Summer 2017 Workshop:  
Computational tools for developing and testing models of quantum cognition

2017 William K. and Katherine W. Estes Fund
Advanced Training in Mathematical and Computational Modeling for Psychological Science

Date: July 21, 2017  
Location: University of Warwick, Coventry CV4 7AL UK

Rational for time and place:
Our meeting will occur immediately before the Society of Mathematical Psychology (SMP) meeting and at the same location. Also the SMP meeting will be held jointly with the European Mathematical Psychology group, and the International Computational Cognitive Modeling Society. Cognitive Science will be held in London shortly afterwards.

Registration: None required.
However, as soon as possible, try to make a reservation at the Scarman Conference Center [http://www2.warwick.ac.uk/services/conferences/spaces/scarman](http://www2.warwick.ac.uk/services/conferences/spaces/scarman). If rooms are filled, try at the sister centre, Arden, which is a 10 minute walk from Scarman. Arden – Arden@warwick.ac.uk T: 02476523904

Lead Organizer  
Name*: Jerome Busemeyer  
Affiliation*: Indiana University  
Email*: jbusemey@Indiana.edu  
Phone*: 8128554882

Organizer 2  
Name: Tim Plesckac  
Affiliation: Max Planck Institute Human Development  
Email: pleskac@mpib-berlin.mpg.de  
Phone: +49 30 82406-451

Organizer 3  
Name: Emmanuel Pothos  
Affiliation: City University, London  
Email: Emmanuel.Pothos.1@city.ac.uk  
Phone: +44 (0) 207 040 0267

Organizer 4  
Name: Jennifer Trueblood  
Affiliation: Vanderbilt  
Email: jennifer.s.trueblood@vanderbilt.edu  
Phone: 615-343-7554

Organizer 5  
Name: Zheng Wang  
Affiliation: Ohio State University  
Email: wang.1243@osu.edu  
Phone: 61478769
I. Workshop General Purpose:

This 1-day workshop is an exposition of a rapidly growing new alternative approach to building computational models of cognition and decision based on quantum theory. The cognitive revolution that occurred in the 1960’s was based on classical computational logic, and the connectionist/neural network movements of the 1970’s were based on classical dynamical systems. These classical assumptions remain at the heart of both cognitive architecture and neural network theories, and they are so commonly and widely applied that we take them for granted and presume them to be true. What are these critical but hidden assumptions upon which all traditional theories rely? Quantum theory provides a fundamentally different approach to logic, reasoning, probabilistic inference, and dynamical systems. For example, quantum logic does not follow the distributive axiom of Boolean logic; quantum probabilities do not obey the disjunctive axiom of Kolmogorov probability; quantum reasoning does not obey the principle of monotonic reasoning. It turns out that humans do not obey these restrictions either, which is why we consider a quantum approach.

This workshop will provide an exposition of the basic assumptions of classical versus quantum theories. These basic assumptions will be examined, side-by-side, in a parallel and elementary manner. We will show that quantum theory provides a unified and powerful explanation for a wide variety of paradoxes found in human cognition and decision ranging from attitude, inference, causal reasoning, judgment and decision, and memory. This workshop introduces and trains psychological and cognitive scientists on this promising new theoretical and modeling approach.

This workshop will introduce participants to an entirely new area and no previous experience or background with quantum theory will be assumed. No background in physics is required. In fact, except for a few simple examples to motivate the idea, little or no reference to physics will be made during main part of the workshop. What is required is an elementary background in classical logic and probability.

We have conducted similar previous workshops and symposia in the past. A one day version of this workshop has been presented at the Cognitive Science meetings in Nashville (2007), Washington DC (2008), Amsterdam (2009), Sopporo (2012), Berlin (2013), Quebec City (2014), and Pasadena (2015) with about 30 to 50 participants each time. The ratings from participants after the workshop were all very positive.

This proposed workshop is designed to be different from previous workshops in the following ways. First the workshop will be more intensive and last for a longer period of time allowing us to go into more concrete application details. Second the workshop will include commentators who can constructively criticize or add new directions to the presented ideas. Third we are
trying to reach out and draw in a broader range of students, both post doctoral and graduate, male and female, across the international world.

