Uncertainty in games – potential benefits and disadvantages*

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Abstract: The aim of the article is to indicate different types of uncertainty in games and to present them in the light of neurophysiological research and selected theories of motivation. The paper analyses pure, system-generated randomness (gambling and accidental luck), game complexity, and elements that relate on a tactical or strategic level to the human factor. In particular, the application of rules enabling games based on the power of the mind is discussed. The article concludes with the presentation of benefits and disadvantages following the potential implementation of elements inducing uncertainty.

Keywords: uncertainty, games, randomness, game mechanics

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1. Introduction

Play is an

> uncertain activity. Doubt must remain until the end. … In a card game, when the outcome is no longer in doubt, play stops… In a lottery or in roulette, money is placed on a number which may or may not win. In a sports contest, the powers of the contestants must be equated, so that each may have a chance until the end. Every game of skill, by definition, involves the risk for the player of missing his stroke and the threat of defeat, without which the game would no longer be pleasing. In fact, the game is no longer pleasing to one who… wins effortlessly and infallibly (Caillois, 2001, p. 8).

The above observation may be explained in various ways. From the neurophysiological point of view, the uncertainty of winning increases the release of the "reward" neurotransmitter – dopamine – in a player's brain. The same phenomenon occurs also during reward-oriented behaviours such as eating or sex (Arias-Carrión & Pöppel, 2007; Niv, Duff, & Dayan, 2005). On the other hand, in an imaginary, repeatable game environment, the risk of a defeat – as the condition of the satisfaction from winning – enables players to safely overcome difficulties and raise competences (Juul, 2013, p. 7) or allows an escapist compensation of one's own deficits (Calleja, 2010). The aim of this paper is to present and discuss the different types of uncertainty and to place them in the context of selected theories of motivation.

2. Neurophysiology of uncertainty

In the natural conditions, dopamine is released when an individual expects that their behaviour will yield a reward (Arias-Carrión & Pöppel, 2007). When the reward is bigger than expected, it results in an increased activity of dopamine neurons (*post factum*), which in turn leads to the rise of expectations and motivation related to its future occurrence. Hence, dopamine is a reinforcing factor while learning new behaviours; on the psychological level, it is responsible for the pleasant state motivating one to perform certain – still relatively new – reactions. What is interesting, a higher level of dopamine may be observed in a situation of uncertainty rather than when gratifications are certain. In monkeys, the maximum dopamine dose is released when the probability of a reward is in the middle between full unpredictability and certainty (Fiorillo et al., 2003).

Berridge and Robinson (1998) indicate another important function of dopamine. They differentiate between "like" and "want". On the psychological level "want" plays a strictly motivational role, determining the desire for a stimulus associated with the reward. On the other hand, "like" is related to an emotion, a hedonistic pleasure of consuming the stimulus. In one study, raising the dopamine level in rats facilitated "wanting" and learning of an incentive motivation task for a sweet reward, but the elevated dopamine did not increase the "liking" of the sweet taste (Pecina et al., 2003). In the context of games, it is also necessary to distinguish between the motivational aspect of uncertainty and its emotional evaluation. The uncertainty is appealing and attracts attention, making a player who awaits rewards – now or in the future – undertake certain (even uninteresting) actions. Some empirical evidence supports the thesis of similarity between the effects of the drug *ecstasy* and the impact of games (Weinstein, 2010). In both cases there exists a mechanism characteristic of addictions: tolerance. The dopamine receptors, "exhausted" in an earlier hyperactivity, need bigger than standard doses of the substance or the game rewards. In players – contrary to drug addicts – dopamine is released in a natural way (Koepp et al., 1998), but a higher tendency to game addiction may be observed in individuals of certain temperament traits (higher reward dependency) and brain biochemistry (increased prevalence of the DRD2 TAQ1A1 and COMT alleles related to D2 dopamine receptors) (Han et al., 2007). It should be also noted that video game addicts compared to non-addicts have a higher level of physiological arousal (Griffiths & Dancaster, 1995).

3. Types of uncertainty

3.1. Costikyan's classification

There are eleven sources of uncertainty, according to Greg Costikyan (2013, pp. 71–103). They are listed below. The subsections in the classification indicate characteristic features, context, and use examples of a particular category.

