsterdam

Session:
Neurocognitive modeling – live on Tuesday, July 12, at 16:00 EDT

Traditional cognitive models, such as sequential sampling models (SSM), are unable to address some research questions about cognition and related neural mechanisms since they rely solely on behavior and lack explanations of brain data. Electroencephalography (EEG) can help a popular model of SSMs, the drift-diffusion model, to unravel latent processes that have not been previously discovered. For instance, although perceptual decision making often involves both decision processes and non-decision processes, researchers often seek to anatomize the subprocesses of decision variables while being less aware of the impact of some cognitive manipulations on the non-decision processes. We propose neuro-cognitive models that can utilize behavioral data and neural signals simultaneously to constrain two distinct groups of parameters as well as predict the onset time of evidence accumulation by single-trial EEG in occipito-parietal areas. Specifically, we strove to investigate a research question, why does performance in decision making improve when participants are exposed to top-down spatial orientation cues before the appearance of stimuli? Using a public dataset, we found evidence that spatial top-down attention can manipulate both visual encoding time (VET) and other non-decision times, but not decision variables such as evidence accumulation during a face/car perceptual decision-making task. To make this inference we used "directed" neurocognitive models that have previously been used to find single-trial relationships between EEG measures and cognitive parameters. However we have also tested new "integrated" models that predict EEG measures. These integrated neurocognitive models predict two sources of variance in EEG measures across single-trials: variance related to trial-by-trial changes in non-decision times versus measurement error in the observed EEG measures. We discuss how we fit these two classes of models and how they can be used to answer similar questions in future work.

Incorporating exogenous and endogenous sources of evidence in recognition memory to explain trial-by-trial drift rate variability in the diffusion decision model

Sun, Jie
University of Melbourne

Osth, Adam
The University of Melbourne

Session:
Neurocognitive modeling – live on Tuesday, July 12, at 16:00 EDT

The diffusion decision model (DDM) has been successfully accounting for reaction times distribution and accuracy for simple choice tasks by assuming a diffusion evidence accumulation process. However, the model has been criticized for its ad hoc distributional assumptions of cross-trial variability in its parameters, such as the drift rate. Using a word recognition task with electroencephalography recording, the current study aims to include both exogenous factors (e.g., word frequency and study-test lag) and EEG signals corresponding to retrieval success as endogenous factors to account for trial-to-trial variability in drift rate. The EEG signal was calculated based on two classic components observed in recognition memory tasks that differentiate types of memory judgement, namely the frontal negative component (FN400) and the late positive component (LPC). As such, these EEG components were suggested to index memory processes. Our results have shown when assuming individual trial drift rate as a linear combination of these factors, better model fits were observed as indicated by superior model selection scores. While model fit did not improve for randomly selected EEG signals unrelated to the memory process, the benefit from the EEG endogenous factors (FN400 and LPC) further suggests an involvement of these EEG components in the evidence accumulation process.

A Bayesian hierarchical model for EMG data

Gronau, Quentin Frederik
University of Newcastle

Salomoni, Sauro
University of Tasmania

Hinder, Mark
University of Tasmania

Stevenson, Niek
University of Amsterdam

Matzke, Dora
University of Amsterdam

Heathcote, Andrew
University of Tasmania

Session:
Neurocognitive modeling – live on Tuesday, July 12, at 16:00 EDT

Recently, cognitive modelers have become increasingly interested in supplementing behavioral data with neural or physiological measures. In order to complement approaches that use a generative cognitive model of behavioral choice data, we develop a generative model of modulations in the variance of the electromyographical (EMG) recordings associated with pressing one or two response buttons. This model provides estimates of key quantities of interest such as onset, offset, and amplitude of EMG bursts for each response. The hierarchical structure (i.e., trials nested within participants) yields group-level estimates for these parameters for each participant. We use particle Metropolis within Gibbs sampling (Gunawan et al., 2020) to efficiently obtain posterior samples from the model. The model can be used to address questions of interest about the EMG signal itself (such as between-condition differences) but also holds the promise of linking EMG parameters to cognitive model parameters in a joint model.

A neural index of resource availability: Unifying subsequent memory effect, primacy serial position effect, and word frequency effect

Ma, Si
Rutgers University, New Brunswick

Popov, Ven
University of Zurich, Switzerland

Zhang, Qiong
Rutgers University, New Brunswick

Session:
Neurocognitive modeling – live on Tuesday, July 12, at 16:00 EDT

Humans have a limited amount of cognitive resources to process various cognitive operations at a given moment. Based on the Source of Activation Confusion (SAC) model of episodic memory, resources are consumed during each processing and once depleted they need time to recover gradually. This has been supported by a series of behavioral findings in the past. However, the neural substrate of the resources is not known. In the present study, over an EEG dataset of a free recall task, we identified a neural index reflecting the amount of cognitive resources available for forming new memory traces. We showed that consistent with the model predictions, the index was able to capture the sequential effect of word frequency and the primacy serial position effect. In addition, greater available resources at encoding, as characterized by the neural index, are associated with better memory at recall. This provides an alternative explanation for the subsequent memory effect (SMEs, i.e. differential neural encoding patterns between subsequently recalled versus subsequently non-recalled items), which has been previously associated with attention, fatigue and properties of the stimuli.

fddm: an R package for fitting the Ratcliff diffusion decision model

Foster, Kendal
University of Warwick

Singmann, Henrik
University College London

Session:
Evidence accumulation – live on Tuesday, July 12, at 15:00 EDT

The Ratcliff diffusion decision model (DDM) is the most prominent model for jointly modelling binary responses and their associated response times. The DDM can decompose behavioural data into cognitive processes that are assumed to underlie performance in binary decision-making tasks. However, the DDM is notorious for being difficult to actually fit to such data. We have developed an R package, fddm (https://cran.r-project.org/package=fddm), simplifying the fitting process for the 5-parameter DDM with drift rate, drift-rate variability, boundary separation, start-point, and non-decision time.
fddm provides the ability to fit the DDM using the R formula interface. We have added one function, ddm(), that allows fitting the DDM to any number of conditions where the mapping of conditions to DDM parameter can be specified through the R formula interface, separately for each parameter. In addition, fddm comes with a number of methods common for fitted model objects, such as for the print() and summary() function, integrating it into the R ecosystem. This makes it easy to perform likelihood-ratio tests or other similar procedures for model comparison.
fddm uses a newly developed mechanism for selecting the faster among two equivalent formulations of the probability density function. Furthermore, fddm uses the analytical gradient for the full 5-parameter DDM variant when numerically optimising the log-likelihood function. Therefore, fitting with fddm is usually faster than with comparable packages.

Linear ballistic accumulator models of confidence and response time.

Chen, Haomin
The University of Melbourne

Heathcote, Andrew
University of Tasmania

Sauer, Jim
University of Tasmania

Osth, Adam
The University of Melbourne

Palmer, Matt
University of Tasmania

Session:
Evidence accumulation – live on Tuesday, July 12, at 15:00 EDT

Accurate decisions tend to be both confident and fast. Nonetheless, there are relatively few models that can simultaneously address this three-way relationship, especially for single stage decisions where participants indicate both their choice and their confidence. Extending on a common decision architecture of the linear ballistic accumulator framework, two models have been proposed – 1) a Multiple Threshold Race model which instantiates the Balance-of-Evidence hypothesis where confidence is determined through the difference between accumulated evidence for competing options (e.g., Reynolds, Osth, Kvam, & Heathcote, in revision), and 2) a newly developed Confidence Accumulator model which assumes that confidence itself is accumulated independently for each confidence option. To test these two confidence architectures, we ran two experiments manipulating the length of the confidence rating scale across 2-, 4-, or 6-options in a recognition memory task along with a perceptual task. Different models were compared that made different allowance for how the length of the confidence scale affected model parameters. While both model classes found that thresholds were affected by the length of the scale, drift rates were only minimally affected. Implications for models of confidence and response time will be discussed.

Open system model of choice and response time

Epping, Gunnar
Indiana University Bloomington

Kvam, Peter
University of Florida

Pleskac, Tim
University of Kansas

Busemeyer, Jerome
Indiana University

Session:
Evidence accumulation – live on Tuesday, July 12, at 15:00 EDT

Sequential sampling models have provided accurate accounts of people's choice, response time, and preference strength in value-based decision-making tasks. Conventionally, these models are developed as Markov-type processes (such as random walks or diffusion processes) following the Kolmogorov axioms. Quantum probability theory has been proposed as an alternative framework upon which to develop models of cognition, including quantum random walk models. When modeling people's behavior during decision-making tasks, previous work has demonstrated that both the Markov and
quantum models have their respective strengths. Recently, the open system model, which is a hybrid version of the Markov and quantum models, has been shown to provide a more accurate account of preference strength compared to the Markov and quantum models in isolation. In this work, we extend the open system model to make predictions on pairwise choice and response time and compare it to the Markov and quantum random walk models.

Timing during gaps in the stimulus: A drift-diffusion analysis

Zwicker, Jason
Royal Military College of Canada

Ludvig, Elliot
University of Warwick

Rivest, Francois
Royal Military College of Canada

Session:
Evidence accumulation – live on Tuesday, July 12, at 15:00 EDT

Animals are very efficient at estimating elapsing time intervals, maximizing their responding around the time reward generally occurs. To assess the psychological mechanisms underlying this timing ability, one strategy has been to examine behaviour when a gap or pause is inserted into the stimulus that indicates the time to reward. In such a gap procedure, animals will generally show delayed responding after the gap, peaking after the time reward would have occurred. The standard animal response pattern to the gap procedure sees two periods of increased responding, one on either side of the gap. Most current models of interval timing are not able to simulate the gap procedure, and there is an open question as to whether the animals sense of time decays or resets during the gap.

To date, only gaps that occur before the usual time of reward have been examined. Using an unpublished dataset with rats that has gaps 10 and 30 seconds after the time of reward, two new observations emerge. First, there is no secondary increase in responding when the gap is after the rat's peak response (or its expected time of reward). Second, the rat's behavior in response to a gap is different pending whether its subjective estimate of the time to reward has elapsed or not.

Existing models, such as Scalar Expectancy Theory (SET) and the Time-adaptive Drift Diffusion Model (TDDM) have difficulties modeling the GAP data. Here, we extend the recently published Probabilistic-Response Drift-Diffusion Model (PRDDM) to the gap procedure and show how it can reproduce the data well. In all cases, PRDDM's performance on gaps after the usual time of reward are more realistic than competing models–and is the only model that allows for responding to stop after a late gap. PRDDM's behavior after the estimated time to reward is novel, in that the DDM's accumulator is decreasing towards zero which simulates that animals decrease in interest in the stimulus. Unlike other models, a secondary peak when simulating gaps after the time to reward does not occur. In addition, we evaluate the PRDDM with four different possible mechanisms during the gap: Decay, Probabilitstic Reset, Decay and Probabilistic Reset, and a Hybrid model with different behaviors before and after the gap. We use these models to simulate the gap procedure and attempt to answer the questions of what occurs during the gap. Preliminary results show that the differences between these variants are practically indistinguishable, suggesting that further empirical data will be needed to pinpoint the psychological mechanism at play.

Defining one's boundaries: Exploration of the decision threshold parameter space during a reward maximisation task.

