Moving forward in uncertainty? A serious game for validating interventions to manage uncertainty in public-private collaboration for sustainable mobility

Ruben Akse[a], Simone Ritter[a], Vincent Marchau[a], Wijnand Veeneman[b]

[a] Institute for Management Research (IMR), Radboud University Nijmegen, P.O. Box 9108, Nijmegen 6500 HK, The Netherlands

[b] Faculty of Technology, Policy and Management, Delft University of Technology, P.O. Box 5015, Delft 2600 GA, The Netherlands

Email addresses: ruben.akse@ru.nl (R. Akse), simone.ritter@ru.nl (S. Ritter), vincent.marchau@ru.nl (V. Marchau), w.w.veeneman@tudelft.nl (W. Veeneman)

Abstract:
Public and private actors who develop mobility innovations in practice often rely on control and reduce strategies when facing uncertainty. Different strategies to deal with uncertainty have been proposed in theory that are more adaptive and robust, such as joint-fact finding and other collaborative governance approaches. Question is how to stimulate actors to use these approaches in practice. This paper has evaluated the effectiveness of an intervention on mindset and synergy, to test the idea that stimulating behavioural conditions can lead to more collaborative responses to uncertainty. This intervention was evaluated in a control and intervention session of a serious game that simulates a multi-actor decision-making process of negotiating about mobility innovations for a sustainable mobility plan. Both sessions were compared in terms of negotiation process and outcome, and strategies to deal with uncertainty. We found that in both sessions actors used collaborative strategies to deal with uncertainty, but in the control session participants were also applying control strategies for their own organization to reduce uncertainty, because of the inhibiting conditions on mindset and synergy. We conclude that combing a psychological perspective with governance approaches for uncertainty is a promising way to experiment with interventions to deal with uncertainty.

Key words: Uncertainty; Risk; Serious Game; Intervention; Decision-making

1. Introduction

In the context of a transition and implementing corresponding socio-technical innovations, public and private actors must collaborate (Ansell & Gash, 2007), especially in the field of transport (Lyons & Davidson, 2016; Martens & van Weelden, 2013). Making choices under uncertainty collaboratively is part of establishing a transition towards a sustainable society (Köhler et al., 2019). Where transition research is 'relatively strong in explaining past transitions and case studies, it seems less strong in designing (practical) interventions' (Zolfagharian et al., 2019, p. 11). Such interventions are necessary though, as actors struggle with finding appropriate responses towards uncertainty, and tend to rely on control strategies via traditional project management approaches, thereby ignoring the unpredictable and unknowable nature of innovations and transitions (Akse et al., 2023) .

In the literature, a broader set of go-alone and concerted strategies for dealing with different types of uncertainty has been proposed (Dewulf & Biesbroek, 2018), ranging from improving information exchange between actors, joint fact-finding, to stimulating trusting relations. The question is how to stimulate actors to use these approaches in practice. Different methodologies have been developed in other domains to stimulate collaboration and moving forward *despite* uncertainty, ranging from psychological interventions regarding judgement and uncertainty (Mussweiler & Posten, 2012) to analytical modelling approaches for constructing adaptive policy pathways (Marchau et al., 2019). Although such methodologies are promising in itself as a way to reflect on the role of uncertainty for individuals and organizations, there is a large challenge to connect these methodologies with actual decision-making practices and find conditions that help implementing them. In other words, there is a gap to apply promising approaches in a behavioural setting that does right to the complexity of an uncertain decision-making processes.

Therefore, we built a non-digital serious game that simulates a decision-making process in a transport context, with the aim of testing a multi-layered intervention. Serious games offer great opportunities to test and play with interventions in a controlled environment (Lukosch et al., 2018; Vervoort et al., 2022). In literature, a serious game is often treated as an intervention with the aim of education and learning (Stanitsas et al., 2019). It can be a form of decision-making support so that organizations can learn about a complex environment (Mayer et al., 2016; Meijer, 2012), or be part of an intervention in the design of the decision-making process without actively intervening in the behaviour of actors (Bekius et al., 2021). In this research, we take a hybrid approach, where we use a serious game as a scientific tool to experiment with an intervention that primes participants in changing their decision-making behaviour throughout the game. The research question this paper wants to answer is: How do conditions regarding mindset and synergy-thinking stimulate or inhibit decision-making practices under uncertainty in a serious game?

2. Theoretical Framework

2.1 Actor behaviour under uncertainty

Multi-actor decision-making for innovations involves two types of uncertainty (Mayer, 2009): system uncertainty, related to the unknown physical and technical state of the system that includes an innovation, and governance uncertainty, related to the social-political issues as a result of the interactions between multiple actors who have diverging and conflicting interests. Uncertainty is not just a characteristic of a system, independent of actors' interpretation of it. However, many studies do consider uncertainty in this way (Jensen & Wu, 2016; Lyons & Marsden, 2019). The consequence of conceptualizing uncertainty in that way is that both actors and scientists look for ways to reduce uncertainty, by getting a better understanding of the

system through gaining more knowledge about that system. Uncertainty is thereby outsourced and externalized by the decision-maker, without reflecting on underlying mechanisms, causes and values and assumptions that support behavioural responses to uncertainty in the form of double-loop or triple-loop learning (Argyris & Schön, 1978; Tosey et al., 2011).

This paper separates therefore an actors' *experience* of uncertainty in the decision-making process and response to it by specific strategies of dealing with uncertainty (Akse et al., 2023). Separating these concepts enables us to pinpoint specific behavioural conditions that stimulate or inhibit specific behavioural responses to uncertainty. In other words, it opens the opportunity for a more intervention-type of thinking in complex decision-making processes, which does right to the *human* aspect of uncertainty and its interpretation by actors in the field. In the design and playing of the serious game, we have developed an intervention that builds on two behavioural building blocks: mindset and synergy. We will theoretically work out these two concepts below.

