

# Developing Multi-Genre Games to Detect Depression and Anxiety Disorders

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**Abstract**—Depression and Anxiety are prevalent mental health disorders affecting millions worldwide. Identifying these disorders accurately and promptly is crucial to ensure that individuals can receive appropriate treatment. To address this issue, this paper proposes using a game to identify behavioral patterns that indicate depression and anxiety. Our study involved 56 university students. In this paper, we used statistical tools such as calculating Correlation, Linear Regression, Kolmogorov–Smirnov, ANOVA, and Mann–Whitney U test to analyze our data. For this research, we designed a shooter and a memory-based game that can challenge disorders by creating exciting and stressful moments. Using serious games offers several advantages over traditional methods, like increasing accuracy and reducing bias by removing self-reports and sampling with monitoring player behaviors for extended periods. Our results indicate that several parameters are significantly related to depression and anxiety. These parameters include the number of guesses and surrendering in memory games, manner of movements, losing perks, losing lives, number of enemies colliding with the player, and number of playing to win in shooter games. We also found that log size and skipping game tutorials in each game were related to depression and anxiety. Lastly, age and getting help from others were identified as significant factors. Overall, our research highlights the potential of games as an alternative tool for assessing and understanding depression and anxiety disorders. By leveraging the interactive nature of games, researchers and clinicians can gain valuable insights into individuals' mental health conditions, leading to improved identification and treatment outcomes.

**Keywords**—Data Analytics; Behavioral Analysis; Human-Computer Interaction; Mental Health Assessment; Serious Game; Depression and Anxiety;

## I. INTRODUCTION

Mental health is a cornerstone of human ability and social values, supporting independence, happiness, and solidarity. Therefore, safeguarding mental health should be a top priority for all individuals, communities, and societies worldwide [1]. Mental health, according to the World Health Organization (WHO), is described as a condition of overall well-being in which individuals can reach their full potential, effectively manage typical life pressures, perform productively and successfully, and make valuable contributions to their community [2].

Mental health issues are increasing globally [3], and one in five young people and those aged 15-29 have mental health problems, with suicide as a top cause of death [4]. These conditions can have far-reaching consequences, impacting school or work performance, relationships with loved ones, and community participation. Both depression and anxiety, two of the most prevalent mental health conditions, cost the global economy an estimated \$1 trillion yearly [5].

Depressive disorder, commonly known as depression, is a common mental health condition characterized by persistent sadness or lack of interest in activities. Unlike ordinary fluctuations in mood and emotions, depression can significantly impact various aspects of one's life, including personal relationships, school performance, and job productivity. Although depression can affect anyone, individuals who have experienced traumatic events or significant losses are at higher risk of developing this condition. Furthermore, statistics show women are more prone to depression than men [6]. Anxiety can be described as a feeling of apprehension, unease, or tension that arises from the anticipation of internal or external danger. Some definitions differentiate between anxiety and fear by considering fear as an emotional response to a known and real threat. In contrast, anxiety is a fear response when no such threat is present. However, it is necessary to note that anxiety and fear have similar physical manifestations in the body [7].

The COVID-19 pandemic has clearly and undeniably influenced people's mental health. However, we still do not fully understand the extent of this impact worldwide. To learn more, researchers have looked at data from surveys conducted before and during the pandemic that measured levels of anxiety and depression [8]. Their findings show that rates of major depressive disorder and anxiety disorders have significantly increased since before the pandemic, affecting people of all genders and ages [9]. This is especially concerning because these disorders were already a major contributor to global disability [10]. That's why diagnosing and intervening as soon as possible is essential to managing these conditions effectively. Early identification and intervention are vital for students to prevent future problems [11].

Traditionally, mental health professionals diagnose these disorders through standardized assessments, interviews, and

questionnaires [12]. However, these methods can be time-consuming and costly and may not capture real-time symptom fluctuations. While questionnaires can be a valuable tool for assessing depression and anxiety, there are also some potential disadvantages to this measurement method [13-15].

**Self-report bias:** Questionnaires rely on individuals' self-report, which can be influenced by social desirability bias or other factors that may affect their responses [16].

