Workshop programme

Computational complexity and economic decision making

Organised by Leverhulme International Professorship in Neuroeconomics

Friday, 23 of February

10:00-10:15	Welcome and coffee	
10:15-11:15	David Kutner	How hard can payment scheduling be?
11:15-12:15	Adam Sanjurjo	Complexity in Choice
12:15-13:15	Jose Apesteguia	Revealed Lottery Complexity and Risk Attitudes
13:15-14:00	Lunch	
14:00-15:00	Gonzalo Arrieta	Procedural Decision-Making In The Face Of Complexity
15:00-16:00	Pauline Vorjohann	Reference-dependent Choice bracketing
16:00-17:00	Modibo Camara	Computationally Tractable Choice
17:00-18:00	Peter Bossaerts	Approximation Complexity
18:00	(Optional) dinner	

List of Abstracts

How hard can payment scheduling be?

David Kutner[1]

[1] Department of Computer Science, Durham University, UK

We introduce the Interval Debt Model (IDM), where a financial network is represented by nodes (banks) interconnected by weighted directed edges (debts), each debt being due within some time interval. In this paradigm, we study the Perfect Scheduling problem: given an IDM instance, is there a schedule of payments such that all debts are paid in full and on time? This problem can be naturally generalized in various ways. For example, which is the size of the smallest bailout package which would enable a perfect schedule (Bailout Minimization)? Or, what is the smallest number of banks that will go bankrupt under any schedule without using any bailout (Bankruptcy Minimization)?

We are interested in how easily these problems can be solved, depending on the input network's topology, the system's lifetime, and various restrictions on payments (e.g. the admission or exclusion of fractional payments). On the negative side, we show that all three problems are intractable in highly restricted cases; for example, Bankruptcy Minimization is NP-complete even if the topology is fixed with 32 nodes. On the positive side, Bailout Minimization and Perfect Scheduling are always tractable if fractional payments are allowed.

Complexity in Choice

Adam Sanjurjo[1]

[1] Department of Economics, University of Alicante, Spain

In computer science, the computational complexity of a problem is often measured by its space complexity, which quantifies the working memory resources required by an algorithm or machine to solve the problem. I implement this measure in a canonical multi-attribute choice problem, in which each attribute of each alternative is first processed sequentially, in any order. I quantify the space complexity when varying the size of the problem, the processing order, and the information structure, and characterize the minimum complexity algorithms. I then introduce a choice model that incorporates space complexity as an input, and test it using human choices from an existing experiment. A simple one-parameter version of the model closely tracks a complicated pattern of choice errors across six treatments. Lastly, I provide a novel structural explanation for the appeal of two well-known choice heuristics: satisficing and elimination-by-aspects.

Revealed Lottery Complexity and Risk Attitudes

Jose Apesteguia[1], ***Miguel Ballester***[2]

[1] Department of Economics and Business, Pompeu Fabra University, Spain
[2] Department of Economics, University of Oxford, UK

There is increasing attention to the role of complexity in decision making under risk. In this paper we build a theoretical framework to obtain from data: (i) the endogenous complexity ranking of lotteries, and (ii) the channel through which complexity affects risk attitudes. This allows us to separate risk and complexity attitudes, and to derive the corresponding estimates.

Procedural Decision-Making in the Face of Complexity

Gonzalo Arrieta[1], ***Kirby Nielsen***[2]

[1] Department of Economics, Stanford University, USA
[2] Humanities and Social Sciences, Caltech, USA

A large body of work documents that complexity affects individuals' choices, but the literature has remained mostly agnostic about why. We provide direct evidence that individuals use fundamentally different choice processes for complex and simple decisions. We hypothesize that individuals resort to "procedures"—cognitively simpler choice processes that we characterize as being easier to describe to another person—as the complexity of the decision environment increases. We test our hypothesis using two experiments, one with choices over lotteries and one with choices over charities. We exogenously vary the complexity of the decision environment and measure the describability of choice processes by how well another individual can replicate the decision-maker's choices given the decision-maker's description of how they chose. We find strong support for our hypothesis: Both of our experiments show that individuals' choice processes are more describable in complex choice environments, which we interpret as evidence that decision-making becomes more procedural as complexity increases. We show that procedural decision-makers choose more consistently and exhibit fewer dominance violations, though we remain agnostic about the causal effect of procedures on decision quality. Additional secondary evidence suggests that procedural decision-making is a choice simplification that reduces the cognitive costs of decision-making.