2.2 Intervention for uncertainty management

2.2.1 Mindset

Mindset plays a crucial role in how individuals and groups perceive and manage uncertainty. The interplay between mindset and uncertainty can significantly impact emotional responses and actions, for example, in the context of information processing, approach to problem-solving, willingness to collaborate, or decision-making (Dweck, 2006).

People with an open mindset, in situations of uncertainty, are more likely to embrace challenges as opportunities (Baas et al., 2011; Silvia et al., 2009). This mindset fosters a more explorative and resilient approach to uncertainty, where the focus is on what can be learned or how one can adapt rather than on the potential for failure. People with an open mindset typically view uncertainty as a puzzle to be solved, which can lead to innovative problem-solving and creative thinking (McCrae, 1987; Williams, 2004). They are more likely to engage with complexity and seek out new information to navigate uncertain situations effectively and collaboratively (Grant & Berry, 2011).

Important to realize, an open mindset is not inherently a stable personality trait; rather, it can be viewed as a dynamic state that can be actively developed and stimulated through various practices and experiences. This view aligns with the broader understanding that many aspects of our personality and behaviour can be influenced by intentional actions and environmental factors (Steg & Vlek, 2009).

Two key approaches to stimulating and cultivating an open mindset are framing and inducing a promotion focus. Framing refers to the way information is presented or structured. The frame that surrounds a set of facts can alter perceptions by highlighting specific aspects, thereby influencing how people interpret, feel about, and react to information (Tversky & Kahneman, 1974).

For instance, framing information in terms of potential gains vs. losses leads to a promotion focus vs. a prevention focus. Promotion vs. prevention focus is known to lead to different thoughts, emotions, and behaviour (Higgins, 1998). The concept of framing is extensively used in psychology, marketing, politics, and media to guide opinion and behaviours in a specific direction (Levin et al., 1998). In the current study, we induced an open mindset and a promotion focus by how we framed the title of the game as well as the role description.

2.2.2 Synergy

In addition, cooperative and synergetic approaches towards dealing with uncertainty can be found in multiple fields of literature. Actor network theory (ANT) (Latour, 2007) points at the synergies that actors can develop, by finding shared solutions for in principle unshared problems. In the interaction with the other, actors can experimentally define how they complement each other's perspective and codevelop solutions that fit those perspectives. This is described in a more normative sense in the works on network management in decision-making processes (De Bruijn & Ten Heuvelhof, 2018; Koppenjan & Klijn, 2004). Moreover, contract design and management literature suggests practical incentivization of synergies via the usage of cooperative approaches (Roumboutsos & Pantelias, 2014), for example through revenue and risk sharing. When uncertainty is coming from actor interactions with possible conflicting goals, experimental cooperation is an enabling condition for trust building and solution finding so that different goals can be part of a shared solution. Adaptive co-management and trust building are thereby key in conditions of uncertainty (Armitage et al., 2009). Collaborative multi-actor approaches emphasize synergetic thinking as a way to deal with uncertainty of innovations, as these synergies can compensate for large uncertainties. Also, actors can embrace synergies as an instrument for designing future systems. In the current study, we induced synergy thinking by how the game was introduced to the players and by adding bonus effects between different innovations.

3. Game Description

To assess the effect of a multi-layered intervention on the decision-making behaviour under uncertainty, we developed a negotiation game in which a government, a public transport company and a start-up must negotiate in multiple rounds to develop a sustainable plan for a city region. The game includes a fictive but realistic setting of dilemmas and dependencies between multiple stakeholders about deciding which innovations will be part of the plan, and under which conditions. The game is open, in a sense that players have a lot of freedom to define these conditions in line with their need to accommodate and prepare for uncertainties that are inherently part of the innovation options and negotiation process. We played the game in an intervention and a control session, to compare how different conditions leads to different decision-making behaviour and outcomes. The intervention on mindset affected the players individually, and the intervention on synergies affected the relationship between the players and the different innovation options. An overview of the game is displayed in Figure 1. We will go into more detail about the scientific set-up and interventions of the game in Section 3.2.

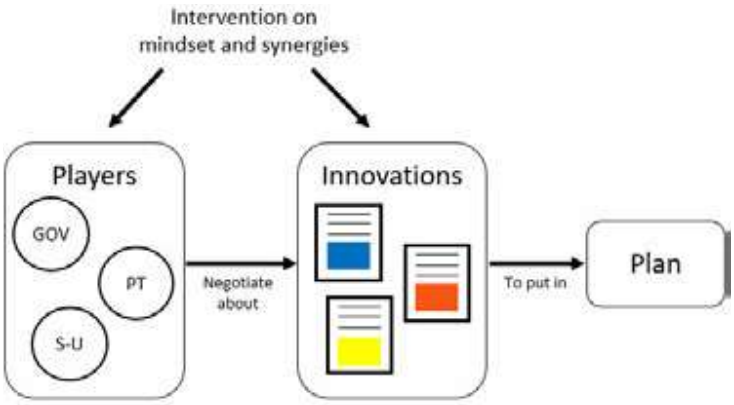


Figure 1: Overview of game, including the intervention. GOV = Government, PT = Public Transport Company, S-U = Start-up

