USABILITY EVALUATION FRAMEWORK FOR MOBILE GAMES FOR LDERLY PEOPLE

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Abstract

The success of mobile game is measured based on the experiences of its players. Usability of mobile games is of great importance because their success depends on the principles of usability. The criteria for judging the success of mobile games can be defined by the level of user's satisfaction and user's interaction with the user interface of mobile games. Mobile games have positive impact on the health of elder adults. Benefits of mobile games for elder adults includes reducing depression, improving decision-making, enhancing abilities of cognitive control and improving mental and emotional health. In this research benefits and challenges faced by elder adults while playing mobile games are presented. Motivational factors which motivate elder people to play the mobile games are identified. A framework of usability evaluation is proposed and a prototype of mobile game is developed for elder adults. A survey was conducted for the purpose of collecting data from elder adults of age 50 or above. The survey conducted in this research comprises of two rounds initial survey and Post-Study survey. Based on the responses of participants in the first round, a prototype of mobile game for elder adults was developed. Results of both rounds analyses the defined objectives of the research and problems of usability faced by elder adults in mobile games were also identified. In the end it is evaluated that the developed prototype mobile game can enhance the aspects of usability among elder adults.

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Dedications

I would like to dedicate this thesis to my beloved parents whose unconditional love and support is always with me. This accomplishment would not have been possible without their support. I have been extremely lucky to have such parents, who cared so much about my research. Their love, support and belief in me made me accomplish my goals successfully. They have given me strength to deal with each and every problem with determination. I am grateful to them for teaching me to have strong faith in Allah Almighty. Further, I would like to extend my dedication to my beloved brother, sisters, family, friends and especially to my supervisor Dr. Awais Majeed whose support and guidance made me capable to complete this research.

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Chapter 1

Introduction

1.1. Overview

Mobile phones and especially android phones for playing games have become a common source of entertainment that fascinates lots of mobile phone users globally. Mobile games development has become more popular as compared to the development of computer games. The major aim of mobile game developers is to develop a game that is entertaining and thrilling for mobile games players. Designing a mobile game is not a simple task and it takes long periods of time to complete the development of a game. It is never guaranteed that users will appreciate the game regardless of all the efforts and money invested by the game companies.

Aspects of mobiles games that are enjoyable to play refer to experiences of players and usability of that game. Positive experience of players while playing mobile games is an essential factor to determine success of mobile games. Mobile games are one of those product groups which are reviewed by game evaluations and usability of mobile games. Recommendations of best games from game players are used to select the mobile games. If the experience of a game is not satisfactory, players can shift to other games which are more entertaining and satisfying.

1.2. Motivation

Usability refers to ease of usage and ease of learning to use a software product. Usability is the capability of any software application to be understood, learned, simple, easy and satisfied by the users. Measuring usability is a necessary task to ensure that mobile games are usable. The major goal of conducting usability evaluation is to ensure that mobile game applications are accurate, efficient and are easy to use.

Analysis of research studies indicates that measuring usability for game applications is a necessary task to ensure that these applications are usable and accurate in mobile platforms. Seven factors which affect the usability of mobile game applications are learnability, efficiency, memorability, errors, user satisfaction, simplicity and comprehensibility. Two approaches discussed in this study are expert review and user testing. In expert review two experts were selected to evaluate mobile games based on their expertise. In user testing method six expert mobile gamers were involved to play the mobile games and their performance was analyzed. Both methods have playability issues due to the difficult user interface [1].

Mobile games provide entertainment to elderly people and help them to overcome their mental stress. Elder users are unable to operate mobile games without detailed manual or specific usability guidelines. Usability guidelines for mobile game applications of elderly people are lacking because usability evaluation of mobile games is not conducted efficiently. There exist many usability guidelines for mobile game applications, but the existing guidelines are inadequate to be used for designing an effective and user-friendly interface for mobile games of elderly people. There is a need to improve techniques of conducting usability evaluation for mobile games for elder users and it is required to provide extensive usability guidelines of mobile games to ease the understanding of elder users.

In this research usability evaluation of mobile games for elderly people will be investigated to identify the factors that are required for efficient usability evaluation of mobile games. Effective usability evaluation framework for mobile games of elderly people will also be proposed. A prototype of mobile games for elder people will be developed by using those identified factors and proposed framework.

1.3. Problem Statement

According to previous studies frameworks of usability evaluation of mobile games for elder users have certain limitations due to which elderly people face many challenges while playing mobile games. The challenges faced by elderly people while playing mobile games includes complicated interfaces, repetitive tasks, lack of proper

guidelines, positions of the game blocks not visible, small size of game blocks and boring missions. Effective methods of usability evaluation for mobile games for elder people are also not implemented due to which elder users are unable to operate mobile games efficiently. Inadequate research has been done on usability evaluation of mobile games for elderly people. There is a need to evaluate and improve the usability of mobile games for elderly people.

To cover this gap a research is needed to propose an efficient framework for usability evaluation of mobile games for elderly users. Hence this study focused on evaluating the usability of mobile games for elderly people and a framework of usability evaluation for elderly people will be proposed. To implement the proposed framework a prototype of mobile games for elderly people will be developed. Moreover, this study emphasize on improving the usability of mobile games for elderly people and identifying problems of usability in mobile games for elderly users.

1.3.1. Research Questions
The following research questions will be addressed to achieve the objective of this research:-

- What are the benefits, challenges and motivational factors of mobile games for elderly people?
- Which factors influence usability of mobile games for elders?
- Which of the design principles can help in improving the usability of mobile games for elders?

1.4. The aims and objectives
The objective of this research is to investigate usability evaluation of mobile games for elderly people. This research aims to propose an efficient framework for usability evaluation of mobile games for elder people which will help to enhance the usability of mobile games for elder people. The proposed framework will be implemented through developing a prototype of mobile game for elderly people; the developed

prototype will improve the usability and motivate elderly people to play mobile games. Our research objectives are: -

- To identify the benefits, challenges and motivational factors of mobile games for elderly people.
- To propose usability evaluation framework for Mobile games for elders.
- To propose design guidelines in the usability evaluation framework and implement the proposed framework of usability evaluation through developing a prototype mobile game for elderly people.

1.5. Research Methodology

A comprehensive literature study is carried out by gathering material related to usability in general, frameworks of usability evaluation and usability evaluation of mobile games for elderly adults. Benefits, challenges and motivational factors of mobile games for elder adults will be identified through literature review. A survey will be conducted in which questionnaire method will be used to collect data. A prototype of the mobile game will be developed based on problems identified through the analysis of responses. Feedback of elder adults will be taken by conducting another post-survey in order to validate the prototype.

1.6. Thesis Organization

The rest of the thesis is organized as follows:

Chapter 2 presents an overview of usability along with the common mechanisms and frameworks of usability evaluation of mobile games for elder adults. This chapter provides information about the existing mechanisms of usability evaluation and their use in evaluating mobile games for elder adults. Furthermore, this chapter discusses various benefits, challenges and motivational factors of playing mobile games for elder adults.

Chapter 3 describes the research approach that we used for our study. A survey was conducted in the study to perform usability evaluation of mobile games for elderly

adults. Questionnaire method was used for collection of data. This chapter also provides justifications of selected research design and methodology which helped to accomplish objectives of this research. This chapter also discusses the proposed framework of usability evaluation of mobile games for elderly people. Selected parameters of the proposed frameworks and their categories are also described in detail. Justification of selected parameters of usability and proposed framework is also provided in order to explain how they are helpful in conducting usability evaluation of mobile games for elderly adults.

Chapter 4 presents the results and analysis of both initial survey and post-study survey. The results gathered from a survey method for evaluating the selected mobile games of elderly adults and prototype of mobile games are reported in this chapter. This chapter describes all the details of tools used to develop the prototype of mobile game. Furthermore, this chapter provides details about the implementation of usability framework through development of a prototype mobile game for elderly adults. Moreover, this chapter describes the usability problems identified through analysis of data collected with the help of a questionnaire.

Chapter 5 summarizes this thesis; major contributions of the research are discussed and some ideas for future research are presented.

Chapter 2

Literature Review

This chapter presents an overview of usability, together with investigation of common usability methods and frameworks that can be utilized to evaluate mobile games. Effectiveness of various mechanisms of usability evaluation is also presented. Various mechanisms of usability evaluation are also presented which are specifically designed for conducting usability evaluation of mobile games for elder adults. Benefits, challenges and motivational factors of mobile games for elder adults are also discussed. Few studies have been analyzed for developing prototype of mobile game for elder adults.

