Check for updates

BRIEF REPORT

REVISED Investigating immersion and migration decisions for agent-based modelling: A cautionary tale

[version 3; peer review: 4 approved]

Jakub Bijak[1], Ariana Modirrousta-Galian[1], Philip A Higham[1], Toby Prike[2], Martin Hinsch[3], Sarah Nurse[1]

[1]University of Southampton, Southampton, UK
[2]University of Adelaide, Adelaide, Australia
[3]University of Glasgow, Glasgow, UK

v3 **First published:** 20 Feb 2023, **3**:34
https://doi.org/10.12688/openreseurope.15581.1
Second version: 20 Oct 2023, **3**:34
https://doi.org/10.12688/openreseurope.15581.2
Latest published: 29 Oct 2024, **3**:34
https://doi.org/10.12688/openreseurope.15581.3

Abstract

Background

Agent-based modelling provides an appealing methodological choice for simulating human behaviour and decisions. The currently dominant approaches based on static transition rates or unverified assumptions are restrictive, and could be enhanced with insights from cognitive experiments on actual decision making. Here, one common concern is that standard surveys or experiments may lack ecological validity, limiting the extent to which research findings can be generalised to real-life settings. For complex, highly emotive decision-making scenarios, such as those related to irregular migration, the typically used short, methodical survey questions may not appropriately map onto complex real-world decisions of interest. Immersive contexts may offer more accurate representations of reality, potentially enhancing the usefulness of experimental information in multi-disciplinary modelling endeavours.

Methods

This preregistered study, aimed directly at examining the effect of immersion on risk-taking in the context of migration decisions, and indirectly at informing a multi-disciplinary construction of an agent-based model of migration, presents a choice-based interactive fiction game in which players make migration decisions to advance through

Open Peer Review

Approval Status ✓ ✓ ✓ ✓

	1	2	3	4
version 3 (revision) 29 Oct 2024	✓ view	✓ view	✓ view	✓ view
version 2 (revision) 20 Oct 2023		? view	? view	? view
version 1 20 Feb 2023	? view	? view		

1. **Bruce Edmonds**, Manchester Metropolitan University, Manchester, UK
2. **Melania Borit**, UiT The Arctic University of Norway, Tromsø, Norway
3. **Puyang Li**, Duke Kunshan University, Kunshan, China
4. **Anne Goujon**, International Institute for Applied Systems Analysis, Laxenburg, Austria
Sebastian Poledna, International Institute for Applied Systems Analysis, Laxenburg, Austria

Any reports and responses or comments on the

a story.

Participants

(N = 1000 Prolific users) took part in one of four experimental conditions, three involving different renditions of the game attempting to create immersion, with the last condition presenting the decisions in standard survey format.

Results

Although addressing the lack of ecological validity in survey data is important for improving agent-based modelling methodology, the experimental design used to tackle this issue, while responding directly to modelling needs, proved too complex. The created experimental conditions ended up too distinct from each other, involving stimuli that differed in quantity and content. This introduced several unintended and uncontrolled confounds, making it impossible to meaningfully interpret the results of this experiment on its own. Our results act as a cautionary tale for agent-based modellers, highlighting that the modelling needs should not override the principles of experimental design, and provide motivation for more rigorous research on this topic.

Keywords
Agent-based modelling, cognitive experiments, decision-making, interdisciplinary, migration, migration decisions, risk-taking, serious games

article can be found at the end of the article.

This article is included in the Political Science gateway.

This article is included in the European Research Council (ERC) gateway.

This article is included in the Horizon 2020 gateway.



This article is included in the Migration collection.

Corresponding author: Jakub Bijak (j.bijak@soton.ac.uk)

Author roles: Bijak J: Conceptualization, Funding Acquisition, Methodology, Supervision, Writing – Original Draft Preparation, Writing – Review & Editing; **Modirrousta-Galian A**: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Software, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Higham PA**: Conceptualization, Formal Analysis, Investigation, Methodology, Supervision, Validation, Writing – Review & Editing; **Prike T**: Conceptualization, Formal Analysis, Investigation, Methodology, Software, Validation, Writing – Review & Editing; **Hinsch M**: Conceptualization, Methodology, Writing – Review & Editing; **Nurse S**: Conceptualization, Methodology, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: This work has received funding from the European Union's Horizon 2020 research and innovation programme; European Research Council grant 725232 BAPS: Bayesian Agent-Based Population Studies.
The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Copyright: © 2024 Bijak J *et al*. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

How to cite this article: Bijak J, Modirrousta-Galian A, Higham PA *et al.* **Investigating immersion and migration decisions for agent-based modelling: A cautionary tale [version 3; peer review: 4 approved]** Open Research Europe 2024, **3**:34 https://doi.org/10.12688/openreseurope.15581.3

First published: 20 Feb 2023, **3**:34 https://doi.org/10.12688/openreseurope.15581.1

REVISED **Amendments from Version 2**

Version 3 of the paper has been amended to directly address some of the very helpful reviewers' comments to Version 2, for which we are very grateful. The key changes included clarifying the this dual study aims, with the general objective of assessing the feasibility of using experimental data in agent-based models, and the specific objective related to studying the impact of immersion in the context of risky migration decisions. We have also described the game design, clarified the experimental setup and the process of recruiting participants, and added a summary of the collected demographic information. In this version, we also signpost to the follow-up study, which has since been published (Modirrousta-Galian *et al.*, 2024, *Simulation & Gaming*, 55(4): 716–735). The details of the revisions made are listed in our responses to the individual reviews.

Any further responses from the reviewers can be found at the end of the article

Introduction

Agent-based modelling (e.g. Bonabeau, 2002), where simulated 'agents' represent people, groups, or institutions interacting with themselves and their environment, offer an appealing methodological choice for simulating human behaviour and gaining insights into the emergence of individual- and macro-level patterns. However, the currently dominant approaches, based on static transition rates or unverified assumptions for agents, are limiting, and the existing secondary data are sometimes sparse for the task at hand. Under these circumstances, agent-based models could be enhanced with quantitative insights gained by collecting primary data on actual decision-making from, for example, surveys or cognitive psychology experiments (Bijak *et al.*, 2021). By carrying out simulation experiments with models, and analysing their results, we can identify these model elements, such as parameters or rules, which would benefit the most from additional information. This information could have interdisciplinary provenance resulting from psychological or sociological insights.

At the same time, standard surveys and experiments may lack ecological validity. There has been a longstanding concern regarding the extent to which survey results about hypothetical decisions can be generalised to real-life settings (Cicourel, 1982). For example, real-life migration decisions, especially in irregular contexts, are often highly emotive, involve costly trade-offs, and may threaten one's personal safety. These aspects are poorly represented by the short, methodical questions commonly used in surveys. With that in mind, it is reasonable to expect immersive contexts to offer more accurate and engaging representations of reality and provide better tools for capturing such complex decisions (Rossetti & Hurtubia, 2020).

Consequently, this study was motivated by the need to formally, yet realistically, represent migration decisions in the context of an agent-based model of migration route formations (Bijak *et al.*, 2021). In particular, for migration decisions that may involve different levels of risk, we wanted to ascertain whether immersive experiments might provide useful data to help inform the model as well as its assumptions and parameters that represent decisions.

In light of this aim, the preregistered (https://osf.io/tpqxa) research question of this study was the following: Does immersion affect risk-taking in the context of migration decisions? The broader, indirect objectives of this study, however, were related to testing the feasibility of informing a multi-disciplinary construction of an agent-based model of migration with experimental data from an online text-based game. In this paper, we present specific results related to the former, preregistered research question, while reflecting more broadly on the general feasibility aspects.

To address the preregistered research question, in an exploratory study, we created a choice-based interactive fiction game in which participants made migration decisions to advance through a story. Choice-based interactive fiction games are fully text-based games where a player progresses by selecting from a list of possible actions (Hausknecht *et al.*, 2020). There are examples of other text-based games about migration (e.g., BBC's *Syrian Journey* and IOM's *Migrant Journey*), as well as similar story-based games on popular gaming platforms, such as Steam, which include *Bury Me, My Love,* and *The Night Fisherman*. Some of these games have been used in empirical studies to examine their impact on certain outcomes, such as prejudice (Lee & Chen, 2023). However, as far as we know, these games are not specifically designed for academic research, so they have more complex designs that do not facilitate the investigation of players' in-game actions. Therefore, these games differ considerably from ours in terms of research applicability, focus, and design.

In our game, to achieve immersion, we incorporated two elements: narrative and sense of agency (Fendt *et al.*, 2012; Keen, 2006; Lu *et al.*, 2012; McMahan, 2003; Rafael, 2018). The narrative element involved brief statements about the character's internal thoughts and feelings. The sense of agency element involved repeated decision-making, with each decision being followed by a distinct piece of text outlining its consequence. Unbeknown to the players, their decisions did not impact the game's overall story or conclusion. The experiment included four conditions. The first condition involved playing a version of the game with both narrative and agency. The second and third conditions involved playing versions of the game with only narrative and only agency, respectively. The fourth condition involved playing a survey version of the game without narrative or agency.

