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Video games as a path to a contextualized cognitive science, or How to move beyond 20 questions with nature

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Introduction

In his famous address "You can't play 20 questions with nature and win", Newell (1973) predicted that experimental psychology's focus on falsifying theories of individual phenomena (e.g., subitizing, directed forgetting, etc.) would not lead to a unifying theory subsuming several (let alone all) of the phenomena. Instead of seeking to detect effects, and binary searching our way to the explananda of these phenomena, Newell argued psychologists should build predictive theories of behavior by modeling 1) the structure of the task environment (i.e., context), 2) the subjects' own goals, and 3) the invariant structure of the subjects' processing mechanisms. Newell concludes that psychology will only make real progress in understanding the mind by 1) targeting tasks that are complex enough to cover the space of naturalistic behavior, 2) developing models that can competently perform the task, and 3) generalizing such models to perform multiple complex tasks. For 1), Newell chose to study chess; we believe he would find video games an even more compelling paradigm (see Gobet, 2017).

This workshop will explore how video games may be exemplary "complex tasks" that can be leveraged to collect rich, fine-grained behavioral data in the context of known goals and a rich task environment that is amenable to building cognitive models that promise to explain diverse cognitive strategies and capacities. While this workshop is primarily focused on evaluating the argument for video games' sufficiency as a platform for building general (and testable) theories of cognition, our speakers will also give examples of a diverse sample of video games, explain how these games engage cognition in context, and show how the rich behavioral data from games can be used to synthesize theories of cognition, and even to be used as interventions.

Video games' rise in popularity has been meteoric: over 3 billion people play games, and the average gamer reports playing over an hour each day (MIDIA, 2022). Cognitive scientists have begun to leverage game mechanics in their experiments to engage more users for a longer time period, yielding rich datasets on a range of aspects of intelligent behavior (see Brändle et al., 2021; Long et al., 2023). However, gamified experiments are oftentimes still used in service of answering a single binary question about nature (though see Opheusden et al., 2021), and thus offer no salve to Newell (1973). In contrast, off-the-shelf video games tend to show more complex, naturalistic situations which may recruit multiple cognitive skills. Indeed, while simple "brain training" games–often based on classic cognitive psychology tasks–have not been found to have generalizable benefits for cognition (e.g., Stojanoski et al., 2020), a recent meta-analysis of commercial video game interventions showed beneficial impacts in perceptual, attentional, and cognitive skills (Bediou et al., 2019; but see also Sala, Tatlidil, & Gobet, 2018). Further, multiplayer games provide opportunities for machine players to "sub in" for a human player. For this to be successful, the machine will likely need a human-like theory of mind and not just be able to solve the task. For example, a team of five machine agents can beat a team of expert human agents in a popular online video game, but the machines fail to team properly with humans (OpenAI DOTA2; 2019).

The aim of this workshop is to discuss how cognitive scientists should aim to analyze data from video games that engage multiple cognitive skills in the service of accomplishing clear objectives in realistic environments. It is our contention that using such games to elicit and record diverse behavior will serve as a foundation for building general cognitive models that are goal-oriented and contextually-sensitive.

Goal and Scope

This workshop will bring together cognitive scientists who have used video games as a platform for understanding individual differences in cognition. We have invited researchers who can speak to the potential and limitations of video games, with the broader goal of sparking a discussion about prospective paths toward a general, integrated theory (esp. computational models) of human intelligence. Main topics of discussion will be:

- How can behavior in video games help us understand individual differences in goal-oriented behavior?
- How can video games help us build a cognitive science that models naturalistic behavior involving multiple skills?
- Which types of video games and mechanics involve which cognitive skills?
- What are the advantages and disadvantages of games, in comparison to traditional psychology experiments?
- How can models that play games be used to examine individual differences in people's gameplay?
- When are traditional experiments better suited for constructing theories of intelligence?

In M. Goldwater, F. K. Anggoro, B. K. Hayes, & D. C. Ong (Eds.), *Proceedings of the 45th Annual Conference of the Cognitive Science Society.*

Target Audience

We expect that the topic of this workshop will be of broad appeal to the cognitive science community, as our motivation for it stems from a philosophical argument made by one of the early great cognitive scientists (Newell, 1973); the content spans all areas of cognitive psychology; and the premise, if accepted, could influence the methods and practice of all experimental psychologists, as well as researchers in artificial intelligence. Finally, video games are of great relevance in society, at large, and have been the subject of much research in anthropology, developmental psychology, and linguistics. The workshop's webpage is games4understanding.com.