**Limited scope:** Questionnaires may not capture the full range of symptoms and experiences associated with depression and anxiety.

**Lack of context:** Questionnaires do not provide contextual information about an individual's circumstances or environment, which can be essential to understanding their mental health.

With the advent of new technologies, mental health professionals have been exploring new ways to diagnose these disorders more efficiently and effectively [16, 17]. One such method is using serious games. Serious games differ from traditional games in that their primary purpose is not entertainment, enjoyment, or fun [18]. Instead, serious games are designed for various purposes, such as education, training, human resource management, health improvement, and behavioral analysis [15]. The term "serious games" was popularized after the 2000s [19]. Since then, the development and utilization of serious games have significantly increased, particularly games to assess cognitive processes such as attention, memory, and problem-solving skills, which are affected by depression and anxiety [20]. These games offer a non-invasive way to assess individuals' cognitive and emotional states while providing a fun and engaging experience [21]. So, they have gained popularity in recent years due to their accessibility and ability to assess cognitive function [22]. Such benefits make these games attractive for mental health professionals to use in their diagnostic tools.

To address this issue, we require a reliable psychological assessment to juxtapose with our games' event records. Hence, we have chosen to utilize tests invented by Aaron T. Beck. The Beck Depression Inventory (BDI) [23] is a highly utilized tool for identifying depression and assessing its behavioral manifestations and severity. It applies to individuals ranging from 13 to 80 years of age and consists of 21 self-report items that require multiple-choice responses [24]. The completion time for the BDI is approximately 10 minutes. Its effectiveness has been extensively tested and demonstrated across diverse populations worldwide, ensuring its validity and reliability [25]. The BDI comes in three versions: the original BDI, which was first published in 1961; the BDI-1A, which was revised in 1978; and the BDI-II, which was published in 1996. In this study, we used BDI-II. The second version differs from the first version in two ways. Firstly, respondents in BDI-II were required to select the option that best describes their situation in the past two weeks, and secondly, some of the questions have been altered.

The Beck Anxiety Inventory (BAI) [26] is a tool individuals can utilize to evaluate the degree of anxiety symptoms they are experiencing. It is a self-report inventory designed to be administered to adolescents and adults. This

inventory comprises 21 questions about common psychological and physical signs of anxiety. The symptoms asked in the BDI-II and BAI are listed in Table I [23, 26]. The questions are rated on a scale of 0 to 3, with 0 indicating no presence of the symptom and 3 indicating a high degree of presence. The total score from all the questions ranges from 0 to 63 and can indicate a level of anxiety ranging from minimal to severe. The standardized cutoff scores of **BDI-II** are:

- [0–13]: Minimal depression
- [14–19]: Mild depression
- [20–28]: Moderate depression
- [29–63]: Severe depression

And the standardized cutoffs of **BAI** are:

- [0–7]: Minimal anxiety
- [8-15]: Mild anxiety
- [16-25]: Moderate anxiety
- [26-63]: Severe anxiety

TABLE I. THE SYMPTOMS INVESTIGATED IN THE BDI AND BAI QUESTIONNAIRES

BDI-II	BAI
Sadness	Numbness or tingling
Pessimism	Feeling hot
Past Failure	Wobbliness in legs
Loss of Pleasure	Unable to relax
Guilty Feelings	Fear of the worst happening
Punishment Feelings	Dizzy or lightheaded
Self-Dislike	Heart pounding or racing
Self-Criticalness,	Unsteady
Suicidal Thoughts or Wishes	Terrified
Crying	Nervous
Agitation	Feelings of choking
Loss of Interest	Hands trembling
Indecisiveness	Shaky
Worthlessness	Fear of losing control
Loss of Energy	Difficulty breathing
Changes in Sleeping Patterns	Fear of dying
Irritability	Scared
Changes in Appetite	Indigestion or discomfort in the abdomen
Concentration Difficulty	Faint
Tiredness or Fatigue	Faint
Loss of Interest in Sex	Sweating (not due to heat)

Some research used a game to detect depression and anxiety disorders. A survey states that virtual reality (VR) games are mostly used to recognize anxiety, while video games are utilized for depression in papers published from 2000 to 2021. Moreover, these studies find a strong relationship between player performance and these disorders. Based on the gathered data, this area is become more popular after 2013, but it still needs more research [12].