Performative uncertainty

- players with higher skills are more likely to defeat those with lower skills (they are less uncertain of winning);
- skills (speed and sequences of reactions, precision, interface mastery) can be trained;
- the highest level of uncertainty is when game participants have similar skills;
- typical use: first-person shooters, action/adventure games, driving games, etc.

Solver's uncertainty

- game progress is possible (or facilitated) after solving a certain puzzle (e.g. how to get to a certain place; how to use a given object); the state of uncertainty is related to hidden game elements; the content is not algorithmically generated but designed beforehand,
- typical use: puzzle-based games; role-playing games designed to be played once.

Player unpredictability

- opponents may undertake various strategic decisions (e.g. competition or cooperation; attack or defense; decision to sell or wait for a better moment)[1];
- typical use: multiplayer games.

Randomness

- progress or benefits in a game depend on luck, bad luck leads to a loss; uncertainty is related to the result of randomization;
- in video games results are generated randomly (e.g. *loot* from a killed monster; a standard hit or a 'critical' one); in board games gameplay is dependent on a roll of dice or drawing a card;
- there is no relation between players' skills and the probability of success;
- typical use: gambling (roulette), board and card games; more or less all other games.

[1] Costikyan refers here to the unpredictability of the other person (not related to the uncertainty of one's own behaviour). This kind of uncertainty can be compared to the uncertainty of a general giving orders to his troops. Working out an opponent (reducing uncertainty) is one of the key elements of success. In everyday life, this type of uncertainty happens rarely (people usually behave conventionally in shops or at parties).

Analytic complexity

- decisions undertaken by players have long-term effects; successful play is based on careful progress planning (e.g. choosing appropriate options on a skill tree; concentration on technology or military power);
- a high level of uncertainty is associated with the difficulty to analyse all possible interactions and mastering game rules (especially in video games);
- excessive analytic complexity may result in a lack of game balance;
- typical use: strategy games, chess.

Hidden information

- a player must make some steps to reveal hidden information (in-game world exploration); it may also happen automatically during the gameplay (uncovering cards in board or card games);
- hidden information may be generated randomly (card games) or pre-designed (*fog of war*);
- typical use: board and card games, turn-based and real-time strategies.

Narrative anticipation

- uncertainty is related mainly to the game storyline, raising curiosity and making players pursue actions to satisfy it;
- narration encompasses mainly storytelling ("How will it end?") or character development (getting to know new places; gaining new skills), but also – though to a smaller degree – broadly understood progress (creating an empire in strategy games);
- typical use: single- and multiplayer RPGs.

Development anticipation

- the majority of satisfied players anticipate new game versions (new additions or expansion packs);
- in case of MMORPGs, uncertainty associated with the introduction of new game versions may discourage some players (acquired items and skills may lose their value);
- typical use: video games.

Schedule uncertainty

- uncertainty is related to the time spent on playing a game (frequent short sessions instead of a long presence in a game);

- game mechanics may discourage constant playing because of the schedule of rewards (intervals of regenerating energy or crop vegetation; daily or weekly limits of gained experience points, e.g. *daily quests*);
- typical use: single – and multiplayer RPGs.

Uncertainty of perception

- sensory complexity (visual and/or auditory) leads to uncertainty related to determining what is a figure and what is its background;
- perceptive puzzles may be an important game element (e.g. camouflaged door);
- typical use: games like *Tetris*, FPSs, some musical games.

Malaby's semiotic contingency

- some games consciously create cultural meaning; players ascribe meaning to outcomes;
- game elements may be a parody of elements from different games (e.g. leaping on a flagpole in *Super Mario Bros*. frees someone who is imprisoned; in *Syobon* – it kills the character);
- typical use: parodies of games.

The above classification is based on the criterion of the sources of uncertainty. In some cases one element may belong to various categories. For example, narrative anticipation (7th type) seems to be a higher-level category, related rather to a player's state of mind than the game structure. In a way, all players, even those facing only abstract graphical elements, tell stories (Scholla & Tremouletb, 2000). Predicted alternative endings or simple curiosity about "what happens next" are associated with both analytic complexity (e.g. narration about style, personality, or emotions of an opponent) and player unpredictability. The author of the classification himself notices also (Costikyan, 2013, pp. 81–82) that unpredictability of a computer opponent is simulated by randomness of actions in singleplayer games.

