INTERNATIONAL JOURNAL OF FILM AND MEDIA ARTS (2023) Vol. 8, Nº. 1 pp. 36-51

ijfma.ulusofona.pt
doi: 10.24140/ijfma.v8.n1.02

USING GAME-BASED LEARNING TO ENHANCE DECISION MAKING UNDER UNCERTAINTY

DIMITRIOS LAPPAS
HELLENIC AIR FORCE ACADEMY (GREECE)

GEORGIOS KOTTIS
HELLENIC AIR FORCE ACADEMY (GREECE)

PANAGIOTIS KARAMPELAS
HELLENIC AIR FORCE ACADEMY (GREECE)

Dimitrios Lappas is a Major serving with the Hellenic Air Force Academy as a military instructor. He has a bachelor's degree from the Educational Design Department of the University of the Aegean and a master's degree in Models of Educational Planning and Development at the University of the Aegean. Also, he is a Phd candidate at University of the Aegean. His research interests primarily lay in decision making under uncertainty in dilemmas. ORCID: 0000-0001-6922-2611

Georgios Kottis is a second Lieutenant serving with the Hellenic Air Force as a pilot. He has a degree from Hellenic Air Force Academy. Currently he is training at the T-6 Texan aircraft, as a future fighter pilot. His area of research concerns game-based tactics from which useful results can be inferred.

Panagiotis Karampelas is an Assistant Professor at the Department of Informatics and Computers, Hellenic Air Force Academy teaching courses to pilots and engineers and supervising a number of dissertations in the area of programming information systems and cyber security. His areas of research interest include Social Network Analysis, Cybersecurity, Counterterrorism Informatics, Big Data Analytics, Data Mining, Information Visualization, Serious Games and Artificial Neural Networks. He has also published a number of books and research articles in his major areas of interests in international journals and conferences. ORCID: 0000-0003-1684-7612

Corresponding Author
Dimitrios Lappas
dlappas.aegean@gmail.com
Hellenic Air Force Academy
Dekeleia Air Force Base
Acharnes, 13671
Greece

Paper submitted: 12th June 2022
Accepted for publication: 16th February 2023
Published online: 15th June 2023

Abstract

How do people make their decisions? Searching for the answer in the relevant literature, we can find that decisions are based either on rationality or intuition. Rational thinking is mainly observed in situations characterized by certainty (in terms of data or the consequences of decisions), while heuristic intuitive methods are mainly observed in situations of uncertainty. Training for the enhancement of decision making skills usually employs problem-based activities which mainly focus either only on rationality or only on intuition. However, problems in real life cannot always be solved with the contribution of only one way of thinking. In a decision making process often rationality works up to an extent and then intuition will lead to the final decision. For this reason, we designed and developed a game-based learning activity that enhances both rational and intuitive decision making skills. More specifically, we created a decision scenario in a virtual environment in which participants were provided with uncertainty-based information in their decision making process. As they tried to follow a rational decision making process, most of them realized that based on the given information they were confused and they had to decide intuitively at the end. This experiential learning activity was a tickler for the participants to decide under uncertainty and trust their intuition.

Keywords: Uncertainty, Decision-Making, Uncertainty-based Information, Game-based Learning Activity, Serious Gaming, Virtual Environment

Introduction

Traditional decision theory mainly focuses on three basic stages (Simon, 1960): intelligence activity, design activity, and choice activity. In case there is ambiguity of intelligence, e.g., due to the limitation on the reliability of the information source, then the context in which the decision should be made is characterized by uncertainty (Han et al., 2011). In this case, the decision maker is often faced with dilemmas, as uncertainty factors do not allow him to choose a course of action easily and rationally (Lipshitz & Strauss, 1997). From another point of view, uncertainty at the initial stage of a decision making process can be a motivation for further studying and analyzing the existing intelligence (Bammer, 2013).

In general, there are two models of thinking: system 1 in which someone thinks quickly and intuitively; and system 2 in which someone thinks slowly and uses the analytical thinking approach (Hogarth, 2001; Kahneman & Frederick, 2002; Sloman, 1996). Most decisions are made intuitively by an unconscious thinking system, system 1 (Kahneman, 2011). Heuristics and biases guide system 1, while rationality and analytical thinking guide system 2 (Tversky & Kahneman, 1974). In uncertain environments, the decision-making process is mainly based on intuition, in contrast to rationality which is mainly observed in environments of certainty (Agor, 1986; Burke & Miller, 1999; Marchisotti et al, 2018). Moreover, under uncertain situations, people tend to develop heuristic mental judgment processes based either on similarities to other situations, or by comparing similar cases or correlating them with known data (Tversky & Kahneman, 1974; Mousavi & Gigerenzer, 2014).

The development of attention and memory functions through appropriately oriented decision-making training, mainly based on assessment and analysis of the situation, can help in making quick and instinctive decisions (Kahneman, 2011). In other words, in case we want to train people in system 1 thinking (intuitive), we must train them in system 2 thinking (analytical), as system 2 can influence how system 1 works (Kahneman, 2011).

