Personalized Crisis Management Training on a Tablet

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ABSTRACT

In this paper, we propose a framework for personalised crisis management training through the use of an applied game. The framework particularly focuses on ubiquitously assessing and manipulating player stress levels during training, and evaluating player performance by providing personalised feedback. To achieve these goals, the framework leverages techniques for multi-modal player modeling through physiological sensors, in-game events and self-report data. Specifically, the present paper (1) discusses design decisions for the personalised crisis management training framework, and (2) presents the game prototype with which user-studies will be performed. Presently, the game prototype is being developed in close collaboration with actual crisis management experts.

CCS CONCEPTS

• **Human-centered computing → HCI theory, concepts and models**; • **Applied computing → Interactive learning environments**;

KEYWORDS

Game-based training, personalized gaming, serious games, multi-modal player modeling, crisis management

ACM Reference format:
Paris Mavromoustakos-Blom, Sander Bakkes, and Pieter Spronck. 2018. Personalized Crisis Management Training on a Tablet. In *Proceedings of Foundations of Digital Games 2018, Malmö, Sweden, August 7–10, 2018 (FDG18),* 10 pages.
https://doi.org/10.1145/3235765.3235771

1 INTRODUCTION

Game-based training [19] is a field that throughout the years has grown in impact and public adoption. Particularly for the domain of safety administration (e.g., Bacon et. al. [4]), there are clear benefits for being able to train in controlled environments [22, 29, 37]. What is more, personalisation of the training process can be expected to further enhance the efficacy of the presented training [22].

However, traditional crisis management training methods generally do not succeed in inducing stress onto trainees –as may be expected in real-life crises– [5]. Training sessions revolve around simulating a real-life crisis situation and are mostly focused on team-level communication, collaboration and problem solving. Thus, performance evaluation is also provided at team-level, while trainees receive very limited feedback on the development of their individual decision making skills and personal performance.

Our proposed crisis management training framework, aims at addressing the aforementioned issues. We designed a crisis management training game which allows trainees to individually train on the efficiency of their decision making under severe time constraints and high cognitive load. Real-life crisis situations (such as floods, accidents, etc.) are simulated as in-game scenarios. In order to obtain an estimate of player affective states, we enable player modeling through physiological measurements, in-game data and self-reports. Furthermore, our game's components are designed to be adaptable, so that adjustments made during gameplay may influence player stress levels, and provide individual-level feedback.

The crisis management training game discussed in this paper is currently under development, in close collaboration with Veiligheidsregio Twente (VRT), the local security association of the Twente area in the Netherlands. It is part of the Data2Game project, which investigates how, and to what extent, the efficacy of computerised training games can be enhanced by tailoring the training scenarios to the individual player. The game will be supplementary to the existing crisis management training scheme, to which it contributes through personalised feedback, dynamic content adaptation and individual performance monitoring. In the following sections, we first present related studies in the fields of affective computing, multi-modal player modeling, game personalisation and game-based training, in the context of crisis management training through applied games in particular. Next, we discuss the main game design principles, and describe the framework of a personalised crisis management training game, which will ultimately be employed to train the VRT.

2 RELATED WORK

Here we discuss how our design decisions relate to (and expand on) findings in the fields of affective computing, multi-modal player modeling, game personalization and game-based training.

2.1 Affective Computing

Affective computing refers to computing that relates to, arises from, or influences emotions [21]. Detection of human emotions is becoming an essential tool in human-computer interaction, while multiple ways of detecting, identifying and inducing human emotion have been investigated.

In order to implement an effective personalised crisis management game, we employ certain findings in the field of affective computing. In particular, we are interested in physiological sensor data analysis in order to extract information on player affect. Our goal is to correlate player self-reports and in-game measurements

FDG18, August 7–10, 2018, Malmö, Sweden

ACM ISBN 978-1-4503-6571-0/18/08…$15.00
https://doi.org/10.1145/3235765.3235771

with physiological sensor data, in order to enable player modeling even when physiological sensors are not available. Furthermore, we expand on the below mentioned studies by designing a game that will not only predict player stress levels, but also employ these estimations to generate personalised training scenarios.

Physiological sensors are increasing in popularity, as they are capable of providing measurements of player affect [3, 15, 20, 42, 43]. In our research, physiological sensors are employed in order to measure player arousal, commonly described as stress. Ideally, to create a personalised training environment, we aim at influencing player stress levels during gameplay, through adaptable game components. In order to achieve that, an accurate estimate of player stress levels must be extracted through physiological sensor data.

Mandryk et. al. [23] present a study where objective measurements of player affective state (as extracted from physiological sensors) are correlated to subjective measurements (as ranked by participants), during video game playing sessions. In more detail, they interviewed participants and asked them to rate different conditions of the same video game in terms of challenge, excitement, boredom and fun. Player ratings were correlated to physiological data extracted from Respiratory, Electromyography, Heart rate and Galvanic Skin Response sensors, showing that physiological results are mirrored in players' subjective scores.