3.1 Outline of game

The game is played in-person in a room, where the local public transport company and start-up have been called by the government to present their innovation options that could be part of the sustainable mobility plan of the government. Eventually, the practical aim of the game is to draft and negotiate a sustainable mobility plan for a city region that works towards zero emission in 2040. Previous research has described several elements that are useful for setting up a game that incorporates uncertainty. For example, Avendano-Uribe et al. (2022) have developed a serious game that allows a local community to play with uncertainty to build resilience. Uncertainty elements built in the game include role-playing cards, different scenarios, disaster dice and conflicting variables. Similarly, Schueller et al. (2020) let participants play a game to assess how uncertainty impacts the processing of information during natural disasters. Leclercq et al. (2023) developed a game-based learning workshop using role-playing activities and increasing self-awareness and reflection on participants' attitude towards uncertainty. van Schaik (2023) played two board games that include multiple roles and measures, aiming to ask participants to identify uncertainties. Other studies use digital tools, in the form of virtual reality (Hajahmadi & Marfia, 2023), or use a co-design approach to develop a game that helps make decisions under uncertainty for an ecological water system (Powell et al., 2021).

The building blocks for our game are the following:

- The transport planning context consists of a city region of about 150.000 inhabitants and is expected to grow by 20% by 2040. There are local diesel trains and buses, and intercity train station.
- Each player has multiple options in its portfolio to put into the sustainable mobility plan. These options have an expected estimated range of investment costs, realization time, emission effect and passenger revenue.
- An independent Assessment Agency provides feedback to the players by presenting the effect of the draft mobility plan regarding emission effect and passenger revenue.

A game session has the following structure:

1. Introduction of the city region, and division of roles between the players. Two participants play one role, and they read their role description and look into their budget and portfolio regarding mobility innovations. The government can pick from land-use measures such as a station renovation, densification, or bus-lanes. The public transport company has more incremental innovation measures in its portfolio such as a data-dashboard, electric buses, or on-demand transport. The start-up had more radical innovations in its portfolio, like mobility hubs, autonomous vehicles, and a drone delivery service system. A summary of the roles is given in Table 1.
2. The first negotiation round starts, and players talk about their measures and preferences
3. After a short individual reflection, players start a second round of negotiation and develop a draft plan with innovation options.
4. The independent Assessment Agency calculates the effect of the draft mobility plan. These numbers are not dependent on the players' plan and are used to put pressure on players to make a more ambitious plan. Also, three scenarios are presented to the players to stress-test their draft plan against.
5. In a final negotiation round, players can change their draft plan based on the calculations and stress-test against the three scenarios. Then, they deliver a final plan and then the game is over.

6. Individual filling in of a post-game survey and plenary de-brief regarding what went well, what could have been better and the role of uncertainty in the game.

Table 1: Players of the game

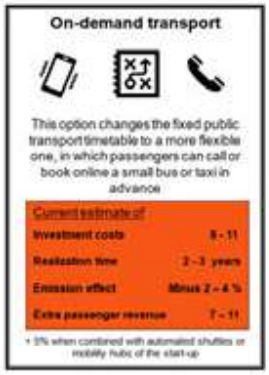
	Government	Public transport company	Start-up
Budget	50	10	5
Playing card typology	Land-use measures and station upgrade	Improving incrementally the existing public transport system	More radical innovations
Range of effect	Possibly large effect, but also high costs	Smaller effects, but lower range difference	Larger effects, but higher range difference

Uncertainty comes into the game in two ways. Firstly, the measures in the portfolio of players do not show exact estimates of the effects of each measure. Moreover, it is unknown what the total number of selected innovations does to the overall emission reduction of the mobility system. These elements refer to system uncertainty in the game. Secondly, in the negotiation rounds players do not know what options are available with other players, or how to value the estimates that other players present to them. Can they indeed rely on the numbers and narratives presented, or is the innovation overhyped? Players have the freedom to use and interpret the numbers to what they think is wise. This means they can also be overly optimistic or just lie to other players. These elements refer to governance uncertainty.

3.2 Scientific set-up of intervention

We developed two versions of the game in the form of a between-subjects design, where a control session is compared with an intervention session. The multi-layered intervention focuses on changing relevant conditions for actors (Rauws, 2017), priming them towards different decision-making behaviours. The conditions in the control session are not neutral, meaning that the difference between both sessions is just the intervention. Rather, we designed the two groups in such a way that the control session worked under inhibiting conditions for collaborative and adaptive decision-making behaviour, and the intervention session worked under stimulating conditions for collaborative and adaptive decision-making behaviour, based on theoretical insights on mindset and synergies as set out in Section 2.2. The intervention consists of two elements: (1) priming a different uncertainty mindset of promotion-focus that stimulates collaboration and (2) emphasizing synergies and design thinking between different types of innovations. An overview of how these concepts have been operationalized for the two different sessions is displayed in Table 2. A different mindset was induced by the title of the game and the given role description to players. A different synergy effect was induced by describing the aim of the game and the innovation bonuses on the playing cards.

Table 2: Operationalization of conditions in control and intervention session

	Operationalization	Control Session	Intervention Session
Mindset	Name of the game	"A safe journey to the future"	"Design the future together"
	Role description (example of government)	Pay attention: • You don't have experience with the start-up • You do not feel much support from the local alderman • You want to reduce the risks as much as possible for your organization	Pay attention: • You have successfully worked together with the start-up • You do feel much support from the local alderman • You would like to explore together to come a robust and sustainable plan
Synergy	Introducing the aim of the game	• Distribute the investment costs • With a focus on an optimum of costs and revenues	• Realize as much benefits as possible • With a focus on the other and a sustainable future
	Playing cards (example of public transport company)		

