

Using agent-based modelling to explore the effect of beliefs on active travel

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Introduction

Active travel

- Active travel is when physical activity is performed for a functional purpose, such as walking or cycling to work.
- Active travel has wide population health benefits [1]; however, what makes an intervention successful is unknown [2,3].
- I suggest that the key to understanding the success and failure of active travel interventions is a representation of our psychological state—beliefs.

What is a belief?

- The definition of beliefs I use differs from that in everyday language.
- A belief is, roughly, something we consider to be true [4].
- e.g., “I believe that I cannot *afford* a car.”

Why do beliefs matter?

- Beliefs are closer to the decision point. In the belief–desire–intention (BDI) model [5], beliefs cause our desires which cause our intentions which cause our behaviour.
- This means in order to change our behaviour, we need to change our beliefs.
- e.g., building a cycle path. This doesn't cause us to cycle. It changes our beliefs about cycling safety and efficiency. This then causes the change in our desires, intentions, and, finally, behaviour.

Beliefs cause behaviour

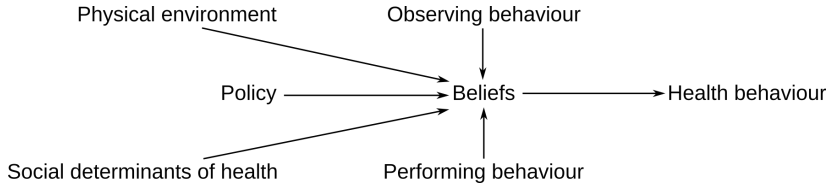


Figure 1: Beliefs cause behaviour.

What am I proposing to do?

- Create a model of belief–behaviour interaction.
- Conduct a systematic review to obtain the beliefs believed to influence travel behaviour.
- Apply these beliefs to the model of belief–behaviour interaction.
- Use this model to investigate a range of interventions.

A model of belief-behaviour interaction

Setup

- There is a set of agents and a set of beliefs.
- Each agent holds some beliefs.
- For each belief they hold, they hold it with some strength. This is their *activation* ($\text{Activation}(a, b) \in \mathbb{R}$).
- The agents belong to a social network, represented as a weighted digraph.

Feedback loops between observing and performing behaviour

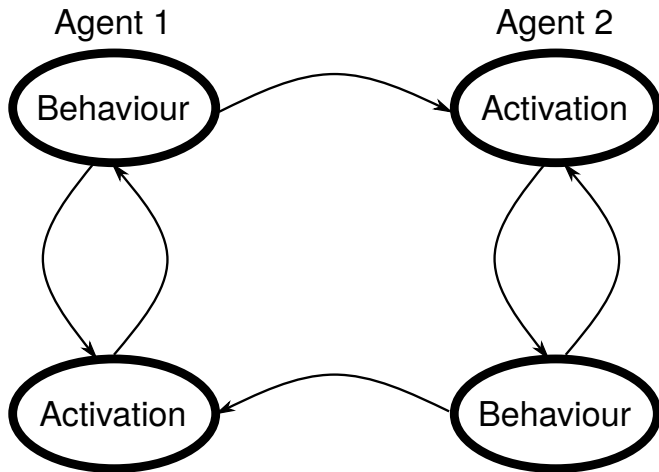


Figure 2: Feedback loops between observing and performing behaviour.

Observing behaviour I

- Observing behaviour is how we perceive the beliefs of others.
- It is not a requirement that the agent who is observed holds the same belief as the observer.
- What this seeks to capture:
 - How does the observed behaviour relate to beliefs?
 - Who do we observe the behaviour from?
 - What is the context of all of our beliefs?
 - What happens to our beliefs if we don't observe relevant behaviour?

Observing behaviour II

- A number of steps to updating activation based upon observing behaviour:
 - For each belief:
 - For each agent observed (sum all of this):
 - How relevant is the behaviour to each belief?
 - Weight this by the strength of connection between yourself and the observed agent.
 - Put this into context of the other beliefs you hold. This is the *value* of observing behaviour
 - Without observing any relevant behaviour, activation either increases, decreases, or stays the same at each time step.
 - Add the value of the observed behaviour to the increased, decreased, or the same activation. This is the new activation.

Performing behaviour I

- Performing behaviour is a consequence of our beliefs and our environment.
- What this seeks to capture:
 - How do our beliefs relate to possible behaviours?
 - How strongly do we hold beliefs?
 - What is the context of all of our beliefs?
 - How does our local (i.e., agent level) and global (i.e., simulation level) environment influence our possible behaviour?