Based on the above-mentioned theories that training for system 2 can enhance system 1 thinking (Kahneman, 2011) and system 1 thinking is mainly used in decision making under uncertainty (Marchisotti et al, 2018), we developed a game-based learning activity in a digital simulation environment (ARMA III) for the purpose of:

- Empowering the analytical thinking system of the participants, by forcing them to organize the information received during the game in order to be able to later analyze them and base their final decision on rationality (system 2 training);
- Introducing uncertainty factors in the gameplay, by providing uncertainty-based information in order to enable participants to understand that the analytical thinking system cannot always lead to a decision. In that case, other approaches should be followed, such as intuition or previous experience to reach a decision (system 1 training).

In that sense, our work contributes to the following:

- Proposes the design of a game-based learning activity for the enhancement of decision making skills through experiential learning.
- Coordinates the training of the two models of thinking (rational and intuitive) in one learning activity.
- Confirms that in uncertain situations, intuition plays a significant role in the decision-making process.

The rest of the paper is organized as follows: Theoretical part section states the objectives of game-based learning, analyses the term of uncertainty and defines the functions in the decision-making process under uncertainty. Following that, the principles of the design of our game-based learning activity are described. The next section then presents the assessment of the activity and discusses the results. The paper closes with the concluding section.

Theoretical Part

Game-based learning

The use of games in different aspects of life finds its roots in the ancient world. In ancient Egypt but also in ancient Greece and later in the Roman era, games were used to facilitate decision-making processes in war (Hammond & Pötzsch, 2019). A board-game with one king, 'hnefatafl', was used by the Norse as a war-game around 400 AD (Schulte, 2017). Similarly, there is evidence that the ancestor of modern chess, called 'chaturanga', was also used as a war game around the seventh century in India (Young, 2004). In the 1800s, other games found use for military training as war-games such as kriegsspiel supported by the Prussian Chief of the General Staff which was enriched with 26 battalions, 40 squadrons, 12 batteries, 1 pontoon train, rulers and dividers for calculating distance during the gameplay in the maps, a dice for deciding which actions should be taken and a manual for the game rules (Peterson, 2012). In modern times armed forces during World War II frequently used war games to facilitate commanders' decisions (Mietzner & Reger, 2005). A team had the role of the enemy and another team had the role of friend forces. Every team had to make its strategic decisions according to the other's team actions. From then on, many types of games have been used to support training activities and learning goals (Coleman, 1971). Currently, the development of ICT tools offers greater opportunities for game-based learning, e.g., computer games, video games. Virtual reality environments can enhance game-based learning activities, as they offer immersion in virtual worlds and thus can simulate real life decision cases with high precision (de Freitas, 2006).

In game-based learning activities, various scenarios (interactive or non-interactive) are used as basic tools of the teaching and learning process (Clark, 2009). As a result of the use of scenarios, many active learning strategies (such as problem solving) are supported and students are given the opportunity to learn and apply their learning to real-world experiences (Errington, 2005). Students work through a story, based on a problematic situation that they are asked to solve. In other words, students apply their knowledge, critical thinking and problem solving skills in a safe environment that resembles the real world (realistic learning environment). Errington (2010) points out that learning scenarios aim to promote deep learning and awareness by involving students in realistic critical incidents. In that way, learners are forced to consider a wide range of factors, make decisions and think about the results of their actions in an insightful way.

In evaluating the studies that have been carried out on learning through scenarios in electronic simulation environments, Hew and Cheung (2010) highlighted the following characteristics in every learning simulation:

- The existence of a scenario (in which narratives and/or representations take place) providing the basis for a simulation.
- Interactive scenarios based on communication which offer opportunities to students for exchanging information in verbal and non-verbal forms.
- Students learn by doing (experientially); first they act and then they observe their results; in other words, they reflect and gain new experiences.

In our approach, we have followed a slightly different approach from traditional scenarios in game-based learning activities since we do not separate friends and enemies (so participants cannot decide who to trust) and in parallel we attempt to reinforce the experiential learning of the participants by enabling them to visualize the results through the virtual environment as it will be described in the corresponding section that presents the design of our game-based learning activity.

Uncertainty

Uncertainty can be defined as any sense of doubt that can block or delay action (Lipshitz & Strauss, 1997). Uncertainty is found in almost all scientific disciplines (philosophy, economics, statistics, physics, meteorology, engineering, psychology, etc.) with small differences in the factors that cause it (Fischhoff & Davis, 2014). For example, in the science of meteorology uncertainty can be related to the change of an air mass or the change of a barometric (physical factors), while in psychology, uncertainty can be related to personality characteristics of individuals (human factors).

Uncertainty is characterized by a lack of information about a topic of interest or a state of limited knowledge in which it is difficult or impossible to predict the future developments of the topic (Cuzzolin, 2016). The factors that consist the key influences of uncertainty are the following (Han et al., 2011):

- Possibility, which exists because the future cannot be accurately determined.
- Ambiguity, which exists due to limitations in the reliability or adequacy of information.
- Complexity, which exists because of the characteristics of the available information that make it difficult to understand.

