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Impact of metacognition and age group on contemporary video game interface and gameplay design

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Abstract: **Metacognition is about "learning about learning" [1]. However, this theory is far more complicated. This allows people to take charge of their own learning. It involves awareness of how they learn, and evaluation of their learning needs, generating strategies to meet these needs and then implementing the strategies. The theory of metacognition can be identified as humans' survival instinct. Metacognition also thinks about one's thinking process such as study skills, memory capabilities, and the ability to monitor learning [2], [3]. Metacognition refers to higher-order thinking which involves active control over the cognitive processes engaged in learning. This concept needs to be explicitly taught along with content instruction. Metacognitive knowledge is about our cognitive processes and our understanding of how to regulate those processes to maximize learning. From ancient times humans have developed their metacognitive skills as a survival factor. For the survival in a video game, players need to follow instructions to get an idea about the gameplay [4]. But most of the time people are likely to skip the instructions without going through them even for the first time. This scenario is noticeable in mobile gameplay. This research has done to identify the factors which affect this dilemma. Metacognition level of a person and age are the variables that were considered for this experiment in order to address the following hypotheses; The more metacognitive skills people have, the more they will find it easy to play never-before-played games. Age range affects performance when it comes to playing the never-before-played games without direct instructions. At the end of this experiment, the first hypothesis became correct while the second one wasn't. Therefore, people were more likely to ignore direct instructions and go through gameplay successfully when they had a higher metacognitive level, and the age group didn't seem to affect this factor.**

Keywords: *Gameplay, Interface Design, Metacognition, Video games*

I. INTRODUCTION

According to the common mobile game player behavior that has been experienced, the question arises whether instructions are necessary at all and why do people ignore the instructions and just continue to play. This research looked into how does the theory of metacognition help people to understand the functions concerning the age group that they belong, and the impacts of the metacognitive process on contemporary game interface design. It also helps to make ways of building a better and simpler game experience for people. The need for separate sets of instructions in the interface design or allow players to self-learn through the gameplay can be varied according to different levels of cognitive skills of the players and the different age groups that they belong to. The purpose of this study was to determine whether metacognition helps people to understand gameplay and game interface without going through instructions and whether this has been affected according to age groups that they belong to. Games are rated by IARC (International Age Rating Coalition) according to suitable age ranges. Therefore, a game is designed according to its target market which has to be released. The need for direct instructions or giving them through the gameplay can be decided according to the final result of this research. Including instructions in the game techniques effects the whole gameplay design.

This research looked into this problem in search of factors that cause this particular problem and the answers help to broaden the knowledge of the game design field and make ways of building better game experience.

II. PREVIOUS STUDIES

A study on the effects of age on metacognitive efficiency was done in 2014. The primary aim of this study was to investigate the effects of age on metacognitive efficiency in healthy adults between the ages of 18 and 84. They have found that perceptual metacognitive efficiency declined with age, despite task performance being controlled to ensure all participants performed with the same accuracy [5]. In this study, game-related motives are not included and only the psychological side is considered while only considering adults for their experiments [6]. According to the latest video game demographics, details identified that young adults are mostly engaged in gaming [7], [3]. The age rating for gaming is also opened from children to adults and therefore, had to focus on young adults and ages between 7-18 for the research. According to the previous study mentioned above, a hypothesis made for this study that 'age affects the performance when it comes to playing never-before-played game without direct instructions', but later found that even though the cognitive efficiency fade with age, that does not affect when different people from different age groups having same metacognition level.

Game design, UI design, gamification related research topics are frequently found [8], [9], [10], [11], [12], [13], especially regarding how to design games to enhance metacognitive abilities via educational games. But this concept was far more different from the suggested study.

III. OBJECTIVES

The main purpose of this study was to determine whether metacognition helps people to understand gameplay and game interface without going through instructions. The study helps to broaden the knowledge of game design and help design better game experience. This study also helps to identify creative learning and teaching methods based on metacognition and games.