Below I present my own classification, separately categorizing uncertainty of which the sole source is the system, and separately the one related to the human factor[2]. In the former category there is randomness of some elements (Costikyan's 4th type) or system complexity (Costikyan's

[2] By uncertainty I mean such a game design that will ensure – from a player's point of view – the lack of certainty of succeeding.

5^{th} type); in the latter one there are all the rules which enable the use of human skills and emotions to induce a feeling of uncertainty.

3.2. System as a source of uncertainty

3.2.1. Randomness

Randomness is related to the introduction of a gambling factor (which always carries the risk of losing one's own resources) or a non-gambling element. In each case a game should be balanced in such a way that unlucky players should be able to compensate for the losses with their skills or time effort. It is obvious in the gambling case – the invested resources (and the risk of losing them) would be counterbalanced by other ways of achieving a reward. An example of it is a *lotto* feature in KOTS2000, where a lottery ticket bought with the game's virtual currency provides a chance to win points needed to buy certain skills. This element is also used in different types of random gift boxes (e.g. *Perfect World*).

It is somewhat more difficult to reach a sense of justice with the non-gambling elements. Some players dislike it (or believe so) when they win or lose by means of luck. One might consider that individuals who like strategies do not engage in games which may be won because of something else than mental effort, whereas the skill-and-action gamers will prefer to win solely thanks to their skills (Costikyan, 2013, p. 82). However, as it was indicated in the subsection about neurophysiological correlates of uncertainty, pure randomness may become a powerful tool of releasing positive emotions, intensifying playfulness and attachment to a game. Poker (or other card games) would be tedious as a one-deal gameplay, in which much depends on chance. But it is quite fascinating as a game of many deals, when in the longer perspective chances for a good poker hand are distributed according to the theory of probability. From a game addictiveness point of view, the matter of the schedule of reinforcement of certain behaviours is also worth mentioning. An individual will perform some repeatable actions longer – e.g. killing some type of monsters in order to gain a certain item – when at every turn they think that success will come now. This schedule is a variable-ratio one: the more reactions (the more killed monsters), the higher probability of gaining the reward, but an individual does not know when exactly the reward will come. It may be contrasted with a non-random, fixed-ratio schedule, in which the moment of gratification is always strictly determined.

The examples of using randomness in games are:

- gambling elements (gains, lack of gains, or losses after investing resources);
- consequences of a roll of dice or drawing a card;
- *loot* from killed monsters in RPGS (variable-ratio schedule);
- a standard hit or a 'critical' one in RPGS or FPSS (variable-ratio schedule);
- choice of strategy or tactics of artificial intelligence in strategy games (and gameplay).

3.2.2. Complexity

The system complexity leading to a sense of uncertainty is involved when a player lacks the cognitive resources to assess a game state. They are not able to accurately predict the way the gameplay will go; They do not know the further moves of artificial intelligence and how to react or counter it. The level of uncertainty resulting from this factor depends on the skills and experience of the player. First, intellectual abilities help predict the course of the gameplay, assuming that the player fully understands the game rules and is able to mentally embrace the potential interactions. For example, in the case of uncomplicated games (tic-tac-toe), the number of possible choices made by the system is so small that an intelligent human opponent is capable of reacting in an optimal way even without prior acquaintance with the game. Second, experience with a game helps a player to get to know the behaviours of the artificial intelligence. And because the discussed complexity factor is not related to randomness, the moves performed by the system are based on programmed algorithms of 'if a then b' type, leading to predictable consequences. To learn the game is to learn the algorithm. In case of low complexity, players are quick to detect the possible sequences of reactions of the artificial intelligence. For example, killing monsters in RPGS is not a particularly exciting challenge, because their actions are based on relatively simple, easy-to-master algorithms. That is why a game against artificial intelligence is hardly ever related to a challenge. An implementation of artificial intelligence whose choices would be unrecognizable from human ones happens to be extremely difficult. It stems mostly from time limits (computational capabilities): striking a blow should be almost instant. Additionally, to achieve full unpredictability, the computer should take into account the way each player behaves (i.e. their sequence of reactions) independently of the other ones. It should also include such behaviours of the artificial intelligence that are erroneous or unreasonable. Game designers may compensate for this by adding new random elements or programming varying approaches to human and system opponents, which is exemplified by the technique of vast resources (Crawford, 1982)[3].