An important element in the game flow is the so-called 'stress-testing' of the draft plan by players, which involves an examination of how it would perform in different possible futures (Marchau et al., 2019). When a plan is seen to perform less well, it may prompt either a rethink of the plan or consideration whether implementation should be delayed until clearer indications how society is changing, or whether implementation should proceed with the option to scale back if change is unfavourable. Stress-testing is based on the idea of dynamic or adaptive robustness, by making adaption key in the plan formulation (Moallemi et al., 2020). Through monitoring and mid-course corrections, actors keep the system headed towards the original goals while the future unfolds. In the context of our game, we let players stress-test their draft plan against three different scenarios:

- Scenario 1: The 15-minute city has become a prominent paradigm to plan the urban system by
- Scenario 2: Current trends of higher individualized mobility and increasing travel distances by car continue
- Scenario 3: There are lower entry barriers for companies to enter the mobility market, so that there is more competition and flexibility in transport market

The purpose of the stress-testing element in the game is to trigger participants to reflect about the robustness of their plan, and whether the interventions on mindset and synergy influence

participants in the form of choosing for adaptive actions as a response to the three different scenarios.

3.3 Data gathering and analysis

We have played the control and intervention session with a mix of professionals having a background as a practitioner or scientist in the field of transport, mobility, and planning. Each role was played by a team of two persons, so that players had the opportunity to discuss and reflect within their team. To test the game, we piloted the control version of the game in three sessions with master students who had a background in geography and planning. Different authors of the paper facilitated the control and intervention session, but used the same game, session-specified presentation, and a facilitator script.

Research data has been gathered both on a content and process level. Content-wise, the sustainable plan itself has been compared in terms of cohesion. Through observations and transcribing the conversations between players, uncertainty management strategies have been retrieved and compared between the control session and the intervention session. A post-game survey asked questions about the level of uncertainty that players experienced, and the extent to which they collaborated well with other players.

4. Results

4.1 Overall impression

In both the control and intervention session, participants struggled with the uncertainties in the game in the form of unknown estimated effects of the innovations and uncertainties related to interaction with other players. In the de-briefs, participants mentioned about system uncertainty that they 'found it hard to compare two measures with each other, even when there is no different range of effects. How can I negotiate based on that, while I am not entirely sure myself?'. Participants mentioned about governance uncertainty for example that 'especially in the beginning, I was not sure what the government wanted. And I could not see all the cards, for example the parking option was a bit hidden'. Participants appreciated some elements in the game as very realistic, such as the promises made by companies about sustainable effects and the role of the Independent Assessment Agency who presented cost-benefit calculations and emission effects. Because the government had significantly more budget than the other players, they also had a strong say in both mediating and selecting innovations as part of the mobility plan, just as in practice. Some players missed an element to make a balance between long-term and short-term effects of innovations, but this can also be related to the real-life uncertainties of innovations in practice. When comparing the test sessions with planning students with the sessions with work professionals, it was striking to see that the students were highly focused on cost-effectiveness of innovations, calculations, and the division of investments between players. Participants with work experience in control and intervention session, however, acted more vision-led based on the possibilities of innovations, supported by their experience with such innovations in the work-field.

4.2 Control session versus intervention session

We will now analyse the effect of the intervention by comparing the game sessions of the control session with the intervention session, according to two categories: negotiation process and outcome, and strategies to deal with uncertainty.

4.2.1 Negotiation process and outcome

After reading their role and deciding on the strategy to go for, both the governments in the control session and the intervention session started with explaining their goals for the city. In

the control session the government only discussed their goals, and then led the PT company and start-up present their options. Then, the government presented their vision on being a 15-minute city with a strong PT backbone, which meant that that they would go for densification and an upgrade of the train station. Since these options were quite long-term, they were looking for more complementary short-term innovations by the PT company and start-up. The government was open about their budget and asked whether the companies also had money to invest into the plan. The companies did not reply directly but stated that they had some budget but extra investment from the government was necessary. The start-up presented its innovations as short-term solutions, and the PT company presented itself as a reliable partner that could provide door-to-door services in a flexible PT system. The government selected on-demand transport from the PT company as an option that links with densification, and the mobility hubs from the start-up as an option that could function as a switch between the rural areas and inner-city area. In the second negotiation round started, the government still wanted to strengthen the existing PT network, so they selected bus lanes as an option for the plan. The shared scooters option from the start-up was also selected, but only when the scooters were replaced by e-bikes in the mobility hubs. The start-up pushed for its own innovation (autonomous vehicles) though because this option had higher profit estimates. The PT company presented their real-time data dashboard as an innovation option that fitted with the demand-responsive transport option. The bus lanes were also added by the government because that was not expensive. After the calculations by the assessment agency, it became clear that the sustainability goal would not be reached by 2040. Therefore, the government asked for other options so that the goal could be reached. The options presented by the start-up (autonomous shuttles and drones) were rejected by the government because of institutional problems and lack of willingness by politicians, but the electric buses from the PT company were added to the final plan because this option gave a reliable decline of emissions.

In the intervention session, the government had a similar 15-minute vision for the city, based on the densification and train station upgrade. The government was open for options as presented by the companies and mentioned that the transport market was free to join for all without additional investments by the government. Then, the PT company and the start-up started to present their options to the government and emphasized the synergy effects of combining some of their options with other innovations. For example, the mobility on demand option was selected because it had a synergy effect with mobility hubs. And the mobility hubs were firstly selected by the government because it would fit with their vision of the 15-minute city. All players were open about their budgets. Both the PT company and start-up were pre-selecting options that they thought would be most cost-effective and fitting with the sustainability goals of the government. After some calculations made by the government, they thought there would be room for extra investments to achieve their sustainability goals. Therefore, they added shared scooters, digital twins, data analysis and parking tariffs based on the expectation that the overall designed system would have such synergy effects. These synergy benefits would outplay the initial investment costs. After the calculations by the assessment agency, it became clear to the players that more action was necessary but that no investment budget was available anymore. Therefore, a deal was made by the government to add the data dashboard along with the electric buses from the PT company, and the autonomous shuttle along with the bus lanes from the start-up. It was agreed upon that the potential extra benefits because of the expected synergies would be used to cover the extra investment costs of the innovations.