2.2 Multi-modal player modeling

Player modeling includes the detection, modeling, prediction and expression of human player characteristics which are manifested through cognitive, affective and behavioral patterns in games [44]. Relevant studies have investigated how multiple modalities can be leveraged to create accurate player models [18, 27]. Yannakakis et. al. provide an overview and describe the key components of player models [44].

Player modeling is a crucial part of personalised crisis management personalisation. A player model built on multiple modalities enables player affective state estimation, based on which, game personalisation will be applied. To build an accurate model of player affect, we need to (1) define the model's desired output and (2) define a dataset of accurate descriptors as model features. Below, we present relevant studies which propose methods of processing and combining affective input data to build user models.

Bailenson et. al. [6] propose three types of models to classify emotions (amusement and sadness), using facial feature tracking and physiological response data. First, a "universal" model, trained on multiple subjects and aimed at interfaces with multiple users (such as public computers). Second, an "idiosyncratic" model which uses data extracted from a single subject, to classify unknown instances of the same subject. Lastly, a gender-specific model that is aimed at classifying instances exctracted from subjects of one particular gender. Since we aim at developing a personalised game used by crisis management staff on an individual level, the "idiosyncratic" approach is relevant to our study. Bailenson et. al. report an increase up to 50% in emotion classification accuracy when using the "idiosyncratic" model instead of the "universal" one. Also, improvement is detected in all models' performance when physiological measurements are added as a feature along with facial feature tracking data.

Holmgård et. al. [17] investigate the potential of multi-modal modeling methods towards detecting severity and type of PTSD through a simulation game. Their experiments mainly focused on player physiological responses, employing two modalities: Blood Volume Pressure (BVP) and Skin Conductance (SC). Participants were also asked for self-reports on experienced stress level. Results presented show that both SC and BVP levels during game sessions are correlated to diagnosed PTSD severity, while specific SC-based features and BVP-based features are also correlated to patients' self-reports. Lastly, they run a Principal Component Analysis to reduce the initial number of features into two distinct components. In our research, we aim to apply similar methods to accurately model player stress levels, through Photoplethysmography (PPG) and SC sensor data. We will further involve in-game measurements and correlate these to physiological sensor data and player self reports, in an attempt to enable player stress estimation through detection of player interaction patterns.

Bacon et. al. [4] propose player behavioral modeling in game-based crisis management training, by defining key "affective factors" that play a role in decision making in a crisis situation. Such factors include personality traits, leadership style, background experience, self-efficacy, stress and anxiety. Crisis scenario progress is dynamically adapted based on a constantly updated player model, which also relies on frequent player self-reports. In this study, we aim to adopt a similar approach, by constantly updating a player model and dynamically adapting game content based on it.

2.3 Game Personalization

In order to provide each member of the crisis management staff with an effective training tool, tailored to their behavioral competencies, game personalization methods need to be employed. A personalised game is a game that utilises player models for the purpose of tailoring the game experience to the individual player [7].

Game personalisation has been achieved in multiple ways, such as personalised content generation [8, 39], and narrative adaptation [25, 30, 36]. We refer readers to Bakkes et. al. [7] for an extensive literature study on personalized gaming.

Through game personalisation, we aim to dynamically adapt training scenarios in order to influence player affective state. Since our proposed game is mostly text-based, game personalisation will rely on adaptation of game text. While this may be interpreted as narrative adaptation, in fact, the game engine will be modeling player affective state, and adjusting in-game "difficulty" (game-induced stress level) based the underlying player model.

Narrative adaptation enables players to make decisions that directly affect the direction and/or outcome of the narrative experience being delivered by the computer system [31]. A study on narrative adaptation has been presented by Riedl et. al. [30] where the in-game narrative is revised according to user actions, in order to accomodate player expectations. In our concept, narrative adaptation is enabled through adaptable scenario, decision and NPC related texts. We aim to minimise scenario "linearity", e.g. generate narratives during gameplay based on previous player decisions, instead of pre-defining scenario components.

Game-based simulation applications have been employed in order to assist crisis management training [35, 37]. Polese et. al. [28] conducted a study on "Cascading Effects Scenarios", where in-game "incidents" follow a probablistic transition matrix; the probability of an in-game event's appearance is based on previously triggered events. This approach implies that crisis scenarios are generated during actual gameplay. Similarly, in our research, we aim to dynamically adapt the training scenarios' texts based on previous player decisions.

2.4 Game-based Training

The use of gamification in learning and/or training applications has been adopted in many fields, including education (refer to Girard et. al. [14] for an extensive study on serious games as educational tools), crisis management training [4, 9, 34, 35] and training of behavioral competencies such as leadership [29], stress management [1, 5] and decision making [11, 38].

The Pandora project [22] is closely related to the Data2Game project. Pandora is a multi-agency crisis management game, aimed at training the strategic planners of crisis management teams. Pandora focuses on providing a realistic stress-imposing training environment, to specifically train user decision making consistency under high-pressure situations. Training is personalized through biometric data tracking (e.g. Heart Rate), self-assessment and trainer assessment during training sessions, and modeling of player behavioral competencies.