Reference-dependent Choice Bracketing

Pauline Vorjohann[1]

[1] Department of Economics, University of Exeter, UK

I derive a theoretical model of choice bracketing from two behavioral axioms in an expected utility framework. The first behavioral axiom establishes a direct link between narrow bracketing and correlation neglect. The second behavioral axiom identifies the reference point as the place where broad and narrow preferences are connected. In my model, the narrow bracketer is characterized by an inability to process changes from the reference point in different dimensions simultaneously. As a result, her tradeoffs between dimensions are distorted. While she disregards interactions between actual outcomes, she appreciates these interactions mistakenly with respect to the reference point.

Computationally Tractable Choice

Modibo Camara[1]

[1] Department of Economics, Stanford University, USA

I incorporate computational constraints into decision theory in order to capture how cognitive limitations affect behavior. I impose an axiom of computational tractability that only rules out behaviors that are thought to be fundamentally hard. I use this framework to better understand common behavioral heuristics: if choices are tractable and consistent with the expected utility axioms, then they are observationally equivalent to forms of choice bracketing. Then I show that a computationally-constrained decision maker can be objectively better off if she is willing to use heuristics that would not appear rational to an outside observer.

How Well Do Humans Approximate Optimality In Computationally Hard Resource Allocation Problems?

Peter Bossaerts[1], ***Juan Pablo Franco***[2], ***Anthony Hsu***[2], ***Carsten Murawski***[2], ***Nitin Yadav***[2]

[1] Faculty of Economics, University of Cambridge, UK
[2] Centre for Brain, Mind and Markets, The University of Melbourne

It is often suggested that people use heuristics to overcome intractable problems and that the resulting decisions closely approximate optimality. However, computational complexity theory predicts that solutions to certain problems cannot be approximated well. In a laboratory experiment, participants were asked to make decisions about three ostensibly similar resource allocation problems that nevertheless differed in approximation complexity. Quality of decisions appeared exactly as predicted by the theory. Our results demonstrate that computational complexity theory could be used to identify the economic problems that are particularly hard for humans and therefore require decision aid.

Useful Information

Talks will be held at the **Garden Room** of Robinson College. It is situated on the ground floor of the auditorium building (see entry 14 on map of college on next page)

Coffee breaks and lunches will be offered in the nearby **Seminar Room** of Robinson College.

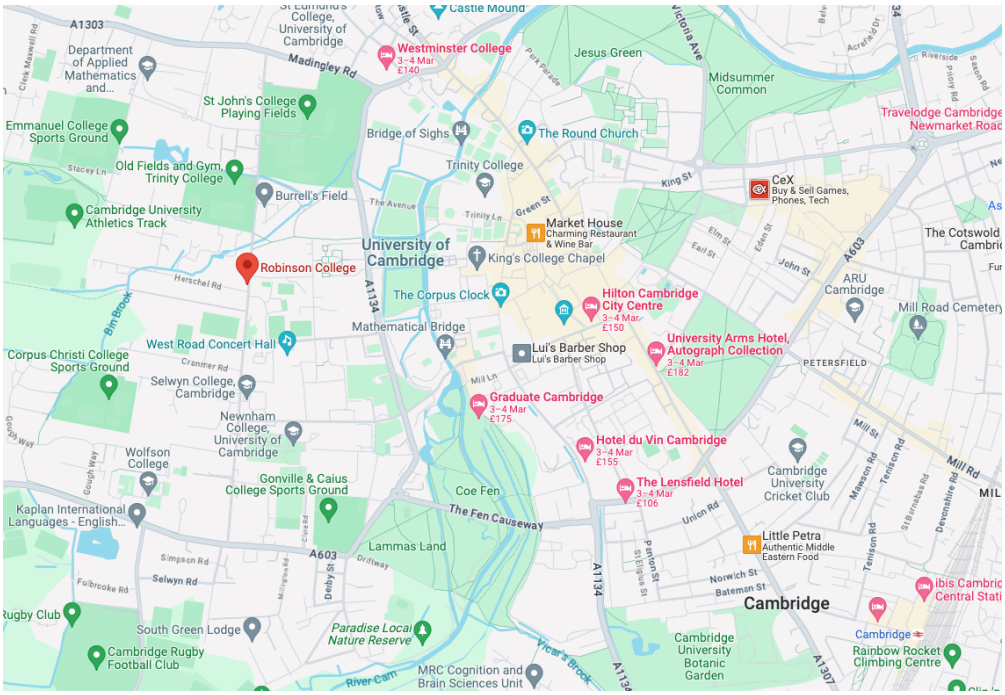
Wi-Fi will be available during the conference via the eduroam network.