Stuchlý, Erik
University of Hamburg

Malhotra, Gaurav
University of Bristol, United Kingdom

Ludwig, Casimir
University of Bristol

Session:
Evidence accumulation – live on Tuesday, July 12, at 15:00 EDT

Models of decision-making assume an accumulation-to-threshold mechanism, whereby an individual pre-selects a single decision threshold such that the speed and accuracy of their responses are balanced. However, when the goal is to maximise an outcome variable (such as reward rate), it is very likely that the decision maker would keep adjusting the initially adopted threshold until satisfactory performance is reached. The standard assumption of stationarity leads to a threshold estimate that reflects the averaged performance, which may not necessarily be representative of the participant's strategy at any one time.
We analysed data from an expanded judgment task where the goal was to maximize reward rate, and estimated the height and slope of the decision threshold in a sliding window of trials, as well as over all trials.
The overall best-fitting threshold parameters of a participant were often not representative of the estimated thresholds used in smaller windows of trials at any point during the experiment. This is largely because the majority of participants explored the threshold parameter space throughout the task, rather than settling on a specific threshold early on. Importantly, this exploration was not driven by the reward rate that a particular threshold yielded – in fact, the exploration often resulted in a lower average reward rate late in the experiment, relative to early trial windows. As such, participants failed to approach the threshold parameters that were optimal with respect to the task – i.e. those that would maximize reward rate.
Our findings indicate that participants sample various distinct decision thresholds during a reward optimization task, rather than adopting a single threshold as is frequently assumed by models of decision-making. These results also introduce the question of whether such exploration is random, or whether it is modulated by a different variable (other than reward rate) that decision-makers prioritise instead.

EZ-CDM: easy estimation of circular diffusion model parameters

Qarehdaghi, Hasan
Shahid Beheshti University

Amani Rad, Jamal
Shahid Beheshti University

Session:
Evidence accumulation – live on Tuesday, July 12, at 15:00 EDT

Recently, a circular diffusion model (CDM) (Smith, 2016) has been developed to handle both choices and response time for decisions in a continuous option space. It assumes that the process of evidence accumulation progresses following a Brownian motion within a circle and it terminates whenever the accumulator reaches any point on the perimeter, so a decision is made. While this model is excellent at capturing different continuous behavioral phenomena, it has not yet been welcomed and tested by decision psychologists due to its mathematical complexity. Here we propose a simple method for estimating the circular diffusion model parameters which only requires the calculation of straightforward formulas with some statistics of data. The method is based on the traditional method of moments. The accuracy in parameter recovery for the method is shown to be nearly the accuracy of the maximum likelihood method.

Race Levy-Brownian model: An evidence accumulation model with both Levy flight and diffusion properties

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Shahid Beheshti University

Session:
Evidence accumulation – live on Tuesday, July 12, at 15:00 EDT

Recently, Levy Flight models have attracted much attention. The main reason for their outstanding performance in modeling human behavior is considering a heavy-tailed distribution for the noise of the accumulation process which causes some sudden jumps during the accumulation process. But it is worth mentioning that when the distribution of noise of the accumulation tends to a more heavy-tailed distribution, low values of the noise are less likely to happen, and then the accumulation process between two jumps is less noisy than in the diffusion model. Consequently, in the Levy Flight models, large sudden jumps and low-value noises can not happen simultaneously. Thus, it is not so realistic, because we have both low values of noise and also some jumps during the accumulation process. In contrast with the previous evidence accumulation models that include only one noise distribution, the Levy-Brownian model utilizes both Gaussian and Levy white noises simultaneously in a way that the noise of the accumulation process is a weighted summation of the Gaussian (its weight is equal to lambda) and the Levy (its weight is equal to 1). Therefore, this model is the general form of the Levy Flight model and when lambda is equal to zero, this model is reduced to the Levy Flight model. Considering such a hybrid distribution yields an accumulation process that has both lo value noises and some sudden large jumps at the same time. We have tested the performance of this model on some perceptual and lexical decision tasks and the obtained results exhibit a better performance of the model in comparison with the Levy Flight and diffusion models.

Stronger attentional biases can be linked to higher reward rate in preferential choice

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Session:
Attention and perception – live on Wednesday, July 13, at 16:00 EDT

When attention is biased to a particular option during information search preceding preferential choice, this option is often more likely to be chosen—even if its value is objectively lower than that of the alternative. Here I demonstrate that although attentional biases—even to lower-valued options—may reduce accuracy (the tendency to choose the highest-valued option), they can increase reward rate (the amount of reward obtained per unit of time invested in the choice). To achieve a higher reward rate it is often preferable to choose a lower-valued option quickly rather than spend time trying to identify the highest-valued option. Attentional biases are typically associated with faster choices, and in terms of reward rate, this reduction in response time can often compensate for the accompanying decrease in accuracy. This relationship between attention, response time, and reward rate is modulated by features of the choice environment and by individual differences in choice boundaries and in the attentional amplification of evidence accumulation. These patterns are predicted theoretically by the attentional drift diffusion model (aDDM). A reanalysis of empirical data from several eye-tracking studies shows that these predicted patterns also hold empirically across various domains of preferential choice (riskless and risky choice, options of monetary rewards and of food items). It may therefore often be beneficial for decision makers to allocate their attention in a biased manner—that is, to deliberately ignore information on some options—in order to reduce the time cost of choice and thereby achieve a higher reward rate.

Modular serial-parallel network for hierarchical facial representations

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Session:
Attention and perception – live on Wednesday, July 13, at 16:00 EDT

Researchers in facial perception foster competition between holistic and analytic encoding. Despite the popular belief that faces are perceived in a holistic fashion, both neural organization of the visual system and the phenomenological experience indicate that faces can also be examined analytically in terms of facial parts. This view is further corroborated by the concept of hierarchical object representation, in which selective neural populations are fine-tuned to detect visual properties ranging from simple features to more complex combinations of features. Thus, theoretical developers face two major challenges. The first one is to determine how to integrate both holistic and analytic encoding within the same framework, relying on the idea of hierarchical facial representations. The second is to further integrate these facial perception stages with the higher-level cognitive processes, such as memory and decisional processes. To answer these challenges, we proposed a computational framework of Modular Serial Parallel Network (MSPN), which is a synthesis of several successful approaches in both perceptual and cognitive domains that includes signal detection theory, rule-based decision making, mental architectures (serial and parallel processing), random walk and process interactivity. MSPN provides a computational modeling account of four stages in face perception: (a) representational (b) decisional, (c) logical-rule implementation, and (d) modular stochastic accrual of information, and can account for both choice probabilities and response time measure predictions. In a facial classification task, the MSPN model showed an impressive ability in fitting choice response time distributions, over other facial perception models. The MSPN can be used as a tool to further the development and refinement of hypotheses in facial perception. The analysis of the model's parameter values, estimated from data, can be used to explore distinct properties of the perceptual and cognitive processes engaged in both analytic and holistic encoding. The MSPN could be generalized to other domains in both cognition and perception.

Holistic processing for Chinese characters and English words

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Session:
Attention and perception – live on Wednesday, July 13, at 16:00 EDT

Previous research reported conflicting evidence regarding whether Chinese characters are holistically processed. In past work, we applied Systems Factorial Technology to examine the processing efficiency for Chinese characters and English words. Our results indicated that native Chinese speakers exhibited limited capacity processing both characters and words. To identify the source of that limitation, our current research further investigated the mental architecture of processing Chinese characters and English words. Specifically, we hypothesized that observers' performance would be indicative of a coactive processing architecture, where all information is pooled together to reach a single decision process. This architecture is often considered a benchmark of holistic perception. In Experiment 1, participants were asked to make a same/different judgment on the sequentially presented characters/words which either both or neither of the left and right components differed. The results indicated that participants adopted a parallel self-terminating strategy (i.e., same or both-different structure). Experiment 2 complemented the findings of experiment by examining performance with added conditions that either the left or right component could now be different (i.e., same, left-different, right-different, both-different). With the decisional uncertainty, the results indicated that most participants processed the stimuli with a parallel exhaustive architecture and a few participants exhibited the coactive architecture. To conclude, our current work provided evidence for weak holistic processing (parallel processing) for Chinese characters and English words, with the stopping-rule (self-terminating/exhaustive) dependent on the task and presentation context.

The effects of personalization on category learning: An empirical investigation

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Session:
Attention and perception
– live on Wednesday, July 13, at 16:00 EDT

Personalization algorithms are broadly used on the internet to generate recommendations fine-tuned for individual users. However, these algorithms have also been discussed as the cause of the limited content diversity, which possibly leads people to confirmation bias and polarization (e.g., Pariser, 2011). The mechanism of how such algorithms affect cognitive processes and internal representations has not been understood well. In this study, we investigate how personalization techniques can hinder optimal category learning via an online behavioral experiment and a model-based analysis. In the experiment, participants first studied categories of aliens under different levels of algorithmic personalization, in addition to randomized (i.e., control) and self-directed learning conditions. After the learning phase, participants' knowledge was tested using an independent stimulus set. The result shows that participants in the algorithmic personalization conditions develop selective sampling profiles and more distorted representations of categories. Also, participants in the personalization conditions tend to show inflated confidence, especially when they make incorrect categorization decisions. In particular, the frequency with which each category is presented during the learning phase is a key variable in explaining overconfidence. To pursue a mechanistic explanation of the personalization effect, we also fit the Adaptive Attention Representation Model (AARM; Galdo, Weichart, Sloutsky, & Turner, 2022) to the collected data. The model-based analysis suggests that it is important to comprehend how human evaluates the similarity between exemplars when stimulus information is only partially encoded. If learners assume that unobserved information would be similar to what they have already encoded, this tendency will likely result in higher confidence.

A scaling study of novel auditory stimuli for creating artificial events

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Session:
Attention and perception – live on Wednesday, July 13, at 16:00 EDT

Research in categorization, memory, and visual cognition typically employs isolated, static stimuli, whereas most events that are experienced in life are extended in time and potentially overlapping. A challenge in studying these more ecologically valid kinds of events is that it is difficult to relate their physical dimensions with their psychological representations. We begin to address this gap by developing a set of novel auditory stimuli with experimentally controlled physical features that can be related to psychological representations. The auditory modality is not only integral to many real-life events (e.g., speech and music), it is also well-suited for combining stimuli both within and across time. Our stimuli were generated by manipulating the frequency bands above a 200hz fundamental of seven electronically generated sounds such that they exhibited different degrees of spectral overlap. In a scaling study, participants listened to pairs of these sounds and rated their subjective similarity. We used non-metric multidimensional scaling to obtain a three-dimensional psychological representation of these stimuli. One dimension appears to correspond to timbral roughness, while other dimensions do not admit simple verbal labels. There were individual differences in the degree to which participants attended to these dimensions, potentially related to degree of musical expertise. Implications for using these stimuli in memory and categorization paradigms are discussed, particularly in relation to how they may be combined either sequentially or simultaneously to create artificial "events" that mimic the complexity of more naturalistic events.

The effects of value and probability on the utilization of the perceptual decision strategy

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Session:
Attention and perception – live on Wednesday, July 13, at 16:00 EDT

This study investigates how people processs the value and probability information and to what extent their processing strategies are affected by these factors. We employed Systems Factorial Technology and conducted the redundant-target task to infer the participants's decision strategy. Participants were required to detect the presence of any target presented at the top or bottom of the screen and feedback (gain/loss point) was provided after their responses. Target location probability and value were simultaneously varied across two conditions while the expected values of the top and bottom locations remained the same. Specifically, in the first condition, participants were instructed that in the single-target trials one location would have lower probability than another with a ratio of 2:3 and the corresponding payoff was ±105 or ±70. In the second condition, we adjusted the relative differences by increasing the ratio (1:4) and its corresponding payoff (±280/ ±70). Our results showed individual differences in strategy adoption. That is, three participants maintained a parallel self-terminating strategy across conditions. The other five participants alternated between the serial and parallel processing across conditions. These individual differences were less likely associated with the relative probability and reward manipulations since most participants were consistently more sensitive to the stimulus saliency at the high probable locations. Although our results are inconclusive to provide a mechanistic explanation about the individual differences, the shift between parallel and serial processing implies the potential interaction between value and probability processing on decision-making strategies.