Organizers and Presenters

Joseph Austerweil (organizer) is an associate professor at the University of Wisconsin-Madison. His lab investigates how people represent, retrieve, learn, create, and teach knowledge using computational modeling and behavioral experiments.

George Kachergis (organizer) is a senior research scientist at Skillprint, Inc. and at Stanford University. He has studied language acquisition with memory and learning models, viewing the learning as a self-supervised, active process that is leveraged in both games and life.

Joaquin A. Anguera is an Associate Professor in Neurology and Psychiatry at the University of California San Francisco, and the Director of the Clinical Program at Neuroscape, a center within UCSF. His research involves the implementation of digital technologies to remediate cognitive deficiencies and/or robustly characterize distinct cognitive abilities outside of the laboratory.

Stephen Blessing is a Professor of Psychology at the University of Tampa. He teaches an introduction course to cognition using games to explain the different cognitive processes. He has also used games in his research to explore cognition in action.

Fernand Gobet is a Professorial Research Fellow in the Centre for Philosophy of Natural & Social Science at the London School of Economics. His research interests include the psychology of expertise and talent, the acquisition of language, scientific discovery, and computational modeling.

C. Shawn Green is a Professor of Psychology at the University of Wisconsin-Madison. His research examines the factors that influence how quickly individuals learn perceptual and/or cognitive skills, how deeply they learn, and whether their learning generalizes to new contexts.

Celia Hodent holds a PhD in psychology from the University Paris 5 Sorbonne and has been working in the video game industry for over 15 years as a UX strategist (Ubisoft, LucasArts, Epic Games, and as an independent consultant). She is the author of *The Gamer's Brain*, *The Psychology of Video Games*, and *What UX is Really About*.

Frank Leoné is an Assistant Professor at the Donders Institute for Brain, Cognition and Behavior at Radboud University, with a primary interest in converting cognitive science insights, through game and experience design, to educational practices.

Christopher MacLellan is an Assistant Professor in the School of Interactive Computing at Georgia Institute of Technology. His work on cognitive systems aims to advance our understanding of how people teach and learn and to build AI systems that can teach and learn like people do and in ways that are compatible with people.

Catherine Sibert is an Assistant Professor of Human-Computer Collaboration in the Bernoulli Institute at the University of Groningen. She is interested in the intersection of human intelligence and machine intelligence, specifically investigating what AI tools can reveal about the mechanisms of cognition, and how these insights can inform the design of human-usable AI systems.

Aaron Seitz is a Professor of Psychology, Physical Therapy, and Art + Design at Northeastern University, and director of the Brain Game Center for Mental Fitness and Well-being. His lab researches, tests, and disseminates evidence-based, scientifically optimized apps to better understand and train perceptual and cognitive processes and to benefit real world activities.

Workshop Structure

We propose a full-day workshop consisting of five parts. Two parts will be a series of 20-minute talks and 5-minute discussions, outlined in Table 1. Participants will be invited to discuss their favorite games, and groups will be led in analyzing the cognitive skills in a few popular games. A poster session will be held after lunch, and the workshop will end with a panel discussion about industry partnerships (panelists: Anguera, Hodent, Leoné, and Seitz).

Table 1: Presenters and talk topics.

Presenter	Topic
Gobet	How video games can revitalize Newell's program of research
Blessing	Using games to understand cognitive psychology
Hodent	Commercial video games in academic research
Kachergis	Using mobile game telemetry to assess cognitive skills and traits
Group activity	*Practice cognitive analysis of games*
Austerweil	Uncovering human knowledge with games
Green	Assessing planning ability via traditional psychology tasks and mini-video games
Seitz	Serious games are seriously hard
MacLellan	Leveraging games to build teachable agents for human-machine teaming
Leoné	From cognitive science insights to educational game design
Anguera	Designing and validating games for clinical interventions
Sibert	Exploring human expertise in Tetris with machine learning models

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