Games are rated (IARC ratings, ESRB ratings) according to different age groups that these games are suitable (according to the content of each game). Therefore, each game has a target market according to that age range restriction. If there is a connection between the age of a player and the need for instructions, that helps for the gameplay design of the overall game. Therefore, this helps to design the game correctly to the target market from the early stage while helping to market the game to the target market in the correct way.

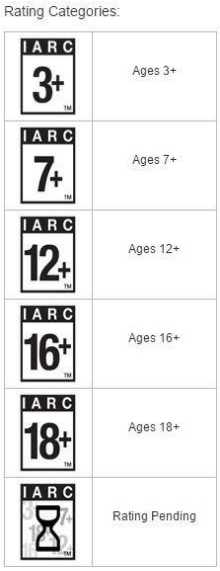

Fig. 1. IARC (International Age Rating Coalition) age rating according to suitable audiences

Fig. 2. ESRB (Entertainment Software Rating Board) age rating according to suitable audiences

For this study, the following questions were addressed.

- Based on the theory of metacognition, will people find it easy or difficult to play a never-before-played game without instructions according to their metacognitive skills?
- Does their age affect this?

Accordingly, this investigation included two research hypotheses.

H1: The more metacognitive skills people have, the more they will find it easy to play never-before-played games

H2: Age affects performance when it comes to playing a never-before-played game without direct instructions.

IV. THEORETICAL FRAMEWORK

The theory of metacognition defined that a person is capable of understanding or knowing his or her thinking process and manage it. This idea can be explained by dividing it into 3 parts [14], [15].

- Person knowledge (declarative knowledge) which is understanding one's capabilities
- Task knowledge (procedural knowledge) which is how one perceives the difficulty of a task which is the content, length, and the type of assignment
- Strategic knowledge (conditional knowledge) which is one's capability for using strategies to learn information. Young children are not particularly good at this; it is not until upper elementary where students start to develop an understanding of strategies that will be effective.

These three components are the necessary skills that you need to "survive" in a game and real life as well [4]. These components can be measured according to the following components.

- Metacognitive knowledge (also called metacognitive awareness) is what individuals know about themselves and others as cognitive processors.
- Metacognitive regulation is the regulation of cognition and learning experiences through a set of activities that help people control their learning.
- Metacognitive experiences are those experiences that have something to do with the current, ongoing cognitive endeavor[16].

These components help to identify the level of metacognition of a person with regard to gaming which was ultimately helped to figure out whether metacognition has an impact on understanding gameplay and game interface.

A. The level of metacognition

The level of metacognition is an equation designed by the researcher to calculate the level of metacognition of a person performing a task. According to John Flavell's (1979) explanation of metacognition as a theory, he explains that metacognition consists of two main parts named metacognitive knowledge and metacognitive regulation. He further states that the metacognitive knowledge can be divided into 3 parts as, person variables, task variables and strategy variables [17]. Considering all these facts the researcher was able to derive an equation to compare the levels of metacognition of different persons in a specific task. The key here was that the task has to be specific and the same for everyone to get an accurate reading.

*Level of Metacognition = Experience in the Task*Role (1)*

The role here meant the role of the person doing the task. The role can be broken into several parts to get a reading. It consists of personal belief in achieving the task, the ability and experience to assess the task, and the ability to use

strategies in the task. The personal belief in achieving the task depends on the confidence and personal preference it means that to achieve a higher level of personal belief one has to have good confidence in himself to do the task and he should like or prefer what he has to do. The ability and experience to assess the task and the ability to use strategies depend on the performance and preference of similar tasks in the past [18]. For example, if someone has good performance in playing strategy games his level of metacognition in organizing a battle could be high because he could be able to assess the overall situation and use strategies to achieve his final goal of winning. The variables of this equation cannot be measured directly. However, they could be compared to get a reading for the level of metacognition in a certain task. Measuring the level of metacognition helped to find tangible answers to the research question. Even though there are no direct equations mentioned for this scenario, a rough equation can be formulated according to John Flavell's (1979) explanation of metacognition. 'Role' was proportional to 'level of metacognition' according to that explanation. The state of the 'experience in the task' factor was not mentioned as 'role', but it mentioned that this factor was also proportional to the level of metacognition. After considering all the information, this rough equation could be formulated for further calculations.