2.1. Usability Evaluation of Mobile Applications

Alton *et al.* [2] proposed game named MARGE. Two main objectives of the study are to introduce Mobile Alternate Reality Gaming Engine (MARGE) and usability evaluation of this game. MARGE includes multiplayer, prevalent elements of games for content sharing tasks of mobiles. It permits mobile users to interpret locations of the real world with multimedia content and gives chances to play through producing and keeping engage collaborative elements of games. Usability evaluation of the game was conducted on undergraduate and graduate students which show that participants were happy about the features of MARGE .The interface of the game was easy to use and supported sharing of content. It has few limitations as well like difficulty in typing extensive textual content and there were so many remarks on the screen which make playing games difficult sometime. Karima *et al.* [3]conducted experimental study which is based on a set of parameters for usability evaluation of mobile applications. The mobile applications for usability evaluation were running on different platforms which include iOS and Android. A framework is developed for usability evaluation and is evaluated by a group of 32 participants. Questionnaire is used to gather

information from participants. Analysis of results indicated various use ability issues that need to resolve to enhance the usability of mobile applications.

Rachel *et al.* [4] presented a review of models used for usability evaluation of mobile applications. Analysis showed that usability is generally measured based on three parameters: satisfaction of users, efficiency and effectiveness. Some other parameters such as cognitive ability are likely to be unnoticed in the models of usability evaluation despite of the fact that these parameters have an impact on success of mobile applications. A model is proposed to overcome the limitation of existing models of usability. This is a complex model which combines various parameters from different models of usability evaluation.

2.1.1.   Heuristics for Mobile Games

Sarmad *et al.* [5] proposed a method of heuristics evaluation which is used to identify playability issues. This method is difficult to apply as it uses some playability heuristics to find out issues. The major purpose of the study was to identify playability issues more deeply, but analysis showed that some issues were still unrevealed by the method proposed. Survey was conducted and questionnaires were distributed among students. Results of survey revealed that majority students gave positive feedback. New heuristics for playability of mobile games are also proposed which will help to identify issues of playability. David *et al.*[6] introduced set of heuristics which can be used for conducting usability evaluation of mobile games. These heuristics of usability help to recognize issues of usability in mobile games. These guidelines were developed by analyzing popular mobile games which include 18 games of different genres. Reviews of participants were analyzed and categorized twelve common problems of usability in mobile games. Ten heuristics of usability were proposed based on problems and these heuristics describe how usability problems can be avoided.

Hannu *et al.* [7] proposed heuristics of playability that are designed precisely for evaluation of mobile games. The proposed heuristics build a basic model of usability

that is usable for evaluation of all types of mobile games. The model comprises of three components which includes usability of game, Flexibility and game playing. An iterative model is used to design these heuristics. Five mobile games are evaluated by using these heuristics and an expert evaluation technique is used for this purpose. The results showed that issues of usability and flexibility of mobile games are easy to recognize but issues of game playing are difficult to identify. Mikko *et al.* [8] examines opinions of different game development companies about heuristics of mobile games usability. Surveys conducted in different American game companies indicated that all companies consider usability as very important aspect of games. Usability is essential to confirm acceptance of mobile games and successful usability evaluation of games contribute to more profit for the companies. According to results of survey degree of usage of heuristic evaluation method for mobile games is overestimated.

Daniela *et al.* [9] presented a formal methodology which can be used to develop usability guidelines. Several sets of guidelines are proposed using this methodology which can cover user interactions from every aspect. These guidelines are also used to evaluate features of applications related to experience of users. This methodology provides a clear protocol to develop guidelines of usability for mobile applications. The methodology is validated by experts and can be applied for creating guidelines for mobile games.

2.1.2.　　　Usability Evaluation of Different Mobile Games

Pop *et al.* [10] has discussed Magic herbs game and its stages of evaluation. Ten principles of usability and four rankings of severity have been used for the issues of usability. The game discussed is a new action mobile game which is very adventures for players. The game is evaluated by three people; one is the designer of the game and the other two are players who are using the game. The players are familiar with this game as they provided their feedback during the development phase of game. Solutions to most severe issues are proposed after analysis of evaluation. Paulyne *et al.* [11] proposed a card mobile game and conducted it usability evaluation by using

method of Heuristic Evaluation. This method of usability evaluation is helpful to avoid inconsistencies in ratings of evaluation. Different evaluators are engaged by the game proposed in process of usability evaluation. Rules to validate this card game and result of validation are also presented. The game can enhance user satisfaction due to its easy user interface.

José *et al.* [12] conducted usability evaluation of mobile game by using method of Heuristic Evaluation. Various guidelines of usability were used to recognize common features and how these features require changes in the original rules of the game. This game can be used by students and experts to manage activities of heuristic evaluation. Steps to conduct usability evaluation are demonstrated and any usability guidelines can be used to conduct heuristic evaluation.

2.2. Usability Evaluation Mechanisms for Mobile Games

Sarmad *et al.* [13] has developed an automated system named playability heuristic evaluation system (PHES) which is specifically designed for conducting usability evaluation for mobile games applications. Iterative waterfall model is utilized for the implementation of the system It is a web-based system which is implemented for usability evaluation of games by using integrated heuristics of playability. This automated system allows users to address more usability issues effectively within time limits. It also reduces efforts needed for manual usability evaluation. PHES can also be used for remote usability evaluation of games as it is a web-based system. M. Cui and L. Zhu [14] introduced methods of usability evaluation for user interface of mobile game applications. A model of usability evaluation is also developed based on interviews from users and questionnaires. User interface of mobile games were evaluated using Delphi methods and usability index weight dissemination map was generated. The method of gray correlation gives improved evaluation of the proposed model. Performance analysis indicates that fuzzy methods of usability evaluation are the efficient methods as they evaluate gaming interface accurately and provide the easiest and user-friendly interface of mobile games.

Rosa *et al.* [15] proposed a modular approach which is based on the grouping of mobile game heuristics. This approach uses a tool named Meta-heuristics usability Evaluation (MUSE) and metadata. This approach can be used for usability evaluation of games of different categories. With the help of this tool new heuristics guidelines can be built and this is based on selection of metadata. These guidelines are generated to achieve a custom list for real cases of mobile game evaluation. These new heuristics guidelines permit consideration of various aspects in mobile games can address usability problems efficiently. Performance analysis of MUSE is conducted through comparison of two different games. This tool is proved to be an efficient and effective tool for usability evaluation of mobile game applications. In this paper Raheel and Nosheen [16] presents various issues of usability for mobile games. To identify the problems of usability for mobile games from the perspective of players a survey is conducted. One major genre of games is selected for the survey. New heuristics for usability of mobile games is proposed based on analysis and issues identified through the survey. These heuristics are helpful to enhance the efficiency of usability evaluation of mobile game applications. These heuristics can also be utilized as guidelines to redesign a mobile game with improved usability. The participants of the survey evaluated the redesigned mobile game, and the results show that the proposed heuristics has increased the usability of mobile game applications.

Hannu *et al.* [17] used expert review method of usability evaluation to compare two heuristics of playability for evaluation of mobile games. Experimental results showed that these heuristics are helpful to evaluate graphical user interface and game playing features of the mobile game. There is a need to develop more heuristics of playability so that they can be used by experts during usability evaluation of mobile games. Existing heuristics of playability need to be improved so that clear and unambiguous heuristics can be obtained.

Rosa *et al.* [18] presented a systematic review of 187 articles. Two methodologies for usability evaluation of mobile games are discussed which includes: removal of traditional methods of evaluation and developing new methods which are especially concerned with mobile games and applying existing techniques of usability evaluation.

A new usability evaluation methodology is needed that can consider important parameters of usability for mobile games.

2.2.1. Usability Evaluation Mechanisms of Mobile Games for Elderly People

Cristina *et al.* [19] developed an android game which is specifically designed for elderly people. Usability and user-friendliness criteria of this game are mainly focused on elderly people. To conduct usability evaluation of this game a technology acceptance model is used. This game is evaluated by total 63 elder people in groups of 10. Some parameters were identified due to which elder people face difficulty in playing game and those parameters includes: positions of the block were not visible, time limit in which blocks are shown and small size of the blocks.

Omar *et al.* [20] presented an approach which is used for developing and evaluating mobile games for the elderly people. It is a user-centered approach whose objective is to encourage elderly people to play mobile games and to make their time enjoyable. Walk 2 Win game is developed specifically for elderly people. This game has two levels: easy, difficult and this game can be played by both single and multi-players. Results of usability evaluation revealed that elder people enjoyed the simple level of the game, but they were not happy with the complicated level. It was also identified that elderly people are more interested to play mobile games in a team, for example with their grandchildren. Kathrin *et al.* [21] discussed a design of mobile game for elderly people who are facing cognitive and physical challenges. A case study is evaluated which provides a new relaxation activity to fragile elderly people. Usability evaluation of games showed that games were considered an enjoyable activity as they can improve the quality of life for elderly people. The complexity of this mobile game was high due to its difficult interface as they were not understandable by the elderly people.

Lawrence *et al.* [22] has discussed a framework named First Time User Experiences (FTUEs) which is used for evaluating the usability of mobile game applications. This

framework uses two independent variables as input which are: guidance and information obtained from first experience of user. The output generated by the framework is a dependent variable which is usability of the mobile game. Two games named 'Super Mario Run' and 'Linia' were selected to conduct usability evaluation and to compare the results. The comparison shows that Super Mario is a difficult game as the game player enters directly to the hard levels at the start of the game which creates frustration for the user. On the other hand, Linia is a simple game as it provides proper guidance and hints to the player at initial levels of the game also its interface is easily understandable by the user.

