Visual Agent-Based Model Communication using Storyboards in Public Health: A case study using the potential effect of Autonomous Vehicles on Physical Activity

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1 Introduction

The proper documentation of any model, including Agent-Based Models (ABMs), is paramount for its trustworthiness [1]. Currently, the standard format of documentation utilized for ABMs is the Overview, Design concepts, and Details (ODD) protocol, a format that requires structured and thorough documentation of the details related to any ABM [1]. The ODD format is beneficial in many ways [1], however it also has its challenges. Clear model communication using the ODD requires training and is often arduous to complete, particularly for complex models [1]. While its comprehensive nature is beneficial in many scenarios, there are always exceptions to the rule. One such example may include policymaking scenarios, and in particular, decision-making for pressing, unforeseen, and 'wicked' problems. In such scenarios, ABMs must be adaptable to allow clear communication of the model itself to aid with its rapid development. To this end, rapid, easily understood, and clear communication is vital [2].

Storyboards, described as 'short graphical representations of a narrative' [3], are visual representations of a story within a series of panels, often used in the creative fields [4] but are increasing in use in various forms of engineering [5-7]. A storyboard permits the communication of various types of 'stories', which can be both actual, such as the process of product assembly, or abstract, such as stories for TV commercials [5]. In both cases, storyboarding requires an understanding and representation of underlying processes [5]. Previously, it has been suggested that a means of communicating the underlying processes within an ABM could be through telling the 'story' from the perspective of the agents as they step through the model [8-10]. For example, Reinhardt et al. [11] applied the provenance approach to a case study investigating decision-making

involved in migration. If such an approach is utilized and taken a step further using storyboards, the visualization component within a storyboard would allow the underlying processes to be rapidly communicated to non-expert audiences alongside rigorous documentation such as the ODD. The present study aims to explore and develop guidelines for visual accompaniments to formal documentation in the form of a storyboard to aid communication with multidisciplinary groups. This will be explored using an example ABM that explores the potential consequences of a future containing autonomous vehicles (AVs) on sedentary behavior.