Measuring coherence in reasoning

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Session:
Reasoning and metacognition – live on Wednesday, July 13, at 15:00 EDT

Consider the inference sequence "The glass had orange juice, therefore it had orange juice or tequila, therefore if it did not have orange juice then it had tequila". How convincing is it? To draw inferences like this, people may consider the meanings of the statements involved (how is "or" and "if" to be interpreted?), their degree of belief that each statement is true (do we know for certain that the glass had orange juice?), and any logical relations between the statements (e.g. does one statement entail or preclude another?). In reasoning research, these three pieces of information have often been treated as independent and potentially conflicting – with the logical information considered rational, and the content and beliefs considered biases. But theoretically such a conflict is not necessary, and empirically it does not seem plausible. In the Bayesian approach to reasoning described here, the three pieces of information are integrated and jointly necessary to draw good inferences. This approach is based on the concept of coherence. Degrees of belief in statements are coherent iff they follow the principles of probability theory (e.g. the glass cannot be less than empty or more than full; and if it contains orange juice and we add tequila, then the volumes of the two liquids will add up). But measuring the coherence of people's uncertain reasoning is not straightforward, especially in situations in which the information available is uncertain, incomplete and changeable. To make such measurements, we must account for how logical constraints between probabilities shift when new information becomes available; define and adjust for the probability of making a coherent response just by chance; and ascertain which patterns of statement probabilities would allow us to make plausibly falsifiable, and thus informative, assessments of sensitivity to coherence. I describe some of these challenges, and discuss how we might be able to tackle them in the quest to increase our understanding of reasoning under uncertainty.

Decision strategy adaptation to time constraints

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Session:
Reasoning and metacognition – live on Wednesday, July 13, at 15:00 EDT

Time limits are common constraints that can change decision making. However, despite experimental evidence for many effects of time constraints, the overall empirical evidence has mixed findings about when specific changes in decision making do or not occur. We argue this uncertainty is facilitated by the methods commonly used to select time constraints in experiments, which create general time pressure but are not designed to prevent specific decision processes. We demonstrate a novel method for selecting time constraints for experiments. First, we draw from the optimal experimental design literature to design choice tasks for inferring decision strategy use. Then we measure response times of human participants using specific decision strategies on these tasks (Experiment 1). We analyze the response times to identify time constraints that should preclude specific decision strategies, and then attempt to replicate previously observed effects, such as shifts from weighted additive strategies to lexicographic strategies under stricter time constraints (Experiment 2). Experiment 2 found that participants shifted their decision strategies even in response to the most lenient time constraint, and that participants at all levels of time constraint made decisions consistent with a weighted additive strategy more often than predicted. The first finding is consistent with time-monitoring focused theories of time-constrained decision making, and the second finding raises the question of whether previous findings were influenced by experimental paradigms that prevented automatic processing. The empirical findings and the time constraint selection method are discussed for their methodological and theoretical relevance for studying decision making under time constraints.

Polarization & extremism when sampling qualitative information: Choosing between options worse than estimating relative preferability or independent ratings

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Session:
Reasoning and metacognition – live on Wednesday, July 13, at 15:00 EDT

Previous work shows that task structure affects sampling behavior: when prompted to choose between two options (choice task), people sample information that is polarized from and more extreme than the underlying true information and that this polarization/extremism disappears when people instead estimate the relative preferability of two options (estimation task). However, these findings focused on information which was numeric ("Option A is 45% more efficient than Option B") and pertained to the same criterion ("efficiency"). Real-life information is often qualitative ("Option A is expensive") and considers multiple criteria (efficiency, environmental concerns, personal preferences, etc.). In a set of 3 studies, we test if sampling qualitative and independent information covering several criteria in choice (vs. estimation) tasks still lead to polarized and extreme samples.
In the first study, we collected and analyzed participant-generated qualitative information about the options in a wide variety of dilemmas, retaining the most frequent entries. In the second study, participants rated these information on how likely they were to choose an option. These ratings were used to quantify the sway/weight of each qualitative piece of information. In the third study, participants freely sampled these information to evaluate several dilemmas in two of the following three task conditions: (a) choose between given option (i.e., choice task), (b) estimate which option is better and by how much (estimation), and (c) rate the quality of each option independent of the other. We show that the decision condition led people to gather polarized samples of information relative to the other conditions, and that the rating condition encouraged more information sampling overall compared to the other two conditions. These results suggest that independent rating goals can reduce information polarization and improve information search.

Learning the order of things: Modeling encoding- and retrieval-based strategies for transitive inference

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Session:
Reasoning and metacognition – live on Wednesday, July 13, at 15:00 EDT

Transitive inference (TI) is a fundamental form of reasoning whereby, after learning a set of premises (e.g., A < B, B < C), people infer the relationship between novel pairs of items (e.g., A < C). Existing computational models of TI differ on how premises are combined to support novel inferences: According to encoding-based models, people form a unified cognitive map of the hierarchy (e.g., A < B < C < D . . .) during training and directly compare items' positions during inference, with faster, more accurate judgments for items that are more distant. Under retrieval-based models people retrieve and integrate premises at the time of test, but because distant inferences require the retrieval of more intervening premises, these models predict slower, less accurate judgments for more distant inferences. Previous studies have examined either encoding- or retrieval-based models, while little existing work has considered how the reliance on these strategies might differ across individuals, training conditions, or even for different judgments within the same task. The present study examined how the use of encoding- and retrieval-based TI depends on the difficulty of training, with more difficult training expected to interfere with the construction of a unified cognitive map and increase the reliance on retrieval-based inference. While there was little evidence of pure retrieval-based inference, more difficult training conditions were associated with increased use of a hybrid strategy such that people relied on an unified map for distant inferences, while resorting to more effortful premise retrieval for inferences about nearby items whose positions in the hierarchy were more uncertain. I present a novel approach for identifying this hybrid inference strategy using Bayesian hierarchical modeling, with models fit to both choices and RTs during inference. These findings suggest that individuals adaptively recruit direct premise memory to complement inferences supported by unified cognitive maps.

Hedonism in information search – biased information-seeking leads to biased beliefs

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Session:
Reasoning and metacognition – live on Wednesday, July 13, at 15:00 EDT

Selective bias in information-search contributes to the formation of polarized echo-chambers of beliefs. However, the cognitive mechanisms underlying this bias remain poorly understood. In this study, we aimed to isolate the role of affective content on information source selection. In Experiment 1, participants won financial rewards depending on the outcomes of a set of lotteries. They were not shown these outcomes, but instead could choose to view a prediction of each lottery outcome made by one of two sources. Before choosing their favored source, participants were first shown a series of example predictions made by each. The sources systematically varied in the accuracy and positivity (i.e., how often they predicted a win) of their predictions. Choice behavior was analyzed using a hierarchical Bayesian modeling approach. Results indicated that both source accuracy and positivity impacted participants' choices. Importantly, those seeking more positively-biased information believed that they had won more often and had higher confidence in those beliefs. In Experiment 2, we directly assessed the effect of positivity on the perceived credibility of a source. In each trial, participants watched a single source making a series of predictions of lottery outcomes and provided ratings corresponding to the strength of their beliefs in each source. Results suggested that positively-biased sources were not seen as more credible. Together, these findings suggest that positively-biased information is sought partly due to the desirable emotional state it induces rather than enhanced perception of credibility. Information sought on this basis nevertheless produced consequential biased beliefs about the world-state.

Flexible cdf-quantile distributions on the closed unit interval

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Session:
Formal analysis – live on Thursday, July 14, at 15:00 EDT

For some time modeling doubly-bounded random variables has been hindered by a scarcity of applicable distributions with finite densities at the bounds. Most of the useful distributions for these variables have finite density only on (0,1) or, at best, inconsistently on [0,1]. This talk presents a flexible family of 2- and 3-parameter distributions whose support is the closed interval [0,1] in the sense that they always have finite nonzero densities at 0 and at 1. These distributions have explicit density, cumulative density, and quantile functions, so they are well-suited for quantile regression. The densities at the boundaries are determined by dispersion and skew parameters, and a third parameter influences location. These distributions have a single mode in (0,1) but also can simultaneously have modes at 0 or at 1, or they can be U- or J-shaped. Some of them include the uniform distribution as a special case. Their location, dispersion, and skew parameters are easy to interpret and each of them can have a submodel with its own predictors. They have been implemented in packages for R and Stata.

Constructing an unobservable critical path network from observable slacks

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Session:
Formal analysis – live on Thursday, July 14, at 15:00 EDT

Critical Path Networks are models of the Psychological Refractory Period and of some cognitive tasks, such as visual search. A Critical Path Network is a directed acyclic network in which each arc represents a process that must be completed to perform a task, The processes on a path must be executed in order on the path. Processes not on a path together are unordered, and can be executed simultaneously. Each process has a duration. The time to complete the task, the response time, is the sum of the durations of the processes on the longest path through the network. If a process X precedes a process Y, the slack from X to Y is the longest amount of time by which X can be prolonged without making Y start late. Suppose processes in a task are executed in a Critical Path Network, but the network is unknown. By observing effects on response time of selectively influencing processes, one can learn for each pair of processes whether the pair is ordered or unordered. If they are ordered, one can learn the value of the slack from one to the other. From the order information a directed acyclic network can be constructed with the Transitive Orientation Algorithm. From the slacks a duration can be determined for each process. Several directed acyclic networks may be possible and the durations are not unique. If the slack values are valid for one of the possible directed acyclic networks, they are valid for all.

Estimating parameter confidence intervals in possibly misspecified parameter redundant models

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Session:
Formal analysis – live on Thursday, July 14, at 15:00 EDT

Modelers are often faced with the dilemma of deciding how to parameterize a probability model. Too few parameters may yield a misspecified model with uninterpretable parameter estimates due to model misspecification, while too many parameters may yield a correctly specified model which fits the observed data with uninterpretable parameter estimates due to parameter redundancy. During the model development process, it is therefore likely that situations will arise where it is desirable to evaluate possibly misspecified or parameter redundant models. In the context of maximum likelihood estimation, it has been shown (see Ran and Hu, 2017, and Cole, 2020, for relevant reviews) that the presence of parameter redundancy corresponds to situations where the Fisher Information Matrix (FIM) (i.e., the covariance matrix of the log-likelihood per data record) does not have full rank. Local identifiability in maximum likelihood estimation often corresponds to checking if the Hessian of the log-likelihood (LL) has full rank (e.g., White, 1982, Theorem 3.1). Classical asymptotic theory (e.g., White, 1982) often assumes that both the FIM and LL Hessian are full rank in order to obtain analytic formulas for estimating parameter confidence intervals. In this presentation it is shown that analytic formulas for estimating confidence intervals for some but not all parameters can sometimes be obtained in the presence of parameter redundancy (i.e., without the assumption that the FIM has full rank). Some preliminary simulation studies are reported to illustrate the practical applications of the theoretical results.

