Design and Analysis of Human Experiments in Dynamic Decision-Making Tasks

1 Background

The Capability Systems Centre (CSC) is exploring the possibility of collaboration with researchers with expertise in the design and analysis of human experiments in computer-based tasks. We are particularly interested in dynamic decision-making tasks, where participants are confronted with the challenge of predicting and controlling a dynamic system. CSC calls for EOIs from interested researchers with the suitable background and expertise to tackle the following work package.

2 Work package overview

CSC is interested in developing a research agenda focused on establishing an empirical understanding of how decision-making tools (primarily simulation models) influence human learning and decision making in complex problems characterised with feedback interactions, information delays, and incomplete information. As a first fundamental step towards this direction is to establish a well-grounded view of existing experimental literature using a solid theoretical basis on the concept of 'task complexity'. The purpose of this work package is to draw on existing definitions and theoretical conceptualization of 'task complexity' in other disciplines (e.g. Gill and Hicks, 2006), and use this conceptualization to assess and map how this conceptualization has been operationalised in literature.

2.1 Scope

There is already an extensive body of knowledge geared towards human understanding of dynamic decision-making tasks (e.g. Gonzalez et al., 2017). One of the most prominent examples from this class of problem found in the literature are variations of an accumulation over time, with additions being made by an input rate of change and depletions by an output rate of change, with or without a delay being involved. This class of problems is known as "Accumulation" or "Stock-and-Flow" problems. Many experimental studies have systematically demonstrated the poor performance, even of highly educated subjects with mathematical background, in the stock and flow problem (e.g. Cronin et al., 2009).

The Stock-and-Flow class of problems is an interesting research problem for understanding dynamic decision making because the stock and flow structure is the fundamental building block for dynamic systems (Sweeney and Sterman, 2000). Poor performance in the simple stock and flow problem is taken an indicator for failing to understand and control dynamic systems. For example, Sterman (2008) attributed the public's 'wait-and-see' attitude towards climate change policies to the poor stock-and-flow understanding of CO_2 concentrations in response to carbon emissions. In another example, Abdel-Hamid et al. (2014) attributed some of weight loss struggles to people's basic misperception of how the body weight (i.e. stock) retains and losses calories through food intake (i.e. inflows) and exercise (i.e. outflow). Using a Stock-and-Flow problem to examine individual's dynamic decision making in laboratory experiments allows for generating empirical knowledge on dynamic decision making that transcend application domains.

2.2 Focus

In the dynamic stock problem literature, there is a dominant view of narrowly conceptualizing task complexity in terms of the complexity of the simulation model used in the experiment (e.g. Gonzalaz and Dutt, 2011). This view is very limited as it overlooks the fact that human performance during the experiment is determined by the whole experimental task design settings (e.g. novelty of the information to the participant), rather than 'just' the structure of the used simulation model. Failure to characterise the dimensions and elements that constitute task complexity limits our ability to: (1) compare studies and contrast their findings in light of the complexity of used tasks, (2) effectively design experiments by having insights into what/how to control variables. Therefore, overcoming such barrier do not only improve how we interpret the accumulated knowledge on human performance in such tasks, but also generate insights that can lead to design of tasks to enhance poor performance (Stouten and Größler, 2017). In this study, we aim to contribute to bridging this fundamental research gap, by addressing the following questions:

1. How can we conceptualize the concept of task complexity in the context of dynamic stock control tasks?
2. How has this conceptualization been operationalized in the literature?
3. How can we assess the levels of tasks complexity in past experimental stock control tasks?
4. What are the insights to be gained from this assessment on:
    a. the effect of different task complexity levels on human performance,
    b. the quality of experimental design in past research (e.g. reporting standards), and
    c. informing CSC future research efforts in this topic
5. What is the opportunity of using meta-analysis techniques (Schmidt and Hunter, 2014) to build on and complement the insights gained from the above questions?

2.3 Milestones and Deliverables

Milestone #	Milestone description	Date
1	Initial workshop with CSC staff to establish working arrangements, further define the problem and to clarify any questions or issues	Within two weeks of commencement of agreement, Location: TBD
2	Literature review of various task complexity conceptualization and assessment approaches, with a focus on their applicability to the dynamic stock control problem described above. The review should result in: (a) articulating clear and transparent criteria on which approaches have been assessed for their suitability and adoption in the inquiry, (b) proposing task complexity conceptualization and assessment approach to be used in the inquiry.	
3	Use the proposed approach to describe, assess, and interpret past research into dynamic stock control tasks	
Deliverable 1: Joint paper with CSC staff covering Milestones 1-3 to be submitted to relevant journal (TBD)		

4	Given the knowledge and insights gained so far, explore the potential of using meta-analysis techniques to provide a consolidated and quantitative review of past empirical studies.	
5	Design the meta-analysis study, including a clear work plan of the objectives, questions to be answered, methods employed, and potential biases that may result in the analysis, and how they are to be mitigated in the study design.	
6	Use the outlined design to analyse literature, and derive findings.	
Deliverable 2: Joint paper with CSC staff covering Milestones 4-6 to be submitted to relevant journal (TBD)		

3 References

Abdel-Hamid, T., Ankel, F., Battle-Fisher, M., Gibson, B., Gonzalez-Parra, G., Jalali, M., ... & Martinson, B. (2014). Public and health professionals' misconceptions about the dynamics of body weight gain/loss. System dynamics review, 30(1-2), 58-74.

Cronin, M. A., Gonzalez, C., & Sterman, J. D. (2009). Why don't well-educated adults understand accumulation? A challenge to researchers, educators, and citizens. Organizational Behavior and Human Decision Processes, 108(1), 116-130.

Gill, T. G., & Hicks, R. C. (2006). Task complexity and informing science: A synthesis. Informing Science, 9, 1.

Gonzalez, C., & Dutt, V. (2011). A generic dynamic control task for behavioral research and education. Computers in Human Behavior, 27(5), 1904-1914.

Gonzalez, C., Fakhari, P., & Busemeyer, J. (2017). Dynamic Decision Making: Learning Processes and New Research Directions. Human Factors, 0018720817710347.

Schmidt, F. L., & Hunter, J. E. (2014). Methods of meta-analysis: Correcting error and bias in research findings. Sage publications.

Sterman, J. D. (2008). Risk communication on climate: mental models and mass balance. Science, 322(5901), 532-533.

Stouten, H., & Größler, A. (2017). Task Complexity in Individual Stock Control Tasks for Laboratory Experiments on Human Understanding of Dynamic Systems. Systems Research and Behavioral Science, 34(1), 62-77.

4 Requirements

Please provide:

- A brief CV describing your research background.
- A focused statement of your suitability for undertaking the work detailed above.
- A detailed description outlining how you would undertake the research described above.
- A brief project plan attaching dates and an outline budget to the milestones outlined above.

5 Submissions

Submissions must be lodged via email, as a PDF file, to: capabilitysystems@adfa.edu.au.

Inquiries may be directed to: Associate Professor Mike Ryan, Director, Capability Systems Centre, capabilitysystems@adfa.edu.au.