At the broader level, the design of our study was driven by the interdisciplinary needs of agent-based modelling endeavours, discussed in detail in Bijak *et al.* (2021). In summary, in the background study to which our research was intended to contribute, the process of building an agent-based model of migration route formation was bottom-up, starting from a simple representation of reality, and adding increasing detail in an iterative way. A statistical analysis carried out at each iteration of model building enabled identifying the key information gaps, which, if filled, could bring about the highest gains in terms of model performance. We attempted to fill these gaps

where possible with existing secondary data, but also, specifically with respect to human decision making, with additional quantitative data from psychological experiments, such as those described in this paper, and several others (Bijak *et al.*, 2021; Modirrousta-Galian *et al.*, 2024).

In this way, the primary data collected through experiments was intended to respond to specific modelling needs, in this case, related to modelling human decisions under varying levels of risk and reward, operationalised in the context of modelling migrant journeys through travel speed, perceptions of safety, and travel cost. Despite—or perhaps because of—close alignment to the modelling needs, dictated by the parameterisation of the model, the experiment we implemented eventually proved too complex, making the results on their own difficult to interpret. In particular, we identified trade-offs between conducting experiments that provide valuable psychological insights, and those that can inform agent-based models. Critically, to inform an agent-based model, large amounts of data for various different variables are required, with the likely trade-offs involving sacrificing experimental simplicity and control in order to obtain richer empirical material. In this paper, we present the lessons learned from this experimental exercise, and provide recommendations for future interdisciplinary research.

Methods

Participants

The study was carried out on Prolific (https://www.prolific.co), with the participant pool approximately balanced in terms of sex and restricted to those fluent in English, residing in the UK at the time of the study, and with a Prolific approval rate above 90. After excluding three participants for completing the study in under 20% of the expected time and one for failing to complete the study, the final sample consisted of 1000 individuals. This included 491 female and 494 male participants, 10 individuals who identified as "other", and five individuals who preferred not to disclose their gender. Participants were between the ages of 18 and 78 (M = 37.07, SD = 13.29) and were paid at a rate of £5.00 per hour. The minimum age for our study was determined by Prolific, which requires participants to be at least 18 years old. We did not set a maximum age for our study.[1]

To replicate this experiment without participant costs, we recommend advertising the study on social media websites such as Twitter and Reddit. This is an increasingly common data collection method for psychological research, which we plan on using for future studies.

Experimental design and research variables

A between-subject, multi-group experimental design was used, with participants taking part in one of four conditions: (a) narrative and agency; (b) narrative-only; (c) agency-only; and (d) survey (without narrative or agency). The independent variables were agency (yes, no), narrative (yes, no), decision stage (one, two, three), and trade-off (chance of success, safety, travel speed). The dependent variable was participants' responses to migration decision(s). Ten control variables were collected for exploratory purposes, listed under 'Demographic Questions' below. All the authors and acknowledged team members tested the surveys prior to data collection, which led to the migration decisions being updated several times. Consequently, we pilot tested the final version of the study with 200 participants to identify potential problems, but we did not find any.

Game design

Schell (2008) defined game design as "the act of deciding what a game should be" (p. 24). With this in mind, we outline the rationale behind the key design choices for our choice-based interactive fiction game. The game consisted of a prologue, three migration decisions (see the "Migration decisions" section), and an epilogue. This structure—comprising a prologue, user commands, and epilogue—is typical of interactive fiction games (Montfort, 2003). We opted for a choice-based interactive fiction game because it requires minimal programming compared to other types of games, which increases the likelihood that it will be used in research if it is shown to be suitable for capturing complex decision-making.

We created the game on Qualtrics (https://www.qualtrics.com/), a platform for building and distributing online surveys. Despite not being game design software, Qualtrics allows for the implementation of HTML, CSS, and JavaScript, which are commonly used to create text-based games. The development process was iterative (Bannon, 1995; Raghothama & Meijer, 2018). This entailed distributing the game among the authors and personal contacts, which included both migrants and non-migrants. We then updated the game based on the feedback, and redistributed it again for further review. We repeated this process until no additional improvements were recommended.

Rafael (2018) suggested that emotional immersion, which denotes an emotional connection to the characters or social context of the game (Zhang *et al.*, 2017), can be established in text-based games by gaining insight into the mental state of the characters. Relatedly, Lu *et al.* (2012) argued that creating positive affect for the protagonist, which can be achieved in various ways, such as making them an important source of information and beliefs, is vital for developing an immersive narrative. Consequently, we incorporated brief statements about the character's internal thoughts and feelings, which

[1] We randomly chose what condition (narrative and agency, narrative-only, agency-only, or survey) to run first and invited participants to take part. Once the number of participants reached our desired sample size, we closed that condition and randomly chose which one to run next, excluding participants who had previously taken part. We did this until the experiment was completed for all four conditions. This sampling design deviated from the preregistration, where we stated that participants would be randomly allocated to one of the four conditions. The reason for this deviation was that we could not think of a fair way to implement true random assignment considering the different completion times (and thus payments) for each condition, which Prolific did not account for at the time of writing.

we refer to as narrative, in the game to foster immersion, since they provide insight into the mental state of the character and are believed to evoke emotion in readers, particularly empathy (Keen, 2006).

Furthermore, McMahan (2003) argued that for a game to be immersive, the players' actions must have a non-trivial impact on the game, which refers to a concept commonly known as player agency. However, Fendt *et al*. (2012) found that making players feel as if their actions had a non-trivial impact on the game, even when they did not, led to similar feelings of agency than actually making players' actions have a non-trivial impact on the game. Therefore, considering that simulated agency is much easier to implement than actual agency, which would involve multiple story arcs and decision trees, we opted for the former. Specifically, we created a sense of agency in the game through repeated decision-making, with each decision being followed by a distinct piece of text outlining its consequence. These consequences made participants believe that their decisions were impactful; despite being dependent on the participants' decisions, they did not affect any of the later decisions or the conclusion of the game.

Migration decisions

The experiment involved nine migration decisions, divided into three stages, each including three decisions. The three decisions in each stage corresponded to three different trade-offs, namely travel speed versus safety, chance of success versus safety, and chance of success versus travel speed. Although these different trade-offs were present at all three stages, the specific scenario and context for the decision differed between stages. For example, at Stage 1, the trade-off for travel speed versus safety involved either getting on an unsafe boat now or waiting for a safer boat; at Stage 2, the trade-off involved crossing a minefield or taking a long detour; and at Stage 3, waiting longer to cross with a safer smuggler versus crossing the border now with a less reputable one. This variability was implemented to enhance realism and ensure that the migration decisions seemed appropriately embedded within the current stage of the migration journey. However, as we discuss further in the conclusion, this strategy also led to difficulties in interpreting the results.

Participants were not presented with the same trade-off more than once. Therefore, at Stage 1, the first decision was randomly selected from the three trade-offs. At Stage 2, the second decision was randomly selected from the two decisions involving the remaining trade-offs. At Stage 3, the third decision presented the trade-off that had not been presented in either of the preceding stages (e.g., if a participant made a chance of success vs. travel speed decision at Stage 1 and a chance of success vs. safety decision at Stage 2, they would be presented with the safety vs. travel speed decision at Stage 3).

The pools of potential migration decisions for the narrative-and-agency and narrative-only conditions were identical. However, in the narrative-only condition, participants were shown the outcome of the first two migration decisions (randomised in the survey) and only made the third migration decisions. In the agency-only condition, descriptions of the character's thoughts and feelings were omitted. Finally, for the survey condition, the migration decisions were heavily stripped-down versions of those presented in the other conditions. Thus, each experimental condition was essentially a different version of the choice-based interactive fiction game.

All migration decisions and their different versions were created by the researchers following interdisciplinary discussions within the team about the requirements of the agent-based model of migration route formation (Bijak *et al.*, 2021). To make the decisions as realistic as possible, we drew inspiration from both first-hand and second-hand accounts of migrant journeys. These were obtained from the website Telling the Real Story (https://www.tellingtherealstory.org/en/) and from YouTube videos published by various news channels (e.g., BBC News and Sky News). The final conditions were set up so as to correspond as closely as possible to the simulated environment and decisions made by the agents in the model.

We took the above-mentioned steps (see also our iterative design process in the "Game design" section) to ensure our migration decisions had a high level of content validity. Nevertheless, we did not establish their construct validity. This is often done by examining convergent validity—the degree to which different measures designed to assess the same construct yield consistent results. However, to the best of our knowledge, no comparable measures of migration-specific risk-taking existed at the time of our study.

Demographic and general questions

A total of 10 demographic and general questions (see Table 1) were asked in all conditions, including questions about the participants' emotional investment and sense of agency while playing (adapted from Jennett *et al.*, 2008), age, gender, number of children, how often they play games, whether they have ever considered migrating or have actually migrated, whether they think the number of immigrants in the UK should increase or decrease (adapted from The Migration Observatory, 2020), and how warm their feelings are towards migrants (adapted from Pawlicka *et al.*, 2019). Originally, we wanted to add these variables as covariates in the analyses to determine how they influence risk-taking in the context of migration decisions. However, considering that the analyses already produced results that were impossible to meaningfully interpret, we decided not to add any more variables. Therefore, we did not examine how these variables influenced migration-specific risk-taking.

