# Chapter 29
# An Online Implementation of a Virtual Agent-Based Experiment Tool—An Exploration


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**Keywords** Online experiments · Experimental method · Implementation

## Introduction

Social simulation targets social science problems and challenges, of theoretical, empirical and applied nature, using simulation. This implies contributing to the development of theory/explanations of social phenomena or using existing theories and models to understand or predict outcomes of social processes. The different uses of social simulation and the different roles it can play in the research process make it the Swiss army knife of social research.

In this paper we will focus on advancing the understanding of group processes for sustainable management of a common pool resource (CPR) in dynamic social-ecological environments. More specifically, the causal relations underlying cooperative sustainable resource use, namely confidence, individual and shared knowledge and uncertainty about the environment and others in common pool resource (CPR) problems. This issue has been studied using behavioural experiments, such as used in behavioural economics and psychology. The use of the experimental method is adopted to be able to develop causal explanations, moving beyond correlational

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P. Ahrweiler and M. Neumann (eds.), *Advances in Social Simulation*,
Springer Proceedings in Complexity,
https://doi.org/10.1007/978-3-030-61503-1_29

understanding of CPR problems, since an experiment is a randomised/controlled evaluation of human behaviour. This allows for collecting empirical data of actual behaviour to test the causality between factors (instead of correlations) and thus enables testing of underlying assumptions of theory and explore empirical patterns when there are no theories (yet). These are very strong reasons for using the experimental method, however there are like any method also some limitations.

1. Control: although having a high control over the situation, this does not extend to the participants themselves, i.e. one cannot look into their heads to see why they choose to do something.
2. Cost: It is costly to perform, both in time and money.
3. Reach: Also, the explanation is bound one (or two) variables simultaneously that can be tested.
4. External validity: is the experiment an actual representation of/corresponds to reality, or rather lack thereof is a frequent critique by opponents of the method and a major concern of experimentalists.

Triggered by the observations in the lab experiments done [1–3], the inability of theory to explain the phenomenon of cooperative overexploitation was identified. To be able to explain this it was important to develop an explanation of why and how individuals decide and are influences in such a setting (limitation 1 and 3). As a result, a social simulation version of the experiments was developed, with artificial subjects (called AgentEx) allowing for testing an explanation for this particular observation [4, 5]. The use of social simulation was meant to counteract the first three issues mentioned above in the following ways:

- High control over the artificial agents participating in the place of human participants, both in manipulation and data collection. Enables to develop and test explanations/hypotheses of individual decision making within a group (dynamic) context.
- After development of the agents and simulation platform the cost of running experiments is lower as no human participants were used. An online tool would lower costs even more as the need to be in a specific location disappears.
- Allows for exploring and testing many relations that may potentially be important, both in the environment/situation and in the agents. This could allow for a less costly way of exploring factors one can then test for in experiments.
- Although it is costly to develop a simulation, when the model is there, the addition or diversity in things one can explore is relatively cheap.

The process and actual availability of AgentEx triggered many relevant questions and knowledge needs. E.g. what is the role of scaling it up beyond the one group of four experiment participants, by having multiple groups or more participants? And, what does actually happen in the communication process? How are group knowledge and agreements formed? Addressing these issues partially resulted in developing adaptations/extension to the existing AgentEx model and adaptations to the post-experimental questionnaire of the lab and field experiments. However, the limitations

to and interests in, require (large amount of) human participants or a combination of human and artificial participants. This led to the idea of an online AgentEx, allowing for both the mix of participants, collecting data on the communication stage, and reaching a higher and maybe more diverse or fitting population of participants.

In the remainder of the paper we will introduce AgentEx-Online, its components and the lessons learned during its development.