In the case of games which allow many alternative outcomes of a situation, the complexity of the system may be a factor leading to a high level of uncertainty. The extreme example of this is chess. Artificial intelligence reacting in a multilevel way (analysing possible configurations and effectiveness of moves many steps ahead) will be unbeatable by a good chess player. Similarly, a system learning human behaviours, based on, for example, neural networks (Mnih et al., 2015), taking into account not only the present state of the gameplay, but also the temperament, preferences, habits, or weaknesses of a particular player, may have an analytic "ability" outclassing the experience and intuition of many experienced players. In the second case, what we have is a peculiar "arms race". Designers aspire to create more and more complex, sophisticated "human" intelligence. Players, on the other side, try to work it out[4].

Below are presented the examples of system complexity generating a sense of uncertainty in players (from the highest to the lowest complexity):

- chess or Go gameplay;
- board game gameplay;
- macromanagement in strategy games (selection of strategy and tactics);

[3] In addition, a person may have a more limited amount of information. For example, the fog of war in strategies may only be present for a human player, while the system "sees" the entire battleground (Ontanon et al., 2013).

[4] Real-time strategies (*RTS*) or non-turn *RPG*s are assumed to have strict time requirements (e.g. artificial intelligence in *StarCraft* must respond within 55 milliseconds). In this case, the technological capabilities of current gaming platforms make it impossible for the system to control a game to the highest degree. In addition, unlike with board games, it is infeasible to create opening and ending databases for *RTS* games (Oh et al., 2017).

- micromanagement in strategy games (selection of strategy and tactics);
- selection of weapons and tactics during combat (RPG, FPS).

3.3. The human factor as a source of uncertainty[5]

The uncertainty-generating role of the system cannot be reduced to mere randomness. Additional sources of uncertainty are all the rules which oppose the unpredictability of a strategic misleading of an opponent (or attempting to understand them) to predictable results of skill and narrowly understood intelligence. A trivial example of it might be a possibility of performing a dodge or breaking out of a standard sequence of reactions in FPS or MMORPG games. In this context a well-designed game is based on algorithms which allow reaching a goal in different ways (replication of a learned routine may lead to a failure). On the other hand, an extremely untrivial example will be a poker bluff[6]. The bluff relies on many factors: a ratio between the size of the pot and the size of the bet a player is facing (*pot odds*), opponents' unverbal behaviour, their previous decisions and perceived personality traits. Although poker is usually recognised as a typically random game, some research shows that in a longer perspective more skilled players win more often (Czajkowski, 2015). A similar situation can be observed in other apparently random games (e.g. rock-paper-scissors). In the case of poker, the systemic element generating uncertainty is related to the rules – to the possibility of betting inadequately to the possessed cards (the so-called hand).

Between the above frames many other examples of players' choices may be found where a psychological competition plays a greater or lesser role:

- strategy in *StarCraft* (Ontanon at al., 2013);
- combat strategy in battlegrounds in *World of Warcraft*;

[5] The human factor stands here for a player's activity (the activity of game designers is related to the uncertainty stemming from the system).

[6] According to the Cambridge Dictionary (2019), the verb 'bluff' in American English means "to try to trick someone into believing something, esp. in order to get an advantage over that person". The bluff is associated with a psychological game that uses the power of the mind (or the use of specific acting skills) and corresponds to Costikyan's third type. The sense of uncertainty stems from ignorance (partial knowledge) about an opponent's resources and from the possibility of sending incorrect signals. In this context, the feigned manifestation of weakness or anxiety can also be treated as a bluff.

- fight or flight in MMORPGs;
- price competition (auction houses in MMORPGs);
- selection of a weapon and tactics during combat (FPSs, arcade games).