It should be emphasized that the term "uncertainty" is different from the term "risk", where it is often used to express an uncertain situation. Risk is a result of uncertainty, i.e., all risks contain uncertainty, but not all uncertain situations are characterized as risk situations (Toma et al., 2012). Situations involving risks are characterized by known components of uncertainty, which if they are present then they will affect the developments of the situation (Toma et al., 2012). On the contrary, uncertain situations contain components which may still be unknown. In case these components appear, they may affect the development of the uncertain situation in an unexpected way from the initial assessment. Furthermore, in the case of uncertainty, new information may modify a person's initial assessment, while in the case of risk any new information maintains the same degree of risk (Dobbs, 1991).

In our game-based learning activity, we used the term uncertainty in order to express uncertainty-based information. Information can be "incomplete, imprecise, fragmentary, not fully reliable, vague or contradictory or deficient" and thus may result in different types of uncertainty (Klir & Wierman, 1999). Moreover, uncertainty-based information cannot lead decision makers in a direct decision, as the information includes aspects that must become clearer in order to be more useful in the systematic process of decision making. In that sense, we engaged in our scenario intelligence sources which developed a complexity in the situation due to the contradictory information they spread. The effect of this specific adoption is that decision makers can be led to different results considering different pieces of information. Moreover, uncertainty was also enhanced by the fact that the reliability of the information sources could not be assessed by the participants as it will be presented in the corresponding section that presents the design of our game-based learning activity.

Decision making process under uncertainty

Decision making can be defined as the process of choosing between two or more alternatives in a problematic situation, or the process of choosing between two or more actions in situations with challenges, opportunities, etc. (Eilon, 1969). Choosing between proposed solutions or actions in a problematic situation and implementing solutions or actions chosen aims to improve the current situation and achieve a final desired state (Anderson et. al., 2012).

Decision making can be applied in an environment of either certainty or uncertainty. In case of uncertainty, decision-making becomes a more complex and multidimensional process (Xiong et. al., 2014). In the decision making process, uncertainty is characterized as one of the most critical factors as it can cause deviations in the choices of those involved (van den Heuvel et al., 2011). Furthermore, uncertainty in the decision-making process can have many dimensions which must be clearly defined before starting the actual process (Sniazhko, 2019). In many cases, uncertainty is confused with the error, deviation, or precision of the results but also with the verification or validation of the results (Trucano et. al., 2005; Cunha, 2017). In practice, the lack of clear distinctions between the different dimensions of uncertainty does not help to correctly perceive the real dimensions and variables of the environment and subsequently leads to dangerous and unjustified decisions (Brouthers, 1995).

The degree to which uncertainty affects decision-making varies in each uncertain situation. Not all people deal with uncertainty in the same way in a decision making process, as there are subjective methods of determining uncertainty. Every decision maker considers different factors of uncertainty in the decision making process, so there is a variation on the results (Bammer, 2013; Gluckman, 2016; Sniazhko, 2019). On the other hand, if there is uncertainty in a decision making process, this does not necessarily mean negative effects on the results of the decisions (Wheeler et al., 2020). There is a high likelihood that that uncertainty can lead to positive effects, especially when uncertainty is detected in the initial stages of research studies, where it becomes a driving force for initiation (Bammer, 2013).

The decision making process can be based on either rationality or intuition (Marchisotti et. al, 2018). Rationality is mainly observed in environments of certainty, where there are specific choices with predictable outcomes. Decision making is based on rules and models that lead to rational decisions with the help of tools such as flow charts, affinity diagrams, cost/benefit analysis, decision trees, etc. (Leitão, 1993; March, 1994). However, in case the decision making environment is characterized by uncertainty, where either there is contradictory information for a given situation, or information whose reliability cannot be assessed, then rationality does not support the decision making process (Marchisotti et al, 2018). Instead, decisions are made mainly intuitively.

Intuitive decision making is used in situations where there is a lot of uncertainty, there is a lot of contradictory information, there are no comparable similar situations from the past and there is also time pressure (Agor, 1986). According to Tversky and Kahneman (1974) under uncertain situations people tend to develop heuristic mental judgment processes based on the evaluation of the following factors:

- Representativeness or similarity to other situations, when they are asked to judge the probability that an event belongs to a certain group of events.
- The availability of similar cases or scenarios when asked to assess the frequency of a particular development.
- Correlation with known data, which is known as cognitive bias or anchoring, where it is mainly used in numerical prediction when a relevant value is available.

Lipshitz and Strauss (1997) have distinguished two main dimensions by which uncertainty in the decision making process can be understood. The first is the uncertainty at the stage of gathering information from the sources, e.g. incomplete or contradictory information. The second dimension of uncertainty concerns the decision, e.g., the results, the final situation or the alternative solutions.

