Designing engaging computer based simulation games for increasing societal resilience to payment system disruptions

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ABSTRACT

Large or lengthy disruptions to the card payment system are threats that can cause crisis in society, especially in countries where other payment options are scarce. This paper presents a study that provides suggestions on how to improve a simulation game used to increase societal resilience to payment system disruptions. Questionnaires and interviews have been used to investigate how 16 participant in crisis exercises experience realism, relevance and validity in such exercises. Suggestions on how to improve the simulation game are provided, such as improvements to the graphical interface and introducing supporting roles from the exercise management.

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CCS Concepts

• Software and its engineering→Software design engineering

Keywords

Simulator design; Crisis response; Critical infrastructure; Resilience; Payment system

1. INTRODUCTION

Sweden is one of the most "digitalized" countries in Europe according to the DESI index[1]. In Sweden, more than 80% of all payments are made by debit or credit card[2]. Many stores even refuse to accept cash payment. There are other means for payment, for example smartphone-based solutions, but these are not widely accepted at petrol stations, pharmacies, restaurants or supermarkets. What would you do, living in such a society, if you could not pay with your debit or credit card for ten days?[3] Would you have enough resources such as cash, fuel or food for you and your family? What societal services are you dependent on? This scenario is

[1] https://ec.europa.eu/digital-single-market/en/desi accessed at 2019-09-20

[2] Statistics from 2018, analysed by the Swedish Riksbank, see https://www.riksbank.se/globalassets/media/statistik/betalningsstatistik/2018/payments-patterns-in-sweden-2018.pdf

[3] There are several reports of such disruptions in the card payment system, although the duration of the disruptions were shorter than ten days. See for example (all accessed on 2019-10-17):

https://www.bbc.co.uk/news/business-44335804

https://www.thesun.co.uk/news/6766131/mastercard-down-issues-card-payments-uk/

https://www.huffpost.com/entry/black-friday-macys-credit-card-crash_n_5a186a87e4b0cee6c04f8e64?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAIb-SVWyntgzO7jMKcQPtM-SkffLho_bB-2X0bltH1EWnOwseiVBmjRxeY-ymXNTvcv_0_dfG9AZN4bwGds4BeljmO45NR_J7e82cbn48XLX8EOJwtYvKG1Onaf3dazPo5ARpbcuH_pBlVqvRBjk_NwkEdaMsdDSQCRe1WC0UUou

studied on a societal level in a project called Creating Collaborative Resilience Awareness, Analysis and Action for Finance, Food and Fuel Systems in INteractive Games (CCRAAAFFFTING) and is the context of this study [1]. CCRAAAFFFTING is a project that studies resilience, the ability to handle sudden crises and recover in the aftermaths of events, by a set of games where participants from different private and public sectors participate in a simulation game where they role-play that they have the control over a society during a ten days disruption in the payment system. The society in crisis is simulated, where outcomes from the simulation game is presented to the participants in form of graphs and changes in simulated stores inventories. Assessments of workload, team trust, perceived complexity, shared understanding etc. are performed during the exercises. An analysis of observations made during the exercises reveal that the participants mainly are making assumptions of the society rather than checking what is actually true according to the simulation that is serving the participants data [2] a fact that is believed to hamper the resilience of the crisis response team. The participants in the simulation games do not show the ability to monitor ongoing events, i.e., to be able to detect and take actions based on discoveries of events. This ability (to monitor the crisis) has been pointed out as essential to be resilient by several authors [3], [4], [5]. Having participants engage in monitoring activities during the simulation games is thus an explicit purpose of conducting the games in the first place [6]. Jaber et al. [7] suggest two reasons for the lack of observations of the monitoring ability, the first reason originating in the behaviour of the participants, and the second reason concerns how the game is designed and conducted.

This paper examines explanations for the lack of observations of the monitoring behaviour by exploring the participants experiences of the games. This understanding of the participants' view of the games is going to be used to propose how to further develop the visualisations of the simulation. This is to support the participants in behaving more resilient. In a longer perspective the goal is to increase societal resilience towards disruptions in the payment system by enhancing the training environment.

1.1 The CCRAAAFFFTING project

The CCRAAAFFFTING project is a five-year project funded by the Swedish Civil Contingencies Agency (MSB), initiated in 2016. The project has three areas of interest: understanding resilience, developing computer based simulation gaming exercises, and measuring collective actions for coping with disruptions in the payment system [1]. The goal is to create insight into what kinds of consequences a breakdown in the payment system could have, to develop a simulation environment that enables participants to increase their understanding on their actions' impact in such an event, to develop understanding of resilience, and to measure the quality of the identified collective action patterns. Simulation supported crisis management exercises are undertaken where people from retail shops, gas stations, and banks roleplay a scenario where the payment systems cease to function for a long period.