*Level of Metacognition α (Experience in the Task)^p * Role* (2)

Level of Metacognition = k (Experience in the Task)^p * Role* (3)

(k is a constant value, p>0, p is a positive integer constant value)

In this case, related to gaming above equation should be modified accordingly.

Level of Metacognition = k (Experience in the Game)^p * Role in the Game* (4)

(k is a constant value, p>0, p is a positive integer constant value)

When considering a certain game 'Role of the Game' can be defined as the following. The role of the game can be broken into several parts. It consists of personal belief in winning the game, the ability and experience to assess the game, and the ability to use strategies to win the game. A personal belief in winning the game depends on the confidence and preference of the game type. For example, the confidence of a strategy game lover would be high even to play a new strategy game for the first time. The ability and experience to assess the game and the ability to use strategies to win the game depends on the performance and preference of similar game types in the past. For example, a player who prefers and has good performance in RPG (Role Playing Games) may find it difficult to play a single-player 3rd person game.

Therefore, it was clear how to measure the level of metacognition of a gamer. However, it could only be a comparison between several gamers. However, it provided a good platform to monitor the relationship between metacognition and Video game interface and gameplay.

V. METHODOLOGY

The research conducted in the following manner. The first literature review was conducted to determine the theory of metacognition and the methods to measure the level of metacognitive skills of a person concerning gaming.

Then several experiments were conducted with participants of different metacognitive levels who belonged to different age groups. For the experiment, the participants were given a game that they have not played before. They were asked to play the game without reading any instructions. Their progress in the game was measured after the first level of the game was finished. The measurements were: the duration of the activity, the number of failures in the game, the number of first-time successful objectives of the game, their comment on the game (if there were any comments). These data were gathered and then analyzed against their level of, metacognitive skills to determine how metacognition impact on gameplay and game interface.

A. Sampling

The sampling of the participants was done based on age groups and metacognitive skill levels on games based on the theory of metacognition as explained in the theoretical framework section. Samples were taken from those who were new to the experimenting game included;

- Professional gamers
- Gamers who play games regularly as a hobby
- People who usually don't play games
- People who like to play a different genre of games than the experimental game

These samples were tested with the experimental game to gather data.

Additionally, people from the following age groups are considered from each type of players for the research:

- Ages 7+ (Sample includes more people belong to ages between 7 -12)
- Ages 12+ (Sample includes more people belong to ages between 12 -16)
- Ages 16+ (Sample includes more people belong to ages between 16 -18)
- Ages 18+ (Sample includes anyone above 18)

B. Instrumentation

An existing game has used for this research as the experimental game instead of making a customized game for this which is consuming a lot of time and not feasible enough for the given situation.

A game named LIMBO is used as an experimental game. This is a game designed and developed by "Playdead", Denmark. It is considered to be one of the best games to be created based on its simplicity and graphics, with high review scores from IGN, Gamespot, Gamespy, Eurogamer, Edge, etc. [19]. The reason for selecting this for the experiment was that this game has a limited number of instructions and the player has to figure out how to play the game. It provided the perfect conditions for the experiment. The Player was able to restart at the last encountered checkpoint with no limits.