Bacon et. al. [5] describe the Pandora game engine architecture, where crisis scenarios are simulated and controlled at real-time by trainers. A decision branching mechanism undertakes the task of selecting which in-game events will be presented to players (trainees), while trainers have the ability to adjust several in-game variables in order to modify scenario difficulty and complexity. Training goals are defined in advance, and define the flow and final outcome of the crisis scenarios. In this paper, we conceptualize a similar stress-management based crisis scenario simulation, although our design is critical decision-based compared to Pandora's multimedia-oriented design.

The Mayor's Game [12, 40, 41] is an example of dilemma-based decision making games. In the Mayor's Game, players (playing as town mayor) are requested to "solve" a scenario by answering a set of dilemmas. The game also features a number of non-player characters (NPCs) who provide additional political/administrative insight on each dilemma, and propose an answer upon player request. At the end of the game, players receive feedback on pre-defined behavioral competencies based on their answers, while user actions are being logged and made available for further feedback personalisation. Our proposed crisis management training game is closely related to the Mayor's Game design, although scenarios presented in the Mayor's Game are entirely pre-scripted, and dilemmas only have three pre-defined possible asnwers (yes/no/delegate). We expand on the Mayor's Game design by introducing adaptability in scenario, critical decision (dilemma) and NPC level. Figure 1 presents a screenshot of the Mayor's Game.

Figure 1: Screenshot of the Mayor's Game. Players are prompted with text-base dilemmas which they are required answer. In the background, NPCs who represent experts from various institutions, provide additional information on each dilemma.

3 DESIGN GOALS

Our design follows basic concepts of crisis management theory. Through gameplay, we expect professional crisis management staff to improve their level of preparedness regarding real-life crisis situations. For an extensive overview of crisis management theory, we refer readers to Pearson & Clair [26].

Our personalised crisis management training game will be built following high-level design goals, defined collaboratively by researchers and the VRT crisis team. These design goals concern not only the scientific aspects of this project, but also the requirements and preferences of the crisis management administration.

The VRT has specified their preferences regarding the proposed training game, during interviews with the authors. Since their staff will be actively participating in the testing and evaluation process of game prototypes, they have investigated which game design concepts fit their current training scheme best.

3.1 Existing situation

In currently employed crisis management training sessions, the crisis team is alerted and gathered in an office location to collaboratively "solve" a realistic representation of a crisis step-by-step. Their goal is to effectively communicate with the on-site team (located near the incident site) and bring the crisis situation under control rapidly and efficiently. At the end of each training session, feedback is provided, discussing team-level performance and evaluating key aspects of training, including effective communication and collaboration between team members.

Goal 1: Crisis management training on a tablet

Training experts of the VRT crisis team have indicated a preference towards a mobile-based training game, since every trainee of the VRT crisis team is equipped with an Apple iPad tablet.

Tablets have been indicated as the preferred device for emergency responders [2]. Since our proposed game will be supplementary to the already existing training scheme, a mobile game will give trainees the ability to train outside the regular training schedule, even within their home environment.

Furthermore, the use of a mobile game will enable the VRT to shift their training focus from the team as a unit towards individual trainees. While training methods are aiming to improve teamwork and collaborative decision making, individual staff training is necessary, in order to monitor and evaluate each trainee's performance and decision making efficiency.

Goal 2: Multi-modal Player modeling

In interviews with the VRT training experts, it has been discussed that player stress levels should be measured and influenced through the proposed crisis management game. To that end, we have decided upon utilising physiological sensors, to monitor player affective state and build a player model based on their measurements. However, training should also be personalised in cases where sensor data is not available.

Player modeling is essential when personalized games are considered. As discussed in related work, building a model of player affect may enable the personalisation of the training procedure [1, 22]. In a multi-modal setting, player modeling is based on multiple input channels. Through multi-modal player modeling, we aim to acquire both objective and subjective measurements of player affect. Multi-modal player modeling allows us to correlate physiological to in-game measurements, and enable player modeling even when physiological data is not available (non-laboratory settings). To achieve this, we will extract data from the following modalities:

- Physiological Signals
  Physiological signals provide an objective description of player affective state. Physiological sensors are able to stream such signals in real time, providing a plethora of measurements able to model player affect.
- In-game events
  In-game events are necessary features when analysis of player decision making is considered. Furthermore, player interaction metrics (e.g. decision making speed) can be used to model player behavior.
- Self-reporting
  Self-reporting is a subjective means of measuring player affect. We aim to investigate the correlation between player self-reports and physiological signals. In addition, self-reporting will enable player affect modeling when physiological data is not available.

Goal 3: Personalised crisis management training

Two ways in which training sessions should be personalised have been defined, after consulting VRT training experts: (1) training scenarios should be non-linear, meaning that their outcome should not be pre-defined but adapted to the individual trainee, and (2) feedback on player performance should be personalised. As relevant studies have shown, crisis management training can be personalised on those two levels, based on an underlying player model [5, 28].