Another research used machine learning to investigate patterns for depression and anxiety disorders in online games. Based on its findings, a strong relationship was detected. Also, the accuracy of the algorithms can be seen below [27]:

- 99.96% for MLP
- 99.43% for SVM
- 98.54% - 98.04% for GB and XGB

One research used serious games and Physiological Computing (PC) sensors to detect players' depression while playing an OilTrader game. This game simulates trading stocks of an oil company and needs concentration, rapid answering, and overcoming stressful situations. The results were hopeful of detecting or prescribing depression based on physical symptoms during the game [28].

A recent study employed machine learning and data mining techniques in online gaming to identify individuals with depression and anxiety disorders. The results indicated a strong correlation, with the Decision Tree classifier demonstrating the highest accuracy among the four algorithms examined in the study [29].

This article delves into using games to identify depression and anxiety disorders. We will discuss how mental health assessments incorporate these games, as well as their potential advantages and disadvantages. To conduct our research, we surveyed university students and utilized the BDI-II and BAI questionnaires to analyze the relationship between game components and mental health.

## II. METHODOLOGY

### A. Development and game design

As part of our research, we have created a captivating multi-genre game utilizing the Unity game engine. Our game has two distinct gameplay types: memory-based challenges, and shooter games, in which all players use an Android mobile phone to play.

In memory-based games, participants are presented with a grid consisting of cards for a brief period of five seconds, after which the cards are flipped over. The game's objective is for the players to utilize their memory and employ a process of trial and error to match the pairs of cards successfully. Additionally, the game has a countdown timer to add an element of time pressure to the gameplay. The timers were used for competition and to encourage people to solve challenges faster, and to prompt players to surrender after the time was up.

Also, we designed a shooter game that takes inspiration from classic survival games. In this game, the player controls by tilting the mobile device to move the spaceship left or right while tapping the screen triggers shooting. The objective is to survive for 180 seconds to win, but three lives are provided to make the game less challenging. If the player fails three times, they have the option to surrender. The survival shooter genre was chosen for this study as it is one of the most stressful types of games. Therefore, it is a suitable subject for our research purposes.

Once the player finishes all game phases, they have the option to send their logs to our server. If they choose to do so and the sending process is complete, they will receive a five-character text as their username. This username is derived

from the end of the hash code of their logs and will be used for our psychological test.

### B. Demographic information

We have a total of 56 players, with 46 being male and ten being female; most of them are computer engineering students, and their age diversity can be seen in Fig. 1. We have provided Fig. 2 and Fig. 3 to show the distribution of their BDI-II and BAI scores. As mentioned earlier, we consider the minimal and mild scores as low depression/anxiety, while the other two are categorized as depressed/anxious. Table II displays these groups.