Using sampling algorithms to explain human random generation

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Leon Villagra, Pablo
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Sanborn, Adam
University of Warwick

Session:
Formal analysis – live on Thursday, July 14, at 15:00 EDT

Many computational approaches to cognition argue that people's decisions are based on examples drawn from memory. But what mechanism do people use to come up with those examples?
In this work, we study how the mind generates these examples by asking participants to produce long sequences of items at random. Although previous random generation research has exclusively focused on uniform distributions, we find that people can generate items from more complex distributions (such as people's heights), while showcasing the same systematic deviations from true randomness.
We propose that to produce new items, people employ an internal sampling algorithm like those used in computer science – algorithms which have previously been used to explain other features of human behavior such as how people reason with probabilities. We find that these algorithms approximate people's random sequences better than previous computational models. We then evaluate which different qualitative components of the sampling algorithms better emulate human behavior: We find that people's sequences are most similar to samplers that propose new states based on the gradient of the space (such as HMC) and which run several replicas at different temperatures (such as MC3). By identifying the algorithms used in random generation, our results may be used to create more accurate sequential sampling models of decision making that better reflect how evidence is accumulated.

Modeling pilot flight performance on take-off task with QN-ACTR

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Session:
Formal analysis – live on Thursday, July 14, at 15:00 EDT

Cognitive architecture models can help the simulation and prediction of human performance in complicated human-machine systems. In the current work, we demonstrate a pilot model that can complete takeoff tasks. The model was constructed in Queueing Network-Adaptive Control of Thought Rational (QN-ACTR) cognitive architecture and can be connected to X-Plane to generate various statistics, including performance, mental effort, and situational awareness. The model outcomes are determined in combination with declarative knowledge, chunks, production rules, and a set of parameters. Currently, the model can simulate fly operation behavior similar to human pilots in various conditions. In the future, with additional refinement, we anticipate this model can assist interface evaluation and competency-based pilot training, giving a theory-based prediction method supplementary to human-in-the-loop investigations for research and development in the aviation industry.

rolog: Querying Prolog from R

Gondan, Matthias
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Session:
Formal analysis – live on Thursday, July 14, at 15:00 EDT

Prolog is a classical logic programming language with many applications in expert systems, computer linguistics and traditional, that is, symbolic artificial intelligence. The main strength of Prolog is its concise representation of facts and rules for the representation of knowledge and grammar, as well as its very efficient built in search engine for closed world domains. R is a statistical programming language for data analysis and statistical modeling which is widely used in academia and industry. Besides the core library, a lot of packages have been developed for all kinds of statistical problems, including new-style artificial intelligence tools such as neural networks for machine learning and deep learning. Whereas Prolog is weak in statistical computation, but strong in symbolic manipulation, the converse may be said for the R language. The R package Rolog embeds the SWI-Prolog system into an R package, thus enabling deterministic and non-deterministic queries to the Prolog interpreter. Usage of the Rolog library is illustrated by a few examples, including grammars for mathematical typesetting, linguistics, knowledge structures, and interval arithmetic.

Attacker behavior detection in critical infrastructure

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Session:
Formal analysis – live on Thursday, July 14, at 15:00 EDT

Lone-actor (LA) terrorism has been one of the rising security threats of the last decade. The LA behavior and characteristics research has produced valuable information on demographics, classifications, and warning signs. Nonetheless, commonality among these characteristics does not imply similar outcomes for different attacks and the incident-scene behavior varies. Since the security footage videos of LA attacks are not publicly available, associating incident-scene behavior to the early and preparatory attacker behavior is a challenging research field. Serious games have been utilized to evaluate mitigation strategies to a natural disaster. At GRIST Lab at Rutgers University, we design virtual games to simulate real-world conditions to observe an attacker's reaction to incident-scene dynamics. This study aims to identify short-term target and route selection decisions of the attacker through the data obtained from a virtual game; and in turn to develop better first responder allocation strategies against LA attacks. We implement time-series clustering and classification methods to the behavior differences between an attacker and other civilians based on spatio-temporal data. The findings indicate that these methods will be instrumental in developing LA detection and capture strategies.

Cognitive modeling of multi-attribute preferential and perceptual choices

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University of Warwick

Kellen, David
Syracuse University

Klauer, Christoph
University of Freiburg, Germany

Session:
Decision making – live on Thursday, July 14, at 16:00 EDT

People rely on the choice context to guide their decisions, violating fundamental principles of rational choice theory and exhibiting phenomena called context effects. Recent research has uncovered that dominance relationships can both increase or decrease the choice share of the dominating option, marking the two ends of an attraction–repulsion continuum. However, empirical links between the two opposing effects are scarce and theoretical accounts are missing altogether. The present study used eye tracking alongside a within-subject design that contrasts a perceptual task and a preferential-choice analog in order to bridge this gap and uncover the underlying information-search processes. Although individuals differed in their perceptual and preferential choices, they generally engaged in alternative-wise comparisons and a repulsion effect was present in both conditions that became weaker the more predominant the attribute-wise comparisons were. To obtain a model-based characterization of individuals' behavior in terms of latent cognitive processes, we relied on the MLBA, a prominent cognitive model that is frequently used to model multi-attribute, multi-alternative choices in both the preferential and perceptual domain. Despite its past successes, the MLBA was unable to provide an accurate account of the data. Specifically, it was unable to jointly account for choices and their associated latencies, struggling the most with predicting the focal choice phenomenon, the repulsion effect. Altogether, our study corroborates the notion that repulsion effects are a robust and general phenomenon that current theoretical accounts cannot adequately account for and that need to take be taken seriously.

Using Bayesian modeling to assess the similarity between cognitive and physical effort discounting

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Fansher, Madison
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Session:
Decision making – live on Thursday, July 14, at 16:00 EDT

Performing an action often incurs a cost, such as exerting effort for a reward. Previous studies used the Effort Expenditure for Reward Task (EEfRT) to show devaluation of reward value with physical effort. However, it is unclear if a similarly structured attentional task would produce a similar reward devaluation with cognitive effort. In the present work, we propose a new task called the "shell game task" (SGT) as a cognitive effort-based decision-making paradigm. Participants performed both the EEfRT and SGT in a within-subject design. Using computational models of choice behavior, we showed that effort cost induced by the variability of task demands in the SGT is similar to the effort cost from the existing EEfRT in the devaluation of a given outcome in action choice selection. This result suggests that effort cost may be a stable idiosyncratic trait across the two tasks and shows how computational approaches can be used to estimate and compare measures of effort. In addition, the results suggest that the SGT can be used as an alternative to the EEfRT with subject populations with motor deficits.

The impact of experience on preference formation and context effects in multi-alternative, multi-attribute choice

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Trueblood, Jennifer
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Session:
Decision making – live on Thursday, July 14, at 16:00 EDT

Prior experience with options can impact our preferences and future choices. When strong preferences exist, context effects are hypothesized to diminish (Huber et al., 2014). In this study, we probed the effect of prior experience with options on the strength of attraction and compromise effects. Participants had the opportunity to choose from simple cognitive tasks (i.e., counting jobs) and complete the selected task. Using an ecologically valid and incentivized task, we found evidence for the formation of strong preferences with experience, yet reversals of context effects did not attenuate. The results were replicated in a pre-registered study and showed that our findings are robust to payment schemes and display format. These findings suggest that relative evaluation still plays a role in human decision-making, even when inherent preferences are accessible. We suspect what was learned from experience in our tasks is the weights for various attributes. As predicted by many models of multi-alternative, multi-attribute choice, context effects can emerge with unequal attribute weights formed through, for instance, prior experience with options.

Discriminating between models of processing in multi-attribute choice

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Hawkins, Guy
University of Newcastle

Session:
Decision making – live on Thursday, July 14, at 16:00 EDT

Throughout the day, many of our choices integrate information from multiple attributes about an item we are considering. How do people process information about multiple attributes and choose whether to select a presented option? In the simplest scenario, for one option and two attributes, the decision to either accept or reject the option is based on combinations of the two attributes.
Our model represents the evidence from each attribute towards accepting or rejecting the option as an accumulation process. We can model how the participant could combine this information into the final choice as combinations of these racing accumulators. For example, people may reject an option based on a single poor attribute but only accept the option if both attributes are highly valued. We constructed five different processing architectures and integrated them into a latent mixture modelling process to select between them. We use a hierarchical Bayesian approach to estimate individual participant processing architectures and overall group trends.
I will show an initial assessment of our modelling framework using data simulated from the five processing architectures. I will also discuss an experimental task where participants viewed a series of hotel options that differ on two attributes - price and hotel rating. In this task, participants received instructions on how to combine the attribute information for their decisions. The modelling framework recovered the expected processing architectures for the different instruction manipulations, demonstrating good selective influence. Understanding consumer attribute processing helps us present information in such a way as to keep consumers as informed as possible about the consequences of their choices.

The role of entropy in probability weighting

Akrenius, Mikaela
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Session:
Decision making – live on Thursday, July 14, at 16:00 EDT

This talk presents a novel set of empirical data that aims to measure the influence of distributional entropy on the weight given to a particular probability. The experimental protocol extends a gamble-matching paradigm developed by Chechile and Barch (2013), which enables the assessment of probability weights without needing to postulate a choice rule or a utility function. The data is used to compare the performance of several existing probability weighting functions (Tversky-Kahneman, 1992; Prelec, 1998; Goldstein-Einhorn, 1987; Chechile-Barch, 2013) relative to a novel, information-theory-based probability weighting function (Valence-Weighted-Distance, Akrenius, 2020) and it's extension with the Sharma-Mittal family of entropies (Akrenius, 2021). The results of the study shed light on the influence of distributional context on probability weighting, individual differences in perceptions of uncertainty, the existence of probability distortion as a perceptual phenomenon, and the potential of using information entropy as a psychologically grounded construct in models of judgment and decision making.

In search of the preference reversal zone

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Victoria University of Wellington

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Session:
Decision making – live on Thursday, July 14, at 16:00 EDT

A preference reversal is observed when a preference for a larger-later reward over a smaller-sooner reward reverses as both rewards come closer in time. Preference reversals are common in everyday life and in the laboratory, and are often claimed to support hyperbolic delay-discounting models which, in their simplest form, can model reversals with only one free parameter. However, it is not clear if the temporal location of preference reversals can be predicted a priori. Studies testing model predictions have not found support for them but they overlooked the well-documented effect of reinforcer magnitude on discounting rate. Therefore we directly tested hyperbolic and exponential model predictions in a pre-registered study by assessing individual discount rates for two reinforcer magnitudes. We then made individualised predictions about pairs of choices between which preference reversal should occur. With 107 participants we found 1) little evidence that hyperbolic and exponential models could predict the temporal location of preference reversals, 2) some evidence that hyperbolic models had better predictive performance than exponential models, and 3) in contrast to many previous studies, that exponential models generally produced superior fits to the observed data than hyperbolic models.

Effects of parameter prior variation on posterior distribution response times for an Item Response Theory diffusion model

Malaiya, Ritesh
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Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

Diffusion based models have been successfully used to model response time distributions in decision making psychological experiments (see Ratcliff et al. (2016) for a review). van der Maas et al. (2011) proposed an item response theory-based extension of the diffusion model (Q-diffusion) designed to incorporate item-specific characteristics. Kang et al. (2022) and van der Maas et al. (2011) successfully used Bayesian posterior sampling methods to estimate Q-diffusion model response time distributions using a mental rotation dataset and demonstrated model convergence even in the presence of non-informative prior distribution. The current study empirically investigated how the posterior distribution of response times in the Q-diffusion model are affected by difference choices of the mean for a person-specific log-normal prior distribution. Both small and large perturbations of the log-normal mean were chosen to represent situations where a baseline posterior mean is either within or outside the high probability zone of the prior distribution representing "Data-Prior conflict" (see Clarke and Gustafson (1998)). Using the Ruggeri and Sivaganesan (2000) relative sensitivity $R\pi$ metric defined as the square of difference between posterior means of the baselined prior and the perturbed prior distributions and then divided by the posterior variance of the perturbed prior distribution. Results for small perturbations found $0.01 < R\pi < 0.02$ while for large perturbations: $0.2 < R\pi < 0.5$. These results suggest that the posterior distribution of the Q-diffusion model is sensitive to poor choices of the prior distribution but more robust for appropriate prior distribution choices.