The goal of training personalisation is to improve its efficacy by adjusting the procedure to the individual trainee's needs. Through training personalisation, scenarios may be dynamically adapted to improve specific player behavioral competencies. Furthermore,

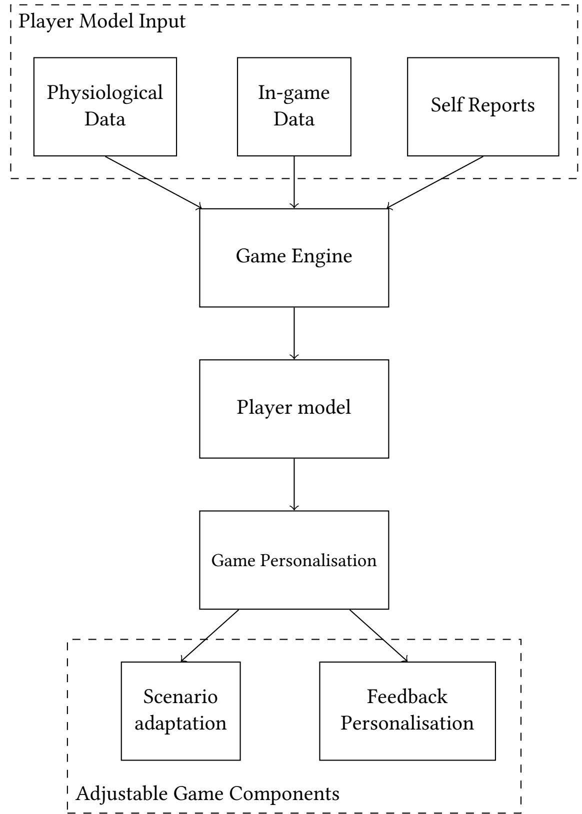

Figure 2: Concept of Game Personalization, for the creation of personalised training scenarios

game personalisation allows the generation of individual-level feedback. In our framework, game personalisation is performed in two distinct manners:

(1) Online game adaptation [1]
All VRT trainees are required to "practice" the same crisis scenarios. However, in a personalised training environment, the scenario progress and final outcome derives from the individual player's affective state model and strategic decisions. In order to achieve training personalisation, the game engine should enable online adaptation of the currently played scenario, i.e., game components should be adaptable, based on measurements extracted during gameplay.

(2) Personalised feedback
Since player performance is assessed on an individual level, our concept's design includes the ability to provide personalised feedback. After each scenario has been "solved", trainees receive an overview of their in-game performance, discussing their decision making efficiency. For the feedback cycle to be constructive and accurate, historical data of previous training sessions should be considered.

[1] We acknowledge that a game may be adapted in an offline manner too, e.g., by automatically selecting training scenarios based on previously completed training sessions. However, in this paper we have chosen to focus on online adaptation, which enables us to directly influence player affective state.

Figure 2 presents an outline of the game personalisation concept. During gameplay, physiological sensor, in-game event and self report data are used as input, based on which a player model is built. According to the player model, game components are adjusted in order to create personalised training scenarios and provide personalised feedback on training performance.

4 CONCEPTUAL FRAMEWORK

In this section, we present the main features of our personalized crisis management game. We describe a crisis management training game, designed to run on a mobile device, capable of providing adequate data for player behavior modeling and dynamic crisis scenario adaptation.

4.1 Crisis scenario gameplay

The main component of our proposed game are crisis scenarios. They describe real-life crisis situations, which need to be handled rapidly and efficiently. Scenarios are "solved" by taking multiple critical decisions, that represent smaller sub-problems which the player needs to decide on. Critical decisions are presented sequentially, and are (optionally) accompanied by expert advice, through NPCs. After taking all critical decisions, players are prompted to a feedback screen, evaluating their decision making.

Figure 3 demonstrates the proposed training scenario gameplay. Derived from the established design principles (Section 3), a natural way to implement a crisis management training environment is as follows:

(1) Starting the game, players will be asked to select a scenario. Scenarios will be designed to vary in difficulty and crisis severity level.
(2) Every scenario will consist of critical decisions, which players will need to take. A critical decision represents a single step which needs to be taken towards solving a crisis scenario.
(3) While taking a critical decision, players will be allowed to consult experts, represented by NPCs.
(4) After submitting their answer to the presented critical decision, players will have the option of giving feedback on their decision as a self-report.
(5) After each critical decision, game personalization will be performed, adjusting the next set of critical decisions, NPCs and scenario parameters.
(6) When all critical decision are taken, the training session ends. Again, players will be allowed to provide feedback through self-reporting, but will also receive feedback based on their progress and decision-making throughout the session.

4.2 Adjustable Game Components

The proposed game engine consists of several components, each of which can be adjusted during gameplay. Our goal is to develop a customizable game, providing both researchers and crisis management staff with maximum control over training personalisation. Table 1 provides an overview of adjustable game components, which may be scenario, critical decision, or NPC-related. Each type of game component is sub-divided into individual parameters (adaptable content) which will be available for adjustment during gameplay.