This experiment aimed to understand how people assess game situations with the help of self-learning ability according to their metacognitive skills. This game provided a clear and enough number of separate situations that could be monitored easily. Puzzle genre was the most uncommon preference upon the players in the data set according to the given questionnaire. Therefore, it was more convenient to choose a never-played-before game with a limited number of direct instructions for all of them, among the puzzle genre with above other requirements for the experiment. Action/multiplayer genres were more familiar with most players in the sample and common techniques are used within the games [20]. Therefore, it was hard to find an unfamiliar action or games with new techniques, for a large sample which consists of 350 people who had majority preference over action/multiplayer games. Casual games were also suitable for this experiment because it also has clear self-learning points which can be used separately to measure player performance [14]. But the number of points available within this kind of game was not enough to get a correct outcome. Puzzle games need more brainpower than other genres, therefore this can be taken as the worst-case scenario experiment. Other genres use this self-learning content in games fairly low rate than puzzle genre. Therefore, the result must be valid for other minor cases as well as in this case used already [21], [22], [23].

VI. Data Collection and Analysis Process

A. Data description

The following data was collected from the experiment.

- The duration of the activity
- The number of failures in the game
- The number of first-time successful objectives of the game
- Personal comment on the game (optional)

These data were cross-referenced against the samples' metacognitive skill level which was determined from the sampling process according to the theory of metacognition. The analysis provided tangible answers to the research problem.

This study was only conducted based on video games because the number of variables can be controlled easily that way and the sampling process is much productive as video games are played by many people. Data were analyzed after the preparation of graphs which shows metacognition level against game points.

Metacognition was calculated with the following equation, and "Experience in the Game" kept as a constant by using a player sample that hasn't played this game before. Therefore, experience in the game becomes the same value for all players." Role in the Game" was changed according to the questionnaire given to them and value was calculated according to their answers in it.

$$\text{Level of Metacognition} = k^* (\text{Experience in the Game})^p * \text{Role in the Game} \quad (5)$$

(k is a constant value, p>0, p is a positive integer constant value)

$$\text{Level of Metacognition} = h * \text{Role in the Game} \quad (6)$$

[h is a constant value because experience in the game is the same value for all gamers, $h = k^* (\text{Experience in the Game})^p$]

Within the game, there wasn't any scoring system. Therefore, a simple tailor-made scoring equation was used to get a score for player performance in-game.

*The score of game = 10*Number of first-time successful objectives of the game (1 point for each) - [Number of failures in the game (1 point for each) * playtime duration/ (playtime duration+30 mins)]* (7)

There are main 9 points in the game that was expected to be successful for the first time without been taught.

- How to push/pull items?
- How to climb to boxes/higher places?
- How to climb a rope?
- How to swing the rope and jump to an available platform?
- How to cross a pond without been drowned?
- How to know an upcoming danger/how to avoid it?
- What happens if feet are put on a trap and therefore how to avoid them?
- How to use a trap against big spiders?
- How can we use spiders to reach our objective?

These values for both levels of metacognition and score were collected from each person and final values were represented through a graph to see overall behavior. Another set of graphs with the same structure represented according to the age groups which needed to be observed. The sample size for the experiment was 350, which was used to create graphs and finally to build the conclusion.

The scoring equation was a self-invention for the representation of the score of the given gameplay because there wasn't any original scoring system in the gameplay. This tailor-made system was used to calculate every gamer's score and values are taken for calculations were fair for everyone in the data set. The Scoring system doesn't use a fixed structure, uses influential factors as variables, and weighed in the scoring system according to the preference of the game developer. (In this case, there wasn't any given scoring system for the game by the developer.)

B. Evaluation result

Two hypotheses which were considered for this research are the following:

- H1: The more metacognitive skills people have, the more they will find it easy to play never-before-played games
- H2: Age affects performance when it comes to playing a never-before-played game without direct instructions.

The first hypothesis has become true while the second hypothesis has become false according to the following diagrams and analyzes results. The sample size is 351 for this research and following each age group consists of 87 samples within the data set.

- Between 7 -12
- Between 12 -16

- Between 16 -18
- Ages 18+ (Sample includes anyone above 18)

C. *Regression analysis*

Calculated results are represented as 'Level of metacognition' in the x-axis and 'Game points' in the y-axis. The first graph represents the overall sample of players while the other four graphs represent above 7, above 12, above 16, and the above 18 age categories.