To sum up, the chosen mobility plan in the intervention contained more investments and innovations than the plan in the control session. Although in both sessions all money was spent,

the players in the intervention session agreed upon more positive estimates of costs and benefits than in the control session. Also, they used money from potential future benefits as investment money in the present. Both in the control and intention session, players looked for a balance between land-use measures and mobility measures, as well as combining long-term measures with short-term measures.

4.2.2 Effect of intervention on mindset and synergy

In the control session, players were quite hesitant to share their budget to other players. Only halfway the game, budgets were openly shared. There was quite some uncertainty and competition in the control session between the PT company and the start-up. For example, when presenting their mobility-on-demand system, the PT company said the following about the options presented by the start-up:

"We want to be reliable. I like the scooters [by the start-up], but they can also break easily. With our buses you know that things will not break. Our service is more about the first and last mile, integrated into the PT network."

The competitive language seemed to be a direct consequence of the condition on synergy that was given to the players, namely that there would be a 10 percent bonus for the individual options when combined with other options from their own portfolio. The uncertainty that was there about the options and budgets of both companies was also strategically used by the government was a way to push the companies to make sharper offers, or to challenge a company to think along with the governments' vision. The government acted here as selector and mediator of innovations, by choosing for innovations that fitted with their vision of the 15-minute city. In general, the start-up was struggling in the control session to be a partner because of the condition on mindset that described that the PT company and government did not have any prior experience with the start-up. The effect of this condition can be illustrated by the following discussion on how to distribute the investment costs of the mobility hubs:

Start-up: "If you could provide more investment in the hub as a government, we have more money available to look into something complementary to the hub, for example the digital twin"

Government: "But when we have a more qual investment in the hub, that would make you also committed to deliver these services. Otherwise there could be a tendency that you say, the hub is nice, but we do other things now."

On several moments in the control session, the government did not choose to collaborate with the start-up because 'local politicians did not like it' or because of politicians 'not willing to take a lot of risk' (as described by the conditions on mindset). In the final stage of the game, the start-up did try to sell the autonomous vehicles and drones, but this was rejected because the government expected that it would take too much time and that the innovations were too new. Here, the uncertainty of innovations influencing the short-run made the government choose for the more reliable option of the PT company.

In the intervention session, however, there was almost no competition at all between the three different players. The PT company thought along with the government by pre-selecting options that would fit their goal of sustainability, not out of self-interest. Also, the PT company and the start-up were actively looking for synergies between the different options, so that it would have the largest emission effect for the government. At first, the start-up framed the estimations for its innovation in a positive way, by referring to a maximum effect at a minimum cost. Because

the PT company was honest about the ranges of effects of innovations, the start-up chose to be open about the ranges as well, 'because we have a good-relationship with the government' as described in the intervention conditions on mindset.

Just as in the control session, the government functioned as selector and mediator in the negotiation process of innovations. But, in contrast to the control session, the players were from the beginning open to each other about their innovations, budget and were collaborative in terms of discussing how each innovation would fit with another innovation. This resulted in the end in agreeing upon a deal where potential future profits of the start-up (then: scale-up) and PT company would be used to fill the gap of initial investments in the now. This deal could be made because the government 'trusted on the good experience and expertise of the start-up'.

4.2.3 Strategies to deal with uncertainty

In comparing the control session and intervention session, we can see similar and different patterns of how players dealt with uncertainty. These patterns are displayed in Table 3.

Table 3: Observed strategies to deal with different types of uncertainties in sessions

Strategies in Control Session	Strategies in Intervention Session	For type of uncertainty
Start with a vision that links specific elements together		System and governance
Be open with other players to ask what options they have in their portfolio		Governance
Finding win-win combinations that provide synergy		System
Being closed on what to spent	Being open on what to spent	Governance
Comparing and framing with innovations of competitor	Collaborate and present options together to the government	Governance
Use optimistic scenario of innovation estimates		System
Use the average scenario of innovation estimates		System
Assuring equal investment shares as government for compliance	Willingness to fund innovations that benefit the government	Governance
Saving budget as government as robustness measure	Spending all budget to achieve the sustainable goals	Governance
Choosing based on what is familiar, institutionalized and you have experience with	Choosing based on trust and positive earlier experience	Governance
Choosing the reliable option	Choosing the option with greatest potential effect	System

We found in both sessions that the government had the lead with stating a vision, and asking the companies what they could offer for the sustainable mobility plan. Also, we found that in both sessions the government was looking for synergies, either based on their developed vision (control session) or the synergy cues on the play cards (intervention session). After the initial phase, however, we see different patterns that can be traced back to the different intervention conditions in both sessions. Where in the control session companies were more competitive, players in the intervention session actively worked together as a team. In the control session the government made explicit choices not to collaborate with the start-up based on conditions that describe bad earlier experiences and risk-averse politicians. In the intervention session, the

choice was made by the government to just experiment and trust the start-up to develop its innovations further with co-funded investments.