The purpose of this paper is to provide suggestions on how to present information from the simulation environment utilized in the crisis exercises. The aim is to engage the participants in monitoring critical information during the crisis exercise as this is one of the core capabilities of a resilient crisis management team.

The research questions are as follows:

- *How do the participants of the CCRAAAFFFTING simulation exercise understand the presented information?*
- *How can the information from the simulation environment be presented in order to engage the participants in monitoring strategies during the exercises?*

The research questions are examined through qualitative interviews with participants from three of the CCRAAAFFFTING exercises. Thematic analysis of the interviews, supported by quantitative measures from a questionnaire answered by the participants in these exercises of the study was the qualitative analysis starting point.

2. THEORETICAL BACKGROUND

The ability to uphold fundamental business functions (to keep providing goods and do transactions) is often referred to as "business contingencies" or "resilience". Literature describes the payment system as an "inverted pyramid". The top of the inverted pyramid reflects the broad base of economic actors whose daily activity in the market economy gives rise to payment obligations. This base of economic actors consists of individuals who use retail payment services provided by banks, and a variety of business enterprises in the goods and service industries. The next level includes very specialized firms, such as brokers and dealers, involved in the money, capital and commodities market, which also rely on bank payment services [8]. Basole and Rouse [9] look at how service value can be created in a network context and how the structure and dynamics of the network, as well as customer expectations, influence the complexity of the service eco system. Their approach aims to describe the nature, delivery and exchange of service value, and direct and indirect relationships between value network actors, as in the payment system.

Resilience is a systemic approach to understand how systems critical to society, such as industry, infrastructure, finance, or ecology, can absorb changes or disturbances and still persist [10], [11], [4], [5]. The financial system is surprisingly robust when considered over a longer time-period, but it is sensitive to local or short-term disruptions which at times have proven to cause severe cascading effects that have an impact even on a global level. Improving resilience of the financial system, or parts thereof such as the payment system, is therefore of great importance to society.

A crisis event is rarely handled by a single individual. Depending on the type of crisis there may exist prepared structures for coping with the crisis, such as professional crisis response organisations. However, other types of events may occur where there are no prepared measures for coping. In such cases, an ad-hoc team of actors usually handles the crisis event. A team is "a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and valued goal/object/mission, who have each been assigned specific roles or functions to perform, and who have a limited life span of membership" [12]. An ad-hoc team is a temporarily organized team where members are included because of their organizational background and experiences, and where team members might not have met prior to being part of the ad-hoc team. For the purpose of handling a crisis situation, these teams are often formed rapidly to deal with a difficult and complex situation in the short-term. In an educational context, ad hoc learning-teams develop by proceeding through stages [13]. To assess learning it is important to define criteria that relate to concepts important for the team task. Berlin and Carlström [14] showed that by strengthening the collaborative components of exercises, the participants' perception of actual emergency work can be advanced. Dillenbourg [15] explore the definition of collaborative learning that two or more persons are learning together. Collaborative learning is not one single mechanism or method. When learning together individual learning

mechanisms are triggered. The collaboration generates activities such as explanations and disagreements that trigger cognitive activity; internalisation and reduction of cognitive load. Schwartz, Tsang and Blair [16] describe listening and sharing as a cornerstone in collaborative learning.

In relation to resilience of the payment system, few simulation-based approaches for supporting collaborative learning or resilient behaviours have been reported in the literature focusing on the banking sector, thus not integrating interaction with the fuel and food sectors. Bedford et al. [17] use a simulation framework for assessing the worst-case impact of operational incidents in large-value payment systems where a typical incident is the inability of one part to send and receive payments. In their study, the liquidity of the banks is simulated through transaction delay factors which increase in the case of liquidity drops. Another approach is presented in Galbiati and Soramäki [18], modelling banks as agents in a multi-agent system simulating how these banks, as artificial decision makers, minimize their own costs due to delays and liquidity acquisition resulting in game-theoretic equilibriums. The CCRAAAFFFTING project is to our knowledge the first project to simulate both food, fuel, and finance as a basis for simulation gaming exercises with stakeholder participants.

2.1 Fundamental resilience functions

The Systemic Resilience Model (SyRes) is a resilience model that combines the contradictions of definitions into one cohesive model suggested by Lundberg and Johansson [5]. The systemic feature of the model is the focus on the constraints emerging from the system, defined as an open sociotechnical system defined by its core goals.