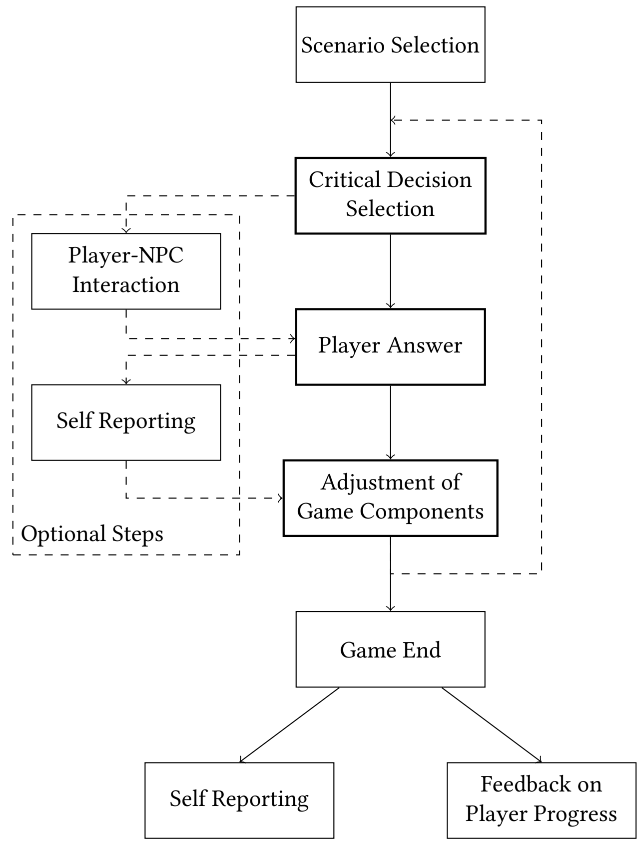

Figure 3: Scenario gameplay. Players are asked to select a scenario, and reach the solution by taking multiple critical decisions.

Table 1: Adjustable game components

Component Type	Adaptable Content
Scenario	Time left to complete Critical decision shown next Time of appearance of next critical decision Number of NPCs
Critical decision	Critical decision Text Critical decision possible answers Critical decision answer scoring (if applicable)
NPC	NPC Type (institution) NPC Advice text NPC Advised answer NPC Advice scoring (if applicable)

4.2.1 *Scenarios.*

Crisis scenarios are the core component of our game engine. Although scenarios are mostly predefined by trainers to resemble real-life crisis situations, their adaptability is key to effective training sessions.

In order to induce severe time constraints on the training process, the remaining time to "solve" each scenario can be adapted. Moreover, to the same end, the exact time of appearance of each critical decision can be altered as well. We believe that adaptation of these two variables will enable control of trainee stress levels, and contribute to effective stress management.

Behavioral competencies such as leadership and decisiveness are also considered necessary to monitor and develop. By adjusting the number of NPCs available to players, the game engine can trigger different decision making styles. With less NPCs available, trainees will be engaged in "taking the lead" and rely less on expert advice, whereas an increase in NPC number can assist in teamwork training.

Lastly, in order to decrease scenarios' "linearity", the selection of critical decisions will be made dynamic. This adaptation can result in different scenario outcomes for each individual player, enabling trainees to play the same scenario multiple times, with different possible results in each session.

4.2.2 Critical decisions. In traditional crisis management training methods, handling a crisis situation involves several critical decision moments, which impact the outcome of the training scenario. Such critical decisions can be evacuation of buildings/areas, setting up perimeters or talking to the media; incidents which are highly likely to occur in real-life crisis situations.

We have chosen to design crisis scenarios as a sequence of critical decisions, describing sub-problems on which trainees have to decide. Following the concept of non-linear scenarios, the critical decision narrative (text) will be made available for adaptation. In that way, we enable the application of data-to-text generation methods, producing model-generated game narratives.

Furthermore, the possible "answers" to critical decisions are designed to be adaptable. That means that trainees may have to choose between more than two possible options, when taking a critical decision. What is more, critical decisions may not present trainees with an obviously "optimal" choice, thus directly influencing player cognitive load. Also, it enables modeling of contradicting decision making styles, when two available answers represent different approaches to a possible solution.

Lastly, scoring of critical decision answers will be available, to enable direct modeling of player answers. In a scenario where a certain behavioral competency is monitored, experts can provide answer scores to measure player performance.

4.2.3 NPCs. Non-player characters (NPCs) play an important role in the proposed game engine. They represent various institutions who normally partake in a real-life crisis situation (police forces, fire brigade, local politicians etc.). NPCs will be designed to give insight on each critical decision; each presenting players with advice that reflects their institution's point of view. NPC institution type will be adaptable and visually presented through an NPC avatar (*cf.* Figure 5), according to each scenario's context.

To fully enable data-to-text generation methods, NPC advice texts are available for adaptation. This means that the advised answer can be altered as well. Similarly to critical decision answers, NPC advice scoring will be possible. By dynamically adapting NPC behavior, scenario complexity can be manipulated, resulting in a increase or decrease of overall scenario difficulty.