Considering all the above details of decision making under uncertainty, it is easy for someone to understand that targeting training in order to develop or enhance decision skills is not an easy issue. The balance of rationality and intuition in everyone's thinking process depends on the decision case. The design of a game-based learning activity which combines both the uncertainty factor in a decision situation and a comprehensive engagement of the two different thinking processes, posed a challenge for us.

Design of a game-based learning activity for decision-making under uncertainty

Games as educational tools can enhance various skills of decision makers (Lauche, et. al., 2009). This can be achieved if the game is based on a complex scenario which leads to a dilemma or an unusual situation (Flin, 1996). Especially, when joining simulation situations, learners can gain experience and accumulate memories that will lead them to a rapid response and to accelerate their reaction capacity in similar future situations.

As mentioned in the theoretical part of the paper, there are two ways of thinking in the decision making process, generally accepted as system 1 and system 2. (Hogarth, 2001; Kahneman & Frederick, 2002; Sloman, 1996). System 1 enables us to decide intuitively and in a strict time frame (Kahneman, 2011) while system 2, which is based on the analysis of the situation, facilitates rational decision making in a more relaxed time frame (Kahneman, 2011). Using system 1, one can recollect someone's appearance to spot them in a crowd spontaneously and quickly. On the other hand, selecting Hawaii as a place for summer holidays is helped by system 2, when someone is looking for interesting places to visit and relax. The latter decision is usually made according to the available financial budget, the vacation duration, the desire for swimming, various environmental factors, etc. which are rationally analyzed.

There are a lot of serious games that can be used for decision making training to reinforce system 2. Companies, for example, usually use management games, also known as tactical decision games, to strengthen the decision skills of their personnel (Janodia et.al., 2008). Usually, a problematic situation is first presented and then the trainees follow the steps of gathering information, assessing the collected information, developing the relevant courses of action, evaluating them and finally choosing the most suitable alternative. In other words, through this process, the participants of this type of management games enhance their system 2 way of thinking.

On the other hand, most of our daily decisions are made by following system 1 way of thinking, which means that they are based on intuition (Agor, 1986; Marchisotti, 2018). Furthermore, in uncertain situations, decisions are made intuitively, in other words system 1 is mainly used (Kahneman, 2011). Based on Kahneman's theory, training for decision making with system 1 includes the development of the functions of attention and memory. Training oriented towards the assessment and the analysis of a situation can help in making quick and instinctive decisions and thus improve both system 1 and system 2. In other words, system 2 has some ability to change the way system 1 works, so training for system 2 can also be considered as training for system 1 (Kahneman, 2011).

Based on the above-mentioned theory, there is a need for a synchronized effort of building training activities that follow the rules of system 2 way of thinking, in which the final decision should be based on intuition, according to system 1. In that way, decision makers will follow all the steps of an analytical and rational decision process and will gain experience in intuitive decisions simultaneously.

In this context, we designed a game-based learning activity which empowers the analytical thinking system of the participants by forcing them to organize the information received during the game in order to be able to later analyze that information and base their final decision on rationality (system 2 training). At the same time, we introduced uncertainty factors in gameplay by providing uncertainty-based information in order to enable participants to understand that the analytical thinking system cannot always lead to a decision, in which case other approaches should be followed such as intuition or previous experience to reach a decision (system 1 training). The anticipated benefit for learners was the experience gained from their engagement in an intuitive decision making process, as well as the enhancement of their memory ability and attention to details, something which also enhances the analytical decision making process.

In our activity, we used the term uncertainty in the context of uncertainty-based information and more specifically in order to express the ambiguity of the information that guided the final decision, as information sources shared contradictory information or information whose reliability could not be assessed. As a result of the existence of contradicting information, learners were led to uncertainty at the stage of their final decision.

For the purpose of our game-based learning activity, we created a hypothetical scenario enriched with all the necessary plot elements to put the participants in a situation in which they have to make their final decision under uncertainty. To assess our activity, we used an open world realism-based environment (Arma III by Bohemia Interactive) to develop all the aspects of our scenario with all possible endings. In this way, participants could not only make their decisions based on the collected information but were also able to visualize the outcome of their decisions.


NEWSPAPER

NOTORIOUS CRIMINAL GETS TRANSFERRED TODAY.

Abdul Rahman Yasin

Altis International Airport

ıe past

JOHN ERNST

ıed in our country, Abdul man Yasin (born April 10,) is a fugitive who helped make ›ombs used in the Trade Center bing attack. He has been acterized in the American media

Back to base…

BY: PAUL SMITH

Fig. 1
The front page of a newspaper

Fig. 2
News bulletin from a TV channel

Game-based learning activity scenario

The scenario of the game-based learning activity described a situation in which a criminal who had murdered many people in the past was arrested in a different country than the one where he committed his crimes. For this reason, he will be transferred from the country where he has been arrested to the country of his origin, in order to go to trial and then to serve his sentence in prison.

The participant-player of the game assumed the role of a relative of one of the prisoner's victims, who wanted to take revenge for the wrongful death of the relative. So, the participant had to go to the airport in which the prisoner would arrive and attack him with the intention to kill him.