A final game element to compare the control and intervention session by is the reaction to the stress-testing scenarios as presented by the independent assessment agency. It was striking that in both sessions the government chose to have a 15-minute vision as a basis. It was therefore also concluded by players that this scenario would be no problem in the future. Also for the other two scenarios, players were positive about the robustness of their initial plan and did not make any changes other than adding innovations so that the sustainability goals would be reached. For example, in the intervention session it was mentioned that in the second scenario of higher individualized mobility, there would be more taxes that could be spent on enhancing the public transport system, and that individualized transport such as shared scooters could be scaled up so that demand would be met. The discussion around the measures of responding to different scenarios remained pragmatic, also because of limited time.

5. Discussion

Developing a serious game requires to create a balance between meaning, reality and playfulness for players (Harteveld et al., 2009). In general, participants found the game quite realistic in terms of collaboration dynamics between different actors, and the uncertainties of innovations that were interwoven in the game. Also, participants appreciated the calculations by the assessment agency and treated its outcome as meaningful based on the expectation that a 'true' model lied behind these calculations. The city map and the play-cards were appreciated by the participants as an engaging way to negotiate about the mobility plan. However, participants did mention that in real life different stakeholders would not talk and negotiate as open as was done in the game. In practice, governments are bounded by concessions and laws that forbids them speaking to companies in an informal way as it could lead to an uneven level playing field in terms of knowledge and information. Also, the element of political uncertainty and media dynamics was mentioned as a relevant in real-life decision-making processes that was missing in the game.

The measurement of how large the effect is on decision-making behaviour due to interventions on mindset and synergy is dependent on specific conditions such as the background and experience of players or the facilitator. However, we can still compare the control and intervention session, by viewing the serious game sessions as a form of case study research in a controlled experimental setting. We indeed found patterns that interventions on mindset and synergy lead to more collaborative strategies to deal with uncertainty by actors, as hypothesized in literature in the field of psychology (Baas et al., 2011; Grant & Berry, 2011) and public-private partnerships (Roumboutsos & Pantelias, 2014). These patterns are not occurring uniformly though. Both in the control and intervention session, players displayed the willingness to look for win-win situations and synergies. However, in the control session, inhibiting conditions made players negotiate also in a competitive way with a focus on reducing uncertainty from an individual perspective, whereas this behaviour was almost absent in the intervention session. Players in the control session were willing to negotiate together when it fitted their vision or strategy, and when this was not the case a player used the inhibiting conditions as an (opportunist) argument not to collaborate. In psychological terms, it seems that the inhibiting conditions in the control session led participants to go into a prevention focus (Higgins, 1998), while participants in both the control and intervention session also made choices based on a promotion focus. This promotion focus might be caused by a positive attitude of participants towards adaptivity and finding the best solution in the game. In the post-game survey and de-brief of the control session, participants mentioned that they acted

collaboratively and consensus-finding, while this is only half the story when looking at actual decision-making behaviour in the game. This re-call bias suggests that participants are indeed willing to look for synergies and collaboration (promotion-focus), but not at the moments when this does not fit with their own agenda or strategy (prevention-focus). In other words, they were not willing to tackle the uncertainties together in a co-development style. This had also an effect on the outcome of the game. Where in the control session all investments were neatly covered and distributed over the game, players in the intervention agreed on a plan that was more open and flexible in terms financial coverage.

A critical reviewer of this study could pose that we merely instructed players to behave differently, instead of observing different individual choices due to the intervention conditions we put them in. There are some reflections to make about this point. Firstly, we observed that players acted naturally in the game, and we saw that different frames and role descriptions were not used ad-hoc but in line with players' overall decision-making behaviour. Secondly, participants told in the de-brief that they were not aware of the interventions during the game, which makes it less probable that they merely acted by blunt following the instructions. Finally, the overall aim of the game was to put players into different settings, so that a difference could be measured between these settings. So even when players did pick up on the different instructions and acted accordingly, it would not make the outcomes of this study less valuable because it proves that specific behavioural conditions affect indeed the overall decision-making process and corresponding negotiation outcome.

It is of course the question how these results can be translated to actual decision-making practices, beyond the controlled experimental setting of a serious game. Future research could look into the application of interventions in real and ongoing cases using game-theory (Bekius et al., 2021), combined with psychological theory on mindset (Dweck, 2006). Together, such interventions could form strong behavioural triggers to inhibit responses to uncertainty based on reduce and control, and stimulate response based on collaborate and experiment (Akse et al., Forthcoming).

Another more theoretical direction for future research could investigate finding clearer relationships between stable personal attitudes, local conditions, and the display of promotion and prevention focus while dealing with uncertainty. Also, future research could look into different types of conditions and cues that might help or hinder stakeholders in making robust and adaptive plans. For example, under which conditions does the upfront mentioning of a stress-test stimulate stakeholders to make a more adaptive plan, and when triggers it stakeholders to make a more conservative plan? Further development of experimental settings could be a way forward here.

The serious game sessions were played by practitioners with a background in Dutch mobility planning, which is highly focused on consensus-finding compared to other institutional contexts (Koppenjan & de Jong, 2018). Playing the game with practitioners working in different institutional settings might provide insight in how uncertainty and interventions affect decision-making practices in for example more competitive transport markets. Such participants might have different experiences and attitudes towards uncertainty, which could alter the effectiveness of an intervention on mindset and synergy.

6. Conclusion

This game study was set up to assess the effect of interventions on multi-actor decision-making behaviour related to uncertainties. A game setting simulated the context of a government, public

transport company and a start-up negotiating about innovations to put in a sustainable mobility plan. In this setting, interventions on mindset and synergy were intended to change the behavioural conditions in which actors make decisions under uncertainty. This application of the serious game is novel, as most games on complexity and uncertainty have the aim of learning or decision-making support (Bekius et al., 2021; Leclercq et al., 2023).