Table 2: Physiological measurements extracted during gameplay, including Photoplethysmography (PPG) and Skin Conductance (SC)

	Measurement	Description
PPG	$E\{h\}$	Mean Heart Rate
	$\sigma\{h\}$	Standard Deviation of Heart Rate
	$min\{h\}$	Minimum value of Heart Rate
	$max\{h\}$	Maximum value of Heart Rate
	$max\{h\} - min\{h\}$	Difference of maximum and minimum value of Heart Rate
	h_{init}	Initial value of Heart Rate
	h_{last}	Last value of Heart Rate
	$t_{max\{h\}}$	timestamp of maximum value of Heart Rate
	$t_{min\{h\}}$	timestamp of minimum value of Heart Rate
	$t_{max\{h\}} - t_{min\{h\}}$	time difference between maximum and minimum value of Heart Rate
	hrv	r-MSSD Heart Rate Variability [33]
SC	$E\{sc\}$	Mean Skin Conductance
	$\sigma\{sc\}$	Standard Deviation of Skin Conductance
	$min\{sc\}$	Minimum value of Skin Conductance
	$max\{sc\}$	Maximum value of Skin Conductance
	sc_{init}	Initial value of Skin Conductance
	sc_{last}	Last value of Skin Conductance
	$t_{min\{sc\}}$	Timestamp of minimum value of Skin Conductance
	$t_{max\{sc\}}$	Timestamp of maximum value of Skin Conductance
	$t_{max\{sc\}} - t_{min\{sc\}}$	time difference between maximum and minimum value of Skin Conductance

4.3 Data Collection

Data extracted during gameplay will enable player modeling through multiple modalities, including physiological sensors, in-game events and self reports.

4.3.1 Physiological Data. Physiological data are used to describe the affective state of the player, and provide the basis for player behavioral modeling. As discussed in the Related Work section, previous studies have proposed methods of modelling player affect through physiological sensor data [18, 23, 32, 43]. Following these studies, we have chosen to integrate Photoplethysmography (PPG)

Table 3: In-game measurements extracted during gameplay.

	Measurement	Description
Critical Decision D	$D_{t_{totalview}}$	Total time critical decision viewed
	$D_{t_{firstview}}$	Timestamp of first critical decision view
	$D_{t_{ans}}$	Timestamp of critical decision aswer
	$\sum D_{view}$	Times critical decision viewed
	D_{ans}	Critical decision answer
	D_{score}	Critical decision answer score (if applicable)
NPC (Advice) A	A_{req}	Advice requested (yes/no)
	$A_{t_{req}}$	Timestamp advice requested
	$A_{t_{view}}$	Total time advice viewed
	$\sum A_{view}$	Times advice viewed
	A_{ans}	Advised answer
	A_{score}	Advised answer score (if applicable)
Scenario S	S_t	Scenario time left
	S_d	Scenario steps (critical decisions) left

and Skin Conductance (SC) sensors. More specifically, we have chosen to employ Empatica E4 [13] wristbands and Shimmer GSR+ [10] sensors, which are capable of measuring both aforementioned physiological signals through a single wearable device. We consider both physiological sensors to be non-invasive, given that they can be attached to trainees' wrists.

Table 2 illustrates the measurements that will be extracted through physiological signal analysis. We have chosen PPG and SC signals as they are measured by both Empatica E4 and Shimmer GSR+ sensors and can be used to describe the affective state of the player. From each physiological signal, various measurements can be extracted, providing possible features for building a model of player affect. Note that each of these measurements will be available at any point in the game, thanks to specialised data streaming APIs provided with the chosen sensors.

4.3.2 In-game Measurements. In-game measurements describe player actions during gameplay, while also provide an overview of the game state. Table 3 presents a list of in-game metrics that will be tracked and made available for player modeling tasks. These in-game metrics have been chosen to describe player behavior during training, focusing on the context of player decision making (decision making style, timing and speed). Note that all measurements will be extracted after a player has taken a critical decision.

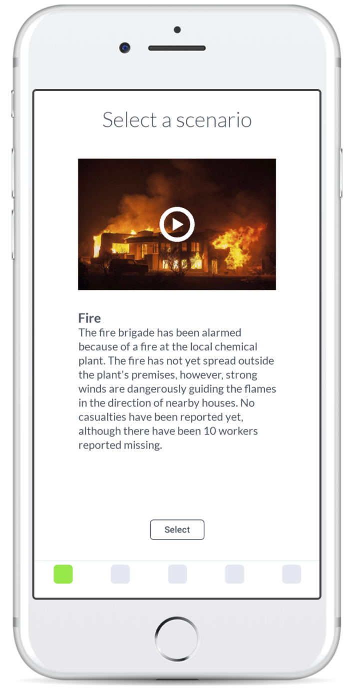

Figure 4: Scenario selection screen.

4.3.3 Self-reporting. In order to extract subjective measurements from players, we propose the use of self-reports to acquire feedback about the *perceived* player affective state. Self reports will not only enable player modeling when physiological data is not available, but can also be used to measure the correlation of objective (as measured by physiological signals) and self-reported affective state. Such ratings of player affect could be used in statistical correlation [27] or ranking [24] tasks.

Self reporting will be available at specific points in the game, as described in Figure 3. More specifically, we consider making self-reports available exactly after critical decision taking, for critical decision-specific feedback, and after a scenario has ended, for scenario-wide feedback.

Although self reporting may interrupt gameplay and have a negative effect on player immersion, it facilitates the employment of personalised behavioral models and active modeling techniques. The utilisation of self reporting will be further investigated in future studies.