The SyRes model consists of four areas: *event-based constraints*, *functional dependencies*, *adjustment of capabilities*, and *strategy* [5]. The core area of the model is the *functional dependencies* which consists of the fundamental resilience functions, or the functional dependencies, needed in order to exhibit adaptive behaviour. The *event-based constraints* area consists of the reasons why the system needs to adapt. The *strategy* area consists of the manifestations of the functions that the system adapts in order to cope with the event. The system also needs to adapt its own functions, which is made in the *adjustment of capabilities* by adjusting and establishing capabilities. The fundamental resilience functions are *anticipation*, *monitoring*, *responding*, *recovery*, *learning and self-monitoring*. The *anticipation* function refers to event detection, to be able to take action, or reason about the potential development of a situation, based on a prediction of an event. This function depends on the nature of the event, if it is a regular, irregular or unexampled event [19]. The *monitoring* function refers to being able to detect and act based on the discovery of an event. Monitoring efforts are guided by the anticipation function, as expectations guide where and for what the participants will look. The *responding* function concerns the ability to act during an event, to detect the direct effects of an event. To adjust to the present circumstances, and either bounce back or go forward to a new state. The *learning* function refers to the adjustment of the system after an event, and this function feeds into the *self-monitoring* function at the centre of the model. This function serves to adjust all the other functions continuously guided by self-reflection about whether or not previous actions and organization of work has been appropriate to cope with the situation at hand [5].

In the context of this paper, it is the manifestation of these functions, i.e. the strategies developed, or suggested, by stakeholders depending on the payment systems that are of interest. A lack of strategies corresponding to the core resilience functions (Anticipating, Monitoring, Responding, Recovery, and Learning) indicate a potential lack of resilience, and hence capability to detect and cope with disturbance in the payment system. As pointed out above, an earlier study has shown that participants in the simulation gaming exercise fail to monitor the development of the situation they are to cope with [7]. Participants generally focus on discussing what could happen or what they believe is happening, hence the anticipation function.

2.2 The simulation gaming exercises

The data collection, which is part of the planned 30 simulation gaming exercises to be conducted within the CCRAAAFFFTING project, so far consists of 15 runs. Each participating team was composed of 6-8 participants from representative businesses, authorities and public organizations. The teams are not identical in terms of what competencies that participated, but they all comprise participants from relevant stakeholders, such as store managers, municipality crisis response personnel, police, petrol station managers, bankers etc. The simulation runs on the AnyLogic™ platform. The model uses a Geographic Information System (GIS) to visualize the locations of food stores, gas stations and ATMs in a region that covers four municipalities in the southern part of Sweden. The total population for the modelled region is 440,000 citizens. Typical shopping behaviour is modelled based on available statistics from SCB (Statistics Sweden) and estimates made by the modelling team [1]. The scenario used describes a disruption in the payment system where card payments go down for ten days. The population at large have no preparedness for a breakdown in the card payment system [20] and the amount of money available in ATMs is not sufficient to support a situation where all citizens needs to pay all their expenses with cash. During game play, the participants are placed around a conference table and are asked to do their best to cope with the payment disruption scenario. At all times, the participants have the possibility to ask questions about the current state of affairs in the simulated environment, or ask the exercise leader about the status of different parameters in the simulation (see Figure 1).

Figure 1. Simulation game session. The participants are positioned around a conference table. Information about the current situation in the simulation is projected on a large screen [7].

As pointed out, this rarely happens. Jaber et al. [7] shows that participants actively look for, or ask for, information about the current situation. This occurs in less than 3% of all observed resilience-related behaviours (three independent observers, averaged observations). The outcomes of the simulation gaming exercises have been analysed from several different perspectives, presented previously [20], [7].

3. METHOD

In order to answer the two research questions *How do the participants of the CCRAAAFFFTING simulation exercise understand the presented information?* and *How can the information from the simulation environment be presented in order to engage the participants in monitoring strategies during the exercises?* this study applied two methods; questionnaires and interviews. The questionnaire was administered after the simulation gaming exercise and included ten statements the participants were asked to rate on a scale from 1-7 (ranging from *not at all* to *very much*).