It should be noted that in video games psychological competition using mental power is of lesser importance than skills and experience. Artificial intelligence cannot equal the best human poker players in the way it deals with the best chess players (Czajkowski, 2015), so in that respect its "abilities" would be limited in single-player games. On the other hand, in multiplayer games it might be difficult to combine/balance elements of skill, narrative, and psychological competition on such a high level as in poker (poker is not an action-based game and it is not based on linear progress).

4. Psychology of uncertainty

Michal Apter (1997) distinguishes four pairs of opposite metamotivational states. The first of these pairs is the telic-paratelic one. The telic state is related to a goal, future orientation, and seriousness. On the other hand, the paratelic one may be described as oriented toward enjoyment, playfulness, and spontaneity. Only one state in this pair can be active at a time, but the reversal between them is possible due to experiencing certain behavioural stimuli. For example, a tiresome preparation for an exam may turn into exciting fun when a student gets "carried away" by an interesting topic. A similar situation can be observed in games. When the initial curiosity (game content, possibilities) is replaced by the drudgery of reaching subsequent levels and collecting points, the player will stop treating the game as fun and start approaching it as a job that should be done. Conversely, a player tired of routine activities may suddenly feel a thrill if they encounter something they did not expect. Uncertainty in games, unless it significantly interferes with the set goal, guarantees to increase its playfulness. The right balance between predictable, control-granting elements constructing a linear course of a game (e.g. earning points for specific actions) on the one hand, and pure fun (e.g. attacking a weak opponent) on the other, can make the game appealing.

The effects of introducing the uncertainty factor may also be analysed in relation to the regulatory focus theory (Higgins, 1987, 1997). Individuals may be approaching pleasure, oriented towards promotion (focus on ideals, maximization of positive effects of actions), or avoiding pain, concentrated on prevention (duties and obligations, minimizing negative effects of actions). The telic metamotivation entails preventive regulation. A development of a vast reward system based on a fixed-ratio or a fixed-interval schedule of reinforcements (regardless of skills – the more or the longer, the better) ultimately leads to fatigue and routine. And a state of uncertainty causes anxiety instead of excitement. In such a situation, a player's priority is not fun, but rather a quick achievement of a goal. Similarly, encountering difficulties that need to be addressed redirects players' motivation into the telic state. Resources are spent on preventive behaviours (avoiding mistakes), actions become slower, more thoughtful and accurate (Slezak & Sigman, 2012). Experiencing uncertainty due to the possibility of unpredictable (random) factors can further increase the level of anxiety and ultimately deter from the game. This may be one of the causes of some players' belief that games in which results may depend not only on skills, but also to some extent on luck, are not very attractive (Costikyan, 2013, p. 82).

The problem can be also explained in terms of a theory of flow (Csikszentmihalyi, 1990). Individuals experience a state of flow when they are maximally immersed in a given activity, forget everything else, and lose a sense of time. This is possible when the performed actions have an optimal level of difficulty and pose a challenge. Too difficult tasks will cause anxiety, too simple – a sense of boredom. In both cases, the key factor is competence. A gifted and trained player will not feel the thrill of competing with a much weaker opponent, as victory will be seen as a formality. Uncertainty stemming from the difficulty of taking into account all the possible factors (including random ones) may result in a more balanced gameplay and optimal challenge levels. However, it should be noted that in games where time and physical or mental effort are rewarded, the increase in uncertainty can be discouraging. Therefore, the best solution will be to introduce alternative forms of gameplay (development paths, modes) in which players will be able to make their own choices.

When analysing the psychological aspects of the sense of uncertainty in games, one should not forget about players' personality traits. The high activity of the BAS (behavioral activation system) (Carver & White, 1994), which regulates appetitive motivation, may promote stronger promotional regulation and greater openness to uncertainty. Especially the two BAS components are crucial in this case: fun-seeking and drive. Also traits distinguished in the Big Five theory, in particular openness to experience, conscientiousness, extraversion, and neuroticism may play a role in preferences regarding uncertainty. However, there is not enough research in this area. A similar case is that of traits distinguished in player taxonomies (Quick et al., 2012).