## AgentEx Online

AgentEx-Online aims to be an online virtual experiment, where the experiment participants play a common pool resource game, bringing AgentEx [5] a social simulation mimicking a lab experiment, online. The experiment participants are part of a (virtual) group and have common access to a resource stock. Participants can harvest resource units and earn points for every unit of resource harvested. They play several rounds, but do not know when the game will end. Each round the participants can communicate using the chat, harvest anonymously and individually, and are presented with the new resource stock before a new round starts.

AgentEx-Online thus connects to the same experimental design in a lab, field and simulation, however due to the medium in which the experiment is performed different questions, manipulations and data can be collected. One can distinguish different experimental forms/methods, for example: conventional lab, framed lab, lab-in-the-field, framed-field and natural field experiments, for a taxonomy, see [6]. The main difference between them is what kind of *participants* they have: student (lab) versus resource user (framed-lab in the field) and the way setup/*situation* approximates or is reality. In Table 29.1 we compare these including with virtual experiments. There we can see that differences between the experimental forms vary not just in the type of participant (student, resource user, agents) and setup (abstract, contextualised or real) the ability to go online and reach a larger pool of participants, with lower cost and having high manipulation freedom is an unique asset of virtual experiments.

### *Implementation*

To recapitulate, AgentEx currently runs with artificial participants, i.e. agents, and has a predefined number of participants. The design requirements for AgentEx-Online are to bring AgentEx online, to also allow for groups that are completely human or mixed, i.e. human and artificial participants, and allow for bigger group sizes. In terms of data collection, this includes the addition of logging functions for the communication among the participants. Although it sounds simple to transform a simulation tool running on a local machine to an online running simulation tool this did not prove that straightforward. In order to develop the online multi-agent

**Table 29.1** Overview of different approaches within the experimental method

| | Lab experiment (clean, framed) | Field experiments (lab-in, framed) | Natural experiments | Virtual experiments |
|---|---|---|---|---|
| Context | [Abstract—Contextualised] | [ Abstract—Contextualised] | Real | [Abstract—Contextualised] |
| Participants | Human<br>[Student] | Resource User | Human<br>[Student, Resource user] | Artificial |
| Experiment | [1—Few]<br>causal relations | [1—Few]<br>causal relations | [1—Few]<br>causal relations | [Few—Many]<br>causal relations |
| Control | Situational: High<br>Individual: Low | Situational: High<br>Individual: Low | Situational: Low<br>Individual: Low | Situational: High<br>Individual: High |
| Time | Development: Costly<br>Experiment: Costly | Development: Costly<br>Experiment: Costly | Development: Costly/None<br>Experiment: Costly/None | Development: Costly<br>Experiment: Cheaper |
| Availability | Offline | Offline | Offline | [Online, Offline] |
| Challenge | External validity<br>Gamification | External validity<br>Gamification | Low control over manipulation & participants[a] | External validity<br>Gamification |