The game starts with the player being at home and having the opportunity to get information about prisoner's arrival, from two different intelligence sources (Open Source Intelligence – OSINT). The first source was a newspaper on the internet, in which the participant could read the front page with information regarding the historical facts and the arrival of the prisoner (Fig. 1) and the other one was a news bulletin from the local news channel on TV (Fig.2). Both intelligence sources informed the player about the hour of arrival and the gate at the local airport.

Then, the player had to leave their home and go to the airport by bus. There, the player was able to chat with various people working at the airport and collect information about the prisoner's arrival time and gate (Human Intelligence – HUMINT) (Fig. 3). More specifically, the player had the opportunity to chat in the airport with a policeman, a cleaner, a firefighter, an air traffic controller (Fig. 4), an information desk clerk (Fig. 5) and a traveller. The goal was to find out the actual arrival time and gate in which the prisoner would shortly be arriving at.

Fig. 3
Some HUMINT sources in the airport

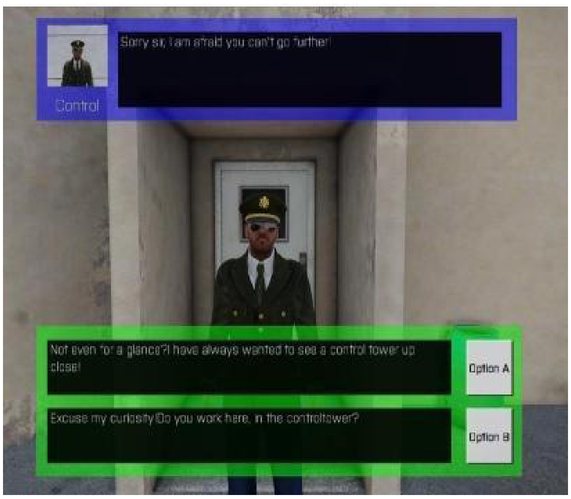

Fig. 4
Meeting an air traffic controller

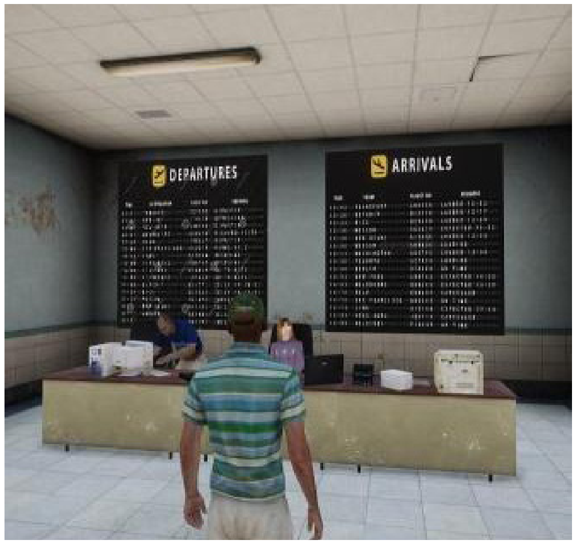

Fig. 5
Meeting an information desk clerk

The conversation with people at the airport was not predefined but the player had the chance to determine the course of the discussion. In every conversation, the player had the opportunity to select between two options for the questions to the corresponding person (Fig. 4). The piece of information that the player finally received from a specific person about the prisoner's arrival time and gate was the same independently of the selections made during the dialogue. We used this trick just for giving the player a degree of freedom in information gathering and making the scenario more realistic.

Before starting the game, each player received a booklet which contained a list of the intelligence sources that were available in the game. Next to each source, the player had to note the information about the prisoner's arrival time and gate at the airport, which was collected from the specific source. The various pieces of information that were offered from the plot of the scenario contradicted each other. The pieces of information from the newspaper and the television reportage were deliberately fake, to simulate the usual attempt of the police to reduce the risk of a possible attack on potential targets, in our case the prisoner. According to our scenario, human intelligence sources at the airport offered diverse information. Some sources offered correct information (e.g., the cleaning lady) while other sources offered deliberately fake information and more specifically the same information announced in press and news (e.g., the policeman). Other sources did not give any information (e.g., the air traffic controller). Gathering all the information, the player was faced with the dilemma of choosing the right time and gate of the prisoner's arrival in order to kill him. In other words, at the end, the player had to choose which would be the correct arrival gate for the prisoner and the correct arriving time. In that sense, uncertainty was inserted in the decision making process since not all information sources suggested the same time and gate for the prisoner's arrival (contradiction and ambivalent reliability of the sources).

When the player had decided about the estimated arrival time and gate of the prisoner, it was possible to move to the specific gate of the airport at the specific time using the bus in order to find the prisoner. If the decision was correct, the player would finally find the prisoner and the game was over. If the decision was not correct, then the game was over without finding the prisoner.

The player had no time restrictions to visit and talk to all the HUMINT sources and collect the available information. However, when the information gathering stage was completed, then the player had limited time to make the final decision, as all possible arrival times were very close to the current game time. Thus, the player at the final stage of the game had to make the final decision under time pressure.