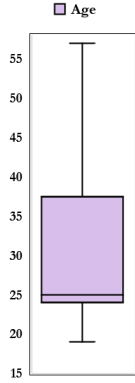


Fig. 1. Participants age distribution

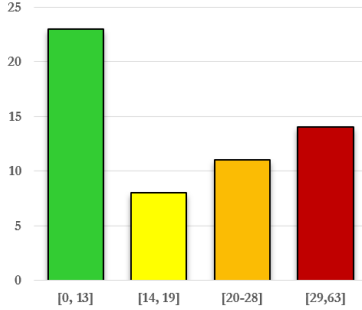


Fig. 2. BDI-II scores of participants

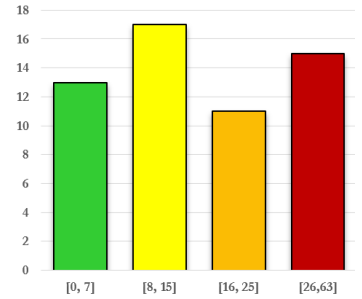


Fig. 3. BAI score of participants

TABLE II. OUR GROUPS AND THE NUMBER OF PLAYERS IN EACH CATEGORY

Groups/Tests	BDI-II	BAI
Low	32	30
Sever	24	26

### C. Evaluation

We utilized Google Forms to present the BDI-II and BAI questionnaires to the participants. After gathering data from psychological tests, we calculate scores for depression and anxiety. Based on what we explained in the previous parts these scores for both are in the range of zero to 63 points, and the bigger the score a player takes, the more deteriorated their psychological condition is. Game data is extracted using C# codes, and some parameters are obtained through a semi-manual approach. The game provides approximately 100 parameters, which include psychological and personal information.

In the next stage, we aim to identify the features strongly associated with depression and anxiety using data analysis techniques shown in Fig. 4 and 5. We utilized IBM SPSS to calculate linear regression, Kolmogorov-Smirnov, ANOVA (when assumptions were met), and Mann-Whitney U test to determine which correlated variables have linear regression and whether their differences in their groups are statistical significance for predicting depression and anxiety. Moreover, to better understand why these phenomena happened, we try to find a reason for each based on psychological references.

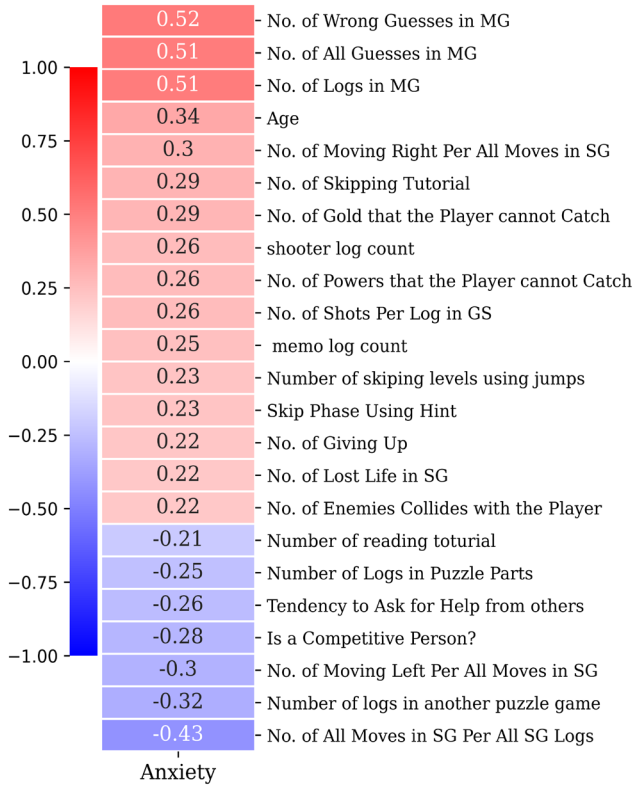


Fig. 4. Most correlated features with anxiety

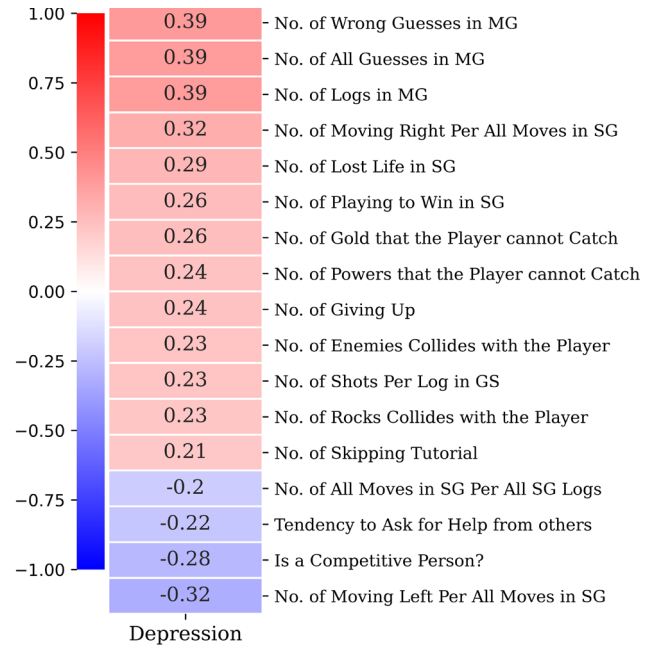


Fig. 5. Most correlated features with depression

### III. RESULTS AND FINDINGS

As mentioned in the previous section, we introduced dozens of variables for the game, and due to their large number, we tried to recognize the most potential variables for our analysis. For this purpose, we used correlation to select the more correlated variables.