Procedure

No device restrictions were applied on Prolific. Before starting the study, participants were shown a combined information sheet and consent form (University of Southampton Ethics approval No. ERGO 68015). After reading the forms and providing informed consent, participants were asked to provide their Prolific IDs.

Participants then took part in one of four conditions: (a) narrative and agency; (b) narrative-only; (c) agency-only; and

Table 1. Demographic and General Questions.

Question	Response option
To what extent did you feel emotionally invested in the survey?	0 (not at all) to 100 (very much)
To what extent did you feel as though your decisions had consequences in the survey?	0 (not at all) to 100 (very much)
What is your gender?	(1) Male (2) Female (3) Other (4) Prefer not to say
What is your age?	Text entry
Do you have children?	(1) Yes (2) No
How often do you play games (e.g., video games, role-playing games, table-top games, or similar)?	(1) Very often: Most days (2) Often: Several times a week (3) Rarely: Less than once a month (4) Never
Have you ever seriously considered and/or made plans to migrate to a new country?	(1) Yes (2) No
Have you ever migrated to a new country before?	(1) Yes (2) No
Do you think the number of immigrants to Britain nowadays should be...	(1) Increased a lot (2) Increased a little (3) Remain the same as it is (4) Reduced a little (5) Reduced a lot
Please indicate how warm or cold your feelings are about migrants and choose the most suitable degree between 0 and 100, where 0 means very cold negative feelings and 100 means very warm positive feelings.	0 (very cold) to 100 (very warm)

(d) survey. Those in the narrative and agency condition made three migration decisions throughout a story that involved both narrative (i.e., descriptions of the character's thoughts and feelings) and agency (i.e., repeated decision-making). Those in the narrative-only condition made one migration decision at the end of a story that involved narrative but no agency. Those in the agency-only condition made three migration decisions throughout a story that involved agency but limited narrative. Finally, those in the survey condition made three decisions presented as simple survey questions.

Once participants had finished their condition-specific task, they completed the demographic questions and were debriefed. The study's length varied across conditions; the narrative and agency and the narrative-only conditions took approximately 15 minutes, the agency-only condition around 10 minutes, and the survey condition around 5 minutes. Since progression was entirely self-paced, the completion time varied between participants.

Results

A series of logistic regression analyses were conducted to investigate the impact of condition, decision stage, and trade-off on participant's decisions. Because participants in the narrative-only condition only made one decision (at the third stage), we first present a series of logistic regression analyses for the narrative and agency, agency-only, and survey conditions, including decision stage as a predictor (as well as condition and trade-off). These logistic regressions were conducted separately for each attribute of the decision (chance of success, safety, and travel speed). We then present logistic regressions on decisions made at the third stage only for

all four conditions, excluding decision stage as a predictor (but including condition and trade-off). These logistic regressions are again conducted separately for each of the three attributes.

Logistic regression analysis excluding the narrative-only condition

A logistic regression analysis was conducted to investigate the relationship between the probability of prioritising one of the attributes of the decision (chance of success, safety, or travel speed) and the condition (narrative and agency, agency-only, or survey), decision stage (one, two, or three), and attribute that it was traded off against (chance of success, safety, or travel speed). Table 2 shows the analysis-of-deviance table produced by Type III Wald Chi-Squared tests. For the model prioritising chance of success, Figure 1 shows the significant two-way interaction between condition and trade-off and the two-way interaction between condition and choice stage. For the model prioritising safety, Figure 2 shows the significant two-way interaction between condition and choice stage, and for the model prioritising travel speed, Figure 3 presents the significant three-way interaction between condition, choice stage, and trade-off.

Table 2. Analysis of Deviance for Logistic Regression Models.

Factor(s)	χ^2	*df*	*p*
Response Variable: Probability of Prioritising Chance of Success			
Condition	7.00	2	.030
choice stage	36.27	2	< .001
trade-off	12.32	1	< .001
condition:choice stage	21.97	4	< .001
condition:trade-off	14.46	2	< .001
choice stage:trade-off	29.17	2	< .001
condition:choice stage:trade-off	7.92	4	.094
Response Variable: Probability of Prioritising Safety			
condition	7.00	2	.030
choice stage	36.27	2	< .001
trade-off	1.69	1	.194
condition:choice stage	21.97	4	< .001
condition:trade-off	5.11	2	.078
choice stage:trade-off	7.67	2	.022
condition:choice stage:trade-off	3.03	4	.553
Response Variable: Probability of Prioritising Travel Speed			
condition	26.04	2	< .001
choice stage	2.81	2	.246
trade-off	6.98	1	.008
condition:choice stage	14.86	4	.005
condition:trade off	13.85	2	< .001
choice stage:trade-off	0.19	2	.911
condition:choice stage:trade-off	10.84	4	.028

Note. The narrative-only condition was excluded.

Logistic regression analysis excluding the first two decision stages

A further logistic regression analysis was conducted on third-stage decisions to investigate the relationship between the probability of prioritising one of the decision attributes (chance of success, safety, or travel speed) and the condition (all four conditions) and attributes it was traded off against (chance of success, safety, or travel speed). Table 3 shows the analysis-of-deviance table for models with response variables related to all three attributes of the decision. For the model prioritising chance of success, although the main effect of condition was significant, a post-hoc Tukey test showed no significant pairwise comparisons, with smallest $p = .058$. The main effect of trade-off was also significant, and a post hoc z-test showed that the probability of prioritising chance of success when it was traded off against safety (mean $M = .29$, standard error $SE = .025$) was significantly lower than the probability of prioritising chance of success when it was traded off against travel speed ($M = .66$, $SE = .026$, $z = -10.40$, $p < .001$).

For the model prioritising safety, the main effect of condition was again significant, and a post-hoc Tukey test showed that the probability of prioritising safety in the survey condition ($M = .83$, $SE = .030$) was significantly higher than: (a) the probability of prioritising safety in the agency-only condition ($M = .67$, $SE = .037$, $z = -3.48$, $p = .003$); and (b) the probability of prioritising safety in the narrative-only condition ($M = .66$, $SE = .038$, $z = 3.69$, $p = .001$). Although the main effect of trade-off was also significant, the probability of prioritising safety when it was traded off against chance of success ($M = .71$, $SE = .025$) was not significantly different from the probability of prioritising safety when it was traded off against travel speed ($M = .75$, $SE = .024$, $z = -0.97$, $p = .334$). For the model prioritising travel speed, in addition to the summary statistics presented in Table 3, the significant two-way interaction between condition and trade-off are shown in Figure 4.

Discussion and conclusion

With respect to our preregistered research question, interpreting the results of the experiment in a meaningful and generalisable way proved challenging. Firstly, both between and within conditions, participants experienced a different number of migration decisions (i.e., stimuli), some of which were presented in different contexts for the same attribute (e.g., boat crossing or landmines for safety), with different migration decisions presented in different orders. Therefore, although participants made conceptually analogous trade-offs, confounds made it difficult to meaningfully interpret the results. Furthermore,

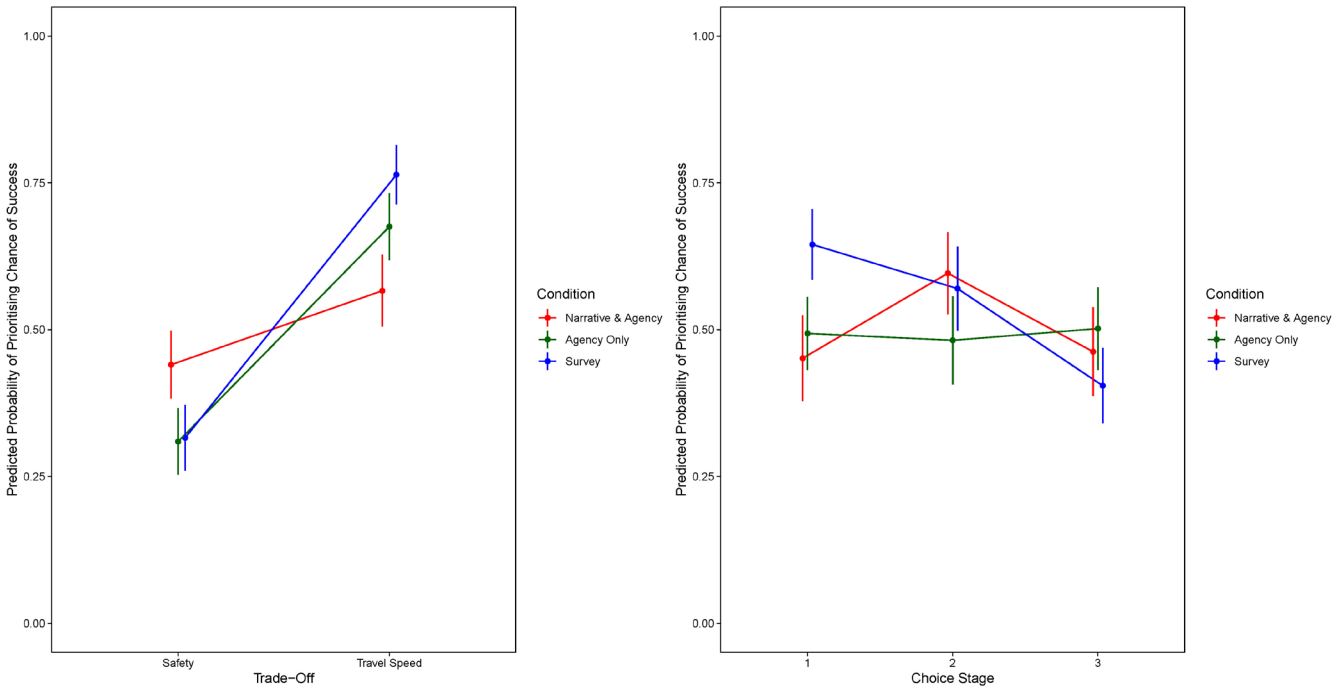

Figure 1. Predicted Probability of Prioritising Chance of Success, by Trade-Off and Condition (Top Panel) and by Decision Stage and Condition (Bottom Panel). The Narrative-Only Condition Is Excluded.