In this paper Charley *et al.* [23] proposed a framework which helps experts of usability in selecting method of usability evaluation for Mixed Reality Games. These games also require a smartphone, and the player needs to change their location. Four different methods are used for usability evaluation in different scenarios. Diary is used when a game is played for longer time period. If more players are playing the game, then there is a need to observe them by experts in this case interaction logs (IL) are suggested to be used. When enough experts are observing the players then game session can take more time in this scenario IL and a spoken diary are used. When enough experts are available and game session do not take more time than it's better to use TA and IDA. The results analysis shows that when RTA is combined with IDA then more effort is required so this method can be replaced with audio diary integrated with interaction logs.

2.3. Benefits of Mobile Games for Elderly People

David *et al.* [24] conducted a survey whose target was adults aged 55 or above. Results of survey revealed various benefits of mobile games for elderly people. Mobile games have socio-emotional benefits for elderly people. Three factors education, facilitation, and support are needed to inspire older people to realize the benefits of playing mobile games. Mobile games can promote positive health among elder people by reducing depression, feelings of isolation and loneliness. Mobile game playing can improve aspects of reasoning like decision-making and cognitive control.

Sunwoo *et al.* [25] conducted usability evaluation of two mobile games for elderly persons. These two games have health related benefits for elderly people. Bowling game is specifically designed to help elder adults to enhance the motion of the shoulder. This mobile game starts by showing a bowling area to the player. The second game Penguin Toss is designed to help elder adults to improve their motion of arms and support their biceps. Usability evaluation of these two games proved that these games are effective for elder people to perform motion exercises. Adriano *et al.* [26] assessed experience of elder adults while playing mobile games. A group of people aged 60 were chosen in order to evaluate mobile games. Four different mobile games were selected, and positive and negative comments of elder adults were recorded. Those comments helped to analyze the benefits and challenges of mobile games for elder adults. Results of analysis revealed that positive comments of elder adults while playing mobile games are higher than negative comments. This shows that playing mobile games has various benefits for elderly people including improving their thinking abilities and making their time full of fun.

Anguera *et al.* [27] discussed that mobile games improves cognitive control in elder adults. Experiments were performed by using simple mobile games and responses of elder adults were recorded. Results of experiments indicate that mobile games enable elder adults to deal with complex situations by taking decision quickly. Mobile games also improve neural processes of elder adults so that they can achieve several tasks concurrently. Mobile games are powerful tools for enhancing abilities of cognitive control and neural mechanisms among elder adults. Patrícia *et al.* [28] examined the effects of mobile game playing on elder adults. Fifty-eight elder adults were selected to obtain training in a target control mobile game. All the participants gave positive feedback from which it was analyzed that mobile games enhance visual attention of elder adults. Mobiles games having less complex user interface are more suitable for elder adults. There is a need to provide more training in playing mobile games among elderly adults. Chris *et al.* [29] demonstrated the cognitive and physical impacts of interactive mobile games for elder adults. Two experiments were conducted among different participants of age 60 or above. According to analysis of results flexible benefits include strength, flexibility and stability. Cognitive benefits are related to

decision making power of elder adults. Mobile games are effective mediation exercise for elder adults as they increase enthusiasm and enjoyment. No adverse impacts of mobile games were identified for elder adults.

Julie A. Brown [30] explained the role of mobile games in the lives of elder adults. There is a remarkable increase in the use of mobile games among elderly adults. A methodology is proposed to find out the impact mobile games and needs of elder adults. Experiences of playing mobile games by elder adults have revealed several benefits. Those benefits are related to physical abilities; mental and emotional health enhanced socialization and improved reasoning abilities.

2.4. Challenges faced by Elderly People while Playing Mobile Games

Antonio *et al.* [31] investigated the experience of elderly people in mobile games. Elder people face many challenges while playing mobile games such as difficulty in using the technology and learning a mobile game. These challenges may result in feelings of low self-esteem among elderly people. Mobile games require a higher level of mental effort and intellectual abilities. This research also identified that there are no accurate tools and mechanisms to evaluate mobile games of elder people. Proper guidelines for elder adults to play mobile games are lacking and there is a need to identify factors which motivate older adults to play mobile games.

Mônica *et al.* [32] a set of 43 heuristic is presented for evaluation of mobile games for elderly people. These heuristics were then evaluated by conducting a user test and results of evaluation were used to identify problems in the prototype of game designed for elderly people. Total 32% problems were recognized and most of the problems were associated to the game playing. Those problems include no rewards given to players, repetitive tasks and boring missions. These heuristics were not able to identify all problems of interface of the game because different problems are encountered by different people.

Laura *et al.* [33] developed a game prototype, conducted playing test and evaluated the responses of players. Some challenges were faced by the players which shows that

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improvements are needed while designing the mobile games. To provide players with good playing experience there is a need to overcome all the limitations and uncertainties faced by the players. Those challenges of mobile games includes: small buttons, unclear images and less interactive tasks. These challenges cause frustration among players due to which it is necessary to pay much attention while designing the mobile games. Jan *et al.* [34] examined motion based mobile games for elder adults and analyzed their experience. Survey was conducted among elder adults for usability evaluation of this mobile game. Analysis of responses showed that games have few visual complexities. All the levels of mobile games have a certain level of complexity. Visual complexity of mobile games affects the experience and performance of elder adults. Due to this visual complexity of mobile games, elder adults faced much difficulty while playing the game. These results of usability evaluation can help to design mobile games according to the needs of elder adults.

Hannah *et al.* [35] demonstrated perspective of elder adults and challenges faced by elder adults while playing mobile games. A mobile exercise game was selected, and experiments were performed to obtain information regarding the perspective of elder adults. Three groups of participants of age 50 to 85 participated in the experiments. Results showed a negative trend from the participants to play the mobile game due to the difficulties faced by them. Most popular challenge faced by elder adults was the complexity of game. Nap *et al.* [36] described the experiences and perceptions of elder adults for playing mobile games. Two different mobile games were selected, and their usability evaluation was conducted. The results of evaluation indicated some challenges faced by elderly people while playing selected mobile games. Those challenges include menus of game are not easily accessible, less interactivity and absence of learning content. There is a need to make mobile games more interactive and provide learning content for elder adults.

2.5. Motivational Factors for Mobile Games for Elderly People

Robert *et al.* [37] has identified various factors which mobile games should have so that elderly people get motivated to use them. This study is based on a case study with some mobile game experts who conducted usability evaluation. The results and information of case study provides some guidelines which should be used to develop mobile games for elderly people. Mobile games are a source of entertainment and learning for elderly people. Few factors that are essential for mobile games of elderly people, such as mobile games, meet expectations of elder users, increase the motivation to use games, meet interest of elder users and understandable by the user.

Tulio *et al.* [38] performed a systematic literature review of some publications which discussed the motivations for playing mobile games and their benefits for the elderly people. There are some factors which increase the motivation of elderly people to play mobile games; those factors include use of descriptions, connection with traditional mobile games, highly interactive and low complexity of mobile games. Casual mobile games are more likely games to be played by the elder adults. Mobile games are an essential source to fight against various diseases of elderly people, for example, treatment of physical, psychological and emotional diseases. Mobile games are also helpful to reduce depression of elder adults by entertaining them.

De Schutter and Culture [39] explored the mobile games for elder adults and identified some motivational factors according to usage and satisfaction of elderly adults. To identify which games are preferred by elder adults a survey was conducted. 124 participants of age 45 to 85 participated in the survey. Results indicated that majority of the players show affection for mobile games. The important motivational factors identified were adventure, social contact and challenge. De Schutter and S. Malliet [40] investigated the use of mobile games for elder adults. Survey is conducted and qualitative research technique is used to find out factors which motivate elder people to play mobile games. Participants of survey are elder adults of age 50 to 74. On the basis of motivation and satisfaction of users five different categories of elder players

are derived which includes: Idlers, Fighters of liberty, attention seekers and game lovers.

2.6. Conclusion

This chapter reviewed various usability evaluation mechanisms and frameworks that can be used to conduct usability evaluation of mobile games. The literature discussed in this chapter identified various mechanisms of usability evaluation that were used to evaluate usability of those mobile games designed for elder adults. Some studies provide various benefits, challenges and motivational factors of mobile games for elder adults. Few studies are examined to observe the development of prototype of mobile games for elder adults.

Chapter 3

Research Methodology

This chapter is divided into six sections. First we describe the research methodology employed to conduct this research. The second section presents details of the proposed Usability Evaluation Framework. Design goal, parameters of the usability evaluation framework are described in detail. The third section describes the mobile games which were selected for usability evaluation and criteria followed to select those games. The fourth section provides details about the data collection and survey used to gather data. The last section presents the conclusion of this chapter.