Assessment of the game-based learning activity

The assessment of the game-based learning activity took place at the Hellenic Air Force Academy (HAFA) in January 2022 as a part of a thesis. There were 30 participants (all males, aged from 20 to 22 years old). For each participant, the participation in the activity was divided into three parts. In the first part, a briefing for the scenario and the corresponding mission was given from the researcher. In the second part, the participant assumed the role of the player of the game. The participant had to collect information for the arrival of the prisoner (time and gate), as mentioned from both human sources (people at the airport) and open sources (internet and TV). The collected information was recorded on the answer sheet in order to help the participant to reach their final decision using the analytical process. In the third part, the player had to make their decision by selecting the correct time and gate of arrival according to the collected information under time pressure. At the end of the game, the participant had to justify their decision by providing information on their decision-making process which was recorded by the researcher.

Results

Out of the 30 total participants, 24 managed to choose the correct time of arrival as well as the correct arrival gate. There were 2 participants who chose a wrong arrival gate and 4 participants who chose a wrong time of arrival (Fig. 6).

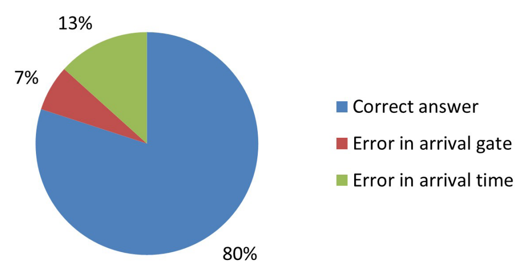

Fig. 6
Correct answers of the participants

After the end of the game all participants were invited to justify their choices. The answers they gave can be grouped into three categories:

- I believed the official announcements (press, news, policeman).
- I didn't believe the official announcements but I believed the people working at the airport.
- I was confused and I didn't know who to believe.

More specifically, as participants claimed, their final decision was based on the following three categories (Fig. 7):

- Rationale: 6 participants
- Intuition: 19 participants.
- Random: 5 participants

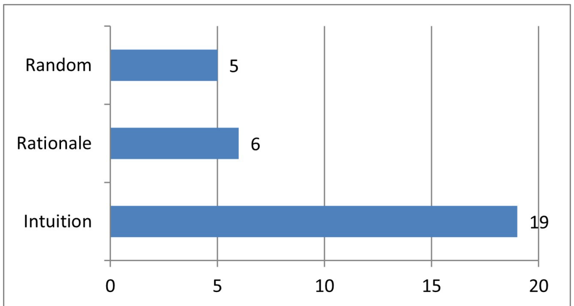

Fig. 7
Participants decision-making process

Discussion

We created a game-based learning activity in which the players had to collect information from different sources, in order to make a decision. Deliberately, pieces of information were contradictory, depending on the source of the information. On one hand, official announcements from the press, the television and the police announced a specific arrival time and gate in the airport for the prisoner. On the other hand, some people working at the airport suggested a different arrival time and gate for the prisoner. The specific situation was characterised by uncertainty-based information, in which the decision maker had to think critically who to believe and then what to decide.

Players were seeking information and recorded every piece of information they gathered in a booklet. They had plenty of time in order to recall, analyse or compare all the information, but limited time to make the final decision when they had finished with the collection of information. Their decision-making process mainly used thinking system 2 in which the information is recorded and analysed, except from the final stage in which there was time constraint for the decision. So, the engagement of the participants in our game-based learning activity enhanced their analytical way of thinking as participants followed a rational flow of a decision-making process. But in the last step of their decision-making process, they were faced with a dilemma as their information was contradictory and they had time restrictions to make their decision. In that point, rationality could not help as the reliability of the information sources could not be assessed and there was not enough time for further analysis.

Based on the findings, even if the activity led them to analyse the collected information and thus apply the analytical way of thinking (system 2), a lot of participants (19 out of 30) made their final decision intuitively as they reported since they had contradictory information and they were not sure about the reliability of each source of information. A few other participants (5 out of 30) made their decision randomly or by chance since they could not arrive at a rational decision and the rest (6 out of 30) reported that their decision was a product of the rational way of thinking (system 2). That means that all participants used the system 2 way of thinking in order to reach the final stage of their decision-making process, however, the uncertainty-based information forced most of them (19 out of 30) to use system 1 to make the final decision as it was expected from the theory (Kahneman, 2011). In other words, the engagement of the participants in our learning activity enhanced not only their analytical way of thinking (system 2), as participants followed a rational flow of a decision making process, but also enhanced the intuitive way of thinking (system 1) by the inserted uncertainty of information.

The analysis of how players made their decision (rationality, intuitively, randomly) was based on participant's answers. The responses of the participants to the questions after the game clearly cannot be characterized as the most reliable tool for gathering information about human thought; however, it is a serious indication that many participants understood that the use of rational thinking throughout the plot of the game could not lead to just one decision.