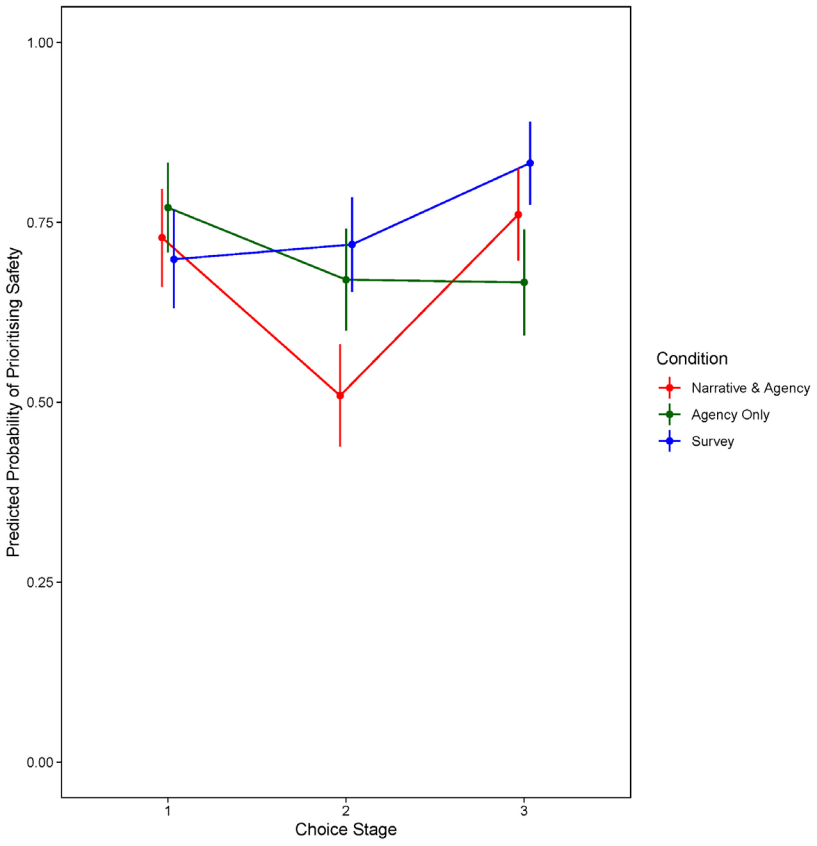

Figure 2. Predicted Probability of Prioritising Safety, by Decision Stage and Condition. (Excluding Narrative-Only).

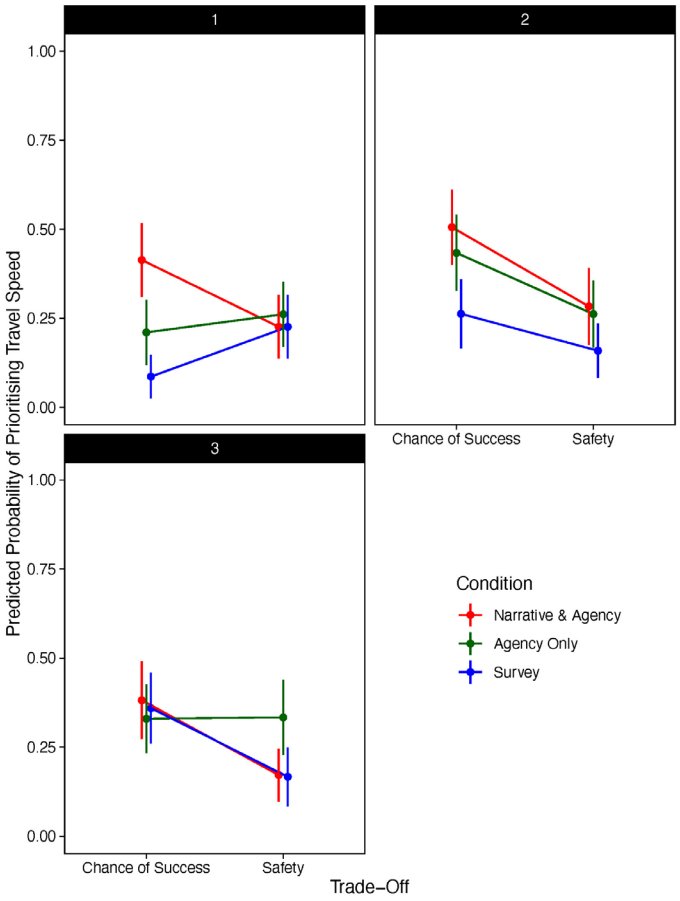

Figure 3. Predicted Probability of Prioritising Travel Speed Against Trade-Off, Decision Stage, and Condition. (Excluding Narrative-Only).

Table 3. Analysis of Deviance for Logistic Regression Models for Stage 3 Decisions only.

Factor(s)	χ^2	*df*	*p*
Response variable: Probability of Prioritising Chance of Success			
condition	8.39	3	.039
trade-off	15.01	1	< .001
condition:trade-off	3.71	3	.295
Response variable: Probability of Prioritising Safety			
condition	8.39	3	.039
trade-off	4.36	1	.037
condition:trade-off	3.32	3	.345
Response variable: Probability of Prioritising Travel Speed			
condition	1.84	3	.606
trade-off	9.75	1	.002
condition:trade-off	12.48	3	.006

Note. Decision stages one and two were excluded.

the conditions proved too distinct from each other, meaning that although the different renditions of each migration decision were intended to be analogous, there were unintended confounds. For example, participants could have made different migration decisions in the narrative and agency condition compared to the survey condition simply because in the former case, the text was substantially longer and contained more details than that in the latter. For these reasons, we could not use the results directly in our agent-based models: the information these results carried was too weak to help us pinpoint specific parameters of the models or instantiate behavioural rules that the simulated agents could follow.

At the broader level, especially with regard to the feasibility of using experimental results in modelling, this study, even if exploratory in nature, illuminated some important tensions and trade-offs present in interdisciplinary research. On the one hand, there are important discipline-specific questions, in our case, around the lack of ecological validity in surveys. On the other hand, there is a need to align the experiment closely with the model needs through greater realism and participant immersion. Due to the need to satisfy the *interdisciplinary* modelling requirements, focusing specifically on quantitative information, from the point of view of experimental psychology, the resulting