R-squared values and angle of the slopes are the most used statistical techniques for this analysis. R-squared value helps to understand whether metacognition level and score level is correlated or not and if they are related then the strength of their association is also indicated.

R-squared value for overall representation = 0.751

R-squared value for above 7 representations = 0.652

R-squared value for above 12 representations = 0.798

R-squared value for above 16 representations = 0.611

R-squared value for above 18 representations = 0.743

Thereby overall, above 12 and above 18 representations are having a strong effect size while others are having a moderate level of effect size. Therefore, overall, above 12 and above 18 representations are highly fitted to the regression line while others are moderately fitted. 75.1% of the variation in overall gamer group's game points earning is explained by the level of metacognition while other separate age groups vary with 65.2%,79.8%,61.1%, and 74.3% amounts respectively. Therefore, it seemed to be that metacognition level and game points were well-associated factors according to this analysis result.

Slopes of these regression lines can also be considered for the analysis according to y= mx +c structured graph formulae of those representations.

y= 107.39x + 203.42 (Overall representation) *(8)*

y= 125.98x + 301.22 (Above 7 representation) *(9)*

y= 102.4x + 172.67 (Above 12 representation) *(10)*

y= 125.31x + 247.38 (Above 16 representation) *(11)*

y= 99.241x + 145.17 (Above 18 representation) *(12)*

TABLE I. DEGREE OF SLOPE

Representation	m value	Radian	Degree
Overall	107.39	1.561	89.47°
Above 7	125.98	1.563	89.55°
Above 12	102.40	1.561	89.44°
Above 16	125.31	1.563	89.54°
Above 18	99.241	1.561	89.42°

Each regression line seems to be had nearly equal slopes according to the calculated angles between the x-axis and the lines. Drastic changes between degree values were not detected. Thereby it seems to be that the effect of the metacognitive level on game point-earning does not change according to the age group. Metacognitive levels can be changed with age, but the nature of the bond between the score and metacognitive level is not affected by the age group.

The results indicated a positive slope when putting on a graph suggesting that the more level of metacognition that a subject has, they are more likely to do the task more successfully and quickly than those who had a low level of metacognition. Of course, there are a few inevitable anomalies but in a general sense, the graph agreed with the first hypothesis.

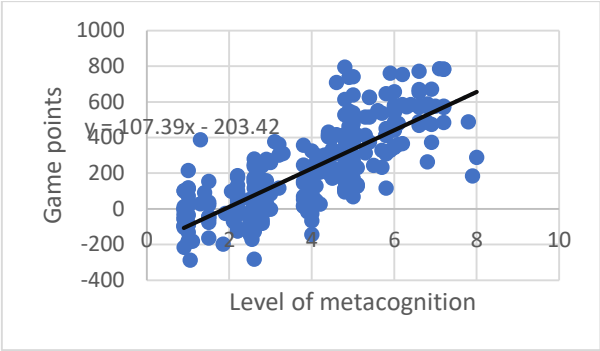

Fig. 3. The graph which displays data of the overall sample of players

According to each of the following graphs, it can be seen that every slope represents similar characteristics as the general slope for the overall result.

Gradient for each regression line is approximately near values which shows that age doesn't affect the performance when it comes to playing, a never-before-played game without direct instructions. Therefore, in a general sense, the graphs don't agree with the second hypothesis.

VII. DISCUSSION

A. *Limitations of the approach*

The study was only be conducted based on mobile games because the number of variables can be controlled easily that way and the sampling process was much productive as mobile games are played by many people.