2 Methods and Results

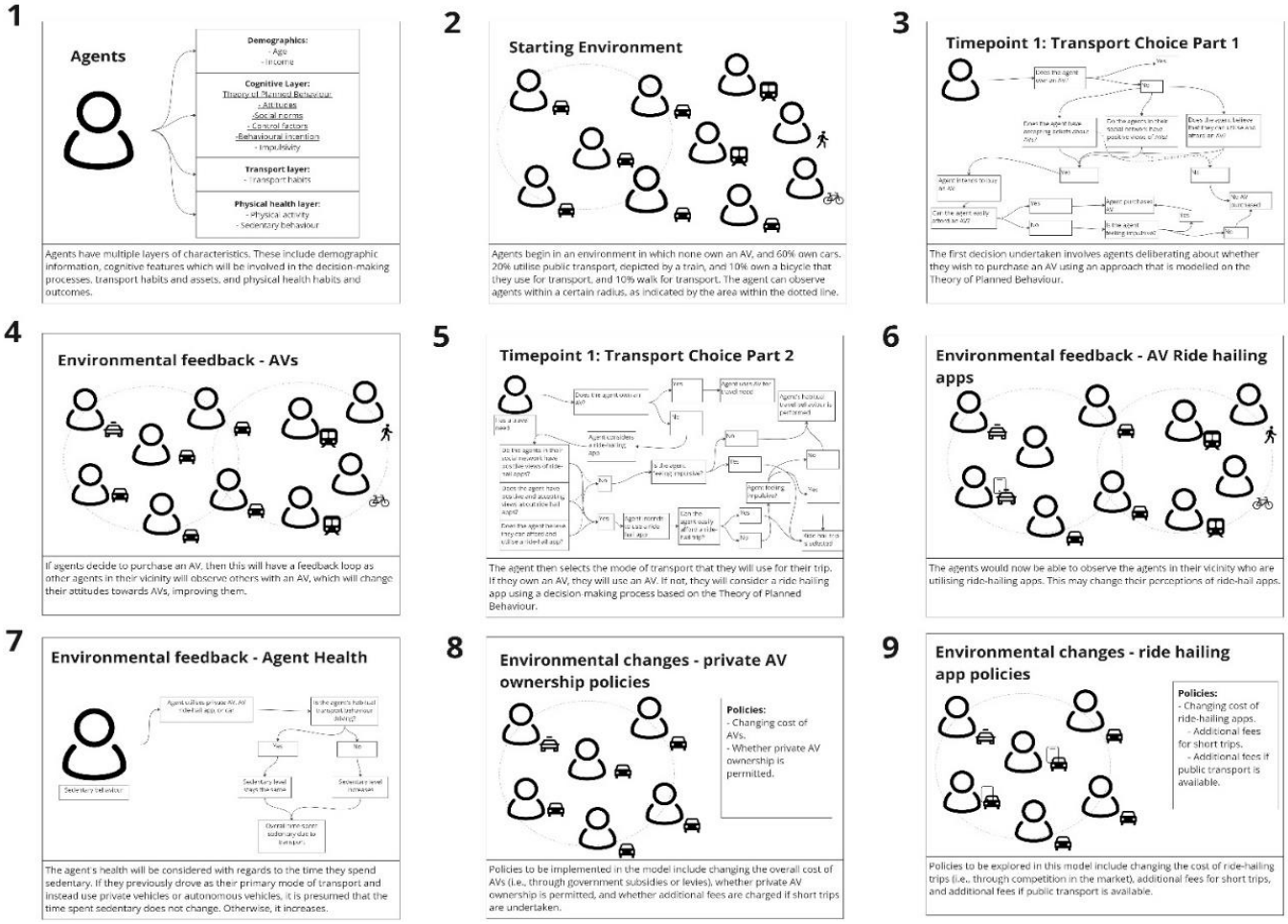

Figure. 1. Storyboard depicting the 'story' of the model through the perspective of both the agent and the model.

The development of the storyboard occurred following initial attempts to capture a 'storytelling' process inspired by previous work [8-10]. The aim of the storyboard was to navigate the 'story' of the agents in a clear and simple manner, along with understanding the processes of their interactions within the model, through a series of 9 panels – chosen to convey sufficient information to be understandable without providing unnecessary detail. This approach is showcased through a case study model aiming to explore the consequences of AV transport on sedentary behavior, built in the Julia programming language.

Communicating agent-related characteristics

Agent characteristics may be depicted in layers. As seen in Figure 1, agent characteristics related to demographics (age and income), cognition (based on the Theory of Planned Behavior [12], along with habits [13] and impulsivity [13, 14]), transport (original transport behaviors - driving, walking, public transport, and cycling, current transport types, and additional ride-hail app usage choices), and health (physical activity and sedentary behavior), were layered in the first panel. Hierarchies between agents, connections between agents, and the types of connections, could be represented using visual hierarchies. Further elaboration about agent characteristics was provided using a short written description underneath the panel, following storyboarding guidelines described by Truong, Hayes, and Abowd [3] and Birchman and Sadowski [5].

Designing the model environment

To represent the model environment within a panel, icons may be used to denote the different types of agents using their defining characteristic, along with representations of their relationships and proximity. The second panel (Figure 1) shows agents depicted via human-like graphics representing people and differences in travel choice through graphical presentations of vehicular choices (e.g., a train, a car, etc.). Their proximity was indicated using a circle to denote the agents within certain bounds of an exemplative primary agent, which was explained further in the text below the panel.

Implementing processes and feedback loops

Feedback following both individual-level and environmental-level processes and interactions can be depicted in separate panels using an example, or series of examples, of potential outcomes. For example, the agents' first process is a transport choice, represented in the third panel using a flow diagram, with the outcome subsequently represented graphically via a transport mode icon. Panels alternating between those depicting flow diagrams and environmental-level panels can show visual changes over time. Through this process, viewers are easily able to observe the potential changes that could result from the individual-level and environmental-level decisions taking place within the model. For example, changes to vehicular ownership after individual decision-making is shown in the fourth panel, which can be compared to ownership after environmental-level feedback in the sixth panel. This occurs through the switch between the different types of visualizations, allowing the effects from 'zoomed-in' decisions to be observed on a larger scale in the 'zoomed out' format. This is seen in the seventh panel, which shows an agent-level process investigating the compounded effects on sedentary behavior due to the individual-level decisions and model-level feedback depicted until this point. The final two panels contain avenues for future exploration of policy scenarios related to private AV ownership and ride-hailing [12]. Initial results from the ABM

indicate that there is a steady increase in sedentary behavior. Private AV cost was the primary factor that affected the outcome of interest, sedentary behavior, and additional outcomes of interest, number of AVs purchased and the number of agents selecting ride-hail trips as their primary transport choice.

3 Discussion and Conclusions

The present study aimed to develop an initial set of guidelines to build on the ideas of a 'visual ODD' mentioned in previous work [1] to encourage further discussion and development. To advance these ideas further, we advocate for a view of ODDs that combines the visual component, some elements of the ODD, and a storytelling component, mentioned in earlier work [8-10]. The development of these ideas has culminated in an initial approach to developing storyboards for ABMs, which can be used for communication purposes as a 'primer' or quick overview that is easily digestible and presentable in several different forums, including presentations and reports.

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