3.1. Research Approach

The goal of the project is to propose a framework to enhance the usability of mobile games for elder adults. Another aim of the research is to develop a prototype of mobile games to enhance the usability of elder adults. A literature survey was carried out in order to identify the benefits and challenges of playing mobile games for elder adults. Various usability evaluation methods and techniques are analyzed and discussed. Motivational factors to motivate elder people to play mobile games are also identified through literature review.

3.1.1. Research Design

Our research design is based on user feedback through surveys to highlight important usability issues based on our proposed framework. Later on, a prototype game application is developed to apply the usability principles based on the feedback received in our initial survey. Feedback on the developed prototype was gathered to get user feedback on the applicability of the proposed usability framework.

This research will be an observational research because to achieve the objective of the research a survey will be conducted. Survey is a type of observational research that is used to collect data by asking some questions from participants. Observation research used in our study follows a qualitative research technique because usability evaluation of mobile game applications is based on user's opinions and their experiences. Two rounds of survey will be conducted which are initial survey and post-study survey. An introduction of the objectives of this research will be given to the participants before starting the survey. This study will also be an experimental research because an experiment will be performed to develop prototype game application. Prototype game application will be a simple experimental model of our proposed solution.

The overall research methodology is summarized below in fig: 3.1. The figure shows each step followed in the methodology.
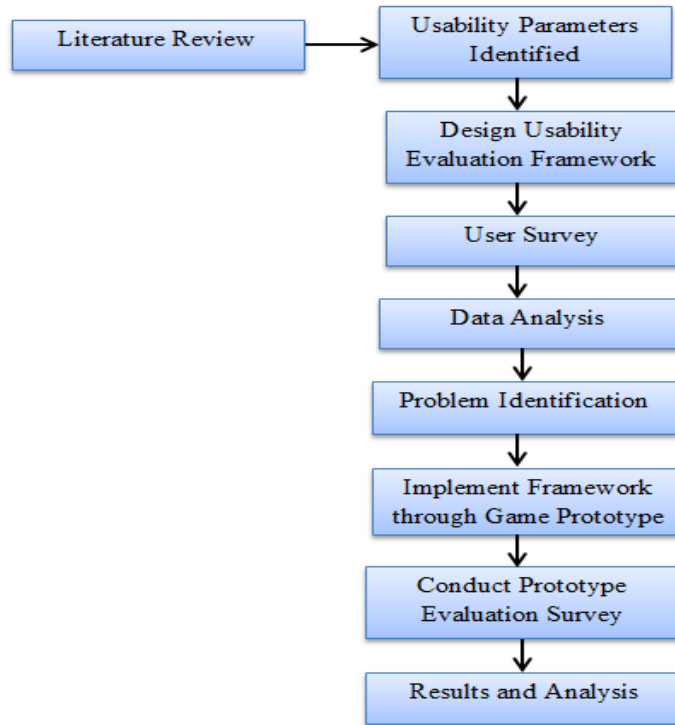
Fig.3.1 Research Design

3.1.2. Literature Review

Literature review presents an overview of usability evaluation methods and frameworks that can be utilized to evaluate mobile games. Effectiveness of various mechanisms of usability evaluation is also investigated. Some mechanisms of usability evaluation which are specifically designed for conducting usability evaluation of mobile games for elderly people are also presented. Benefits, challenges and motivational factors of mobile games for elder adults are also identified through literature review.

3.1.3. Identification of Relevant Usability Parameters

Usability parameters are those features used to evaluate how easy and understandable mobile games are for the users. Four major parameters of usability were selected for our proposed framework and are sub divided into more categories. These parameters

are selected on the basis of previous studies and are then consolidated to design a framework of Usability Evaluation for Mobile Games for Elderly People.

3.1.4. Design Usability Evaluation Framework

The selected usability parameters are consolidated to design a framework of Usability Evaluation for Mobile Games for Elderly People. Our proposed Usability Evaluation Framework for Mobile Games for Elderly People consists of four major parameters of usability which are sub divided into more categories. The proposed framework is specifically designed to perform usability evaluation of mobile games for elderly people.

3.1.5. User Survey

Three mobile games for elderly people were selected to conduct usability evaluation and evaluate these mobile games. A survey was conducted in order to collect data from elderly people. The survey conducted included two rounds of survey; Initial survey and post-Study survey. This was the first round of survey in which each participant was asked to play the three selected mobile games first and complete a questionnaire.

3.1.6. Data Analysis

After the first round of survey was completed, responses of participants were reviewed and analyzed. Different responses were collected from different participants.

3.1.7. Problem Identification

After analyzing the results of a questionnaire gathered through the first round of survey, major problems of usability faced by elder participants in the mobile games are identified. Category of each problem and key issues are discussed. Table 6.2 shows the usability problems faced by elderly people while playing the three selected mobile games.

3.1.8. Implement Framework through Game Prototype

To implement our proposed framework a prototype of mobile games for elderly people was developed. During the design phase of prototype of mobile game for elderly people; focus was on usability of game along with its content. All parameters of our proposed Usability Evaluation Framework were also considered while developing a prototype of mobile game which was designed specifically for elder adults.

3.1.9. Conduct Prototype Evaluation Survey

Post-Study survey was the second round of the survey in which 46 participants participated of age 50 or above. Questionnaire prepared for post-study survey comprises of 33 questions. In Post-study survey each participant was asked to play the developed prototype of mobile game first and then fill a questionnaire. Respondents were asked to tell what they like the most about the prototype of mobile games.

3.1.10. Results and Analysis

After the completion of second round of survey, responses of participants were analyzed. Different responses were collected from different participants. Problems of usability in the prototype of mobile game are identified.

3.2. Proposed Usability Evaluation Framework

A solution of the problem is provided in this research, a framework of usability evaluation for mobile games is proposed which is used to conduct usability evaluation of mobile game applications for elderly adults. The proposed framework consists of four major parameters of usability which are sub divided into sub-parameters. These parameters are selected based on previous studies and are then consolidated to develop a framework of usability evaluation. The proposed framework is specifically designed to perform usability evaluation of mobile games for elder adults.

3.2.1. Significance of Mobile Games for Elderly People

Mobile games have various benefits for elderly people including improving their thinking abilities and making their time full of fun. Mobile games can promote positive health among elderly people by reducing depression, feelings of isolation and loneliness. Mobile games can improve aspects of reasoning like decision-making and cognitive control among elderly people [24]. Elderly people also face many challenges while playing mobile games such as difficulty in using the technology and learning mobile games [31]. Challenges faced by elderly people includes: small buttons, unclear images and less interactive tasks. These challenges cause frustration among players due to which there is need to overcome all the limitations and uncertainties faced by the elder players [33].

Various factors have been identified by the researchers which mobile games should have so that elderly people get motivated to use the mobile games. Some motivational factors that are essential for mobile games for elderly people includes: mobile games meet expectations of elderly users, increase the motivation to use games, meet interest of elderly users and understandable by the user [37].

Benefits, Challenges and Motivational Factors of Mobile Games for Elderly people are listed in the Table 3.1.

Table 3.1 Benefits, Challenges and Motivational Factors of Mobile Games for Elderly People

Benefits, Challenges and Motivational Factors of Mobile Games for Elder Adults			
Sr.No	**Benefits**	**Challenges**	**Motivational Factors**
1.	Positive health among elderly people by reducing depression, feelings of isolation and loneliness [21].	Difficulty in using technology and learning a mobile game. Higher level of mental effort and intellectual abilities are required to play mobile games [28].	Mobile games should meet expectations of elder users, increase the motivation to use games, meet interest of elder users and understandable by the user [37].
2.	Improved thinking abilities and time full of fun [23].	No rewards given to players, repetitive tasks and boring missions [29].	Use of descriptions, highly interactive and low complexity of mobile games [38].
3.	Improved aspects of reasoning like decision-making and cognitive control [24].	small buttons, unclear images and less interactive tasks [30].	Adventure, social contact and challenging tasks [39].
4.	Enhance visual attention of elder adults [25].	Visual complexity of mobile game affects the experience and performance of elder adults [31].	High level of user satisfaction [40].
5.	Effective mediation exercise for elder adults as they increase enthusiasm and enjoyment [26].	Due to complexity of mobile games elder adults faced difficulty to play games [32].	
6.	Better mental and emotional health enhanced socialization and improved reasoning abilities [27].	Menus of game are not easily accessible, less interactivity and absence of learning content [33].	

3.2.2.　　　Selection of Usability Evaluation Parameters

Usability parameters are various features used to evaluate how easy and understandable applications are for the users. According to ISO 9126 usability of mobile games should be evaluated by the following four parameters [3].

1.　Understandability:

Understandability is the capability of mobile games to enable the users to understand how it can be used for certain tasks.

2.　Learnability:

Learnability is the proficiency of mobile games to enable the user to learn its use.

3.　Operability:

Operability is the proficiency of mobile games to enable the user to control and operate the mobile game.