5. Summary

Is it useful to introduce elements that cause a sense of uncertainty in games? Considering the benefits in motivation and emotions procured by uncertainty, the answer should be positive. Nonetheless, one should remember about potential implementation errors. First, an inadequate balance between skill and luck (randomness factor) may discourage high-competence players who will perceive the outcome of a game as not entirely fair. In particular, this is important in action and strategy games. Elements of chance should be only peripheral. Second, for the reasons mentioned above, one should avoid allowing luck to compensate for the lack of effort in games involving long-term development (MMORPG) (or it might be limited only to gambling). Third, if possible, an individual should not be forced to rely on chance when they prefer a certain, though smaller, reward (optimally this could involve the choice of a specific gameplay option or, in the case of RPGs, an avatar feature). Fourth, a game with a high level of uncertainty could generate a sense of lack of control and, consequently, anxiety. Fifth, a largely random game would quickly become boring, while a game based mainly on mental gameplay (e.g. bluff) would transpire as emotionally exhausting.

As it was mentioned above, the game elements causing uncertainty in a player are a powerful tool that generates positive emotions, increases playability and loyalty. It is also worth risking to implement gambling elements, which – as opposed to blind chance – would be perceived as more fair than an undeserved stroke of luck (Howard-Jones & Demetriou, 2008). However, an action game or a MMORPG might benefit from accidental random features. This would allow a player to break away from the routine and temporarily change the motivational focus. Finally, an introduction of some psychological game rules (poker bluff, anticipation of sequences in a rock-paper-scissors game) could enrich the gameplay. Such elements are already used (a feint in action and strategy games), although mainly in the context of tactics, not strategy. The application of high level uncertainty models as rules organizing the gameplay could be tiresome in the long run (e.g. RPG based on poker rules); however, if used complementarily or in parallel with traditional models (certainty of earning points for completed tasks), they would give an alternative to routine actions and might additionally arouse emotions. Models from game theories could be mentioned as examples: standard or iterated prisoner dilemma, centipede, or hawk-dove games. At a very high level, they determine benefits stemming from potential competition or cooperation.

References

Apter, M. J. (1997). Reversal theory: What is it? *The Psychologist, 10*(5), 212–219.

Arias-Carrión, O., Pŏppel, E. (2007). Dopamine, learning, and reward-seeking behavior. *Acta Neurobiologiae Experimentalis, 67*, 481–488.

Berridge, K. C., Robinson, T. E. (1998). What is the role of dopamine in reward: hedonic impact, reward learning, or incentive salience? *Brain Research Reviews, 28*(3), 309–369.

Caillois, R. (2001). *Man, play and games.* Urbana – Chicago: University of Illinois Press.

Calleja, G. (2010). Digital games and escapism. *Games and Culture, 5*(4), 335–353.

Cambridge Dictionary (2019). Cambridge Dictionary. Online: <https://dictionary.cambridge.org/dictionary/english/bluff>. Accessed: 26 April 2019.

Costikyan, G. (2013). *Uncertainty in games.* Cambridge, Massachusetts: The MIT Press.

Crawford, Ch. (1982). Design techniques and ideas for computer games. *Byte Magazine, 7*(12), 96–108. Retrieved on 19 July 2018 from <https://archive.org/stream/byte-magazine-1982-12/1982_12_BYTE_07-12_Game_Plan_1982#page/n97/mode/2up>.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: HarperCollins.

Czajkowski, M. (2015). Poker – gra szczęścia czy umiejętności? Przegląd analiz teoretycznych i empirycznych oraz wnioski dla regulacji. *Ekonomia. Rynek, Gospodarka, Społeczeństwo, 40*(1), 33–57.

Fiorillo, C. D., Tobler, P. N., Schultz, W. (2003). Discrete coding of reward probability and uncertainty by dopamine neurons. *Science, 299*(5614), 1898–1902.

Griffiths, M. D., Dancaster, I. (1995). The effect of type A personality on physiological arousal while playing computer games. *Addictive Behaviors, 20*(4), 543–548.