Does memory noise follow Weber's Law? An investigation in one temporal binding dataset

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Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

Temporal Binding (TB) is standardly regarded as an implicit measure of the sense of agency (Haggard, 2017) though an underlying mechanism has not been agreed upon (Hoerl et al., 2020). Here we propose a memory process as an explanation for the observed effect in two publicly available datasets (Weller et al., 2020). The dataset consisted of two experiments that manipulated 'action type' and length of timing intervals. Replotting the data, we found a classic memory pattern (regression to the mean) in both experiments. We simulated the behavioral patterns using a simple Bayesian model of memory (Hemmer & Steyvers, 2009), which assumes memory to be a combination of episodic and semantic memory. The model provided a good qualitative fit in all but one experimental condition. Adjusting the prior mean for the 'action' condition resulted in an improved fit. Next, we evaluated whether systematic variation in memory noise values follow Weber's law. We hypothesized that increased perceptual noise at longer time intervals also influences memory noise and would be observed as a non-linear regression pattern (Huttenlocher et al., 2000), as observed in this dataset. We calculated an overall Weber fraction constant (K) and scaled memory noise by K. The simulation remained 'too linear' compared to participant responses. We tested various values a memory noise – scaled by K. Finally, we calculate a K per timing interval and use these values to scale the memory noise at each interval. While the memory model provided a good fit to the empirical data, the qualitative fits varied across simulations, indicating that the underlying mechanism might be more complex. We discuss the results in the context of Weber's law and TB. Our findings suggest the TB effect may arise, at least in part, from cognitive processes other than experienced agency.

A comparison of retrofitting multiple knowledge structures to a cognitive diagnostic assessment

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Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

Cognitive Diagnostic Models (CDMs) are widely used psychometric models which assume the probability an exam item is correctly answered is functionally dependent upon the examinee's binary-valued latent skills of the examinee. The skill requirement is formalized by the examiner in the form of a Q-matrix which specifies the skills required to successfully answer an exam item with a high probability. Given the Q matrix may not always be known a-priori, several studies have evaluated ways to retrofit a Q-Matrix to existing assessments (see Ravand and Baghaei, 2019 for a review). In the current experiment, we examined the model fit of two different approaches for constructing the Q matrix for an undergraduate course (n=79). In the top-down approach, each course-level learning objective is utilized as a skill by itself or broken into subcategories. Groups of exam items are then associated with the relevant subcategories. In the bottom-up approach, skills associated with individual exam items are identified and only the most frequently used skills are included in the final analysis. Using a bootstrap simulation methodology, three model selection criteria were used to compare model fits between the two Q matrices – Generalized Akaike Information Criterion (GAICTIC), Bayesian Information Criterion (BIC), and Cross-Entropy Bayesian Information Criterion (XBIC) (Golden, 2020). For different variations in sample sizes and regularization, all three measures consistently selected the bottom-up model as a better model. The results have implications for guiding the development of methods for developing Q matrix specifications (i.e., skill to exam item mappings).

Testing the KRK predictions: Testing knowledge too much leads to learning

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Charles River Analytics

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Workman, Deja

Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

The KRK theory (Kim, Ritter, & Koubek 2013) describes the learning of a complex task in three stages, and describes specific curves of forgetting that occur depending on the stage of learning. Our study of the learning and retention of a complex task, troubleshooting the Ben Franklin Radar System, predicted that these differing curves could be found through using three learning and three retention periods of different lengths. We measured performance on procedural learning by measuring the completion time of troubleshooting problems, as well as recall and recognition-based assessments. We found that while these curves were not seen when plotting learning over multiple sessions, learning from the end of training to the beginning of the testing did follow these curves. Within a session, completion time for trials decreased at the expected trajectory. Additionally, forgetting was more clearly seen between the end of a session and beginning of the next session. Forgetting happens between sessions and is most clearly seen by comparison of performance at the end of the last practice session to performance at the start of the testing session. (We included additional tests to get more stable measures, but due to learning this was not obtained.) These results suggest that the scale at which this theory can be applied may be different depending on task complexity, and whether learning may continue within testing.

Categorization with multiple items: Empirical and modeling results

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Cohen, Andrew

Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

Participants in categorization experiments usually assign a single stimulus to one of multiple categories. Despite the real-world significance, participants are rarely asked which of multiple options belong to a single category. In the current experiment, participants selected the stimulus, from a set of 2 or 3, that most likely to belongs to a learned category. The results of Experiment 1 (1-dimensional stimuli) suggest a repulsion effect, in which a nearby dominated stimulus reduced the probability of selecting the dominating stimulus. The results of Experiment 2 (2-dimensional stimuli) suggest a small attraction effect, in which the probability of selecting the dominating stimulus is increased. We extend standard exemplar-similarity models (GCM) by incorporating random utility modeling (RUM). The modeling results of both experiments suggest that stimulus utility alone may not be able to account for choice, i.e., the model must also incorporate similarity between choice options, although this finding is tentative for Experiment 2 and may represent a spatial bias.

Modeling asymmetric human exploratory choice behavior across the gain and loss domains

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Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

When faced with positive and negative outcomes, people seem to use different learning strategies. Facing losses, people tend to explore their environment more thoroughly by alternating between different options. Facing gains, people tend to explore less and instead exploit known options. Different theoretical explanations for this exploratory tendency have been discussed without agreement on any single theory. Some have considered Reinforcement Learning (RL) models, but have ultimately concluded that human exploratory behavior across domains is best described by either a Win-Stay-Lose-Shift (WSLS) heuristic or the so-called Bayesian shrinkage hypothesis, which assumes different prior expectations by domain. In the current study we conduct simulations to test whether any of these three accounts can re-create increased explorative behavior in the domain of losses as found in human data. We demonstrate that, of the three accounts, only a conventional RL model with neutral initial beliefs exhibited the same sort of asymmetric exploratory choice behavior that has been documented in human learners. Neither simulated WSLS-type learners nor Bayesian shrinkage-type learners–formalized as an RL model with domain-specific initial beliefs–exhibited more exploration in the domain of losses. Ultimately, the RL model's ability to reproduce the exploratory behavior of interest depended on assumptions that must be made about learners' pre-experimental expectations. We highlight how these assumptions are particularly relevant for the design of decision-from-experience tasks, especially those in which exploration is the behavior of interest. Overall, the current study advances the ongoing discussion in the literature about which models are able to account for domain differences in exploratory choice and highlights, yet again, the interdependence of modeling choices and design choices in experiments.

What is more democratic, a stone or a feather? Predicting nonsensical choices using high-dimensional vector representations obtained from a semantic space model

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Bröder, Arndt

Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

Semantic space models are powerful tools in semantic memory research, which use the distributional structure of words in large natural language datasets to derive high dimensional vector representations for the words or concepts in a semantic space. In a recent line of research, these word vectors have been used to predict judgments of similarity, probability, or other quantities. If these spaces capture the structure of human conceptual representations, it should also be possible to predict comparative choices of concepts on nonsensical attributes as long as the concepts are spatially arranged at sufficiently distinct locations along the attribute dimension. In a first experiment, we presented n = 30 participants with k = 60 nonsensical comparisons, in order to investigate the ability of the semantic space model to predict the response of participants. Overall, the analysis using a Bayesian logistic hierarchical regression model showed that the model could predict the responses of participants above chance level, with an accordance rate of model-predicted and observed responses of θ = 57%. However, the results also showed that while there was only a small difference between participants (θ ranging from 53% to 56%), there were large differences between items in how good the model predicted the actual judgment of participants, with accordance rates ranging from θ = 36% to θ = 89%. Given that the observed responses of participants are similar and as predicted by the semantic space model, at least for some items, might indicate that the derived high dimensional vector representation of the semantic space to some extent incorporates some shared aspects of people's semantic memory.

How to know what you should know: Implications of the choice of prior distribution on the behavior of adaptive design optimization

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Cavagnaro, Daniel
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Broomell, Stephen
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Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

Adaptive design optimization (ADO) is a state-of-the-art technique for designing experiments for cognitive modeling (Cavagnaro, Myung, Pitt, and Kujala, 2010). ADO dynamically identifies stimuli that, in expectation, yield the most information about the hypothetical construct of interest (e.g., parameters of a cognitive model). To calculate this expectation, ADO leverages the modeler's existing knowledge, specified in the form of a prior distribution. "Informative" priors, constructed on the basis of domain knowledge or previous data, have the potential to align the prior with the empirical distribution in the participant population, thereby making ADO maximally efficient. However, if the informative prior is inaccurate, i.e., "misinformative," then ADO may be led astray, leading to wasted trials and lower efficiency. To play it safe, many researchers turn to "uninformative" priors. Yet, priors chosen on the basis of their predictive agnosticism rather than insight are also unlikely to align with the population distribution, possibly making them equally inefficient. In on-going work, we investigate the consequences of informative, misinformative and uninformative prior distributions on the efficiency of experiments using ADO.

Keep your eyes on the sky: task prioritisation under high workload in aviation

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Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

While flying aircraft, pilots must balance the physical and cognitive requirements of piloting while also communicating with air traffic control (ATC) via radio. Increased workload, such as extraneous information from ATC or additional cognitive tasks, tax pilots' limited cognitive resources, and subsequently affect performance. To limit this effect, pilots are trained to prioritise those tasks most crucial to safe flight, with verbal communication considered a low priority. Pilot communication has been found to be affected by increased information density from ATC, radio frequency congestion, and higher cognitive workload. However, it is unclear whether this is due to effective task prioritisation or a more general deficit in piloting performance. To examine this issue, avionics data was examined from a previous study in which seventeen pilots participated in a flight simulation experiment. Pilots flew six flights in total, three high-load flights which imposed high workload from different sources (high ATC speech rate, high ATC information density, and a mid-flight fuel calculation respectively), and three low-load flights which matched the high-load flights' profiles, but lacked the additional workload demands. Flight performance was assessed by comparing the pilots' compass heading throughout each flight to the heading they were instructed to hold by ATC, and a time series of heading error calculated. No significant difference in heading error was found between workload level (high/low) or source of workload (speech rate/information density/congitive workload), and Bayesian analysis found evidence against these factors. These results indicate that, while pilots' communication was negatively affected by increased workload, their flight performance was not similarly affected, implying effective task prioritisation under high cognitive workload.