4.　Attractiveness:

Attractiveness is the proficiency of mobile games to have an appealing user interface so that it should be attractive to the user.

The revised ISO 9241-11 subdivided the usability of mobile games into following three factors [3].

1.　Effectiveness:

Effectiveness is the capability of mobile games to which extent users can complete tasks of games with accuracy.

2.　Efficiency:

Efficiency is the capability of mobile games to which extent users can accomplish tasks accurately within available resources.

3.　Satisfaction:

Satisfaction is the capability of mobile games to fulfill the needs of users and is acceptable by the users.

Selected parameters of usability evaluation for proposed Usability Evaluation Framework of mobile games for elder adults are described below: -

3.2.2.1.   Understandability

Understandability is the capability of mobile games to enable the elder users to understand how it can be used for certain tasks. It is very important that users of the game understand the game completely. Users should be able to read and understand all the information displayed on different interfaces of the game. Experts consider that improved graphics can help users to understand the game easily. So, there is a need to improve the graphics of mobile games to enhance the understandability aspect specifically for elder adults. While designing any mobile game it is essential to consider aspects of understandability because understandable games can satisfy the needs, interests and expectations of the users. Understandability is also very important to motivate the users to play the mobile games [16].

Understandability also refers to the Interactive design of the game. Interactive design here refers to UI design of game which should have proficiency to be understandable, persuasive, intuitive and engaging. Major components of complexity of mobile games are UI, game controls and game play. UI of games designed for elders should be simplified, game controls should include simple swipe actions and game flow of game should have controlled movement with balanced speed [21].

3.2.2.2.   Easy Operation

Easy operation is the quality of the mobile game which enables the elder user to control and operate the mobile game easily. Most of the previous studies in the literature review revealed that elder players face difficulties in playing games and misinterpretation of the operation of mobile games. This misinterpretation of the operation is associated with the number of times that elder players have devoted themselves to mobile games. Most of the older players take longer time to operate the mobile games which shows that they were unable to perceive the game easily. It is

important that users can easily learn actions and controls of the mobile game. Easy operation is concerned with how quickly and easily users can achieve game tasks in their first attempt and to which extent users are able to improve their performance in the game [1].

Elder users want mobile games to be easy to operate and compelling. Mobile games for elder adults should have a user friendly and responsive interface. Interface of mobile games should not have unnecessary information and irrelevant content. Too many buttons, text and icons on the interface can cause clarity issues for the users which may lead to difficulty in operating the mobile game. So, it is essential to avoid all the irrelevant content that makes the user interface complicated and unclear for the elder players. The mobile games for elder adults need to be simple enough to be operated by elder users. Simplicity here refers to the extent of comfort with which elder adults can play mobile games and achieve game tasks [15].

3.2.2.3. Mental Exercise

Mental exercise is the ability of users which can be improved by playing mobile games. Mobile games should improve memory skills of elder users by providing them with suitable brain training. Majority of the elder adults face mental and emotional health disorders due to age factors and loneliness. Most of the previous studies in the literature review revealed that mobile games are a source of improving mental and emotional health of elder adults. The major aim of mobile games should be to engage older players and provide relaxation activities full of fun and enjoyment. Entertaining and exciting tasks can provide relaxation to elder adults to overcome their distress [9].

Boring and repetitive tasks of mobile games can cause frustration among elder adults. Mobile games should have challenging missions which can help elder adults to master their skills instead of playing repetitive tasks. Challenging missions of mobile games can be a mental exercise for elder adults and a source of motivation to play mobile games. This can be done by designing some thrilling and interesting game levels for elderly adults in mobile games. Mobile games should have proficiency to enhance the

memory skills of elder adults by providing them with appropriate brain training. There is need to design such memory games which can help elder adults to overcome their mental disabilities and improve their memory skills [19].

3.2.2.4.   Game Flow

Game flow is a scale which is used to measure the player experience. Game flow comprises of eight components which includes: proficiency to concentrate on game tasks, clear game tasks, challenge, skills of users, sense of control, user feedback, engagement and social interaction. The game flow criteria of any mobile game can accurately determine which games are successful and which one fails. The game flow criteria of mobile games can also identify the reasons behind the success and failure of any game. Game flow can also be used to review and evaluate the usability of mobile games [9].

Mobile games should have proficiency to improve player's experience and skills at a suitable pace as the player progresses through different levels of mobile games. Mobile games should have the capability to support competition, collaboration and social interaction among the players of game. While designing mobile games for elder adults, all the components of game flow should be considered. It should be ensured that the game flow components are present in any mobile game so that the success and failure of that game in terms of user experience can be measured accurately [32].

Table 3.2 shows the selected parameters of usability for usability evaluation framework and their source is also provided.

Table 3.2. Selected Parameters of Usability for Usability Evaluation Framework

Selected Parameters of Usability	Source
Understandability	[16, 21]
Easy Operation	[1, 15]
Mental Exercise	[9, 19]
Game Flow	[9, 32]

A table 3.3 shows category of each parameter of our proposed framework of usability evaluation and their description is also provided.

Table 3.3. Categories and Description of Parameters of Proposed Framework

Parameters	Categories	Description
Understandability	Perceivable	The mobile game should enable elder users to quickly and easily perceive the tasks and understand all the terms of use.
	Interactive Design	Interactive design here refers to the UI design of the game. UI design of game should have proficiency to be understandable, persuasive, intuitive and engaging.
	Less complexity	Major components of complexity of game are UI, game controls and game play. UI of games designed for elders should be less complex.
Easy Operation	Friendliness	Mobile games for elder adults should have a user friendly and responsive interface.

	Simplicity	The mobile games for elder adults should be simple enough to be operated by elder users.
Mental Exercise	Entertaining task	The goal of mobile games should be to engage players and provide leisure tasks full of fun and enjoyment. Entertaining tasks can provide relaxation to elderly people to overcome distress.
	Challenging missions	Mobile games should have challenging missions which can help elder players to master their skills instead of playing repetitive tasks.
	Brain Training	Mobile games should enhance the memory skills of elder adults by providing them with appropriate brain training.
Game Flow	Player skills	Mobile games should have proficiency to increase player experience and skills at a suitable pace as the player progresses through the mobile game.
	Social interaction	Mobile games should have proficiency to support competition, collaboration and social interaction among the players of game.

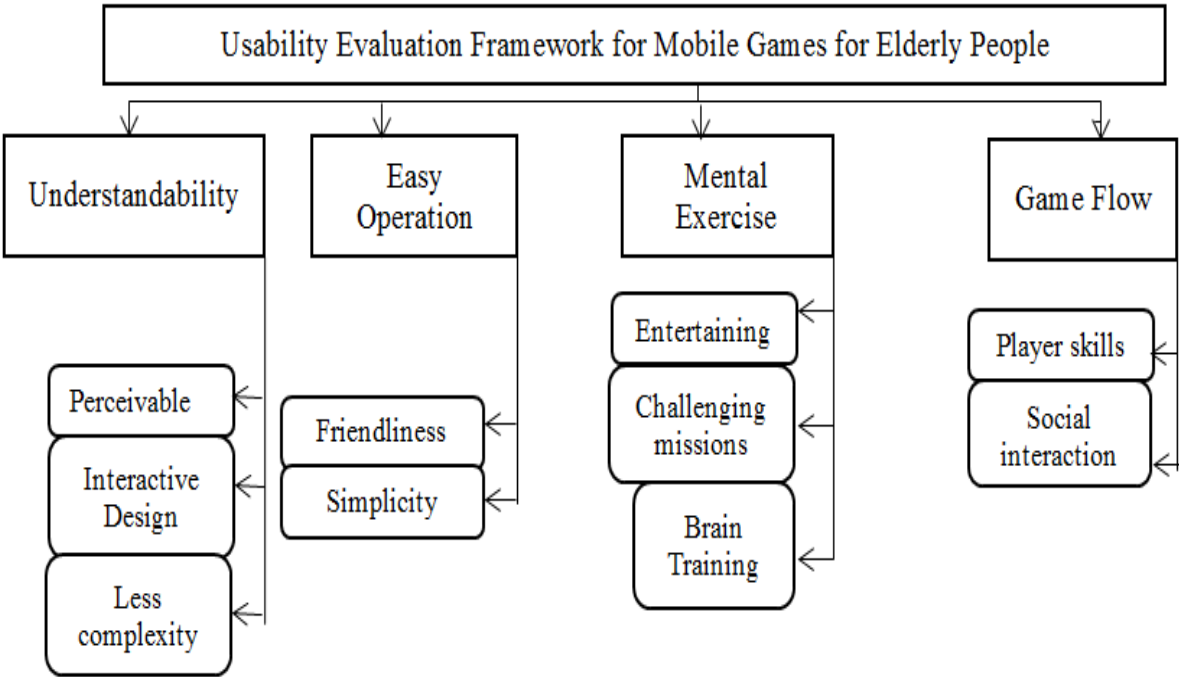Figure 3.2. Shows proposed framework of usability evaluation of mobile games for elderly People.