The interviews were conducted by one of the authors of the present paper. According to Howitt [21] qualitative interviewing involves questions and probes to encourage free and extensive discussion about the topic(s) of the research. The aim of qualitative interviews is to generate extensive and rich data from participants in the study. The interviews conducted in this study were semi-structured and mostly conducted over telephone. All interviews were recorded. A thematic analysis was conducted on the recorded material. Braun and Clarke [22] describe thematic analysis as a flexible and useful research tool for analysing qualitative data. It is a way of identifying, analysing, and reporting patterns (themes) within data. Clarity about the process is vital because of the variations of usage, and the active and vital role of the researcher. The first step described by Braun and Clarke [22] is the coding, where the researcher is to give full and equal attention to each data item. The second step is to find themes in the codes by sorting them and defining their relations. The third step is to review the identified themes. The fourth step is to define and name the themes. The final step is to produce a report and choose examples, the narrative need to go beyond the description of the data and make an argument in relation to the research question.

3.1 Participants

21 participants replied to the questionnaire. Out of these 21, 16 participants stated their interest in being interviewed and 10 completed the interviews. The participants were recruited from the simulation games where the purpose of the interviews was explained. Those who expressed interest in participating were asked to provide their phone numbers and which kind of actor they represented. The participants were contacted within two weeks after the exercise. One participant was interviewed in person directly after the exercise due to his/her preference.

The participants that completed the interview represented local municipality, healthcare, the food or fuel sector, cash services, police, and bank.

3.2 Analysis

The data from the questionnaire was analysed using the mean values. Four answers from the last statement were lost due to technical issues. The results were used to support the thematic analysis.

The initial analysis of the interviews was made during the interviews, when the interviewer took notes on a laptop. The analysis was made with aid from the notes, the memory of the interviewer and the recording if something was unclear.

First the interviews were transcribed and important statements were highlighted, with proposed codes written on the side. The statements were then sorted, and then resorted into themes. In the description of the themes the number of codes was taken into consideration, words used to describe the amount of participants having a similar code were "several" (approximately or more than five), "some" (approximately five to three) or a certain number was used if it was less than three participants.

4. RESULTS

First, the results from the questionnaire are presented, and then the themes found in the thematic analysis are presented.

4.1 Questionnaires

The participants were asked to grade 10 statements (1-7, where 1= disagree completely and 7= agree completely) (Table 1).

Table 1. The statements and their means.

Nr	Statement (1-7)	M (n)
1	I experienced the game as a whole realistic	5,5 (n=21)
2	I experienced the information on the projections to be realistic	5,5 (n=21)
3	I experienced the information on the projections to be well structured	5,1 (n=21)
4	I experienced the scenario to be realistic	5,6 (n=21)
5	I experienced that I played my role realistic	5,6 (n=21).
6	I felt involved in the exercise	6,2 (n=21)
7	I believe that the exercise is important	6,7 (n=21)
8	I have experience from similar role-playing exercises	3,0 (n=21)
9	It has been rewarding for me to participate in this exercise	6,6 (n=21)
10	After the games I got meaningful feedback	6,0 (n=17)

The outcome of the questionnaire reveals that the participants felt the exercise was both meaningful and engaging (questions 6, 7, 9 & 10). Simulation realism was judged as fairly high (questions 1, 2, & 4), but it should be noted that observations of participant behaviour and actions suggest that most participants actually does not use the available information during the games [7]. However, the participants were aware of what kind of information that was available and did at some points during the sessions look at the screen, although in most cases this occurred during pre-game briefings or de-briefings after the game.

4.2 Interviews

The analysis identified five main themes in the interviews. The themes describe how the participants experienced the games. The main themes are *the crisis*, *the society that is handling the crisis*, *the exercise's relation to reality*, *the importance of the group*, and *how the context of the exercise support the interpretation of what is simulated*. In this paper, we will only report findings related to the themes *The exercise's relation to reality*, and *the context of the exercise support the interpretation of what is simulated* as these themes reflect aspects of the simulation that are relevant for the development of the simulation gaming exercises and thus provide input to answering the research questions posted in this paper.

Figure. 2. The main themes and subthemes.

4.2.1 Realism of the simulation

The theme *The Game's Relation to Reality* consists of two subthemes; *The realistic exercise* and *The uncertainty of the real situation*.

The first subtheme considers what role the reality has on the exercise and what effect the exercise has, or could have on reality. *The realistic exercise* is a subtheme that considers how worthwhile the exercise is, how realistic the exercise is, and that there is a desire of stress in the exercise .

Several participants expressed that the exercise was worthwhile, fun, interesting, inspiring and has potential. Some stated that they would like to continue working with similar exercises or questions, and some have already continued working with these questions. One participant desired a preparatory lesson about the payment system and its actors in the exercise, and the same person also asks for a pamphlet with a collection of advice on how to handle a situation like this in reality.