We found that in both the control and intervention session, participants were willing to collaborate and look for win-win situations, but that in the control session participants were also applying control strategies for their own organization to reduce uncertainty, because of the inhibiting conditions on mindset and synergy. These responses to uncertainty made the overall negotiation process less collaborative, which led to a less flexible and open mobility plan than in the intervention session. More experimental sessions are necessary however to validate these findings.

The results of this study in a controlled setting can be used for building larger intervention and training programs in ongoing cases, to change actors' mindset, competencies, and adaptive capacity in dealing with uncertainty. Combing a psychological perspective with decision-making and governance approaches for uncertainty has proven to be a fruitful way to experiment with and test the effectiveness of interventions for collaborative approaches to deal with uncertainty.

7. References

Akse, R., Veeneman, W., Marchau, V., & Ritter, S. (2023). Governance of uncertainty in implementing mobility innovations: A comparison of two Dutch cases. *Research in Transportation Economics, 98*. doi:10.1016/j.retrec.2023.101278

Akse, R., Veeneman, W., Marchau, V., & Ritter, S. (Forthcoming). The interplay of competencies and governance settings in dealing with uncertainty: A comparison of Mobility as a Service in the Netherlands and Australia. *Futures*.

Ansell, C., & Gash, A. (2007). Collaborative Governance in Theory and Practice. *Journal of Public Administration Research and Theory, 18*(4), 543-571. doi:10.1093/jopart/mum032

Argyris, C., & Schön, D. (1978). *Organizational Learning: A Theory of Action Perspective*: Addison-Wesley Publishing Company.

Armitage, D. R., Plummer, R., Berkes, F., Arthur, R. I., Charles, A. T., Davidson-Hunt, I. J., . . . Wollenberg, E. K. (2009). Adaptive co-management for social–ecological complexity. *Frontiers in Ecology and the Environment, 7*(2), 95-102. doi:10.1890/070089

Avendano-Uribe, B., Lukosch, H., & Milke, M. (2022). Playing With Uncertainty: Facilitating Community-Based Resilience Building. *Urban Planning, 7*(2). doi:10.17645/up.v7i2.5098

Baas, M., De Dreu, C. K., & Nijstad, B. A. (2011). When prevention promotes creativity: the role of mood, regulatory focus, and regulatory closure. *J Pers Soc Psychol, 100*(5), 794-809. doi:10.1037/a0022981

Bekius, F., Meijer, S., & Thomassen, H. (2021). A Real Case Application of Game Theoretical Concepts in a Complex Decision-Making Process: Case Study ERTMS. *Group Decision and Negotiation, 31*(1), 153-185. doi:10.1007/s10726-021-09762-x

De Bruijn, H., & Ten Heuvelhof, E. (2018). *Management in Networks*. London: Routledge.

Dewulf, A., & Biesbroek, R. (2018). Nine lives of uncertainty in decision-making: strategies for dealing with uncertainty in environmental governance. *Policy and Society, 37*(4), 441-458. doi:10.1080/14494035.2018.1504484

Dweck, C. (2006). *Mindset: The New Psychology of Success*. New York: Random House.

Grant, A. M., & Berry, J. W. (2011). The Necessity of Others is The Mother of Invention: Intrinsic and Prosocial Motivations, Perspective Taking, and Creativity. *Academy of Management Journal, 54*(1), 73-96. doi:10.5465/amj.2011.59215085

Hajahmadi, S., & Marfia, G. (2023). Effects of the Uncertainty of Interpersonal Communications on Behavioral Responses of the Participants in an Immersive Virtual Reality Experience: A Usability Study. *Sensors (Basel), 23*(4). doi:10.3390/s23042148

Harteveld, C., Guimarães, R., Mayer, I. S., & Bidarra, R. (2009). Balancing Play, Meaning and Reality: The Design Philosophy of LEVEE PATROLLER. *Simulation & Gaming, 41*(3), 316-340. doi:10.1177/1046878108331237

Higgins, E. T. (1998). Promotion and prevention: Regulatory focus as a motivational principle. *Advances in Experimental Social Psychology, 30*(C), 1-46. doi:10.1016/S0065-2601(08)60381-0

Jensen, O., & Wu, X. (2016). Embracing Uncertainty in Policy-Making: The Case of the Water Sector. *Policy and Society, 35*(2). doi:10.1016/j.polsoc.2016.07.002

Köhler, J., Geels, F. W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., . . . Wells, P. (2019). An agenda for sustainability transitions research: State of the art and future directions. *Environmental Innovation and Societal Transitions, 31*, 1-32. doi:10.1016/j.eist.2019.01.004

Koppenjan, J., & de Jong, M. (2018). The introduction of public-private partnerships in the Netherlands as a case of institutional bricolage: The evolution of an Anglo-Saxon transplant in a Rhineland context. *Public Administration, 96*(1), 171-184. doi:10.1111/padm.12360

Koppenjan, J., & Klijn, E.-H. (2004). *Managing Uncertainties in Networks*. London: Routledge.

Latour, B. (2007). *Reassembling the Social: An Introduction to Actor-Network-Theory*. New York: Oxford University Press.