5 GAME PROTOTYPE

We have designed a prototype tablet game, following the Design Goals and Framework discussed in Sections 3 & 4. In this prototype, we implement the main components of our game, including scenario selection, gameplay screen and feedback screen. The goal of this prototype game is to examine how the adaptable game components should be constructed and presented to players.

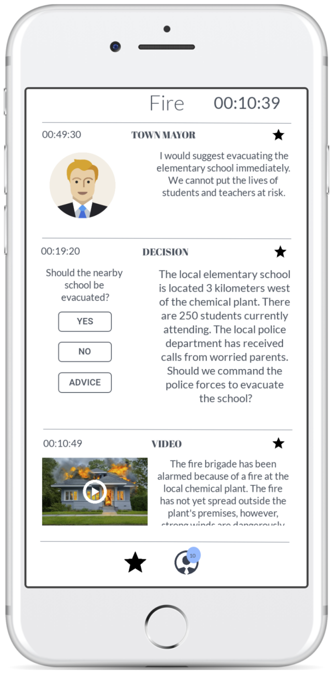

Figure 5: Main game screen. In-game events are presented in a timeline-like fashion; most recent events are placed at the top of the timeline.

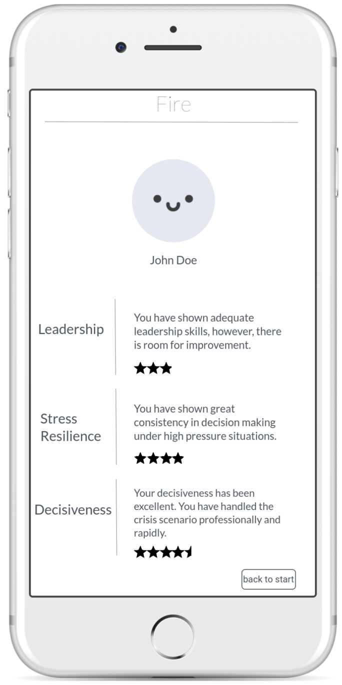

Figure 6: Feedback screen, enabling evaluation on multiple aspects of player behavior.

5.1 Scenario selection

The first screen of our prototype game is the scenario selection screen, illustrated in Figure 4. Trainees will be asked to choose from a variety of scenarios, varying in topic (type of crisis to be solved) and complexity.

Training scenarios will be designed in collaboration with crisis management training experts. As discussed in Section 3, we aim to generate adaptable scenarios, based on an underlying model of player affect. However, in order to ensure the efficacy of such scenarios, the scenario topic and training goals should be pre-defined by training experts.

5.2 Timeline-like gameplay

Figure 5 illustrates the main game screen, which includes critical decisions, NPC advice and a scenario description. We have chosen to follow a timeline-like design, where most recent in-game events are placed at the top of the timeline. We believe that a timeline-like design is relatable to many popular modern mobile applications, and for that reason, may increase the usability and user-friendliness of our game.

In our conceptual framework (*cf.* Section 4), we describe adaptable in-game components capable of influencing player affective state. A timeline-like design can be expected to support this goal; given that all game events are presented in one main screen, rapidly generated events may induce higher stress levels to trainees, regardless of their content. Accordingly, "slowing down" the in-game event generation, may reduce player stress levels.

5.3 Game components

In this prototype, we have designed the main game components, following the conceptual framework discussed in Section 4. The main game components are (1) scenarios (*cf.* Figure 4), (2) critical decisions, and (3) NPCs (*cf.* Figure 5). Scenarios are pre-scripted to define the training goals of each session. Critical decisions and NPCs are presented as text fields, and are accompanied by possible answers in case of critical decisions, or an avatar in case of NPCs. Through adaptation of these game components, we aim to generate personalised crisis management training scenarios.

At the top of the main game screen, players can see the remaining game time, while each game event is also marked with a timestamp. This way, trainees will be aware of time restrictions regarding the training session. Every game event can be marked as a "starred" event, and all "starred" events will be gathered and accessible through a secondary game screen, by tapping the "star" icon at the bottom of the screen, shown in Figure 5.

Critical decisions will consist of adaptable texts and adaptable possible answers, as illustrated in Figure 5. Before taking each critical decision, players will have the option of interacting with NPCs (*cf.* Figure 3 in Section 4). NPCs will provide "expert advice" on answering each specific critical decision through adaptable texts, while the number of NPCs and their "participation" in a specific critical decision are adaptable parameters as well. NPC advice that is "starred" by players will be accessible through a secondary game screen, by tapping the "avatar" button at the bottom of the screen (Figure 5).