The participants have different opinions about whether they experience that the scenario is realistic. Several participants expressed that the simulation created a feeling of realism in the sense that it added identification and depth. Some participants experienced that some things did not match up, such as the way the simulation reflects the usage of alternative payment methods or the feedback given by the exercise leader.

The uncertainty of the real situation is a subtheme that concerns several dimensions: that the real situation would be more difficult, the desire of facts in this kind of situations, that it is important to dare to act, and that there are no right or wrong answers.

The participants experienced a difference in terms of the difficulty in acting in a real situation and acting in the exercise. One participant said that a real situation would have been more difficult, and another stated that the simulation was unrealistic, suggesting that it was easier to make decisions without all the facts. Another participant stated that in a real situation you would have been working with facts more than they did. Further, one participant said that decisions are easy to make but difficult to implement. Some participants desired facts, like real statistics of the payment system and also facts about the current situation in the simulation. This is somewhat surprising as all information in the simulation was available to the participants. The statements may reflect the fact that some participants have difficulties interpreting the information displayed by the simulation.

The participants highlighted the importance of daring to act. One participant stated that it is always difficult to make decisions, but some stated the importance to still make quick decisions. Another said that it is important that there is no fear when you are in a leading position. To get the information about the simulated society with the simulation and the news posters (used as props by the exercise management) was adding a feeling of a crisis and a pressure to act according to one of the participants.

4.2.2 The ability to interpret what is happening in the simulation

The main theme *How the context of the exercise support the interpretation of what is simulated* three the subthemes *the provision of input*, *the layout of the simulation*, and *the simulation's contribution*.

The subtheme *the provision of input* illustrates how the simulation showed the effects of actions taken by the participants. Participants stated that the simulation showed the cause and effect of their actions, providing feedback about whether their actions were right or wrong. Rapid feedback was appreciated and seem to have served as a basis for improved decision making.

The subtheme of *the layout of the simulation* concerns the visualization of the simulation, and the participants lacking understanding of the simulation.

The participants had some thoughts about the visualization of simulation. One participant said that the simulation was equal to the graphs shown to them. There were some participants that had additional thoughts on how to improve the visualizations. Two said that they wanted more pictures, one asked for a longer exercise in order to be able to learn how to understand the visualization. There were also some positive feelings about the simulation; two stated the importance of the visualisation, and one said that the simulation was graphically nice. One person felt that the simulation could as well have been still pictures and that it did not contribute very much. One problem with the interaction with the simulation that was mentioned by one participant was that they did not know the original states of, for example, how many stores that could offer alternative payment methods from the start and thus did not know if their suggestions were realistic or not.

The contribution of the simulation subtheme considers both the aspects of the simulation that had a positive impact and contributed to the games, as well as aspects that did not contribute. Several participants stated that the simulation had a positive impact. One participant said that the simulation was the main part of the simulation game, one said that the simulation was a good tool, another said that the simulation helped, and another said that

without the simulation the games would have been extremely theoretical.

There were also several participants that thought that the simulation did not contribute. One person said that the simulation happened at the side of the game, and another said that it was as a coulisse. One person said that he/she did not learn anything from the information they got from the simulation. There were some participants that stated that the main purpose of the simulation was not for the participants but for other reasons. Two participants stated that the simulator was needed for the game, one said that the project wanted to see the effects of the participant's decisions, and another believed that without the simulation the exercise leader "could have made everything up".

5. DISCUSSION AND CONCLUSIONS

In the light of the experiences of the participants, some suggestions about possible alterations to the current simulation design can be made in order to encourage the participants to engage in monitoring activities during the simulation games. The participants said that the simulation showed effects of their actions. This should be a potential for the participants to want to monitor the simulation to find the effects of their actions. To support this, the participants actions could be visualised as a part of the simulation on some sort of timeline [23].

- The simulation needs to be centred, simplified and made more available to the participants.
- The simulation could be made more available to the participants by making the manipulations more apparent and available to the participants.
- One quick fix would be to use a role played by the project that has the role of a "statistician" who explain the simulation when the participants ask for information.
- A graphical representation of the overall payment system, its actors and the groups, might support the participants in sharing and understanding the actors of the payment system, and the effects their actions has on them, as well as the participants ability to monitor the changes.
- In order to support the impression that the simulation shows effect of the action, the actions could be visualised on a timeline.

Learning how collaborate in order to cope with disruptions in the payment system in a resilient way is a novel field of research that benefit from using simulation games. Gathering participant experience with the purpose of improving such simulations is thus an important effort. This paper has provided some initial suggestions on how to improve the simulation utilized in the CCRRRAAAFFTING project.

6. ACKNOWLEDGMENTS

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