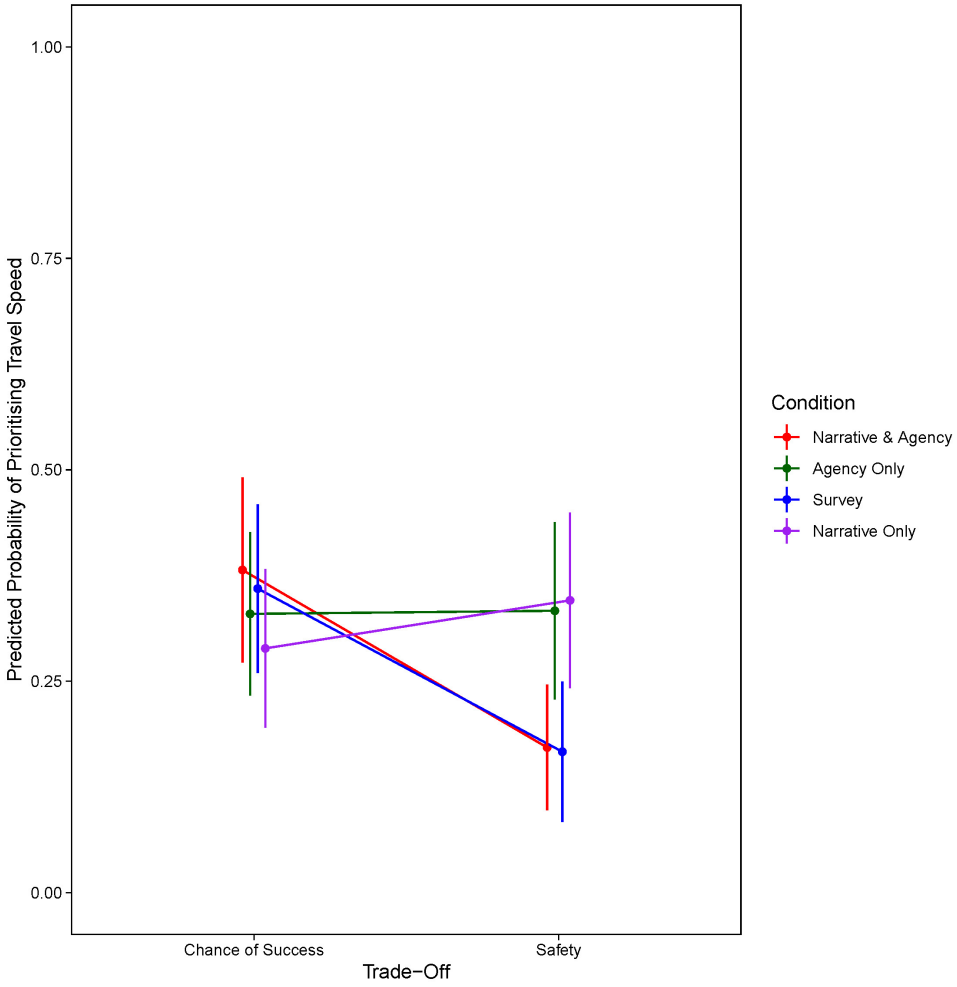

Figure 4. Predicted Probability of Prioritising Travel Speed Against Trade-Off and Condition at the Third Decision Stage.

design ended up being too complex, and we could not obtain the *discipline-specific* psychological insights we had anticipated and desired. There are several significant differences and interactions, indicating that some signal may be coming through from the experimental data. However, because of issues with the study design, it is difficult to identify specific patterns and then interpret and attribute these findings to a particular variable, not to mention generalising them to different contexts.

Alternatively, idiosyncratic differences between the migration decisions across different conditions, as well as between versions of the same trade-off, designed to be analogous but differing in content and wording, dominated over everything else. Together with relatively small effects of immersion, this could have made the results inconclusive. In this interpretation, the main problem is the failure to anticipate the importance of the specific wording and the details of the situation in determining people's responses. As a result, this study failed to provide an answer for both for the preregistered research question as well as the broader question regarding the utility of experimental data for modelling. However, the challenge in informing agent-based models does not solely stem from experimental complexity. In a follow-up study, we ran a simplified version of the experiment, which produced interesting and interpretable results (Modirrousta-Galian *et al.,* 2024). Still, these results—with clear effects of immersion on participants' perception of agency, but no impact on their risky migration decisions—also ended up not being directly useful for informing agent-based models.

Ambiguous results notwithstanding, studying decision-making in richer and more ecologically valid conditions in its own right is a worthwhile endeavour, and the results of the ensuing experiments would enrich the toolkit of agent-based modellers, making the models more realistic and valid. However, as we tried to collect quantitative information about the decision processes, the approach reported in this paper proved at the same time too simple for the question at hand and for realistic applications in agent-based models, and too complex for proper formal analysis from the discipline-specific point of view of experimental psychology. This

lesson cautiously suggests the need to follow a two-pronged approach, where the in-depth exploration of the topic of migrant decision is done by using qualitative methods, and the immersion effect as such can be only properly analysed with carefully designed—and simplified—experimental tools.

In our case, the analysis of immersion through a simplified experimental design provided more conclusive results, confirming the effect of immersion on the perception of agency, but showing no impact on the risky migration decisions made in the game (Modirrousta-Galian *et al.*, 2024). The qualitative exploration was followed through a dedicated ethnographic study amongst Syrian and Afghan migrants, who were interviewed about their journeys to Europe (Belabbas *et al.*, 2022). The results of this study were promising and enabled verifying or validating some of the key assumptions or results of modelling. Four aspects of decisions emerged as key: access to information, the extent of social capital (in particular, social networks), individual circumstances, and finally chance. This confirms the quantitative results reported in Bijak *et al.* (2021), where information and its sharing over networks were found to be some of the key drivers of model behaviour, while the high residual uncertainty of model outputs is corroborated by the salience of chance and unforeseen events for shaping migrant journeys.

We therefore hope that this paper acts not only as a cautionary tale, but also as motivation to conduct more rigorous and broader research on this topic, involving qualitative and quantitative aspects alike. Our main recommendation for future psychological research on immersion is to keep the design simple, with well-controlled differences between conditions carried out step-by-step, to allow for more interpretable results. In terms of the broader aim of this study – assessing the feasibility of informing agent-based modelling of complex social processes with experimental data, such results may be too simple, though, which suggests that the rules on which agent behaviour is modelled, should be based on qualitative information as well. For migration route formation, the early results reported in Belabbas *et al.* (2022) are very promising in that regard. At the most general level, the allure of interdisciplinary research needs to be moderated by discipline-specific rigour.

Ethical approval

This study was approved by the University of Southampton, Ethics approval No. ERGO 68015. Participants provided informed consent to take part in this study and for their anonymised data to be published and uploaded to OSF (please see the combined participant information sheet and consent form at the beginning of all the Qualtrics surveys available on OSF: https://doi.org/10.17605/OSF.IO/PN9EW).

Data availability

Open Science Framework: Modirrousta-Galian, A. (2023). Investigating Immersion and Migration Decisions: A Cautionary Tale. *OSF*, DOI: https://doi.org/10.17605/OSF.IO/PN9EW, accessed on 31 January 2023.

This project contains the following underlying data:

- Data (folder)
  - Agency Only Condition_November 25, 2021_14.13.csv (https://osf.io/8ewcf; raw data file for the agency-only condition)
  - Narrative & Agency Condition_November 24, 2021_16.33.csv (https://osf.io/uxp8d; raw data file for the narrative and agency condition)
  - Narrative Only Condition_November 24, 2021_16.33.csv (https://osf.io/279ux; raw data file for the narrative-only condition)
  - Survey Condition_November 24, 2021_13.53.csv (https://osf.io/uzea2; raw data file for the survey condition)
- Migration Decisions (folder)
  - Migration Decisions.docx (https://osf.io/gcmey; word document with all the migration decisions included in the experiment)
- Pilot Data (Folder)
  - Agency Only Condition_November 18, 2021_19.35.csv (https://osf.io/xdbjp; raw data file for the agency-only condition)
  - Narrative & Agency Condition_November 19, 2021_15.04.csv (https://osf.io/eup2c; raw data file for the narrative and agency condition)
  - Narrative Only Condition_November 18, 2021_16.55.csv (https://osf.io/rzdsv; raw data file for the narrative-only condition)
  - Survey Condition_November 18, 2021_16.08.csv (https://osf.io/8r9ac; raw data file for the survey condition
- Preregistration (folder)
  - AsPredicted Preregistration.pdf (https://osf.io/tpqxa; pdf file of the preregistration uploaded to the AsPredicted website)
- Qualtrics Surveys (folder)
  - Agency_Only_Condition.docx (https://osf.io/c8kgy; full Qualtrics survey for the agency-only condition)
  - Narrative_Agency_Condition.docx (https://osf.io/eqhkf; full Qualtrics survey for the narrative and agency condition)
  - Narrative_Only_Condition.docx (https://osf.io/frw7p; full Qualtrics survey for the narrative-only condition)
  - Survey_Condition.docx (https://osf.io/3j6kv; full Qualtrics survey for the survey condition)
- R Script (folder)
  - chance of success analysis.R (https://osf.io/rpncd; R script for the chance of success analysis)

- demographics.R (https://osf.io/6wv8g; R script for the sample demographics)
- safety analysis.R (https://osf.io/mkep2; R script for the safety analysis)
- travel speed analysis.R (https://osf.io/kjt53; R script for the travel speed analysis)

Data are available under the terms of the Creative Commons Attributions 4.0 International license (CC-By Attribution 4.0 International).

Acknowledgements

This article reflects the authors' views, and the Research Executive Agency of the European Commission is not responsible for any use that may be made of the information it contains. We thank Souhila Belabbas, Jason Hilton, and Peter W. Smith for discussions and help with the testing of the questionnaire. We are also grateful to all five reviewers – Melania Borit, Bruce Edmonds, Anne Goujon, Sebastian Poledna and Puyang Li – for the very insightful comments and suggestions to the first two versions. Needless to say, all errors and interpretations are ours alone.