Leclercq, C., Martino, L., Nicolò, G., Smith, A., & Vrbos, D. (2023). Social learning on uncertainty in risk analysis – an exploratory analysis of the outcomes of an experiential game-based workshop. *Social Sciences & Humanities Open, 8*(1). doi:10.1016/j.ssaho.2023.100510

Levin, I. P., Schneider, S. L., & Gaeth, G. J. (1998). All Frames Are Not Created Equal: A Typology and Critical Analysis of Framing Effects. *Organ Behav Hum Decis Process, 76*(2), 149-188. doi:10.1006/obhd.1998.2804

Lukosch, H. K., Bekebrede, G., Kurapati, S., & Lukosch, S. G. (2018). A Scientific Foundation of Simulation Games for the Analysis and Design of Complex Systems. *Simul Gaming, 49*(3), 279-314. doi:10.1177/1046878118768858

Lyons, G., & Davidson, C. (2016). Guidance for transport planning and policymaking in the face of an uncertain future. *Transportation Research Part A: Policy and Practice, 88*, 104-116. doi:10.1016/j.tra.2016.03.012

Lyons, G., & Marsden, G. (2019). Opening out and closing down: the treatment of uncertainty in transport planning's forecasting paradigm. *Transportation, 48*(2), 595-616. doi:10.1007/s11116-019-10067-x

Marchau, V., Walker, W. E., Bloemen, P., & Popper, S. (Eds.). (2019). *Decision Making Under Deep Uncertainty - From Theory to Practice*. Cham: Springer.

Martens, K., & van Weelden, P. (2013). Decision-Making on Transport Infrastructure and Contested Information: A Critical Analysis of Three Approaches. *European Planning Studies, 22*(3), 648-666. doi:10.1080/09654313.2013.783665

Mayer, I. S. (2009). The Gaming of Policy and the Politics of Gaming: A Review. *Simulation & Gaming, 40*(6), 825-862. doi:10.1177/1046878109346456

Mayer, I. S., van Bueren, E. M., Bots, P. W. G., van der Voort, H., & Seijdel, R. (2016). Collaborative Decisionmaking for Sustainable Urban Renewal Projects: A Simulation – Gaming Approach. *Environment and Planning B: Planning and Design, 32*(3), 403-423. doi:10.1068/b31149

McCrae, R. R. (1987). Creativity, divergent thinking, and openness to experience. *Journal of Personality and Social Psychology, 52*(6), 1258-1265. doi:10.1037/0022-3514.52.6.1258

Meijer, S. (2012). Introducing Gaming Simulation in the Dutch Railways. *Procedia - Social and Behavioral Sciences, 48*, 41-51. doi:10.1016/j.sbspro.2012.06.986

Moallemi, E. A., Kwakkel, J., de Haan, F. J., & Bryan, B. A. (2020). Exploratory modeling for analyzing coupled human-natural systems under uncertainty. *Global Environmental Change, 65*. doi:10.1016/j.gloenvcha.2020.102186

Mussweiler, T., & Posten, A. C. (2012). Relatively certain! Comparative thinking reduces uncertainty. *Cognition, 122*(2), 236-240. doi:10.1016/j.cognition.2011.10.005

Powell, N., Do, T., Bachelder, S., Tattari, S., Koskiaho, J., Hjerppe, T., . . . Księżniak, M. (2021). Rethinking Decision Support Under Conditions of Irreducible Uncertainty: Co-Designing a Serious Game to Navigate Baltic Sea Nutrient Enrichment. *Society & Natural Resources, 34*(8), 1075-1092. doi:10.1080/08941920.2021.1934930

Rauws, W. (2017). Embracing Uncertainty Without Abandoning Planning. *disP - The Planning Review, 53*(1), 32-45. doi:10.1080/02513625.2017.1316539

Roumboutsos, A., & Pantelias, A. (2014). Allocating Revenue Risk in Transport Infrastructure Public Private Partnership Projects: How it Matters. *Transport Reviews, 35*(2), 183-203. doi:10.1080/01441647.2014.988306

Schueller, L., Booth, L., Fleming, K., & Abad, J. (2020). Using serious gaming to explore how uncertainty affects stakeholder decision-making across the science-policy divide during disasters. *International Journal of Disaster Risk Reduction, 51*, 101802. doi:10.1016/j.ijdrr.2020.101802

Silvia, P. J., Nusbaum, E. C., Berg, C., Martin, C., & O'Connor, A. (2009). Openness to experience, plasticity, and creativity: Exploring lower-order, high-order, and interactive effects. *Journal of Research in Personality, 43*(6), 1087-1090. doi:10.1016/j.jrp.2009.04.015

Stanitsas, M., Kirytopoulos, K., & Vareilles, E. (2019). Facilitating sustainability transition through serious games: A systematic literature review. *Journal of Cleaner Production, 208*, 924-936. doi:10.1016/j.jclepro.2018.10.157

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology, 29*(3), 309-317. doi:10.1016/j.jenvp.2008.10.004

Tosey, P., Visser, M., & Saunders, M. N. K. (2011). The origins and conceptualizations of 'triple-loop' learning: A critical review. *Management Learning, 43*(3), 291-307. doi:10.1177/1350507611426239

Tversky, A., & Kahneman, D. (1974). Judgment under Uncertainty: Heuristics and Biases. *Science, 185*(4157), 1124-1131. doi:10.1126/science.185.4157.1124

van Schaik, F. (2023). What happens if …? Uncertainty in games and climate change education. *Environmental Education Research, 29*(12), 1891-1910. doi:10.1080/13504622.2023.2225811

Vervoort, J., Mangnus, A., McGreevy, S., Ota, K., Thompson, K., Rupprecht, C., . . . Kobayashi, M. (2022). Unlocking the potential of gaming for anticipatory governance. *Earth System Governance, 11*. doi:10.1016/j.esg.2021.100130

Williams, S. D. (2004). Personality, attitude, and leader influences on divergent thinking and creativity in organizations. *European Journal of Innovation Management, 7*(3), 187-204. doi:10.1108/14601060410549883

Zolfagharian, M., Walrave, B., Raven, R., & Romme, A. G. L. (2019). Studying transitions: Past, present, and future. *Research Policy, 48*(9). doi:10.1016/j.respol.2019.04.012