The optional **conference dinner** will be determined on the day of the conference.

How to get to the venue?

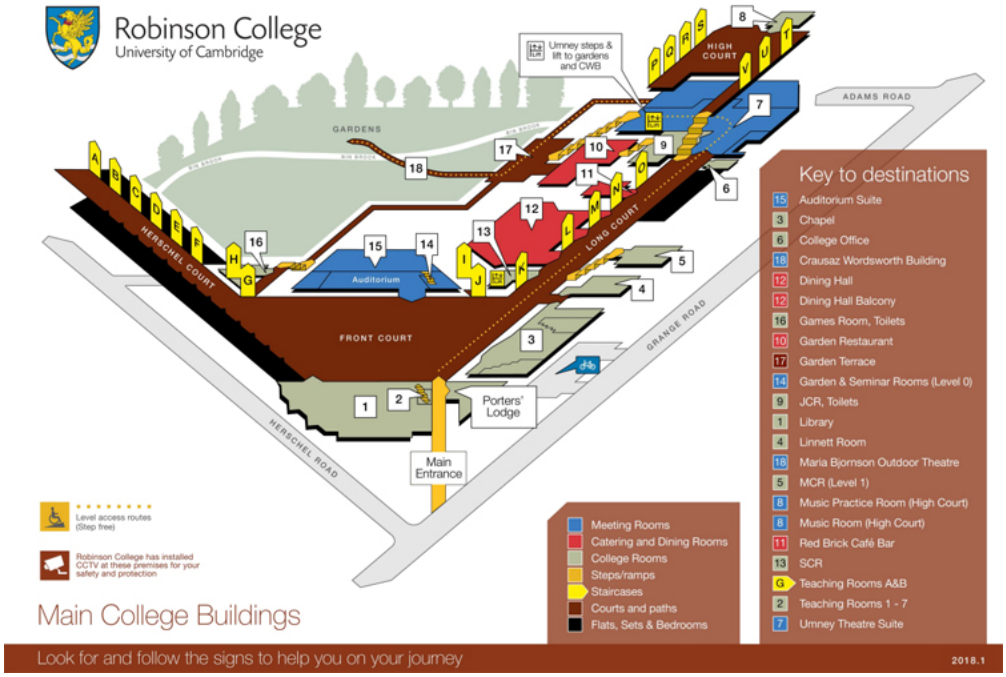
Robinson college is located at Grange Rd, Cambridge, CB3 9AN.[1] It and can be reached by:

- **Walking:** 40-45 minutes from train station
- **Bus:** lines U1, U2 (stop: Robinson College, 20-25 minutes from the train station)
- **Taxi/Uber:** short ride (8-12 minutes from station), price around 10£



[1]The hotel many of you are staying is very close to the train station, so instructions and estimated times to get there are calculated from the train station.

Robinson College Buildings



Robinson College Site Plan

Garden Room

Seminar Room