At the start of each game, players were given two choices: read the manual or dive straight into the game and learn as they played. The evidence shows that individuals with higher anxiety levels had a lower tendency to read the training manual, which has a linear relationship among them.

A possible factor that affects depression and anxiety is the number of incorrect guesses made in a memory game. The Mann-Whitney test showed a notable difference in the distribution of participants between the not/mild and moderate/severe groups. This suggests a significant contrast between those who are depressed or anxious and those who are not. The same trend is observed in the overall number of guesses, which means that depression and anxiety can negatively impact a person's accuracy and memory. As a result, they may need to make more attempts to find the correct answers, leading to an increase in recorded logs.

In the cases of the bounce part in the shooter game, some gold meteorites were generated, and catching them gave a lot of scores to players. People with depression and anxiety tend to lose these perks more than people who were supposed to be normal, and the difference is statistically significant.

Also, certain power-ups were created, and those who suffer from depression and anxiety tended to perform worse in catching these power-ups than those with lower levels of disorder, which linear regression has existed with anxiety, but it is not found for depression; though, difference between these two groups was significant Statistically.

Based on our analysis of the data on shooting and movement, it is clear that individuals with depression and anxiety disorders significantly impact the shooter game. To be specified, they prioritize survival over achieving a high score in shooter games. An explanation can be that anxiety plays an undeniable role in survival [30]. This primary role explains why these individuals focus more on staying alive than collecting items or earning points.

One exciting point about players' movement in the shooter game was that people with anxiety tended to move to the right in all their movements/being stable compared to the non-depressed group, who tended to move to the left. There was no linear relationship, though statistics show that the difference between the two groups is significant.

People with depression lost more lives and had to replay more before finishing the game than the less depressed group. This difference was statistically significant, and the suicide ships in the game collided more with the depressed group. In conclusion, individuals with depression tend to play worse and more carelessly in the shooter genre.

In addition to correlation and linear regression, anxious people have had significant differences in giving up in the challenging conditions in the game. They have decided not to continue the level when faced with problems and have chosen to give up and skip the level after a few attempts and go to another level.

Another factor worth considering is the impact of age on the rise of anxiety among individuals. This particular variable seems to increase linearly, although our present data is insufficient to determine whether there is a significant difference in the distribution and trend of the two groups.

Individuals in good mental states were more inclined to be competitive than depressed people. They used the competition to help them improve and progress, and a linear and meaningful relationship confirmed this hypothesis. Besides, these people were more willing to seek help from others; notwithstanding that the linear relationship existed, the differences between the two groups were statistically insignificant. The summary of our results can be seen in Tables III and IV. In these tables, based on Kolmogorov-Smirnov, our variables do not follow normal distribution except "No. of Logs in Puzzle Parts" in which we used the ANOVA test instead of the Mann-Whitney Test.

TABLE III. SUMMARY OF STATISTICAL TESTS FOR THE DEPRESSION

Feature	Linear Relation	Mann-Whitney Test Exact Sig.
No. of Wrong Guesses in MG	T	0.038
No. of All Guesses in MG	T	0.042
No. of Logs in MG	T	0.042
No. of Moving Right Per All Moves in SG Moves	F	0.137
No. of Lost Life in SG	F	0.012
No. of Playing to Win in SG	F	0.021
No. of Gold that the Player cannot Catch	F	0.026
No. of Powers that the Player cannot Catch	F	0.044
No. of Giving Up	T	0.061
No. of Enemies Collides with the Player	F	0.037
No. of Shots Per Log in GS	T	0.153