Using the association rule mining in psychological research: A case study of trauma data

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Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

By reviewing the literature in psychological sciences it can be found there is no considerable research using rule mining algorithm. The core results relied on the classic statistics aimed hypothesis testing. In practice, there are big recorded data in psychology which have been mostly ignored. The purpose of this study is to clarify the importance of association rule mining which can lead to find micro-theories from messy data. Method: The participants in this research were a sample of 325 (85.3% female and 14.7% male) people living in Tehran in 2021 who were selected by convenience sampling through online platforms supported by the internet. All of the participants completed childhood trauma, social-emotional competence, internalized shame, disability/shame, cognitive flexibility, distress tolerance, The Toronto Alexithymia scales. The data are analyzed using Rstudio.4.1 and Apriori package. Results: 39368 rules initially discovered from 7 variables and 20 top rules with support ranged 0.003-0.243, confidence ranged 0.05-1, lift ranged 0.15-3.43 selected. They indicated new relationships between disability/shame schema and the other 6 variables. There was set at least 2 variables in each of the rules.
Conclusion: Using Association Rule Mining as a knowledge-driven can be used and of interest to all mind researchers for exploring the hidden pattern among a database. This pattern leads to practical and theoretical knowledge.

Separating the roles of orthographic and semantic information in the neural correlates of evidence accumulation for lexical decision-making

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Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

Making decisions requires the accumulation of evidence, which is described quantitatively by the drift diffusion model (DDM). In most of the DDM applications, it is assumed that such evidence is driven by a single process. Yet, in reality, this accumulation could be driven by multiple different sources of information that drive the decision. Here we examine the situation where the accumulation process is driven by orthographic and semantic information, in the service of making lexical decisions. We can separate those factors neatly by using Chinese characters. The DDM was fit to the behavioural data to obtain estimates of its model parameters. We found decreased drift rate, which reflects the strength of evidence, for non-words relative to actual words. There was a negative correlation between the drift rate and subjective word-likeness and familiarity. Although the amplitude of the N1 (which is related to orthographic processing) and N400 (which is related to semantic processing) did not differ across word types, after fitting the ERPs components to separate models as the regressors, the N1 and the N400 did help to better estimate the trial-by-trial estimates of the drift rate in the conditions relevant for orthographic and semantic processing, respectively. Taken together, our study shows how different sources of evidence for lexical decisions are reflected in brain activity and inform the decision making process.

Analogical transfer in multi-attribute decision making

We are sometimes faced with inference tasks in a domain of interest where we do not have sufficient information, but we could use our knowledge from other domains to help solve the problem. We frequently undergo this knowledge transfer process, but what are the underlying mechanisms that enable us to achieve this feat? One possible answer is through analogy. This study is interested in how analogy influences decision making performance in a new environment. The knowledge transferred to a new environment can be the importance of cues, and the strategies. The experiments in the study investigate analogical transfer from one domain to another in multi-attribute decision-making tasks. It investigates whether knowledge, such as cue-criterion correlations and best-performing strategy, can be transferred via analogical mapping. The goal of the modeling is to understand the mechanisms underlying analogical transfer in cue learning and strategy selection. The model has two components: reinforcement learning of strategy selection and analogical transfer. Both components will be implemented in ACT-R because it is a well-established framework for integrating cognitive models.

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Syracuse University

Schooler, Lael
Syracuse University

Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

Determining natural prototypes with a mathematical theory of subjective information

In a seminal work, Rosch (1973) argued for the existence of structured non-arbitrary semantic categories in the domain of form which developed around perceptually salient "natural prototypes". For a working hypothesis, Rosch used the most "ecologically typical" salient forms which she regarded as the "good forms" (i.e., the square, circle, etc.) of Gestalt Psychology. Based on this idea, categories where the presumed natural prototypes were central tendencies were constructed to test participants in her experiment. In this talk we perform mathematical reverse engineering and show that the generative natural prototypes in Rosch's experiments may be determined or accurately predicted from the generated categories using a model and theory of subjective information derived from Generalized Invariance Structure Theory (GIST; Vigo, 2013, 2015) and referred to as Generalized Representational Information Theory (GRIT; Vigo, 2011, 2012, 2015). We also show a natural procedure for n-ary dimensional encoding in GRIT when the number of dimensions involved are insufficient (i.e., when observers conduct dimensional surgery, thereby extending the dimensional space).

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Ohio University, United States of America

Wimsatt, Jay
Ohio University

Doan, Charles
Marietta College

Sedziol, Abigail
Ohio University

Yadav, Raghvendra
Ohio University

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Ohio University

Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

Extending signal detection theory to the analysis of generalization and other tasks using continuous responses to multiple items

Soto, Fabian
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Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

Generalization studies typically use a design in which multiple stimuli vary along a single stimulus dimension and a given outcome or response is associated with a single value in the dimension. This is similar to the method of constant stimuli used to characterize psychometric curves in psychophysics, although in many cases measuring continuous rather than discrete responses to each stimulus. Here, we propose a generalization of the signal detection model for the psychometric curve, that deals with continuous responses. As in the traditional model, we assume normally-distributed decision variables with means and variances that change depending on the presented stimulus. We also assume that a monotonic link function transforms such variables into the measured responses, which are perturbed by random normal noise. The model is a generalization of traditional signal detection models, which are obtained by assuming a staircase link function. We propose an algorithm that uses a combination of quantile functions and monotone spline regression to estimate the parameters of this model from data, and show that the inclusion of a flexible link function allows the model to fit continuous data better than ROC analyses previously proposed for continuous data. Potential applications include the adaptive estimation of generalization curves and application to continuous neural data such as fMRI activity estimates.

matstanlib: A MATLAB library for visualization, processing, and analysis of output from Bayesian models in Stan

Baribault, Beth
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Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

It is increasingly common to use Bayesian modeling techniques that rely on Markov chain Monte Carlo (MCMC) methods, such as the variant of Hamiltonian Monte Carlo implemented by Stan (mc-stan.org). While excellent tools for the processing, visualization, and analysis of output from Stan exist in R (bayesplot, posterior) and Python (ArviZ), few such resources exist for MATLAB users. I created the matstanlib library to fill this gap. In this fast talk, I will demonstrate how matstanlib supports multiple stages of a modern Bayesian modeling workflow in MATLAB. First, I will show how matstanlib automates a full set of computational diagnostic checks, consistent with current best practices for Bayesian sampling methods (e.g., Vehtari et al., 2021; Betancourt, 2018). Next, I'll review matstanlib's diagnostic plots, from trace plots to ESS interval plots to parameter recovery plots, which can be used to better understand model performance. Finally, I'll show how matstanlib can facilitate model-based inference with plotting functions for the visualization of posterior densities and intervals, and analysis functions for the computation of density estimates and model comparison metrics. This fast talk will also serve as a quick-start guide for working with the matstanlib library.

Capacity predictions of nested architectures: application to visual perception across the hemispheres

Thomas, et al. (2019) extended systems factorial technology to nested architectures with respect to the predictions that various mental architectures make for survivor and mean interaction contrasts of response times. In this presentation, we explore capacity coefficient predictions that plausible nested architectures make and apply them to the case of visual perception of compound sinewave gratings across the visual fields to address questions of hemispheric differences in global and local processing of information sources.

Collins, Allan
Miami University, Ohio

Fan, Gaojie
Louisiana State University

Corbi, Peyton
Miami University, Ohio

Thomas, Robin D.
Miami University

Session:
Fast talk session – live on Tuesday, July 12, at 17:00 EDT

Discontinuities in function learning

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Session:
Poster meetup session – live on Tuesday, July 12, at 17:00 EDT

Existing process of models of function learning mostly assume that function learning is a gradual and continuous process (polynomial rule model: Koh and Meyer (1991); EXtrapolation Association Model (EXAM): DeLosh et al. (1997); Population Of Linear Experts (POLE): Kalish et al. (2004)). In contrast, Brehmer (1974) proposed a two-staged hypothesis testing theory of function learning. The first stage involves discovering a suitable rule, and the second stage is concerned with learning the parameters of the rule. Although this theory has not been quantitatively formalized, it differs from the other theories by positing a discontinuity when the learner transitions from discovering a rule to applying a rule. In this extended abstract, we present preliminary evidence of such discontinuities. In a replication of McDaniel et al. (2014), we identified a subset of participants that demonstrated abrupt decreases in error over the course of the experiment. Our computational simulations of existing process models further confirmed that gradual update mechanisms are insufficient to account for these observed discontinuities.

Using GOMS to model individual differences in a competence assessment task

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Cheng, Peter
University of Sussex

Session:
Poster meetup session – live on Tuesday, July 12, at 17:00 EDT

This study aims at modelling individual differences using GOMS. In an attempt to evaluate a competence assessment task in natural language, results revealed limitations of a previous GOMS model that was used to design the task (Ismail & Cheng, 2021). The task, Chunk Assessment by Stimulus Matching (CASM), exploits measurements of chunk signals to assess competence in the English language. It was tested with 34 speakers of English as a second language. Results were compared against the initial GOMS models. The models’ predictions were partially supported, showing substantial performance differences between the levels of expertise. Contrary to expectations, major differences were found amongst those at the same level of expertise. A refinement of the models was built to coherently capture differences between and within levels of competence.

A quantum walk framework for multialternative decision making

Recent findings of Markov violations challenge Markov random walk processes for decision making. On the other hand, quantum walk processes explain these Markov violations in a natural way, but they have only been applied to binary alternative decision making. In this work, we propose a general framework for extending quantum walk processes to multi-alternative decision making. The multi-alternative quantum walk model operates in a direct sum space of the alternatives, with Hamiltonian built for each pair of alternatives to model context effects. Order effects come naturally from the matrix non-commutativity of the Hamiltonians. Future works built on this framework can connect parameters of the models with the expected utilities.

Huang, Adam
Indiana University

Busemeyer, Jerome
Indiana University

Session:
Poster meetup session – live on Tuesday, July 12, at 17:00 EDT

Predicting algorithmic complexity for individuals

How difficult is it to simulate a an algorithm in one's mind and correctly deduce its outcome? In this paper, we present a predictive modeling task in the domain of algorithmic thinking in a railway environment. We present metrics, either based on algorithmic complexity (e.g. lines of code) or on the effect on cognitive resources an algorithm simulation can have (e.g. context switching). We implement the metrics within a benchmark and evaluate their predictive performance on an individual level, by assigning a complexity threshold to each individual. We compare these results to a standard statistical correlation analysis and suggest a different perspective for determining the predictive powers of a complexity metrics as models.

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Chemnitz University of Technology

Brand, Daniel
Chemnitz University of Technology

Ragni, Marco
TU Chemnitz

Session:
Poster meetup session – live on Tuesday, July 12, at 17:00 EDT

Reverse-engineering of Boolean concepts: A benchmark analysis

For a long time the human capability to form hypotheses from observations has been in the focus of research in psychology and cognitive science. An interesting case is to form hypotheses about the underlying mechanisms of technical systems. This process is called reverse-engineering, i.e., to identify how a system works. Research so far has focused on identifying general principles of the underlying reasoning process and lead to the development of at least three general approaches. This paper investigates the predictive power of existing models for each individual reasoner for the first time, i.e., can the individual reasoner reverse engineer the Boolean Concepts from observations. Towards this goal, we (i) defined a modeling task on the individual level, (ii) adapt or re-implement existing models for Boolean Concept learning to make predictions on the individual level, (iii) identify base-line models and additional strategies, and (iv) evaluate the models. By focusing on the individual level, we uncover limitations of current state of the art and discuss possible solutions.