Conclusion

Decisions play an important role in our life. From the simplest decisions (e.g., what clothes to buy) to more critical decisions (e.g., how a company can avoid firing the employees in difficult times), there are two ways of thinking that guide decision-making. The first way of thinking, known as system 1, helps us to make rapid and most of the times intuitive decisions. The second way of thinking, known as system 2, helps us to make decisions rationally, based on the analysis of the situation when more time is available. Under uncertainty and when there is time pressure, system 1 is the main way of thinking, in contrast to certain situations without time pressure in which system 2 is the main way of thinking.

In general, learning activities designed for the development of decision skills usually involve learners in realistic decision situations, in order to gain experience and learn how to deal with them experientially. Based on the theory, training activities for developing decision skills can focus at the same time on enhancing system 1 and system 2 ways of thinking. For instance, in the case of a well-designed learning activity for the enhancement of system 2, system 1 also is reinforced, as learners will practice with the functions of attention and memory which both are critical functions for system 1. On the other hand, in real-problem situations, outside a laboratory environment, it is hard to characterize a situation as certain or uncertain. So, it is difficult to understand which way of thinking (system 1 or 2) is more convenient each time. In that sense, a decision making process can begin in a certain context but finally and for many reasons can end in uncertainty. For instance, a reason that will lead to uncertainty is when the reliability of intelligence sources cannot be estimated or the information collected is contradictory.

In this context, we designed and developed a game-based learning activity in an open world realism-based environment in which the objective was to enable players to make a decision on uncertainty-based information they had collected. We believe that our learning design helped the participants to enhance their decision skills using both ways of thinking, since:

- In a certain environment, players would normally make a decision by following the steps of a rational decision making process. When uncertainty is injected in the process and when the provided time for taking the decision is limited, then intuition plays a significant role. Thus, the participants involved in our learning activity due to the inserted uncertainty factors were forced to use their intuition to make their final decision. In that way, they gained experience on intuitive thinking, in contrast to the majority of learning activities on decision-making processes, which are based only on rationality.
- In enhancing rational decision skills, intuitive decision skills benefit, too. Our game-based learning activity was designed in order to enhance both ways of thinking, used in certain and uncertain situations. More specifically, it was designed in such a way to enhance the analytical thinking (system 2) following the rules of rational decision making process in the collection and analysis of information with the provided tools but also to enforce participants to resort to the intuitive way of thinking (system 1) when uncertainty was introduced at the end of the scenario.

Based on the reported results, our game-based learning activity not only enhanced the rational way of thinking in decision-making process, but also acted as the stimulus for the participants to enable intuition when they understood that they had to deal with uncertainty. Their involvement in the activity at same time provided them with a valuable learning experience on how to deal with such situations even if the conditions or the environment are different. In the future, we hope to apply the same game-based learning activity in a larger context in order to strengthen our results by acquiring quantitative metrics from the participants.

References

Anderson, D., Sweeney D. & Williams T., J., K., (2012). *An Introduction to Management Science.* 13th ed. USA: South-Western Cengage Learning.

Agor, H. (1986). *The logic of intuitive decision-making*. West Port: Quorum Books.

Bammer, G. (2013). *Disciplining interdisciplinarity: Integration and implementation sciences for researching complex real-world problems*. ANU Press.

Brouthers, K. D. (1995). The influence of international risk on entry mode strategy in the computer software industry. *MIR: Management International Review*, 7-28.

Burke, L. A., & Miller, M. K. (1999). Taking the mystery out of intuitive decision making. *Academy of Management Perspectives*, *13*(4), 91-99.

Cunha, A. (2017). Modeling and quantification of physical systems uncertainties in a probabilistic framework. *Probabilistic prognostics and health management of energy systems*, 127-156.

Clark, R. (2009). Accelerating expertise with scenario-based learning. *Learning Blueprint. Merrifield, VA: American Society for Teaching and Development*, *10*.

Cuzzolin, F. (2020). *The geometry of uncertainty: the geometry of imprecise probabilities*. Springer Nature.

Coleman, J. S. (1971). Learning through games. *The study of games*, 322-329.

De Freitas, S. (2006). *Learning in immersive worlds: A review of game-based learning*. London: Joint Information Systems Committee.

Dobbs, P. (1991). Postwar terrorism triggers insurance dilemma. *Risk Management*, *38*(6), 78-84.

Eilon, S. (1969). What is a decision? *Management Science*, Vol. 16 No. 4, pp. B172-B189.

Errington, E. (2005). *Creating learning scenarios: A planning guide for adult educators*. Cool Books New Zealand.

Errington, E. (2010). *Preparing Graduates for the Professions Using Scenario-based Learning.* Australia: Post Pressed.

Hammond, Philip, & Holger Pötzsch (eds.) (2019). *War Games: Memory, Militarism and the Subject of Play*. Bloomsbury Publishing USA.

Han, K., Klein, M., Arora, K. (2011). Varieties of uncertainty in health care: A conceptual taxonomy. *An International Journal of the Society for Medical Decision Making,31*(6), 828–838.