Fig 3.2 Usability Evaluation Framework for Mobile Games for Elderly People

3.3. Selection of Mobile Game for Usability Evaluation

Simplicity makes mobile games easier to be understandable by elder players. Less complex and simple games are suitable for older adults as they require fewer efforts to play the mobile game. Puzzle games are increasingly popular among elder adults due to their simplicity.

We selected three mobile games for usability evaluation based on their popularity among elder adults and their simplicity. Following are the selected games for usability evaluation.

- Tetris
- Dots: A Game About Connecting
- Match 3D-Matching Puzzle Game

These mobile games were selected on the based on their distinct interaction complexity. These games can be controlled with one touch interaction of users. But sometimes combination and precision of user's interactions together with other gameplay operations such as steps, actions, challenges and user's input may differ, and this may lead to avoidance of one touch interaction. It is important to notice that these three selected mobile games clearly belong to different genre of mobile games [16].

We selected three mobile games for usability evaluation based on the statement that the elderly people prefer casual and simple games based on mobile games which provides mental exercises [37] . These games were chosen as they were casual games specifically designed for elders and improve reasoning abilities, insight and memory. Another important reason to select these mobile games was usability and motivational factors. The selected games are very surprising games and are consistently popular among elder adults. They are popular as they meet the criteria for entertainment in games for elderly adults.

Fig.3.3. Selected Mobile games for Usability Evaluation

3.4. Data Collection

A survey was conducted in order to collect data from elderly adults. Data was collected from elder adults of age 50 or above. Participants involved in the survey were familiar with the mobile games. A questionnaire was prepared having 37questions out of which 5 were preliminary questions, 5 questions were about general Usability and remaining questions were about the Parameters of Usability. Participants who filled the questionnaire were employees of an office, teachers of a college, house wives and few retired people. The survey conducted included two rounds of initial survey and post-Study survey. In the first round 40 participants participated, which were elderly adults. Each participant was informed that their identity would be kept hidden .Each participant was asked to play all the selected mobile games first and complete a questionnaire of initial survey. The questionnaire used for initial survey is attached in Annexure 1. Once the first round of survey was completed, responses of participants were reviewed. Then after the development of mobile game prototype Post-Test survey was conducted. In the second round of survey the prototype of the mobile game was tested by asking each participant to play the game and complete a questionnaire of Post-Test survey. After the completion of the

second round the responses of the participants were reviewed and evaluated. The questionnaire used for Post-Test survey is attached in Annexure 2.

3.5. Conclusion

This chapter provided justification of research design and methodology which helped to accomplish objectives of this study. This chapter also discussed the technique that was used to collect and analyze data for conducting usability evaluation. An efficient framework of usability evaluation of mobile games for elder adults is also proposed. The proposed framework of usability evaluation will help to enhance the usability of mobile games for elder adults.

Chapter 4

Results and Evaluation

This chapter describes the results of the survey conducted on the basis of the proposed framework of usability evaluation of mobile games for elder adults. User's feedback was first taken on existing mobile games widely played by adults. Based on the design principles proposed, we developed a prototype game application and once again got feedback from the users to validate the proposed evaluation mechanism. This chapter describes the results of the initial survey and post-Study survey. For analysis, responses of all participants are examined, and results are reported in this chapter. The results will help to identify problems of usability for mobile games which are reported by elder adults. The layout of this chapter is as follows; in first section we present the results of the usability evaluation of existing games on our proposed evaluation framework. In section 2 we present the implementation of our prototype with enhanced usability based on our proposed usability evaluation framework. In section 3 we present the results of evaluation of our prototype and finally we present comparison of both results.

4.1. Pre-Study Survey

A survey is conducted in order to collect data from elder adults of age 50 or above. The survey conducted comprises of two rounds of Pre-Study survey and post-Study survey. Results of both rounds of survey are analyzed and problems of usability in mobile games for elderly people are identified.

Pre-Study survey was the first round of the survey in which total 40 participants participated. Each participant was of age 50 or above. Questionnaire prepared for pre-study survey comprised of 37 questions out of which five were preliminary questions. Five questions were about general usability, and the remaining questions were addressing the parameters of our proposed framework. In Pre-study survey each participant was asked to play the three selected mobile games first and then complete a questionnaire. Different responses were collected from different participants.

After the completion of the first round of survey, responses of participants were analyzed.90% of the participants were between 50-60 age range, 7.2% were between 61-70 age range and only 2.5% of participants were between 81-90 age range. The result for the age range of participants is shown in Figure 4.1.

| Legend	
50-60	90 %
61-70	7.5 %
71-80	2.5 %
81-90	0%

Fig 4.1. Age range of Participants
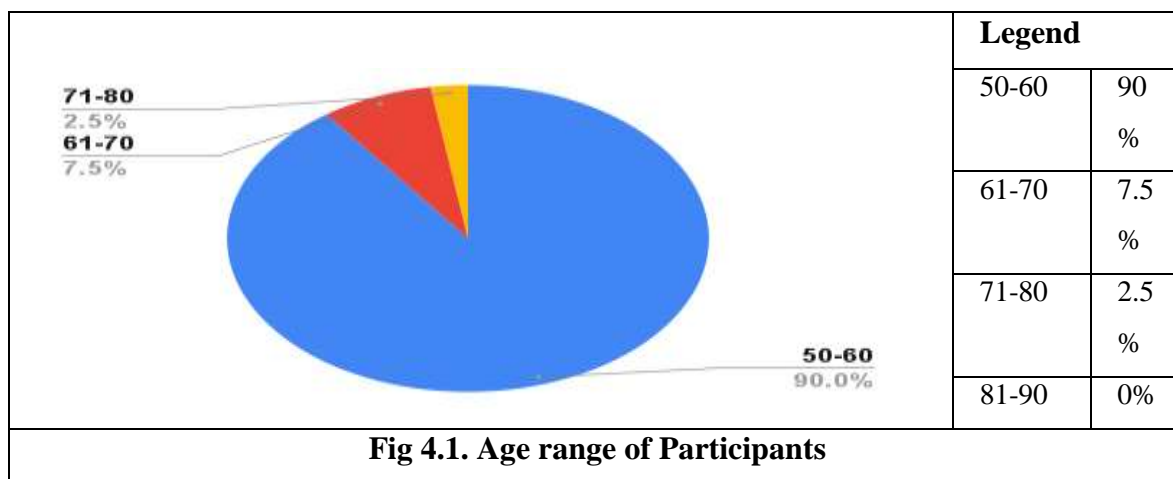
Ease of starting the game: This question focused on how easy it is to start mobile games so that players should not face any difficulty to begin the game. Only 5% of the participants responded that they find it easy to start the selected games. 15% responded

neutral to start the games. 55% of the respondents pointed that they faced difficulty to start the games. 20% of the participants responded that it was very difficult for them to start the selected mobile games. The results are shown in Figure 4.2.

Legend	
Very Easy	5%
Easy	5%
Neutral	15%
Difficult	55%
Very Difficult	20%

Fig 4.2. Easy to Start Mobile games
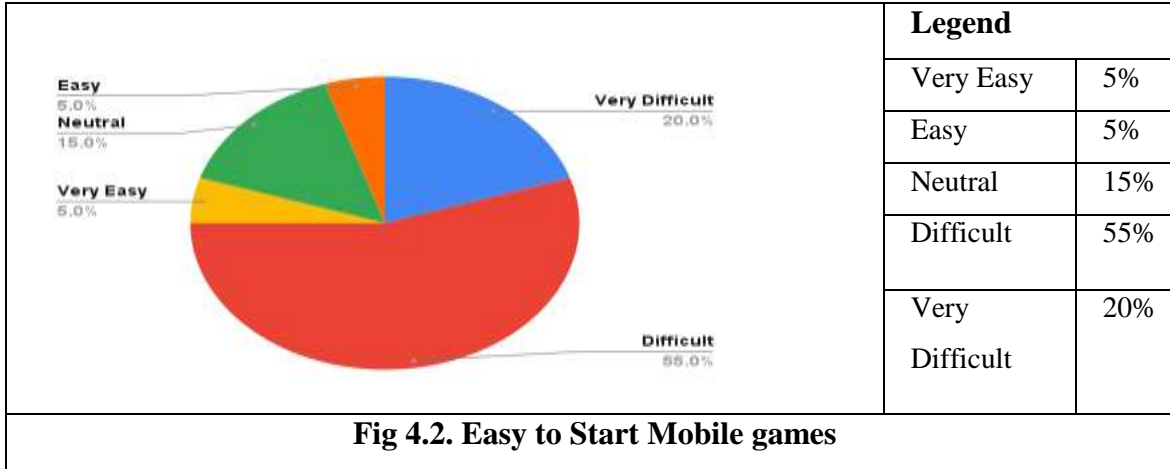
Understandability is an important aspect of usability evaluation. UI design of mobile games should be understandable, persuasive, intuitive and engaging for elderly people. Few questions were asked about the parameter of understandability. 60% of the participants responded that the interfaces of selected mobile games are not interactive. Only 5% participants responded that they find interface of mobile games interactive. The statistics of Figure 4.3 shows that 5% of respondents had neutral response, 7.5% responded strongly agree and 22.5% responded strongly disagree.