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Heinrich, Elisa-Maria
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Brand, Daniel
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Ragni, Marco
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Session:
Poster meetup session – live on Tuesday, July 12, at 17:00 EDT

Predicting learning in the troubleshooting task using a cognitive architecture-based task analysis

Ritter, Frank E
Penn State

Session:
Poster meetup session – live on Tuesday, July 12, at 17:00 EDT

We present a new way to do task analysis that includes learning. This approach starts with a hierarchical task analysis of a troubleshooting strategy and applies a power law of learning to modify the time, mimicking the ACT-R learning equations. We apply this approach to finding faults in the Ben Franklin Radar (BFR) system, a 35-component system, designed to study troubleshooting and learning. In this task, faults are introduced into the BFR, and the participants are responsible for finding and fixing these automatic faults. Pre-vious models in Soar took up to 6-9 months of graduate student to create. This model was created more quickly and provides a model between GOMS and a full cognitive archi-tecture-based model. The predictions will be compared to the aggregate and individuals' data (N=111) and lessons will be reported.

Understanding adversarial decisions for different probing-action costs in a deception game via cognitive modeling

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Aggarwal, Palvi
Carnegie Mellon University

Dutt, Varun
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Session:
Poster meetup session – live on Tuesday, July 12, at 17:00 EDT

In the cyber world, deception through honeypots has been prominent in response to modern cyberattacks. Prior cybersecurity research has investigated the effect of probing action costs on adversarial decisions in a deception game. However, little is known about the cognitive mechanisms that affect the influence of probing action costs on adversarial decisions. The main objective of this research is to see how an instance-based learning (IBL) model incorporating recency, frequency, and cognitive noise could predict adversarial decisions with different probing action costs. The experimental study had three different probing action costs in the deception game: increasing cost probe (N = 40), no-cost probe (N = 40), and constant cost probe (N = 40). Across the three conditions, the cost for probing the honeypot webserver was varied; however, the cost for probing the regular webserver was kept the same. The results revealed that the cost of probing had no effect on probe and attack actions and that there was a significant interaction between different cost conditions and regular webserver probe actions over the trials. The human decisions obtained in the above experiment were used to calibrate an IBL model. As a baseline, an IBL model with ACT-R default parameters was built. In comparison to the IBL model with ACT-R default parameters, the results showed that the IBL model with calibrated parameters explained adversary decisions more precisely. Results from the model showed higher cognitive noise for cost-associated conditions compared to that of no-cost condition. We highlight the main implications of this research for the community.

How do humans revise spatial beliefs?

The way how humans reason about spatial beliefs has been investigated for almost a century. However, how humans update their spatial beliefs and how this can be explained by cognitive models has not yet been systematically analyzed. This paper aims to explore belief revision by (i) establishing and revisiting theories for belief revision, (ii) instantiating those theories into predictive cognitive models and evaluating them on a benchmark set of four different data sets, (iii) provide an ensemble out of all theories for belief revision tailored to the individual and comparing performance to baseline and upper modeling bound from the area of machine learning. This allowed for an analysis on the individual level as well as to investigate which task characteristics favor the application of specific belief revision strategy.

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Brand, Daniel
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Ragni, Marco
TU Chemnitz

Session:
Poster meetup session – live on Tuesday, July 12, at 17:00 EDT

Using deep neural networks for modeling representational spaces: the prevalence and impact of rarely-firing nodes

There is no abstract because this is a 2-page Extended Abstract.

Truong, Nhut
University of Trento (Rovereto Pole)

Session:
Poster meetup session – live on Tuesday, July 12, at 17:00 EDT

A model of motivation and effort allocation in the ACT-R cognitive architecture

Yang, Cher
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Stocco, Andrea
University of Washington

Session:
Virtual ICCM I – live on Monday, July 11, at 14:00 EDT

Motivation is the driving force that influences people’s behaviors and interacts with many cognitive functions. Computationally, motivation is represented as a cost-benefit analysis that weighs efforts and rewards in order to choose the optimal actions. Shenhav and colleagues (2013) proposed an elegant theory, the Expected Value of Control, which describes the relationship between cognitive efforts, costs, and rewards. In this paper, we propose a more fine-grained and detailed motivation framework that incorporates the principles of EVC into the ACT-R cognitive architecture. Specifically, motivation is represented as a specific slot in Goal buffer with a corresponding scalar value, M, that is translated into the reward value Rt that is delivered when the goal is reached. This implementation is tested in two models. The first model is a high-level model that reproduces the EVC predictions with abstract actions. The second model is an augmented version of an existing ACT-R model of the Simon task, in which the motivation mechanism is shown to permit optimal effort allocation and reproduce known phenomena. Finally, the broader implications of our mechanism are discussed.

Do models of syllogistic reasoning extend to generalized quantifiers?

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Ragni, Marco
TU Chemnitz

Session:
Virtual ICCM I – live on Monday, July 11, at 14:00 EDT

Over the last century, a large variety of cognitive models for syllogistic reasoning have been developed, thereby advancing our understanding about the way humans process reasoning tasks.
Most of the research was performed on a restricted set of quantifiers from first-order logic, which simplified model evaluations and comparison due to a well-defined set of tasks and the availability of complete and extensive datasets.
However, as everyday reasoning and communication relies on a large variety of quantifiers, the scope and potentially also the generalizability of the models was severely limited.
The present work aims at extending the domain of syllogistic reasoning to a wider set of quantifiers by
(I) presenting a benchmarking dataset that includes the quantifiers “Most” and “Most not”,
(II) evaluating two state-of-the-art models (the Probability Heuristics Model and mReasoner) with respect to their ability to account for individual reasoners and
(III) set the predictive performance of the cognitive models into perspective by comparing them to upper bounds and providing in-depth insights about their strengths and weaknesses.

Modeling optimal arousal by integrating basic cognitive components

Mind-wandering occurs as emotional arousal decreases, which is related to the level of mastery of the current task. As a worker becomes more proficient in a task, the cognitive resources required to perform the task decrease. Then, surplus resources emerge and are naturally directed to "default-mode thinking," which people usually engage in outside the task. As mind-wandering continues, this default-mode thinking becomes more active and affects the task performance. In this study, we describe this process by combining the basic functions of the cognitive architecture Adaptive Control of Thought-Rational (ACT-R). The chunk activation mechanism represents the on- and off-task thinking loops. Furthermore, we introduce stochastic fluctuation in the chunk activation to change the transition probability between these loops. This fluctuation is assumed to be driven by parasympathetic activity, which increases over time and is suppressed by novel stimuli. To develop this physiological change, this study uses the ACT-R temporal module. Simulations using these modules demonstrate the inverse U-shaped relations between task performance and task continuation. Such a process is consistent with theories of optimal levels of arousal.

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Session:
Virtual ICCM I – live on Monday, July 11, at 14:00 EDT

A comparison of quantum and multinomial processing tree models of the interference effect

We compare the qualitative predictions of an existing quantum model and a novel multinomial processing tree (MPT) model of the interference effect using parameter space partitioning (PSP). An interference effect occurs when categorizing a stimulus changes the marginal probability of a subsequent decision, leading to a violation of the law of total probability.
The PSP analysis revealed that our MPT model can produce the same qualitative patterns as the quantum model.
Further analysis, however, revealed that the models differ in several important ways.
First, a larger volume of the MPT model's parameter space produces a smaller number of interference effects compared to the quantum model.
Second, the distribution of volume across patterns is more diffuse for the MPT model, indicating it is more flexible than the quantum model.
We discuss limitations and future directions.

Fisher, Christopher
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Houpt, Joe
University of Texas at San Antonio

Blaha, Leslie
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Session:
Virtual ICCM I – live on Monday, July 11, at 14:00 EDT

Modeling of multi-defender collaboration in a cyber-security scenario

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Session:
Virtual ICCM II – live on Tuesday, July 12, at 14:00 EDT

While evidence shows that cyber attackers are good at coordinating and collaborating in their attacks, network defenders are notoriously poor at sharing information and collaborating among themselves. To help promote cooperation among defenders, one requires models that can explain and make predictions of emergent cooperation decisions of each defender in a cyber security scenario. We propose a Multi-Agent Instance-Based Learning (MAIBL-PD) cognitive model based on Instance-based Learning (IBL) theory, and founded on the Prisoner's Dilemma (PD) of cooperation. MAIBL-PD aims at explaining how collaborations emerge to share information with other defenders in a group. MAIBL-PD was created to interact in a Multi-Defender-Game (MDG) that was used in an experimental study with human participants, intended to determine the effect of different levels of information sharing on collaboration. MAIBL-PD uses an extension of the utility function in IBL theory to capture the emergence of cooperation with higher levels of social information. Through simulations with MAIBL-PD we collect synthetic data to compare to the data set collected in human studies. Our results help explain the emergence of cooperation at increasing levels of information regarding others' actions. We demonstrate the ability of MAIBL-PD to predict human cooperation decisions in the MDG in situations in which players have only their own information and in situations in which they have information about the sharing behavior of the other players.

Estimating phonological awareness with interactive cognitive models: Feasibility study manipulating participants' auditory characteristics

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Morita, Junya
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Session:
Virtual ICCM II – live on Tuesday, July 12, at 14:00 EDT

The difficulties encountered by children during language development varies among individuals. In particular, immaturity in phonological awareness, which supports speech perception, results in various speech defects. Accordingly, it is important to estimate the individual mechanism behind these problems to ensure proper support. In this study, we propose a method for estimating individual defects in the phonological process using cognitive models. As a preliminary step to targeting phonological processing difficulties in real world, we conducted an experiment with native adult speakers. Audio filters were applied to the output of the system to simulate phonological difficulties. This initial feasibility study revealed consistency in model preferences among participants when a particular audio filter was used. We consider that this study provides an important step toward the realizations of individualized cognitive modeling for mitigating various difficulties in language acquisition.

Towards a method for evaluating convergence across modeling frameworks

Model convergence is an alternative approach for evaluating computational models of cognition. Convergence occurs when multiple models provide similar explanations for a phenomenon. In contrast to competitive comparisons which focus on model differences, identifying areas of convergence can provide evidence for overarching theoretical ideas. We proposed criteria for convergence which require models to be high in predictive and cognitive similarity. We then used a cross fitting method to explore the extent to which models from distinct computational frameworks—quantum cognition and the cognitive architecture ACT-R—converge on explanations of the interference effect. Our analysis revealed the models to be moderately high in predictive similarity but mixed for cognitive similarity. Though convergence was limited, the analysis suggests that interference effects emerge from interactions between uncertainty and the degree to which an individual relies on typical cases to make decisions. This result demonstrates the utility of convergence analysis as a method for integrating insights from multiple models.

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Session:
Virtual ICCM II – live on Tuesday, July 12, at 14:00 EDT

Combining EEG and a cognitive model to infer the time course of game play

We have developed an analysis stream for integrating a cognitive model with EEG data to reconstruct the cognition of individual subjects. A critical component of this method is the Sketch level that combines cognitive modeling and classification of EEG data using an HSMM to identify and place critical events over the timeline of a task. Multiple factors can influence sketch accuracy. In this study, we investigated the effect of game play elements on sketch accuracy across two EEG experiments where subjects interacted with the Space Fortress video game. Experiment 1 consisted of elaborate interface elements that accompanied game events (multiple sound effects, visual explosions). Subjects in Experiment 2 performed the same task, but audio and visual feedback elements were greatly reduced. We find that sketch accuracy while still much better than chance in Experiment 2, was significantly worse than in Experiment 1.

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Carnegie Mellon University

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Educational Testing Service

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Session:
Virtual ICCM II – live on Tuesday, July 12, at 14:00 EDT

Clarifying system 1 & 2 through the common model of cognition

There have been increasing challenges to dual-system descriptions of System-1 and System-2, critiquing them as being imprecise and fostering misconceptions. We address these issues here by way of Dennett's appeal to use computational thinking as an analytical tool, specifically we employ the Common Model of Cognition. Results show that the characteristics thought to be distinctive of System-1 and System-2 instead form a spectrum of cognitive properties. By grounding System-1 and System-2 in the Common Model we aim to clarify their underlying mechanisms, persisting misconceptions, and implications for metacognition.