References

Bannon LJ: **From human factors to human actors: the role of psychology and human-computer interaction studies in system design**. In: RM Baecker, J Grudin, WAS Buxton and S Greenberg (Eds.), *Readings in human-computer interaction: Toward the year 2000. (2nd ed.,)*. Amsterdam: Elsevier, 1995; 205–214.
Publisher Full Text

Belabbas S, Bijak J, Modirrousta-Galian A, *et al.*: **From conflict zones to Europe: Syrian and Afghan refugees' journeys, stories, and strategies.** *Social Inclusion.* 2022; **10**(4): 211–221.
Publisher Full Text

Bijak J, Higham PA, Hilton J, *et al.*: **Towards Bayesian model-based demography: agency, complexity and uncertainty in migration studies.** *Methodos Series.* Cham: Springer, 2021; **17**.
Publisher Full Text

Bonabeau E: **Agent-based modeling: methods and techniques for simulating human systems.** *Proc Natl Acad Sci U S A.* 2002; **99 Suppl 3**(Suppl. 3): 7280–7287.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

Cicourel AV: **Interviews, surveys, and the problem of ecological validity.** *Am Sociol.* 1982; **17**(1): 11–20.
Reference Source

Fendt MW, Harrison B, Ware SG, *et al.*: **Achieving the illusion of agency.** Lecture notes in computer science, Springer. 2012; **7648**: 114–125.
Publisher Full Text

Hausknecht M, Ammanabrolu P, Côté MA, *et al.*: **Interactive fiction games: a colossal adventure.** *Proceedings of the AAAI Conference on Artificial Intelligence.* 2020; **34**(5): 7903–7910.
Publisher Full Text

Jennett C, Cox AL, Cairns P, *et al.*: **Measuring and defining the experience of immersion in games.** *Int J Hum-Comput St.* 2008; **66**(9): 641–661.
Publisher Full Text

Keen S: **A theory of narrative empathy.** *Narrative.* 2006; **14**(3): 207–236.
Publisher Full Text

Lee YH, Chen M: **Intergroup contact with a virtual refugee: reducing prejudice through a cooperative game.** *Psychol Pop Media.* 2023; **12**(4): 383–392.
Publisher Full Text

Lu AS, Baranowski T, Thompson D, *et al.*: **Story immersion of videogames for youth health promotion: a review of literature.** *Games Health J.* 2012; **1**(3): 199–204.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

McMahan A: **Immersion, engagement, and presence: a method for analyzing 3-D video games.** In: MJP Wolf & B Perron (Eds.), *The Video Game, Theory Reader.* Routledge, 2003; 67–86.
Reference Source

Modirrousta-Galian A, Prike T, Higham PA, *et al.*: **Exploring the potential of using a text-based game to inform simulation models of Risky migration decisions.** *Simul Gaming.* 2024; **55**(4): 716–735.
Publisher Full Text

Montfort N: **Twisty little passages: an approach to interactive fiction**. Cambridge MA: MIT Press, 2003.
Publisher Full Text

Pawlicka P, Kazmierczak M, Jagiello-Rusilowski A: **Empathy and social closeness toward refugees from Syria: the mediating role of cultural intelligence.** *J Community Psychol.* 2019; **47**(5): 1014–1031.
PubMed Abstract | **Publisher Full Text**

Rafael S: **Interactive fiction. Narrative and immersive experience in text-based games.** *Proceedings of the 2018 6th International Conference on Illustration Animation.* 2018; 568–576.
Reference Source

Raghothama J, Meijer S: **Rigor in gaming for design: conditions for transfer between game and reality.** *Simul Gaming.* 2018; **49**(3): 246–262.
Publisher Full Text

Rossetti T, Hurtubia R: **An assessment of the ecological validity of immersive videos in stated preference surveys.** *J Choice Model.* 2020; **34**: 100198.
Publisher Full Text

Schell J: **The art of game design: a book of lenses**. Boca Raton, FL: CRC Press, 2008.
Reference Source

The Migration Observatory: **UK public opinion toward immigration: Overall attitudes and level of concern.** 2020.
Reference Source

Zhang C, Perkis A, Arndt S: **Spatial immersion versus emotional immersion, which is more immersive?** *Proceedings of the 2017 Ninth International Conference on Quality of Multimedia Experiment (QoMEX).* 2017.
Publisher Full Text

Open Peer Review

Current Peer Review Status: ✔ ✔ ✔ ✔

Version 3

Reviewer Report 23 January 2025

https://doi.org/10.21956/openreseurope.20172.r45670

© **2025 Borit M.** This is an open access peer review report distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

✔ **Melania Borit**
Norwegian College of Fisheries Science, UiT The Arctic University of Norway, Tromsø, Norway

I would like to thank he authors for addressing my comments. I have no further comments.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Knowledge Integration / Methodologies for Interdisciplinary Research (including Agent-Based Modelling and Game Design)

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 08 November 2024

https://doi.org/10.21956/openreseurope.20172.r45673

© **2024 Edmonds B.** This is an open access peer review report distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

✔ **Bruce Edmonds**
Centre for Policy Modelling, Manchester Metropolitan University, Manchester, UK

All my comments have been dealt with now. Happy for this to go ahead.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Agent-based policy modelling

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 30 October 2024

https://doi.org/10.21956/openreseurope.20172.r45672

© 2024 Li P. This is an open access peer review report distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Puyang Li
Duke Kunshan University, Kunshan, Jiangsu, China

The authors have thoroughly and satisfactorily addressed my review comments from Version 2 in this revised Version 3. I approve indexing of this version of the manuscript.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: geospatial modeling, GIS, remote sensing, agriculture modeling, smallholder management, China and Africa

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 30 October 2024

https://doi.org/10.21956/openreseurope.20172.r45671

© 2024 Goujon A. This is an open access peer review report distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Anne Goujon
International Institute for Applied Systems Analysis, Laxenburg, Austria

Thank you to the authors for revising the manuscript according to the comments. The revisions have improved the readability and clarity of the exercise. I have no further comments.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Demography; ABM

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 2

Reviewer Report 04 July 2024

https://doi.org/10.21956/openreseurope.18028.r41200

© **2024 Goujon A et al.** This is an open access peer review report distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

?

Anne Goujon
[1] International Institute for Applied Systems Analysis, Laxenburg, Austria
[2] International Institute for Applied Systems Analysis, Laxenburg, Austria
Sebastian Poledna
[1] International Institute for Applied Systems Analysis, Laxenburg, Lower Austria, Austria
[2] International Institute for Applied Systems Analysis, Laxenburg, Lower Austria, Austria

Summary of the paper
The paper titled "Investigating immersion and migration decisions for agent-based modelling: A cautionary tale" by Jakub Bijak et al. designed an experiment where participants made migration decisions within an interactive narrative game, aiming to gather more ecologically valid data than traditional surveys. The authors further aimed to use this interactive fiction game to enhance agent-based models (ABMs) of migration decision-making, which was left for future research. The authors further concluded that the complexity of the experimental design resulted in challenges in interpreting the findings, serving as a cautionary tale for interdisciplinary research.

The Idea to Use Choice-Based Interactive Fiction Games
The idea of using a choice-based interactive fiction game to enhance ABMs is innovative and interesting. It is very plausible, that such games, that create a more immersive environment where participants can make decisions that mirror real-life scenarios, could provide richer and more accurate data on migration decision-making. Using this data on migration decision-making to inform ABMs could indeed enhance the results of modelling-based migration studies.

Data availability and preregistration
It is very commendable that the authors made their data and code open-source and preregistered their study. This transparency and commitment to open science not only enhances the credibility of their work but also encourages collaboration and further advancements in the field. However, the link to the preregistration document which is listed in the data availability (https://osf.io/9uh2n) does not work.

Presentation of the paper
While the core idea is compelling, the presentation of the paper could benefit from some rewriting. It took us a while to understand the context of the study and what it is all about. It would be important to mention at one point, possibly in the introduction, that the experiment relates to migrants in an irregular situation. The reader understands this only when reading the Migration decisions paragraph. A short paragraph, mentioning the background for the experiment would be important and would ease the reading. At times, the structure and focus of

the paper can make it challenging to follow the central theme. Some sections, including the introduction, seem to diverge from the main topic of the paper, which is the choice-based interactive fiction game. By focusing on the main contribution of the paper, the paper could be more accessible and engaging for readers.

Confusing claims about developing an ABM
In addition to the above point, the present manuscript goes as far as creating the impression that it develops an ABM directly, which is not entirely accurate. For instance, phrases like "The process we followed for building an agent-based model of migration route formation was bottom up..." suggest direct ABM development. In reality, the focus is on experimental design and data collection to inform future ABMs. Clarifying this distinction would help readers better understand the paper's contributions and scope.

Conclusions of the paper
The conclusion highlights the complexities and challenges faced in the study, noting that the experimental design ended up being too complex to yield clear results needed for agent-based modeling. While an agent-based modeler can understand this point and conclusion, it could also be made clearer for an interdisplinaryaudience.

Comment on the game design
As the game design aspect is not within our area of expertise, we cannot provide a detailed critique. However, the use of interactive fiction games in this context seems a promising and innovative direction. It opens up new avenues for research and data collection that could significantly enhance the development of ABMs.

In summary, while the paper presents an interesting idea to use interactive fiction games to inform ABMs, refining the presentation and focus could enhance its impact. The authors are encouraged to clearly differentiate between the central theme of the paper and the outlook for future research.

Is the work clearly and accurately presented and does it engage with the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

Are all the source data and materials underlying the results available?
Partly

Are the conclusions drawn adequately supported by the results?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Demography; ABM

We confirm that we have read this submission and believe that we have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however we have significant reservations, as outlined above.

Author Response 26 Sep 2024

Jakub Bijak

Thank you very much for your very useful comments and constructive suggestions - they have helped us improve the previous version, in particular by making the objectives and focus clearer. We respond to the main five points raised in your review below.