Legend	
Strongly Disagree	22.5%
Disagree	60%
Neutral	5%
Agree	5%
Strongly Agree	7.5%

Fig 4.3. Interactive Interface of Mobile games
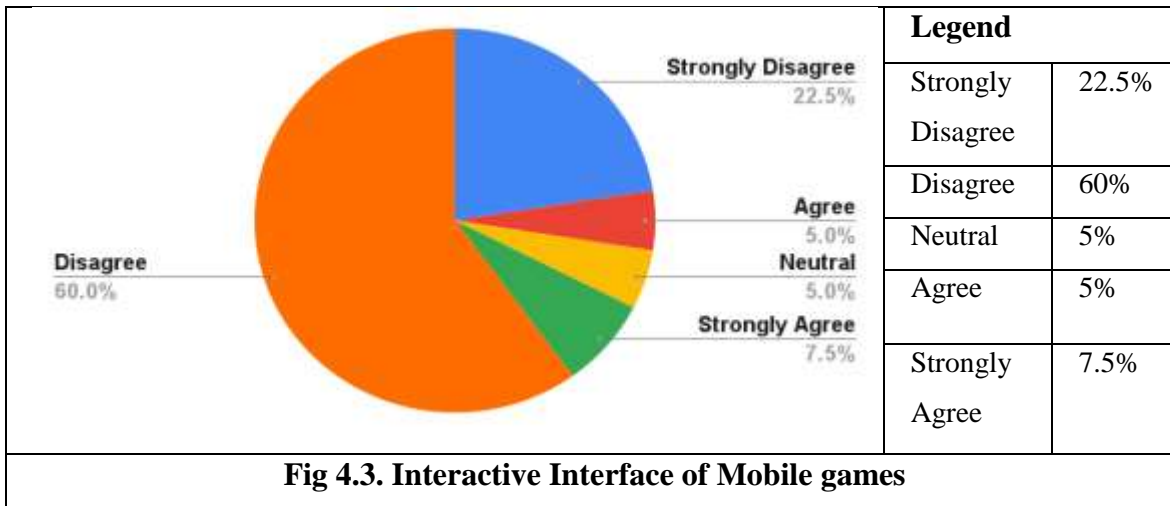
It is important that mobile games should be understood by the users. The mobile game should enable elder users to quickly and easily perceive the tasks and understand all the terms of use. Only 5% of the respondents agreed that the mobiles games were easy to understand.70% participants responded that they did not understand the games. Results of figure 4.4 shows that 5% of respondents responded strongly agree, 5% of respondents had neutral response and 17.5% responded strongly disagree.

Legend	
Strongly Disagree	17.5%
Disagree	70%
Neutral	2.5%
Agree	5%
Strongly Agree	5%

Fig 4.4. Easy to Understand
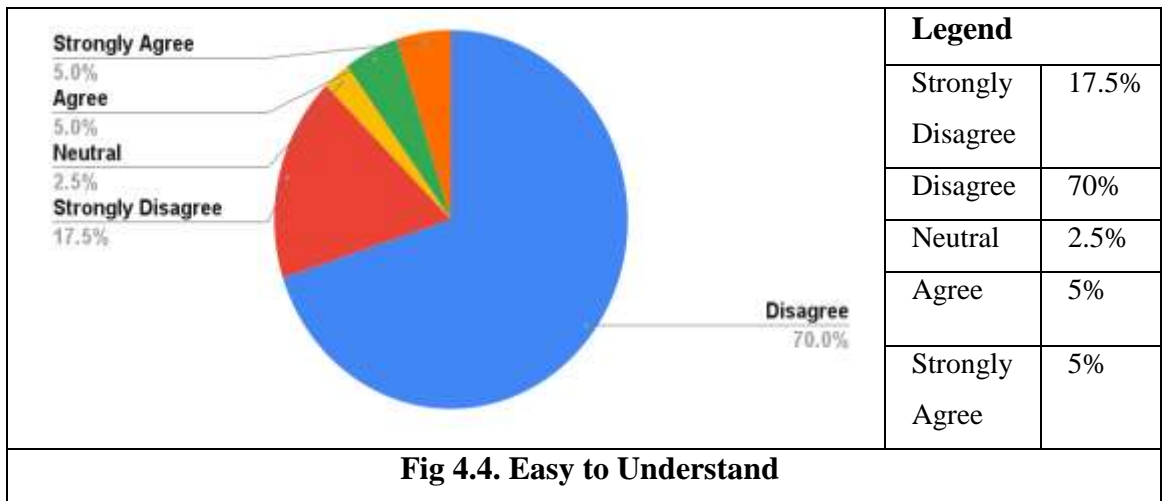
Elder users should be able to read all the information displayed on different interfaces of the game. 57.5% participants disagreed that the font, size and colors of the games are not easy to read. 17.5% respondents responded strongly disagree, 10% of respondents had neutral response, 2.5% responded agree and 12.5% responded strongly agree. Results are shown in Figure 4.5.

Legend	
Strongly Disagree	17.5%
Disagree	57.5%
Neutral	10%
Agree	2.5%
Strongly Agree	12.5%

Fig 4.5 Easy to perceive font, size and colors
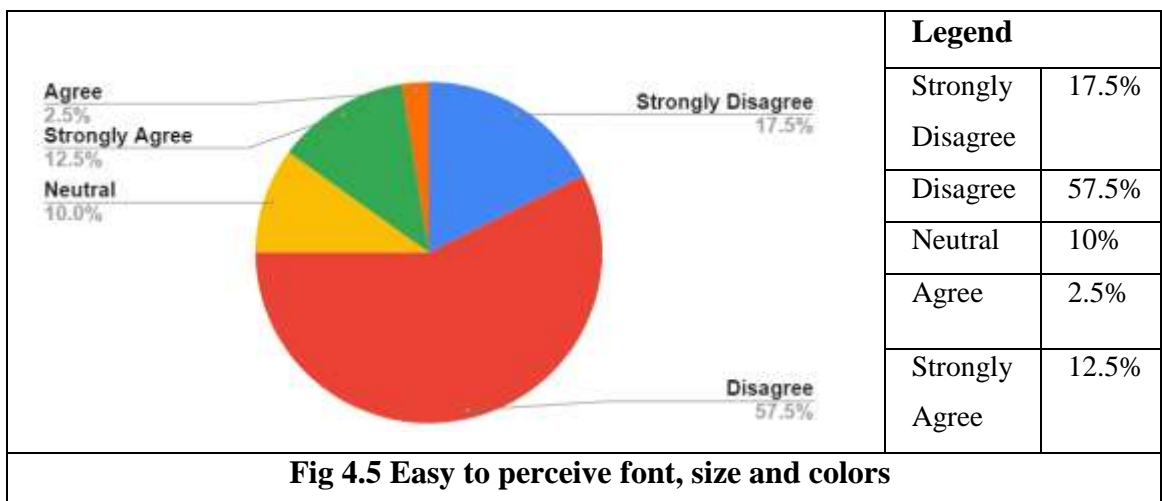
Only 5% participants agreed that content of games is organized in proper manner. 55% respondents responded disagree, 20% responded strongly disagree, 12.5% responded neutral, 5% responded agree and 7.5% responded strongly agree. Results are shown in figure 4.6.

Legend	
Strongly Disagree	20%
Disagree	55%
Neutral	12.5%
Agree	5%
Strongly Agree	7.5%

Fig 4.6 Organization of Games content
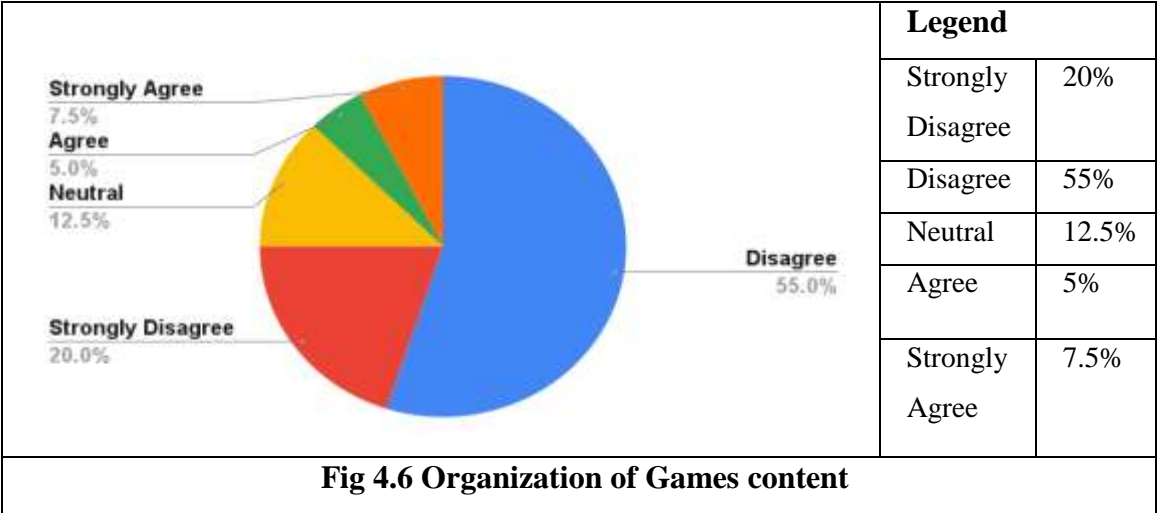
Only 10% participants agreed that tasks of games are less complex while 55% of the participants disagreed to this question. Statistics in figure 4.7 shows that 17.5% of the respondents responded disagree, 15% responded neutral and 2.5% responded strongly agree. This shows that most of the respondents find the tasks of selected mobile games complex.

