Cognitive Modelling: Automatic and Controlled Processing

Introduction

Humans are capable of logical, deliberative thought. This allows us to plan for the future, understanding the long-term impact of our decisions. However, we often fail to act rationally, doing things which may undermine our goals. A common theory that could help explain this, is that decision making consists of varying degrees of intuition and deliberation [1].

The defining features of **intuitive** or **automatic** processing:

- Fast and efficient
- Tailored to specific scenarios
- Overlearned and insensitive to current situation
- Result of practice or instinct

The defining features of **deliberative** or **controlled** processing:

- Slow and requires effort
- Flexible and takes into account available information

By understanding the interaction and use of controlled and automatic processing, it may be possible to gain an insight into some problems that trouble our society.

What is a Cognitive Model?

A cognitive model describes a representation of thinking. These models may be produced through mathematics, computation or as written concept. By focusing on what is key to an idea, models can be used to comprehend and predict behaviour.

Why Agent-Based Modelling?

An agent-based model or ABM, is a simulated system where individual agents interact with each other and their virtual environment. In some scenarios ABMs can provide advantages over regular testing. For example, in many situations, it's easier and cheaper to simulate a number of agents than organise an experiment with real people. It's also possible to simulate timespans for which there is no data or obtaining it is impractical [2].

Previous Work

This project aims to build on previous work on modelling automatic and controlled processing. Two papers were major influences on what was done. The first explores how the portion of the population using a given type of processing may affect their environment , with both mathematical and agent-based models [1]. The second how controlled processing may evolve in a population over generations [3]. The latter experiment was the primary inspiration for the first model. In their model agents competed over time to obtain three different resources, in order to remain 'healthy'.

Model A - Temporal

In the first model agents attempt to find and possibly compete for resources over time. If an agent is unable to consume any resources for an amount of time they 'die'. Each agent has a 'level of control' that determines how likely they are to use controlled processing. The **advantage** of control is represented by having a higher chance to make an informed decision about consuming stored resources. The **cost** of control is defined by a more controlled agent losing out when competing with a less controlled agent. The idea being, that the more controlled agent spent too long thinking.

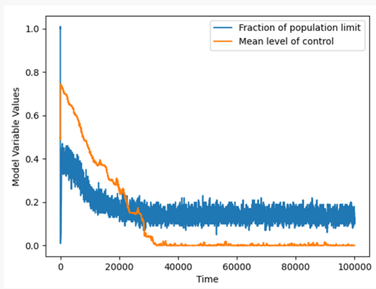
Results for Model A

Results from the first model were comparable to the results of *Rand et al* [1]:

- Automatic processing flourished in an inhospitable world (**Figure 1**)
- Controlled processing dominates in a hospitable world
- There is a region of starting parameters for which the population will cycle between minimums and maximums (**Figure 2**)

Figure 1

Model A Result



Their Result

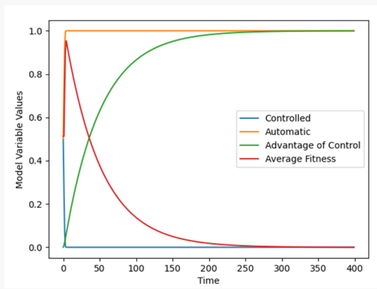
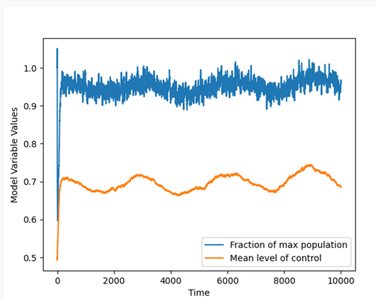
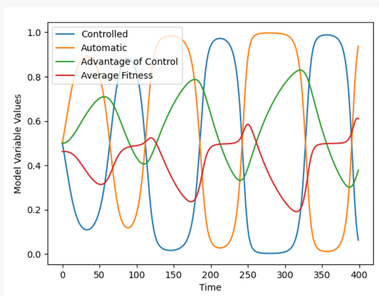


Figure 2

Model A Result



Their Result



Model B - Spatial and Temporal

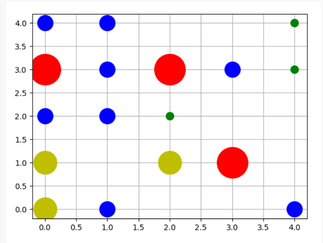
The second model looks at agents in a spatial environment over time. Many of the parameters are the same, but agents compete based on their location. If multiple agents occupy the same space and a resource appears in that space they compete.

Results for Model B

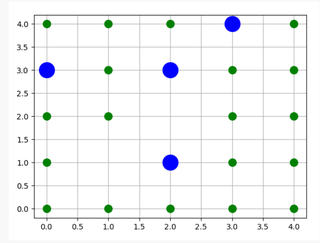
Figure 3 shows how agents are distributed within the 'world'. Larger circles indicates more agents at that position. For the parameters tested so far it seems agents will spread out, and settle at a particular level of control.

Figure 3

Start



End



Further Work

Next, different ways for agents to move will be tested using **Model B**. Potentially more controlled agents will move away from agents that could outcompete them.

In line with similar research, a new model may be made, where agents cannot occupy the same space. In this case agents will compete with their neighbours.

References

[1] Rand, D., et al (2017), Cyclical population dynamics of automatic versus controlled processing: An evolutionary pendulum. Psychological Review, 124(5), pp.626-642.

[2] Madsen, J., Bailey, R., Carrella, E. and Koralus, P, (2019) Analytic Versus Computational Cognitive Models: Agent-Based Modeling as a Tool in Cognitive Sciences. Current Directions in Psychological Science, 28(3), pp.299-305

[3] Tomlin, D., Rand, D., Ludvig, E. and Cohen, J., (2015), The evolution and devolution of cognitive control: The costs of deliberation in a competitive world. Scientific Reports, 5(1)

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