- Regarding the summary of the paper and the comments about open data, we thank you for your kind words and for making us aware of the broken link to the preregistration. We have now updated the link in question: https://osf.io/tpqxa.
- As regards the presentational side, and the need to make the central theme clearer, thank you for this important feedback. As other reviewers have picked up on this as well, we now try to better explain this dualism between the broader aims of assessing the feasibility of using experimental data in ABMs and the specific objectives of this study, related to immersion and risky migration decisions. We hope this comes through clearly now, both in the Introduction and Discussion sections. We have also added the recommended short explanatory paragraph (currently the third paragraph of the Introduction), with thanks for the suggestion.
- As to clarifying the claims about developing an ABM, in addition to making the objectives more transparent, as stated above, the text now reads: "In summary, in the background study to which our research was intended to contribute, the process of building an agent-based model of migration route formation was bottom-up, starting from a simple representation of reality, and adding increasing detail in an iterative way." We also hope the new additions to the text in the Introduction and elsewhere help alleviate any possible confusion.
- In addition, in the Discussion and Conclusions section, we have now added further explanations pertaining to agent-based modelling, which we hope will also speak to interdisciplinary readership.
- Finally, in terms of the game design, thank you for the endorsement of the idea – and as for specific details, we have now added information about our game design, also in response to the comments of other reviewers, in a dedicated part of the Methods section.

Competing Interests: No competing interests were disclosed.

Reviewer Report 27 June 2024

https://doi.org/10.21956/openreseurope.18028.r41201

© 2024 Li P. This is an open access peer review report distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

?

Puyang Li
[1] Duke Kunshan University, Kunshan, Jiangsu, China
[2] Duke Kunshan University, Kunshan, Jiangsu, China

This paper details an exploratory study that examined migrant decision-making at three stages of their journey using a game-based approach. Participants were assigned to one of four conditions, involving three different game renditions and one standard survey. While the complex design aimed to enhance the study of emotive decision-making beyond standard surveys, it ultimately resulted in data that were too difficult to interpret and integrate into agent-based modeling for complex social processes. Despite this, the research could be suitable for approval with significant revisions and elaborations.

Firstly, I have concerns regarding the overall objective of this research. It appears the researchers aimed to create a game to enrich experimental insights as complements or additions to standard survey data, which could be fed into agent-based modeling to better reflect real-world conditions for complex social processes such as migration route formation. If this is accurate, then the research question proposed in the Introduction section is insufficient to summarize the overall objectives and provide a comprehensive overview of the paper.

Secondly, I find it difficult to conclude that an agent-based model (ABM) can "only" be informed by simplified experimental information, although this is the central argument of the research. Therefore, I suggest cautiously proposing a simplified experimental procedure, as the results of this study only weakly support such inferences. This necessitates more elaboration in the discussion section on the potential reasons for the complexity/ambiguity of the experimental outcomes, i.e., could these stem from design issues or a lack of supportive data?

Thirdly, I recommend adding a table describing the demographic questions and variables, detailing how they were formulated and identified. It is also essential to briefly note that if these variables were not considered as covariates, then how were they utilized to affect the experimental outcomes?

Fourthly, there is no validation analysis in this paper. How did the researchers validate the experimental outcomes? I am unsure whether the ethnographic study of Syrian and Afghan migrants to Europe was intended for this purpose. Please clarify.

Lastly, I have a minor question regarding the participants of the game. How were they selected? Were they migrants themselves, recreating their own migration experiences through the game? The identity of the participants could significantly affect the experimental outcomes.

Is the work clearly and accurately presented and does it engage with the current literature?
Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

Are all the source data and materials underlying the results available?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: geospatial modeling, GIS, remote sensing, agriculture modeling, smallholder management, China and Africa

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 26 Sep 2024

Jakub Bijak

Thank you very much for your very helpful comments and suggestions, in particular those related to clarifying the objectives clearer, which helped us focus the paper more clearly. We respond to the main five points raised in your review below.

- First, thank you for the request to clarify the objectives, which was very helpful. We have now added a clarification in the Introduction, to distinguish between the direct objectives of the experimental work (which we did not want to alter, given that this was the way in which they were preregistered), and the broader, indirect aims to test the feasibility of using the proposed approach for informing ABMs. We hope that, together with the changes to the conclusions, as discussed above, this distinction is clear and helps the reader navigate the paper.
- Second, regarding the point that an agent-based model (ABM) can "only" be informed by simplified experimental information, first of all, we apologise for the leftover "only" towards the end of the Introduction – indeed, this could have been misunderstood, and we have rephrased the sentence, which now reads: "Critically, to inform an agent-based model, large amounts of data for various different variables are required, with the likely trade-offs involving sacrificing experimental simplicity and control in order to obtain richer empirical material". We have also extended the discussion to include some of the suggestions above, for which thanks, and to signpost to the most recent results of the simplified experiment in the follow-up study (Modirrousta-Galian et al. 2024, https://doi.org/10.1177/10468781241242925).
- Third, following your recommendation, we have added a table describing the

demographic questions and variables in the “Demographic and general questions” subsection of the Methods. We have left details of how they were formulated and identified in the text. Since these variables were not added as covariates in the analysis, due to the analysis already producing uninterpretable results, they were not utilised to affect the experimental outcomes. That is, we did not examine how these variables influenced migration-specific risk-taking. We have clarified this in the text.

- Fourth, related to the validation analysis, we apologise for the confusion in the previous version. Despite taking steps to ensure our migration decisions had a high level of content validity, we did not establish their construct validity. This is often done by examining convergent validity—the degree to which different measures designed to assess the same construct yield consistent results. However, to the best of our knowledge, no comparable measures of migration-specific risk-taking existed at the time of our study. We now discuss this in the "Migration decisions" subsection of the Methods.
- Fifth, regarding the recruitment of participants, all the selection criteria for participants are now provided in the "Participants" subsection of the Methods. We selected a participant pool that was approximately balanced in terms of sex, fluent in English, residing in the UK at the time of the study, and with a Prolific approval rate above 90. Migrant status was not one of the selection criteria. We did ask participants whether they ever considered migrating or actually migrated to a new country, but demographic characteristics were not included as covariates in the logistic regressions seeing as the analyses already produced results that were impossible to meaningfully interpret. Nonetheless, we completely agree that migrant status could significantly affect the experimental outcomes, which is why we investigated this in our aforementioned follow-up paper (Modirrousta-Galian et al. 2024).

Competing Interests: No competing interests were disclosed.

Reviewer Report 02 January 2024

https://doi.org/10.21956/openreseurope.18028.r35755

© 2024 Borit M. This is an open access peer review report distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

?

Melania Borit
[1] Norwegian College of Fisheries Science, UiT The Arctic University of Norway, Tromsø, Norway
[2] Norwegian College of Fisheries Science, UiT The Arctic University of Norway, Tromsø, Norway

Dear authors,

Thank you for revising your submission.

I read your answer to my comments and here is my response:

1. The text added in the introduction section regarding your choices vis-à-vis immersion should be moved in the methods section.
2. In the introduction and also in the methods section, make clear what is the relation between experiments and playing the game.
3. This comment is related to my original 5th comment (which was misinterpreted; sorry for that, I should have formulated it in a clearer way). The method section has to include a clear and concrete description of how the game was designed, using terminology from the respective field. There is plenty of research on game design and even more on game analysis. Your own statement “At the general level, the allure of interdisciplinary research needs to be moderated by discipline-specific rigour” applies here, too, as game design is a discipline in itself.
4. Furthermore, most likely your game is not the first one of this kind. Any thoughts about this? Have you checked for such games? Have you found any?

I am looking forward to these details related to the design of the game!

Is the work clearly and accurately presented and does it engage with the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

Are all the source data and materials underlying the results available?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Knowledge Integration / Methodologies for Interdisciplinary Research (including Agent-Based Modelling and Game Design)

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 26 Sep 2024

Jakub Bijak

Thank you very much for your very helpful comments and clarifications - they have certainly helped us sharpen the argument and improve the paper. We respond to the main four points raised in your review below.

- First, we have moved most of the text regarding immersion from the Introduction to a new subsection in the Methods titled "Game Design" (see also the third comment below). However, we have kept a description of the two elements incorporated in the game to foster immersion in the Introduction, since they are important for making the relation between the experiment and playing the game clear, also referring to your second comment.
- Second, we have clarified in the Introduction and the Methods that the experiment involved four conditions, each of which had participants play what is essentially a different version of the game.
- Third, we apologise for misinterpreting your previous comment from the first review. We have now added a subsection in the Methods titled "Game Design" that outlines the rationale behind the key design choices for our game.
- Fourth, thank you for raising the important consideration of novelty. To the best of our knowledge, we are the first to create a text-based game specifically to examine migration-specific risk-taking. That being said, there are other text-based games about migration more generally (e.g., BBC's "Syrian Journey" or IOM's "Migrant Journey"), as well as similar story-based games on popular gaming platforms, such as Steam, which include, for example, "Bury Me, My Love", or "The Night Fisherman"). Some of these games have been used in empirical studies to examine their impact on certain outcomes (e.g., prejudice; Lee & Chen, 2023). However, as far as we know, these games are not specifically designed for academic research, so they have more complex designs that do not facilitate the investigation of players' in-game actions. Therefore, these games differ considerably from ours in terms of research applicability, focus, and design. We have now included these comments in the Introduction of the paper.