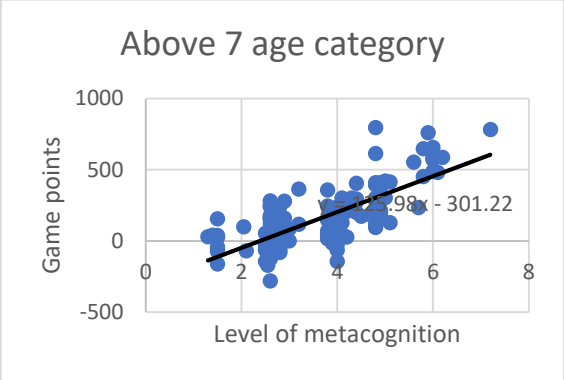

Fig. 4. The graph which displays data of players above the age of 7

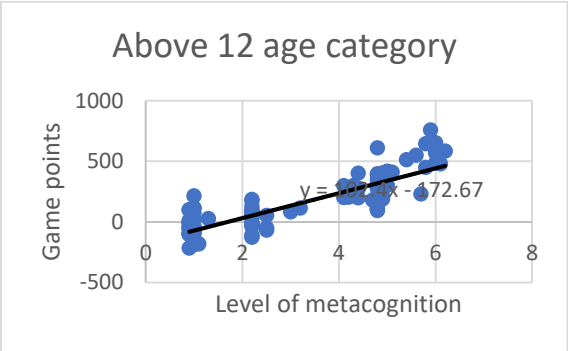

Fig. 5. The graph which displays data of players above the age of 12

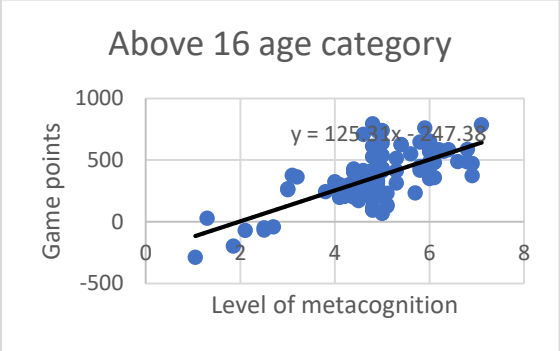

Fig. 6. The graph which displays data of players above the age of 16

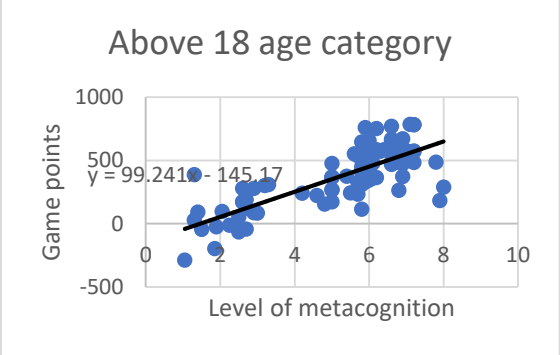

Fig. 7. The graph which displays data of players above the age of 18

Gameplay results are gathered in an indirect method which is not reliable enough. (Some people who play games are unlikely to share a higher number of failures in a game that they play. Couldn't help but following the indirect method for gathering information, because of the large number of people in the sample). The gender of the player can be another variable for this experiment, but it was not considered for this research.

Some players spent a long time on the above game level completion. Therefore, that whole time couldn't be calculated as the exact time they have spent on it because those people could be spending that time on some other tasks while playing them because they play the game for a long time. Therefore, sometimes inputs can be considered rough values because of this reason.

B. Future work

The sample size can be increased and real-time data gathering can be done for the information to be gathered from the gameplay which needs to be observed. The impact of gender can be analyzed with age and metacognition levels in the future. Female representatives in the present sample were not enough to decide on the impact of gender differences on this factor. The impact of different game types and genres on this problem can be a further field to be investigated as an extension.

VIII. Conclusion

The results of the experiment came positive with the first hypothesis which the research was based upon. The first hypothesis was "The more metacognitive skills people have, the more they will find it easy to play never-before-played games". The results showed that the more metacognitive skills people have, the easier it is for them to play games that they have never played before. According to the other experimental result, it can be seen that the age category doesn't affect the above factor which makes the second hypothesis false.

Therefore, designing gameplay which doesn't include many direct instructions and instead of that include that information into gameplay even without any age restriction, seemed to be much more effective according to this experiment.

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