[a] Not randomised, manipulated and who is affected

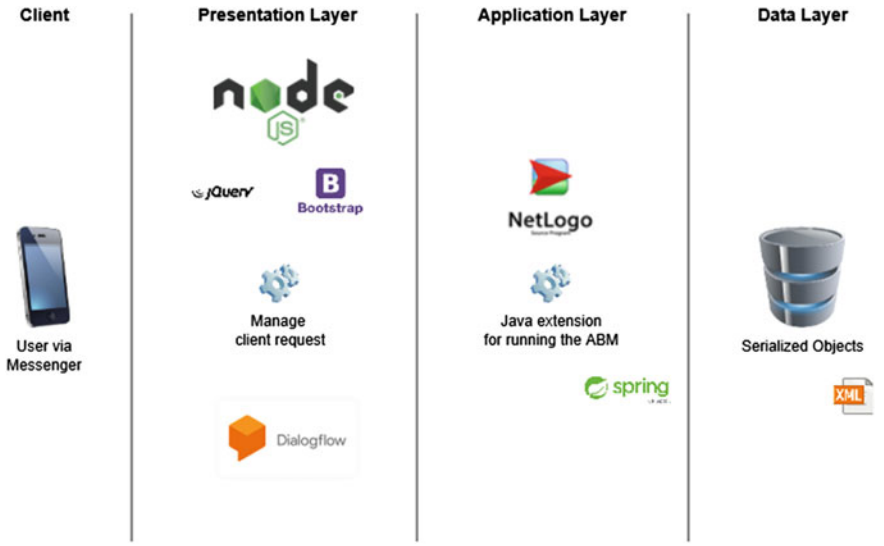


**Fig. 29.1** Architecture of AgentEx-Online: system design and components

solution, AgentEx-Online thus needs to reflect (a) players that play the experiment, (b) an interface that connects players to the experiment, handling the game status and intermediate user interaction, (c) the experiment or AgentEx the simulation, and (d) data collection. This resulted in an architecture visualised in Fig. 29.1.

**Tool selection**. To connect the experiment (that runs on a server) with a participant (using a client) the choice was made to use a Java extension of NetLogo 6 to create a client–server solution. In such a scenario, each client can represent an artificial. (AgentEx) agent or a human participant. The client–server solution thus creates a separation between the application layer and the presentation layer (see Fig. 29.1). The implementation of the client uses Javascript (Node.JS in our case) for handling the game status and intermediation of user interaction. Since communication is a key aspect of the experiment, we aiming for interaction in natural language. For ease of implementation and to fit within the resource for a small-scale project we selected the free Google service for natural language processing DialogFlow,[1] which works very well with Node.js. For the interaction with the presentation layer, the interface towards the human users, we wanted to use a tool that we presume many human participants already use or are familiar with and which is available on many different platforms. To this end we selected Facebook Messenger which also has an easy to use api to connect to the presentation layer. Finally, to allow for a distributed environment in which each artificial agent can run on its own machine, we added a data layer for keeping all ongoing game data stored as well as create log files for each session and session participant.

[1] https://dialogflow.com/.

**Reflections**. A core implementation-reflection concerns the speed of the online experiment. NetLogo is the bottleneck of the architecture, and the slow start-up of new games had to be managed via pooled instances of AgentEx. This decision increased the memory use of the application, but were considered acceptable given to possibility to distribute the application layer to separate machines.

A design-implementation-conceptual challenge concerns the monetary incentive used for participants and necessary to be able to reproduce the same economic lab experiment that AgentEx originates from. The inclusion or exclusion of a monetary incentive is not just a disciplinary rule, it is a core manipulation that may affect the motivation and behaviour of human participant. This is difficult to include in the online setting, unless we involve international online payment systems such as PayPal, ApplePay, AliPay, etc., which would make running experiments online monetarily costlier. Another possible solution to this might be a gamified setting using points and e.g. leader boards for social competition and test the effect of different incentive manipulations (no, monetary, status).

Lastly, another reflection concerns the way the experiment is played. Whereas the artificial participants are well-behaved when it comes to retention and processing time for each decision. The same will not apply to its human participants. They might lose interest in the game and abandon it, especially if the game is experienced to be too slow and where there are little to no consequence from abandoning an ongoing session, in contrast to an experiment in which there is an experiment leader and other participants in the same room.

## Conclusion

The project AgentEx-Online originates from the wish to scale up the existing experiment up (more participants and groups), manipulations that include certain type of participant (artificial participant), and collecting data on the communication stage that seems to be very important in shaping the short- and longer-term group dynamics. Implicitly, this tool also stimulates to think freely about what manipulations are relevant to do, regardless of the disciplinary 'rules' that may exist, e.g. economic experiments always needs to monetarily incentivise the participants, but may not be deceived. But also explore the role of groups size, what happens when groups get bigger, are there systematic differences in the way communication changes and how does this relate to the ability of groups to self-organise and sustain a resource?

For now, we continue with implementing this game and run a test AgentEx-Online experiment, which we will report on during the conference. We continue to think about how such an experiment can be taken to the field, where we want to be able to include participant that may not be able to read and write.

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