II. Workshop Organizers

The organizers will prepare the basic material to be covered as described in section III. Jennifer Trueblood is an assistant professor at Vanderbilt University. She has published many articles on the topic of quantum cognition, and her work, including a young investigator award from the Psychonomic Society and the Association for Psychological Science, has been funded by NSF. Tim Pleskac is a senior research scientist at the Max Planck Institute in Berlin (formerly Assoc Professor at Michigan State Univ). He received a young investigator award from NSF as well as the Societies for Judgment and Decision Making and the European Association of Decision Making, and has published work on quantum cognition in PNAS and Decision. He is also Associate Editor at the Journal of Experimental Psychology: General and Psychological Science. Zheng (Joyce) Wang is an associate professor at The Ohio State University. She was Co-Editor for a special issue on quantum cognition that appeared in Topics in Cognitive Science (2013), Vol. 5 (4)) and she also has published in PNAS. Her work on quantum cognition has been funded by NSF and AFOSR. Jerome Busemeyer is Provost Professor of Psychological and Brain Sciences at Indiana University. He was awarded the Crosby Medal for his work on quantum cognition. He is Editor of Decision and was Associate Editor of Psychological Review, and was Editor of Journal of Mathematical Psychology. He is also author with Peter Bruza of the book Quantum models of Cognition and Decision. Emmanuel Pothos is a professor at City University in London. His work on quantum cognition has been funded by the European Air Force Office of Scientific Research, the Leverhulme Trust, and Horizon 2020. He has authored many important articles including those in Psychological Review and Behavioral Brain Science.

III. Schedule for Workshop

1. Introduction and Background (9 am to 10:30 am, Busemeyer, Pleskac, Wang). First, we will examine major differences between classical versus quantum theories of probability. The concept of superposition is introduced and distinguished from classical probability mixtures. The important issue of measurement in classical and quantum systems will be compared and examined. We will include several dramatic empirical examples illustrating empirical violations of the classical laws of probability (e.g., conjunction, disjunction, and total probability) and the parsimonious explanation of all these violations by quantum theory.

Readings:


Coffee: 10:30 am to 11:am

2. Dynamics. (11 am to 12:30 pm, Pleskac, Pothis) Then we will examine the differences between classical and quantum dynamical systems. The basic idea of a Markov processes will be introduced and compared with quantum processes. A parallel development of Markov and quantum processes will be shown using a concrete empirical example. The concept of a state will be distinguished for Markov and quantum systems. The effects of measurement on the state of the system are compared for Markov and quantum systems. A key goal is to show when and how quantum processes depart from Markov processes, and how we can empirically test whether a system is Markov or quantum.

Readings:

Lunch: 12:30 pm to 1:30 pm

3. Implementing Quantum Models (1:30 pm to 3 pm, Trueblood, Yearsly). In this section, we will provide hands-on experience with an easy to use computer program (JAGS) that will allow you to implement quantum models in a Bayesian framework. We will present the details of classical and quantum models of causal reasoning and illustrate how Bayesian modeling can be used to fit the models. At the end of this section you will have gained the technical skills to implement quantum models.

Readings:

See the references and the website below for additional material to be covered and relevant background material:
Coffee: 3:00 pm to 3:30 pm

5. **Future Directions** (3:30 pm to 6:00 pm).

Finally, we will review progress in quantum cognition research and propose future directions. **This time period will be used for presentations by our commenters listed below.**

**IV. Workshop commentators: (30 minute presentations)**

We invited the following commentators to provide comments and criticisms and raise questions and introduce new applications. Titles given after each person’s name. All have accepted invitation.

1. Steve Sloman (Brown University, US) (30 min)
   [https://www.brown.edu/Departments/CLPS/people/steven-sloman](https://www.brown.edu/Departments/CLPS/people/steven-sloman)
   *Quantum Probability: Interference or Normalization?*

2. Neil Stewart (University of Warwick, UK) (30 minutes)
   [http://www2.warwick.ac.uk/fac/sci/psych/people/nstewart/](http://www2.warwick.ac.uk/fac/sci/psych/people/nstewart/)
   *Quantum cognition for the agnostic*

3. Fintan Costello (University College Dublin, Ireland) (30 min)
   [https://scholar.google.com/citations?user=3z-gY18AAAAJ&hl=en](https://scholar.google.com/citations?user=3z-gY18AAAAJ&hl=en)
   *Measuring angles between mental representations? Challenges for quantum cognition*

4. Riccardo Franco (Italy) Quantum Physicist working in industry. (30 min)
   *Towards a new quantum cognition model*

5. Andrei Khrennikov (Linnaeus University). (30 minutes)
   [https://lnu.se/en/staff/andrei.khrennikov/](https://lnu.se/en/staff/andrei.khrennikov/)
   *Quantum(-like) cognition from the viewpoint of quantum theorist*