Competing Interests: No competing interests were disclosed.

Version 1

Reviewer Report 16 May 2023

https://doi.org/10.21956/openreseurope.16841.r30877

© 2023 Borit M. This is an open access peer review report distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

?

Melania Borit
[1] Norwegian College of Fisheries Science, UiT The Arctic University of Norway, Tromsø, Norway
[2] Norwegian College of Fisheries Science, UiT The Arctic University of Norway, Tromsø, Norway
[3] Norwegian College of Fisheries Science, UiT The Arctic University of Norway, Tromsø, Norway

This paper presents an exploratory study that was carried out to test an experimental design more suitable to developing complex, highly emotive decision-making scenarios than standard surveys. The created experimental conditions ended up to be too complicated and made it impossible to interpret the results of this experiment.

As expressed by the authors themselves, the value of this paper lies in being a story from which other researchers can learn ("cautionary tale"). However, since one could have hypothesized already from the beginning of the study that the results would be ambiguous and difficult to interpret because of the complexity of the experimental design, it is important to understand why the study was carried out in this form (how were the design decisions taken, which decisions are related to working in an interdisciplinary team and which decisions are connected more to the discipline-specific thinking, who were the members of the team and what was their role etc.). As such, the study would be useful from a methodological point of view for interdisciplinary teams working with agent-based modelling. Thus, I suggest enriching the description of the methodology. From my perspective, at least the following aspects have to be described in more details:

- What exactly is the research question / objective / scope of this paper? The authors have to be clearer about that, in order to help the reader through its journey of understanding the cautionary tale.

- How did the team work with the topics of immersion, narrative, and agency? Did the team have expertise in game design? Did the team review the game design research field in order to come up with their design choices related to these topics? There are a multitude of previous studies about the use of narrative as a method to create immersion and about the use of agency for the same purpose; it is not clear whether and to what extent the team working with the current study made use of this previous research.

- How was the narrative on migration designed? The reference (Bijak et al., 2021) is a whole book, which makes it difficult for the reader of the current study to trace back the decisions of the team in order to learn about the interplay between interdisciplinarity and discipline-specific thinking.

- What was the basis for formulating the demographic questions?

- How was the gameplay designed?

- Though the data collection was intended to be used for agent-based modelling endeavours, the current paper does not report anything related to the actual work with this model, thus it is not clear how the experiment is connected to agent-based modelling. More explanations are needed regarding how, theoretically speaking, the results of this study would be connected to agent-based modelling and how the agent-based modelling team worked with designing the experiment so that it fits their modelling needs (said to be

interdisciplinary). If such explanations are not added, then the mentions to agent-based modelling have to be down-played (otherwise, the focus on the agent-based model (as expressed in the title, abstract, and introduction) might be interpreted as misleading).

As a small comment, I would rename Conclusion into Discussion and Conclusion.

Is the work clearly and accurately presented and does it engage with the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

Are all the source data and materials underlying the results available?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Knowledge Integration / Methodologies for Interdisciplinary Research (including Agent-Based Modelling and Game Design)

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 02 Oct 2023

Jakub Bijak

Thank you very much for all excellent comments, which are gratefully received. We have now attempted clarifying our methodological and design decisions in greater detail, as set forth below.

- *What exactly is the research question / objective / scope of this paper? The authors have to be clearer about that, in order to help the reader through its journey of understanding the cautionary tale.*

We have included our preregistered research question in the extended version of the Introduction.

- *How did the team work with the topics of immersion, narrative, and agency? Did the team have expertise in game design? Did the team review the game design research field in order to come up with their design choices related to these topics? There are a multitude of*

previous studies about the use of narrative as a method to create immersion and about the use of agency for the same purpose; it is not clear whether and to what extent the team working with the current study made use of this previous research.

We have now reviewed the literature on immersion, narrative, and agency to develop the design of our game. We have added more information about this in the Introduction.

- *How was the narrative on migration designed? The reference (Bijak et al., 2021) is a whole book, which makes it difficult for the reader of the current study to trace back the decisions of the team in order to learn about the interplay between interdisciplinarity and discipline-specific thinking.*

We have included this information in the Methods section, after the reference. In essence, the design was iterative: the analysis of successive versions of the migration model being developed pointed to gaps in the knowledge about the behaviour of agents. We then attempted filling some of these gaps with knowledge from psychological experiments, of which this is one.

- *What was the basis for formulating the demographic questions?*

We have added information about this in the Methods section.

- *How was the gameplay designed?*

There are two aspects to this question, related to: (1) details on what software we used to design the gameplay; and (2) details on the design of the gameplay itself. In the revised version, we aim to address both. Regarding (1), we have added information about this in the Introduction. Regarding (2), gameplay (how a game is played) is directly related to a game's genre (a category of games with similar gameplay). Therefore, our decision to create a choice-based interactive fiction game determined the gameplay, which is described throughout the manuscript. Nevertheless, we have added information about why we decided to create a choice-based interactive fiction game rather than any other type of game, which was previously missing from the manuscript, to the Introduction.

- *Though the data collection was intended to be used for agent-based modelling endeavours, the current paper does not report anything related to the actual work with this model, thus it is not clear how the experiment is connected to agent-based modelling. More explanations are needed regarding how, theoretically speaking, the results of this study would be connected to agent-based modelling and how the agent-based modelling team worked with designing the experiment so that it fits their modelling needs (said to be interdisciplinary). If such explanations are not added, then the mentions to agent-based modelling have to be down-played (otherwise, the focus on the agent-based model (as expressed in the title, abstract, and introduction) might be interpreted as misleading).*

Thank you very much for these really important points. We now signalled these links at the very beginning of the paper (why the information was needed), and made them more explicit in the expanded discussion in the later part of the Introduction. *As a small comment, I would rename Conclusion into Discussion and Conclusion.* We have renamed the final section as suggested.

Competing Interests: No competing interests were disclosed.

Reviewer Report 16 May 2023

https://doi.org/10.21956/openreseurope.16841.r30875

© 2023 Edmonds B. This is an open access peer review report distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

?

Bruce Edmonds
[1] Centre for Policy Modelling, Manchester Metropolitan University, Manchester, UK
[2] Centre for Policy Modelling, Manchester Metropolitan University, Manchester, UK
[3] Centre for Policy Modelling, Manchester Metropolitan University, Manchester, UK

A game is used to investigate possible decisions a migrant might make at 3 stages of their simulated journey. The researchers gathered some data about the participants and then secretly assigned them to one of four conditions: agency or not x narrative or not (where agency means repeated decision-making and narrative means they are supplied with a narrative of the migrants feelings, motivations etc.). This data was analysed using standard stats. The basic research is interesting enough to be published in ORE.

Their conclusion was that, even given this relatively simple data that it was too complex to be translated into a simulation and hence a simpler experiment was needed. This is, to me, an astounding conclusion. That people's decision-making in such circumstances is complex reflects reality - seeking to force reality to be even simpler to fit one's approach is unscientific. The conclusion I would come to is that the framework that the researchers had in mind for modelling the decision-making is inadequate and their data collection too restricted.

Rather, I suggest that the researchers should collect more informative data about how the subjects come to their decisions using interviews or narrative questions. This may reveal (a) the menu of strategies that the agents are using and (b) some of the context-dependency involved in picking strategies. Agent-based modelling is well-suited to simulating such context-dependent strategies. The problem lies in the bias of the researchers to use experimentation rather than the simulation stage to try and understand what is happening. Narrative data could give valuable clues as to what is happening here. Rather than simplify the design (which is already very simple compared to reality) they should broaden their data collection and utilise the full power of agent-based modelling.

Once the range of strategies and contexts are discovered the appropriate analysis of the single valued data should be more obvious. How people decide is complex - one either faces this or accepts one is not modelling real decision-making (so any simulation that results would be no guide to observed migration behaviour).

I suggest that the researchers expand their conclusions with consideration of a broader range of interpretations and future directions for their research (even if they ultimately decide to follow their stated path).

Is the work clearly and accurately presented and does it engage with the current literature?
Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

Are all the source data and materials underlying the results available?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Agent-based modelling, collecting data from experiments and observations

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 02 Oct 2023

Jakub Bijak

Thank you very much for these comments - we found them really insightful. We have tried incorporating them throughout the new version of the paper, changing the overall message and making it more nuanced (please see especially the new discussion in the Discussion and Conclusion section). The gist of the current argument is that, as we tried to collect quantitative information about decision processes, the approach we tried to follow was at the same time too simple for the question at hand (and for ABM applications more broadly), and too complex for carrying out a proper formal analysis from the discipline-specific point of view (experimental psychology). The answer we now propose is a two-pronged approach, where the in-depth exploration of the migration decisions has been carried out by using qualitative methods, which we indeed followed in Belabbas et al. (2022), while the immersion effect as such can be only properly analysed with carefully designed and analysed experimental tools (which is still work in progress).

Competing Interests: No competing interests were disclosed.