Wallace: Automating Cultural Evolution Experiments Through Crowdsourcing

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Significance of the topic

The experimental study of cultural evolution, social learning, cooperation, and collective decision-making asks fundamental questions about our capacities to learn, decide, and communicate in a world that is shared with other people. Experimental studies of cultural evolution have revealed a wealth of findings, including how structured forms of communication emerge from individual learning and decision-making (Verhoef, Kirby, & Padden, 2011; Claidière, Smith, Kirby, & Fagot, 2014), the inductive biases underlying human decision making (Griffiths et al., 2008), how innovations accumulate in populations to produce technologies that go beyond what any one individual could create (Caldwell, & Millen, 2008; Derex & Boyd, 2015), and how the mode of communication affects transmission and acquisition of new skills (Morgan et al., 2015).

However, in-laboratory experiments of this kind are resource intensive and logistically complex, requiring recruitment and coordination of participants to perform tasks sequentially and in concert, with enough space and time to isolate and control their interactions. These requirements drive experimental designs towards simple network structures (such as the transmission chain), small groups, and limited interaction between participants. Even where such experiments can be carried out using computers, the complexity of each experiment often means that existing software is unsuitable, leading each researcher to build bespoke software for their particular experiment. In addition to slowing the rate at which such experiments can be carried out, this also makes it hard to share code, to replicate other's experiments, and to build off the work of others.

To address these issues, we created a software-based tool for orchestrating cultural transmission using online crowdsourcing. Our tool, named *Wallace*, builds on psiTurk (Gureckis et al., 2015) to provide efficient high-throughput automation for running behavioral experiments involving cultural transmission. Wallace recruits participants, obtains their informed consent, arranges them into a network, coordinates their communication, records the data they produce, pays them, and validates and manages the resulting data. Wallace runs on commodity hardware and cloud platforms, uses a custom API, and uses widely supported languages and markup languages such as Python, HTML5, JavaScript, and CSS. It is released as open-source software under the permissive MIT license.

Wallace is modular and includes a library of components that can be used to quickly create new experiments. Prepackaged network structures include linear chains (e.g., Bartlett, 1932), scale-free networks (e.g., Bednarik et al., 2014), star and burst formations, micro-society (e.g. McElreath et al., 2005), and the discrete generational structure of the Wright–Fisher model from population genetics (Wright, 1931; Fisher, 1930), among others. Prepackaged behavioral tasks include story recall, category learning, function learning, magnitude estimation, a public goods game, stimulus–response mapping, and numerosity judgment. Nonetheless, experiments can also use custom network structures, processes, and tasks, which can be built by modifying the provided templates, allowing experimental designs of arbitrary complexity.

Structure of tutorial and activities

The tutorial will include a mix of presentations, demonstrations, and hand-on activities with the goal of giving attendees enough knowledge to be able to use Wallace to run their own studies and to understand the new scale of experimentation that Wallace makes feasible.

The tutorial will begin with a 60 minute presentation on cultural evolution experiments, describing the intellectual history of the approach, common experimental designs, and the most notable results produced in these paradigms. This will introduce attendees to the sorts of questions Wallace is designed to help answer.

After this, we will introduce attendees to Wallace itself. We will provide a demonstration replication of Bartlett's early experiment using serial reproduction, illustrating the process of running an experiment with Wallace. We will then guide attendees through the installation of Wallace on their machines such that they can run the same replication on their own systems.

Next, we will have a short presentation describing the software's architecture at a conceptual level. This will start with the key object classes around which Wallace is based as well as the key methods involved in experimental design.

Building on this knowledge, we will then return to the example experiment to see how these classes and methods are used to create experiments. We will discuss potential changes to the experimental design and how to choose which experiment to modify. A demonstration of how to go from an existing example experiment to a new experiment will follow. Participants will be given time to implement some simple extensions, such as changing the network structure or altering the kind of information transmitted.

The final tutorial section will teach attendees how to deal with unexpected events, including details of the inner workings of the code base, how to pause Wallace mid-experiment, how to access and repair the database and how to get support from Wallace's development team. We will also show attendees how they can contribute to the development of Wallace.

The day will conclude with an open discussion section where we will cover issues that came up during the day, experimenter best practices, and how Wallace compares with other existing experimental platforms.

Credentials of organizers

This tutorial will be led by the five members of Wallace's core development team, all of whom work with Tom Griffiths' in the Computational Cognitive Science Lab at UC Berkeley. Collectively, their expertise includes iterated learning, cultural transmission, web-based experimentation, and software engineering:

- Jordan Suchow (Postdoc at UC Berkeley, Ph.D. in psychology from Harvard) studies vision, memory, and learning. He is a lead developer of Wallace and has experience in releasing research software packages (memtoolbox.org).
- Tom Morgan (Postdoc at UC Berkeley, Ph.D. in biology from St. Andrews) studies cultural evolution, human evolution, and social learning. He is a lead developer of Wallace and is an expert in cultural evolutionary studies.
- Jessica Hamrick (Ph.D. student at UC Berkeley) studies mental simulation and software-based tools for research. She is a core contributor to the Jupyter and IPython projects and has given lectures, courses, and workshops on various topics related to programming.
- Michael Pacer (Ph.D. student at UC Berkeley) studies how different aspects of communication shape the information that is being transmitted. He has extensive experience designing and carrying out cultural transmission experiments online.
- Stephan Meylan (Ph.D. student at UC Berkeley) has extensive experience with iterated learning and experiments with multiple microtask types. He previously worked as an analyst at Crowdflower, a major crowdsourcing startup.
- Thomas Griffiths (Professor at UC Berkeley) studies cultural transmission and inductive biases. He has extensive experience of bringing computational methods to bear on psychological questions.

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