Conway-Smith, Brendan
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West, Robert
Carleton University

Session:
Virtual ICCM III – live on Wednesday, July 13, at 14:00 EDT

Fast online reinforcement learning with biologically-based state representations

In previous work, we provided a neurally-based Actor-Critic network with biologically inspired grid cells for representing spatial information, and examined whether it improved performance on a 2D grid-world task over other representation methods. We did a manual search of the parameter space and found that grid cells outperformed other representations. The present work expands on this work by performing a more extensive search of the parameter space in order to identify optimal parameter sets for each configuration using one of four representation methods (baseline look-up table, one-hot, random SSPs and grid cells). Following this optimization, the baseline, one-hot and random SSPs methods did show improvement over the previous study, in some cases showing performance as good as grid cells. These findings, combined, suggest that whilst the baseline and one-hot methods do perform well once optimized, grid cells do not necessarily require optimization in order to produce optimal performance.

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Session:
Virtual ICCM III – live on Wednesday, July 13, at 14:00 EDT

On the limits of spreading activation in ACT-R: Predictions and testability

In the fan effect, reaction time (RT) increases as a function of fan size (i.e. the number of associations of a fact). Spreading activation in ACT-R provides a good account of the fan effect at low fan size (i.e., 1–4). However, little is known about the predictions of ACT-R at ecologically valid scales. We developed a general guessing mixture model (GMM) within ACT-R in which a guessing process is triggered by retrieval failures, and analyzed the predictions for fan sizes much larger than those used in laboratory experiments. Our analysis revealed the following properties of the GMM: RT increased as a function of fan size, but stays within a plausible range (< 2 seconds) as long as the retrieval threshold is not excessively low, and, in the limit, accuracy asymptotes at the value of the guessing bias parameter. We discuss practical challenges with testing the predictions at larger fan sizes.

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Session:
Virtual ICCM III – live on Wednesday, July 13, at 14:00 EDT

Estimating ACT-R declarative memory parameters using a drift diffusion model

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Stocco, Andrea
University of Washington

Session:
Virtual ICCM III – live on Wednesday, July 13, at 14:00 EDT

Accurately fitting cognitive models to empirical datasets requires a robust parameter estimation process which is often arduous and computationally expensive. A way to mitigate this challenge is to integrate participant-specific and efficient mathematical models such as a drift diffusion model (DDM) into the parameter estimation process of cognitive modeling. In this study, we exhibit a clear mapping of the parameters outputted by DDM onto the declarative memory parameters utilized in the cognitive architecture, ACT-R. We show a fairly consistent recovery of simulated ACT-R parameters using DDM and a successful application in using this method to optimize ACT-R simulated fit to an empirical dataset. Notably, we show that the DDM-derived estimated parameters are individualized to the original participant, providing a unique opportunity for parsing out individual differences in cognitive modeling. This method outlined here allows one to estimate ACT-R parameters without the need to manually build and run an ACT-R model while also allowing for neural contextualization of DDM parameters.

Leveraging cognitive models for the wisdom of crowds in sequential decision tasks

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Session:
Virtual ICCM III – live on Wednesday, July 13, at 14:00 EDT

Many decisions we face in life are sequential, where alternatives appear over time. We often must decide whether to take the opportunity and stop searching or to continue evaluating potentially better future alternatives. Research suggests that humans are notoriously poor at stopping optimally in sequential decision-making tasks. These sequential decisions are difficult because they involve the consideration of how past, present, and future decisions affect the outcome. Recent research suggests that the wisdom of the crowd (WoC) — that is, aggregated decisions of many people that outperform most individuals — can be applied to sequential decision tasks and potentially help improve stopping decisions. However, current models rely on a process of fitting human data, making it difficult to understand how those individuals would behave in new problems. Furthermore, these models do not account for the learning process that humans experience while making these decisions. In this work, we demonstrate how simulated agents using a cognitive model derived from Instance-Based Learning Theory (IBLT) can produce WoC that is similar to WoC from human participants in two sequential decision tasks. We demonstrate that the WoC performance from simulated groups of agents is better than the performance of most agents and that the Instance-Based Learning (IBL) crowd behavior is similar to the human crowd behavior. Thus, cognitive models that account for learning and experience can be used to inductively predict the behavior of human crowds in sequential decision tasks.

Exploring multitasking strategies in an ACT-R model of a complex piloting task

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Cubic Defense

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Fisher, Christopher
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Klosterman, Samantha

Session:
Virtual ICCM IV – live on Thursday, July 14, at 14:00 EDT

Multitasking is a challenging cognitive task, and there are many factors driving which strategy participants use to complete tasks concurrently. We utilized a model comparison approach to evaluate how participants decide which task to switch to next using the Air Force Multiple Attribute Battery (AF-MATB). We used the cognitive architecture, Adaptive Control of Thought – Rational (ACT-R), to simulate multitasking in the AF-MATB. We varied how the model decided which task to attend to next by comparing a purely top-down strategy, a purely reactive, bottom-up selection strategy, and mixtures of the two. We compared simulations of the model to data from Bowers et al., (2014). The best combination involved a mixture of top-down and bottom-up selection. Neither the purely top-down nor bottom-up selection models performed well. These results suggest that participants use a complex mixture of strategies to multitasking. The use of a top-down strategy suggests participants could develop efficient strategies to multitask successfully, and that participants may be using a more effortful serial search for tasks, as indicated by the model's serial processing implementation.

Modeling prominence constraints for German pronouns as weighted retrieval cues

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Session:
Virtual ICCM IV – live on Thursday, July 14, at 14:00 EDT

We propose an ACT-R model of processing German personal and demonstrative pronouns. The model extends existing cue-based retrieval models of sentence processing (Lewis & Vasishth, 2005; Lewis et al. 2006) and pronoun resolution (Parker & Phillips, 2017; Patil & Lago, 2021) by adding prominence constraints as weighted retrieval cues. We model data from an antecedent selection task reported in Schumacher et al. (2016). The experiment varied word orders (canonical vs. non-canonical) and verb types (active accusative vs. dative experiencer) to test the effect of varying referential prominence on antecedent preferences for personal and demonstrative pronouns. The model with weighted prominence cues captures key effects across two word orders and verb types, and demonstrates that the contrastive antecedent preferences of personal and demonstrative pronouns can be captured using weighted retrieval cues reflecting prominence constraints.

A computational cognitive theory of temporal reasoning

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Session:
Virtual ICCM IV – live on Thursday, July 14, at 14:00 EDT

I describe a novel model-based theory of how individuals reason deductively about temporal relations. It posits that temporal assertions refer to mental models – iconic representations of possibilities – of events. In line with recent accounts of spatial reasoning, the theory posits that individuals tend to build a single preferred model of a temporal description. The more models necessary to yield a correct answer, the harder that problem is. The theory is implemented in a computer program, mReasoner, which draws temporal deductions by building models. It varies three parameters governing separate factors in the process: the size of a model, the typicality of its contents, and the propensity to search for alternative models. Two experiments corroborate the predictions of the theory and its computational implementation. I conclude by discussing temporal and relational inference more broadly.

Combining machine learning and cognitive models for adaptive phishing training

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Session:
Virtual ICCM IV – live on Thursday, July 14, at 14:00 EDT

Organizations typically use simulation campaigns to train employees to detect phishing emails but are non-personalized and fail to account for human experiential learning and adaptivity. We propose a method to improve the effectiveness of training by combining cognitive modeling with machine learning methods. We frame the problem as one of scheduling and use the restless multi-armed bandit (RMAB) framework to select which users to target for intervention at each trial, while using a cognitive model of phishing susceptibility to inform the parameters of the RMAB. We compare the effectiveness of the RMAB solution to two purely cognitive approaches in a series of simulation studies using the cognitive model as simulated participants. Both approaches show improvement compared to random selection and we highlight the pros and cons of each approach. We discuss the implications of these findings and future research that aims to combine the benefits of both methods for a more effective solution.

Modeling short-term fatigue decrements in the successive/simultaneous discrimination task

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Cubic Defense

Morris, Megan Brianne
Air Force Research Laboratory

Session:
Virtual ICCM V – live on Friday, July 15, at 14:00 EDT

Previous research using goal-directed computational models has demonstrated that microlapses, or brief disruptions in effortful cognitive processing, are related to decreases in vigilance as a function of time-on-task in the psychomotor vigilance test (PVT) (Veksler and Gunzelmann, 2018). We extended these computational accounts of fatigue to model performance in two vigilance tasks that differ with respect to demands on working memory, i.e., successive vs. simultaneous discrimination (Davies and Parasuraman, 1982). While task performance was not affected by working memory demands, simulations show that fatigue moderators successfully capture decreases in vigilance over time. Additionally, participants showed greater individual differences in model parameters related to task performance, but not in the effects of fatigue across time. These results highlight the importance of fatigue moderators in computational accounts of vigilance tasks.

Argumentation-based reasoning guided by chunk activation in ACT-R

Dietz, Emmanuelle
Airbus

Session:
Virtual ICCM V – live on Friday, July 15, at 14:00 EDT

Argumentation is a widely studied topic in A.I., philosophy and psychology. In this paper we are particularly interested in its psychological implications. After having conducted several experiments, Mercier and Sperber stated that argumentation is the means for human reasoning. Yet, how can a cognitively plausible argumentation process be implemented such that it accounts for the lower levels of cognition? Taking as theoretical foundation Cognitive Argumentation, we propose two models for conditional reasoning implemented into the cognitive architecture, ACT-R and evaluate them with the responses of a famous reasoning task.

Evolving understandable cognitive models

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Javed, Noman

Pirrone, Angelo

Gobet, Fernand

Session:
Virtual ICCM V – live on Friday, July 15, at 14:00 EDT

Cognitive models for explaining and predicting human performance in experimental settings are often challenging to develop and verify. We describe a process to automatically generate the programs for cognitive models from a user-supplied specification, using genetic programming (GP). We first construct a suitable fitness function, taking into account observed error and reaction times. Then we introduce post-processing techniques to transform the large number of candidate models produced by GP into a smaller set of models, whose diversity can be depicted graphically and can be individually studied through pseudo-code. These techniques are demonstrated on a typical neuro-scientific task, the Delayed Match to Sample Task, with the final set of symbolic models separated into two types, each employing a different attentional strategy.

Specificity of the jumping-to-conclusion bias in social anxiety: An account using the Bayesian computational modelling approach

To date, little is known about the role of social anxiety in the assignment of evidence weights which could contribute to the jumping-to-conclusion bias. The present study used a Bayesian computational method to understand the mechanism of jumping-to-conclusion bias in social anxiety, specifically through the assignment of weights to information sampled. The present study also investigated the specificity of the jumping-to-conclusion bias in social anxiety using three variations of beads tasks that consisted of neutral and socially threatening situations. A sample of 210 participants was recruited from online communities to complete the beads tasks and a set of questionnaires measuring the trait variables including social anxiety and the fears of positive and negative evaluation. The Bayesian model estimations indicated that social anxiety and fears of evaluation did not significantly bias the assignment of evidence weights to information received, except when mostly positive feedback was shown. Our results did not support a significant association between the jumping-to-conclusion bias and social anxiety/fears of evaluation.

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Session:
Virtual ICCM V – live on Friday, July 15, at 14:00 EDT

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