Performing behaviour II

- A number of steps to choosing what behaviour to perform; for each agent:
 - For each behaviour:
 - For each belief:
 - There is a relationship between the belief and behaviour.
 - Weight this relationship by the strength by which we hold the belief.
 - Put this into context of the other beliefs you hold. This is the *contextualised belief-behaviour* value (CBB).
 - Sum up the CBB over all beliefs to give you the *contextualised behaviour* value.
 - How does an agent's local and global environment change your desire to perform a behaviour?
 - Choose between the behaviours.

A systematic review of beliefs

Why conduct a systematic review of beliefs?

- There is no way to capture all the beliefs related to active travel.
- I could just go off my intuition; however, this would likely miss a number of beliefs, some of which may be important.
- A systematic review ensures that I will capture all of the beliefs we *know* to exist.
- (Of course, it will miss those we don't know about)

Creating the simulation platform

Creating the simulation platform

- Using the created belief–behaviour model and the systematic review of beliefs, a simulation platform will be developed.
- The population for the model will be based on Milton Keynes, Buckinghamshire, UK. This is a new town in the South East of England, created from the 1960s onwards.
- Milton Keynes has (arguably) excellent planning with “22 million trees and shrubs, ... more waterfront than the island of Jersey, 200 public works of art and 300km (186 miles) of cycle paths ..., three ancient woodlands”; however, it has also been described as a “centrally-planned slice of Los Angeles” [6].
- The characteristics of the artificial population will be drawn from the UK Census data and the National Travel Survey (for car and bike ownership).

Milton Keynes

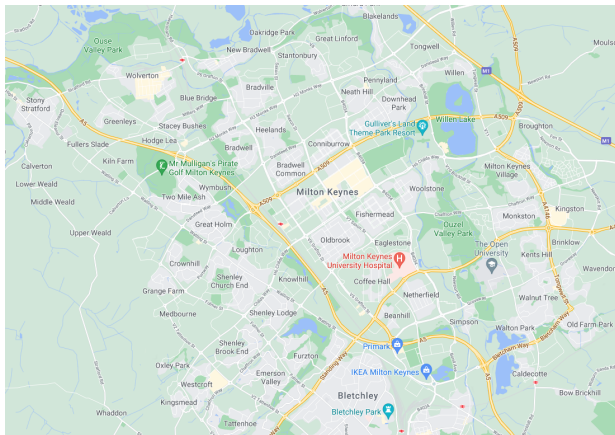


Figure 3: Map of Milton Keynes, Buckinghamshire. Source: *Google Maps*.

Using the model!

Introduction

- I will use the created simulation platform to investigate a range of interventions.
- I will assess the performance of the various runs using a hierarchical Bayesian model [7], comparing the step and slope change in the trend of active travel journeys over time, compared against a control scenario of no intervention.
- Further Bayesian analyses will be conducted to explore how beliefs have changed over time and to see whether certain population subgroups are more affected.

Controlled interrupted time series model

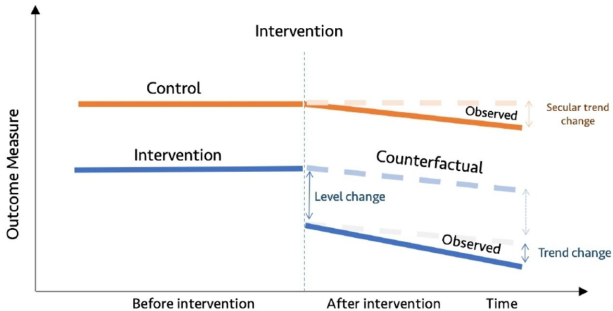


Figure 4: Controlled interrupted time series model. Source: [8].

Non-network-based interventions

- Firstly, I will test a range of non-network-based (i.e., ordinary) interventions:
 - Providing more bicycles to individuals.
 - Increasing the cost of driving by introducing a dirty fuel charge.
 - Increasing the time to take inactive modes by reducing the speed limits on the arterial north–south roads (‘V roads’) and east–west roads (‘H roads’) from 70 mph (112.65 km/h) to 50 mph (80.47 km/h).

Network-based interventions

- Secondly, I will test a range of network-based interventions—i.e., those which seek to utilise the social network to increase levels of active travel:
 - Pay opinion leaders in the network to cycle to work.
 - Provide those who hold pro-environmental beliefs, but don't own a bicycle, with bicycles.
 - Encouraging additional use of the network by those who have recently purchased a bicycle (e.g., recommendations).
 - Create links between those who do commute actively and those who do not in the same neighbourhood (e.g., a buddy scheme).

The end

The end

- Any feedback, comments, or questions on the model of belief-behaviour interaction or the proposed later work is very welcome!

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