No. of Rocks Collides with the Player	F	0.097
No. of Skipping Tutorial	F	0.099
No. of All Moves in SG Per All SG Logs	F	0.055
Tendency to Ask for Help from others	T	0.692
Is a Competitive Person?	T	0.148
No. of Moving Left Per All Moves in SG	F	0.061

TABLE IV. SUMMARY OF STATISTICAL TESTS FOR THE ANXIETY

Feature	Linear Relation	Mann-Whitney Test Exact Sig.
No. of Wrong Guesses in MG	T	0.001
No. of All Guesses in MG	T	0.001
No. of Logs in MG	T	0.001
Age	T	0.110
No. of Moving Right Per All Moves in SG Moves	F	0.015
No. of Skipping Tutorial	T	0.067
No. of Gold that the Player cannot Catch	T	0.007
No. of SG Logs	F	0.068
No. of Powers that the Player cannot Catch	T	0.108
No. of Shots Per Log in GS	T	0.104
No. of MG Logs	T	0.065
No. of Skipping Levels Using Jumps	F	0.132
Skip Phase Using Hint	F	0.132
No. of Giving Up	T	0.043
No. of Lost Life in SG	F	0.308
No. of Enemies Collides with the Player	F	0.251
No. of Reading Tutorial	T	0.066
No. of Logs in Puzzle Parts	F	ANOVA: 0.164
Tendency to Ask for Help from others	T	0.342
Is a Competitive Person?	T	0.047
No. of Moving Left Per All Moves in SG	F	0.015
No. of Logs in Another Puzzle Part	T	0.024
No. of All Moves in SG Per All SG Logs	F	0.100

#### IV. CONCLUSION

In this paper, we managed to use games to assess depression and anxiety disorders. By designing a multi-genre game and collecting data from participants, we were able to analyze the relationship between various game parameters and mental health indicators. We used statistical tools such as correlation analysis, linear regression, Kolmogorov-Smirnov test, ANOVA, and Mann-Whitney U test to evaluate our findings.

The results of our study revealed several significant correlations between game parameters and depression and anxiety. For instance, the number of wrong guesses and the total number of guesses in the memory game showed a linear relationship between anxiety and depression. Furthermore, individuals with anxiety had a lower tendency to read the training manual before playing the game. In the shooter game, it was observed that people with depression and anxiety were more likely to lose opportunities and perform worse in catching power-ups, indicating their focus on survival rather than scoring points.

Additionally, participants with anxiety displayed a greater tendency to move to the right during stressful situations, while those without depression tended to move to the left. Furthermore, individuals with depression lost more lives, requiring more replays to complete the game. They also experienced more collisions with enemy ships. Anxious



individuals were more inclined to give up when faced with challenging levels.

Our findings suggest that games can serve as valuable tools for identifying and assessing mental health disorders. The game design and parameters provided insights into the behavioral patterns associated with depression and anxiety.

## V. LIMITATIONS AND FUTURE WORK

We acknowledge that our research has limitations in terms of gender diversity, which we plan to address in future studies. Additionally, we recognize the need for a larger sample size to identify more general patterns. We also intend to explore other genres to establish links with mental health conditions.

For future work and to enhance our research, we contemplate conducting more extensive studies involving machine learning technology and additional data mining techniques. Our ultimate goal is to develop a model that can effectively recognize these disorders by utilizing this gaming platform as a viable alternative to conventional interviews. Additionally, we believe that games have the potential to delve into other psychological paradigms and mental health-related issues.

Furthermore, one of our results was about the direction of movement amongst the group of people with anxiety, and the people without this problem are fascinating. The anxious people tended to move right more even though other groups desired to move left, which was statistically significant. As it has been said, there is a belief that during negative emotions, such as anxiety, the right hemisphere of the brain is more dominant [31-33], and since the hemispheres of the brain control the opposite sides and movements [34], this possibility and hypothesis can be proposed that there is a tendency exists to hold the left side of the phone higher than the right side during the game pressure and increase the anxiety of the game. According to this game control, the ship moves to the right and vice versa. In the future, research with more games and brain experts' help must be conducted to find the explanation for this phenomenon.

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