Hew, F. & Cheung, W. S. (2010). Use of three dimensional (3-D) immersive virtual worlds in K-12 and higher education settings: a review of the research. *British Journal of Educational Technology*, 41, 1, 33–55.

Hogarth, M. (2001). *Educating Intuition*. University of Chicago Press, Chicago.

Fischhoff, B. & Davis., L. (2014). Communicating scientific uncertainty. *Proceedings of the Natural Academy of Science* 111: 13664–13671. DOI: 10.1073/pnas.1317504111

Flin, R. (1996). *Sitting in the Hot Seat: Leaders and teams for critical incidentmanagement.* Chichester, W.

Gluckman, P. & Bardsley, A. (2016). Making decisions in the face of uncertainty: Understanding risk. *Wellington (NZ): Office of the Prime Minister's Chief Science Advisor. (PMCSA risk series)*.

Janodia, D., Sreedhar, D., Ligade, S. & Udupa, N. (2008). Solution to contentious issue of Article 31(f) of TRIPS agreement. *Indian Journal of Medical Research*, *128*(1), 84-86.

Kahneman, D. & Frederick, S. (2002). Representativeness revisited: attribute substitution in intuitive judgement, in T. Gilovich, D. Griffin, and D. Kahenman (eds), *Heuristics and Biases: The Psychology of Intuitive Judgements,* Cambridge University Press, Cambridge.

Kahneman, D. (2011). *Thinking, Fast and Slow*. New York: Farrar, Straus and Giroux.

Klir, G., & Wierman, M. (1999). *Uncertainty-based information: elements of generalized information theory* (Vol. 15). Springer Science & Business Media.

Lauche, K., Crichton, M., & Bayerl, P. S. (2009, June). Tactical decision games: Developing scenario-based training for decision-making in distributed teams. In *9th Bi-annual International Conference on Naturalistic Decision Making* (NDM9) 9 (pp. 227-234).

Leitão, P. (1993). A decisão na academia II. *Revista de Administração Pública*, *27*(2).

Lipshitz, R. & Strauss, O. (1997). Coping with uncertainty: a naturalistic decision making analysis. *Organizational behavior and human decision processes*, 69(2), 149-163.

March, J. (1994). *A primer on decision-making: how decisions happen*. New York: The Free Press. doi:10.1007/bf03396612

Marchisotti, G., Almeida, L. & Domingos, C. (2018). Decision-making at the first management level: The interference of the organizational culture. *Revista de Administração Mackenzie*, *19*(3). doi:10.1590/1678-6971/eRAMR180106

Mietzner, D., & Reger, G. (2005). Advantages and disadvantages of scenario approaches for strategic foresight. *International Journal of Technology Intelligence and Planning*, 1(2), 220-239.

Mousavi, S., & Gigerenzer, G. (2014). Risk, uncertainty, and heuristics. *Journal of Business Research*, 67(8), 1671-1678. doi: 10.1016/j.jbusres.2014.02.013

Peterson, J. (2012). *Playing at the world: A history of simulating wars, people and fantastic adventures, from chess to role-playing games*. San Diego, CA: Unreason Press.

Schulte, M. (2017). Board games of the Vikings-From hnefatafl to chess. *Maal og minne*, *109*(2).

Simon, H. (1960). The New Science of Management Decision, Harper and Brothers, New York.

Sloman, A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, 119, 3-22.

Sniazhko, S. (2019). Uncertainty in decision-making: A review of the international business literature. *Cogent Business & Management, 6(1), 1650692.* doi:10.1080/23311975.2019.1650692.

Tversky, A. & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, 185*(4157), 1124–1131.

Toma, S. V., Chiriţă, M. & Şarpe, D. (2012). Risk and uncertainty. *Procedia Economics and Finance*, 3, 975-980.

Trucano, T. G., Swiler, L. P., Igusa, T., Oberkampf, W. L., & Pilch, M. (2006). Calibration, validation, and sensitivity analysis: What's what. *Reliability Engineering & System Safety*, 91(10-11), 1331-1357.

van den Heuvel, C., Alison, L., & Crego, J. (2012). How uncertainty and accountability can derail strategic 'save life' decisions in counter-terrorism simulations: A descriptive model of choice deferral and omission bias. *Journal of Behavioral Decision Making*, 25(2), 165-187.

Wheeler, M., Meenken, E., Espig, M., Sharifi, M., Shah, M. & Finlay-Smits, C. (2020). Uncertainty – what is it? In: *Nutrient Management In Farmed Landscapes*. (Eds. C.L.Christensen, D.J. Horne and R. Singh). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 33. Farmed Landscapes Research Centre, Massey University, Palmerston North, New Zealand.

Xiong, C., Johnson, D., Corso, J. (2014). Active Clustering with Model-Based Uncertainty Reduction. *IEEE Transactions on Pattern Analysis and Machine Intelligence*. 39. 10.1109/TPAMI.2016.2539965.

Young, E. (2004). Chess! What is it good for? *The Guardian*, March 4 2004.