Audiovisual media, illustrated in Figures 4 and 5 (bottom of the main game screen), will be employed in order to increase the game's

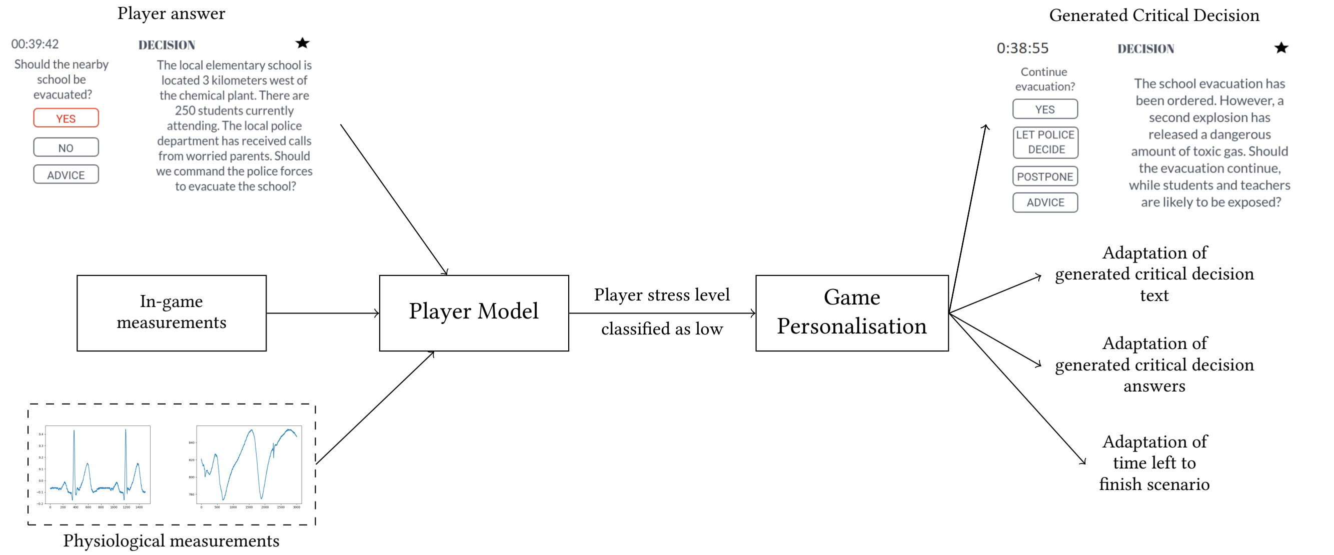

Figure 7: Example one-step gameplay. After a critical decision is answered, the player model is updated with physiological sensor data and in-game measurements. In the example, player stress level is classified as being low, leading to the generation of a new critical decision, adjusted towards inducing stress onto the trainee.

realism and trigger stronger reactions from the trainees. Such media have been proven to be effective in training applications[16].

5.4 Personalised training evaluation

The last screen of our game prototype represents the personalised feedback screen, illustrated in Figure 6. In Section 3, we discuss personalised feedback as a main goal of our crisis management game. Feedback may be focused on more than one behavioral competencies of the player, such as stress resilience, decisiveness, leadership skills etc. Behavioral competencies will be defined as training goals for each individual game scenario.

Feedback consists of an adaptable text field, which may be generated based on the underlying player model built during gameplay. Furthermore, we have designed a 5-star rating field to quantify performance evaluation.

5.5 Gameplay example

In Figure 7 we illustrate a one-step gameplay example. After answering a presented critical decision, in-game and physiological measurements are fed into the player model. In this example, the trainee has taken a critical decision a few seconds after it was presented to him/her, without requesting for expert (NPC) advice, while his/her skin conductance and heart rate measurements describe an unstressed player. The player model is updated, and classifies player stress levels as "low". Based on this estimation, the next critical decision is presented, while its text, possible answers, and remaining game time are accordingly adapted to induce more stress onto the trainee.

The above described gameplay instance, is part of a training session focusing on trainee stress resilience. The goal of this training session is to evaluate the efficiency of trainee decision making under high pressure situations, and evaluate whether (and to what extent) the player is affected by artificially induced stress. By adjusting in-game components such as critical decision text and remaining game time, the game personalisation mechanism aims to maintain player stress at a high level. Having completed several training sessions in highly stressful circumstances, trainees are expected to perform at a consistent level in a real-life stressful crisis situation.

6 DISCUSSION

This paper presents a concept study on personalised crisis management training. We discuss a critical decision-based game design, where trainees are required to "solve" a crisis step-by-step. Our game has been designed to support training on an individual level, supplementary to the already existing training scheme.

Three main design principles are followed: Firstly, our game has been designed for mobile interfaces, enabling crisis management staff to train outside regular training hours, even from their home environment. Secondly, data extraction from multiple modalities is proposed, in order to enable player behavioral modeling. Multimodal player modeling sets the foundations of efficient training personalisation –the third design goal–, which is made possible through adaptable game components and personalised in-game feedback.

We have presented a prototype game design, which addresses the established design goals. The proposed personalised crisis management game is oriented towards tablet devices, enabling trainees to "practice" individually. We propose multi-modal player modelling through physiological sensor, in-game and self-report data, in order to obtain an estimate of player affective state. Furthermore, we enable game personalisation through adaptable game components, aiming towards generating personalised crisis management training scenarios, and providing individual-level performance evaluation.

Future studies with the established personalized crisis management training framework will focus on (1) stress management in high-pressure situations, and (2) evaluating trainee behavioral competencies during crisis management training. The studies will target – and are designed in close collaboration with – actual crisis management experts.

ACKNOWLEDGMENTS

This study is conducted within the Data2Game project, partially funded by the Netherlands Organisation for Scientific Research (NWO).

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