Han, D. H., Lee, Y. S., Yang, K. C., Kim, E. Y., Lyoo, I. K., Renshaw, P. F. (2007). Dopamine genes and reward dependence in adolescents with excessive internet video game play. *Journal of Addiction Medicine, 1*(3), 133–138.

Higgins, E. T. (1987). Self-discrepancy: A theory relating self and affect. *Psychological Review, 94*(3), 319–340.

Higgins, E. T. (1997). Beyond pleasure and pain. *American Psychologist, 52*(12), 1280–1300.

Howard-Jones, P. A., Demetriou, S. (2008). Uncertainty and engagement with learning games. *Instructional Science, 37*(6), 519–536.

Juul, J. (2013). *The art of failure: An essay on the pain of playing video games*. Cambridge: MIT Press.

Koepp, M. J., Gunn, R. N., Lawrence, A. D., Cunningham, V. J., Dagher, A., Jones, T., Brooks, D. J., Bench, C. J., Grasby, P. M. (1998). Evidence for striatal dopamine release during a video game. *Nature, 393*(6682), 266–268.

Mnih, V., Kavukcuoglu, K., Silver, D., Rusu, A. A., Veness, J., Bellemare, M. G., Graves, A., Riedmiller, M., Fidjeland, A. K., Ostrovski, G., Petersen, S., Beattie, Ch., Sadik, A., Antonoglou, I., King, H., Kumaran, D., Wierstra, D., Legg, S., Hassabis, D. (2015). Human-level control through deep reinforcement learning. *Nature, 518*(7540), 529–533.

Niv, Y., Duff, M. O., Dayan, P. (2005). Dopamine, uncertainty and TD learning. *Behavioral and Brain Functions, 1*(6). Retrieved 30 December 2019 from <https://link.springer.com/article/10.1186/1744-9081-1-6>.

Oh, I., Cho, H., Kim, K. (2017). Playing real-time strategy games by imitating human players' micromanagement skills based on spatial analysis. *Expert Systems with Applications, 71*, 192–205.

Ontanon, S., Synnaeve, G., Uriarte, A., Richoux, F., Churchill, D., Preuss, M. (2013). Survey of real-time strategy game AI research and competition in StarCraft. *IEEE Transactions on Computational Intelligence and AI in games, 5*(4), 1–19.

Pecina, S., Cagniard, B., Berridge, K. C., Aldridge, W., Zhuang, X. (2003). Hyperdopaminergic mutant mice have higher „wanting" but not „liking" for sweet rewards. *The Journal of Neuroscience, 23*(28), 9395–9402.

Quick, J, M., Atkinson, R. K., Lin, L. (2012). Empirical taxonomies of gameplay enjoyment: Personality and video game preference. *International Journal of Game-Based Learning, 2*(3), 11–31.

Scholla, B. J., Tremouletb, P. D. (2000). Perceptual causality and animacy. *Trends in Cognitive Sciences, 4*(8), 299–309.

Slezak, D. F., Sigman, M. (2012). Do not fear your opponent: Suboptimal changes of a prevention strategy when facing stronger opponents. *Journal of Experimental Psychology: General, 141*(3), 527–538.

Weinstein, A. M. (2010). Computer and video game addiction – a comparison between game users and non-game users. *The American Journal of Drug and Alcohol Abuse, 36*(5), 268–276.

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Niepewność w grach – potencjalne korzyści i straty

Abstrakt: Celem artykułu jest wskazanie różnych typów niepewności w grze, a także ich umiejscowienie w kontekście badań neurofizjologicznych oraz wybranych teorii motywacyjnych. Analizowane są elementy: 1) czystej losowości (hazard i ślepy traf), generowanej przez system; 2) zaprogramowanej złożoności reakcji sztucznej inteligencji; oraz 3) te, które na poziomie taktycznym lub strategicznym związane są z czynnikiem ludzkim. Szczegółowo omówione jest zastosowanie reguł umożliwiających grę wykorzystującą siłę psychiki. Konkluzja prezentuje zyski i straty płynące z potencjalnego wzbogacenia gier o czynniki wytwarzające poczucie niepewności.

Słowa kluczowe: niepewność, gry, losowość, mechanika gry