Legend	
Strongly Disagree	17.5%
Disagree	55%
Neutral	15%
Agree	10%
Strongly Agree	2.5%

Fig 4.7 Complexity of Game Tasks
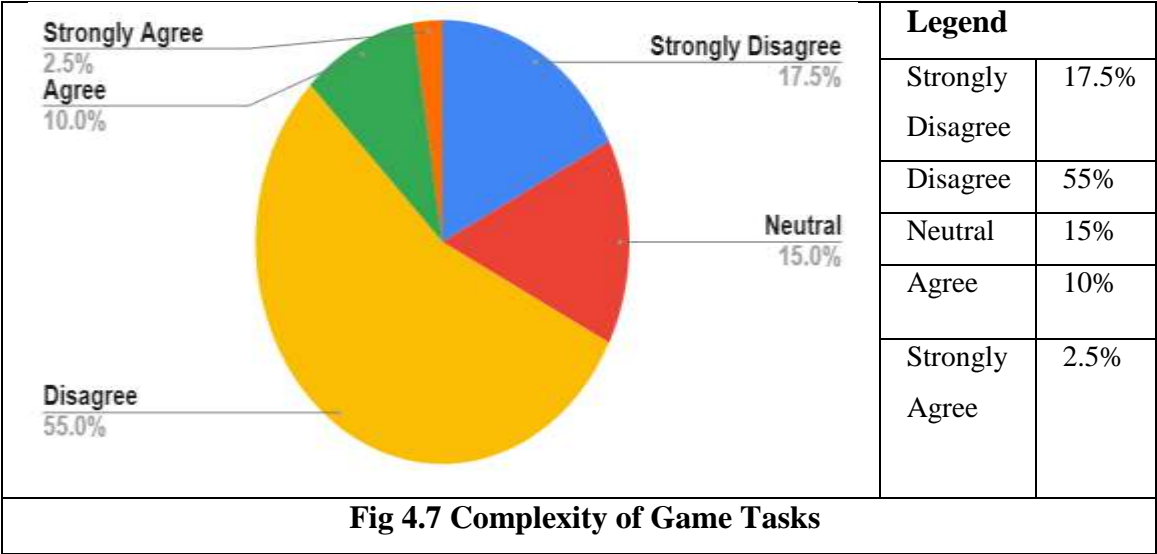
Easy operation is an important aspect for usability evaluation of mobile games. To address this parameter a few questions were asked which were based on categories of this parameter. It is essential that mobile games should be easy to learn. Only 2.5% participants agreed that games are easy to learn.65% of the respondents responded disagree, 17.5% responded strongly disagree, 10% responded neutral and 5% responded strongly agree. Figure 4.8 illustrates the results.

Legend	
Strongly Disagree	17.5%
Disagree	65%
Neutral	10%
Agree	2.5%
Strongly Agree	5%

Fig 4.8 Easy to learn the Game
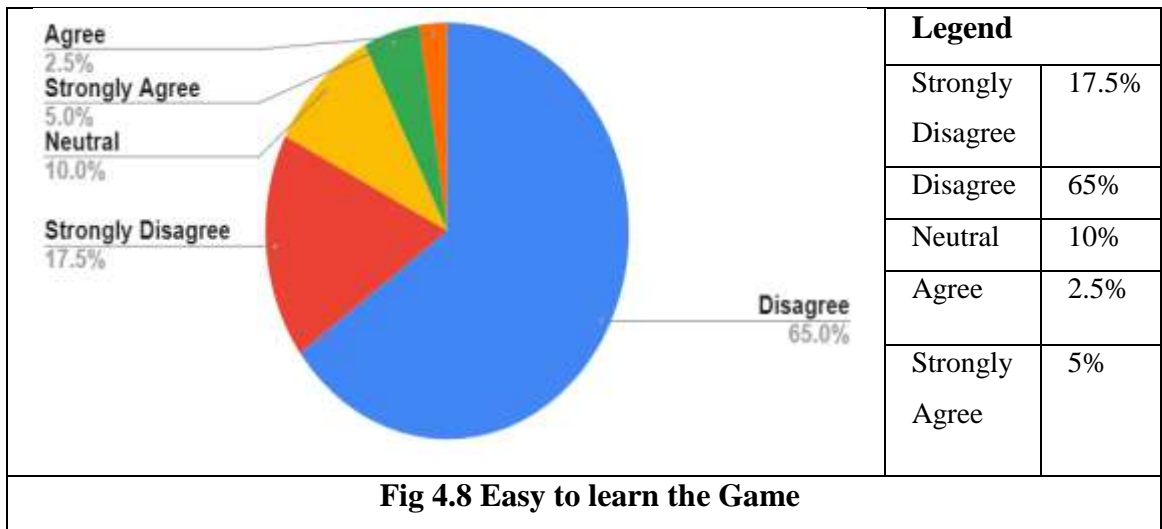
Mobile games should be simple and require a few steps to complete the game tasks. Only 5% of the respondents agreed that selected mobile games are simple and few steps are needed to complete the game tasks.65% of the respondents responded disagree, 17.5% responded strongly disagree, 7.5% responded neutral and 7.5% responded strongly agree. Figure 4.9 shows the results.

Legend	
Strongly Disagree	17.5%
Disagree	65%
Neutral	7.5%
Agree	5%
Strongly Agree	7.5%

Fig 4.9 Few Steps Required to Accomplish Tasks.
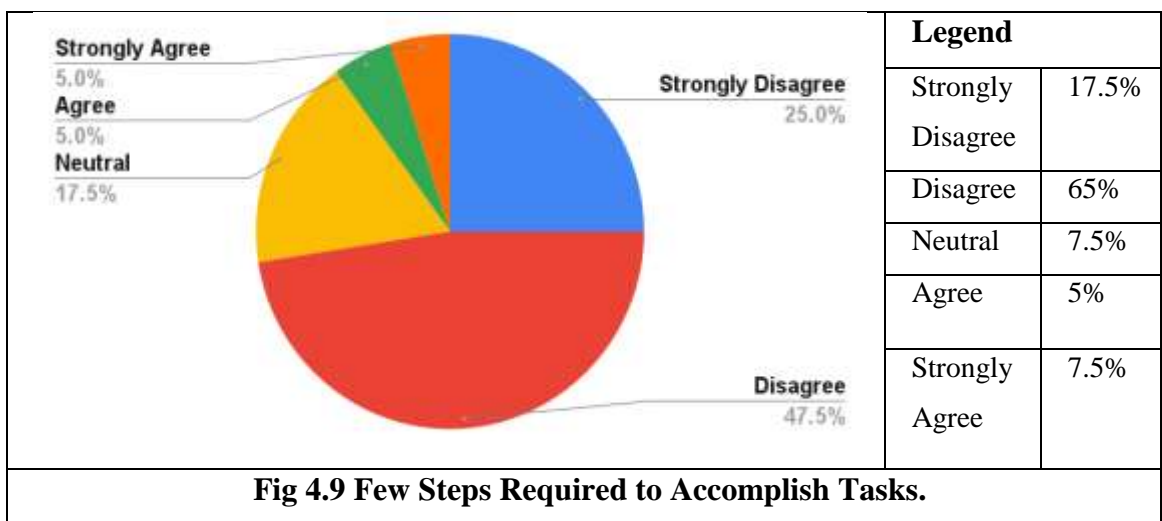
Mental Exercise is another important parameter of usability evaluation specifically for mobile games of elderly adults. A question was asked to investigate whether the selected mobile games provided mental exercise to elderly users. 50% of the participants agreed that selected mobile games provided them with enough mental exercise. 25% of the respondents responded strongly agree, 5% responded neutral, 12.5% responded strongly disagree and only 7.5% responded strongly disagree. Figure 4.10 illustrates the results.

Legend	
Strongly Disagree	7.5%
Disagree	12.5%
Neutral	5%
Agree	50%
Strongly Agree	25%

Fig 4.10 Selected Mobile Games provides Enough Mental Exercise
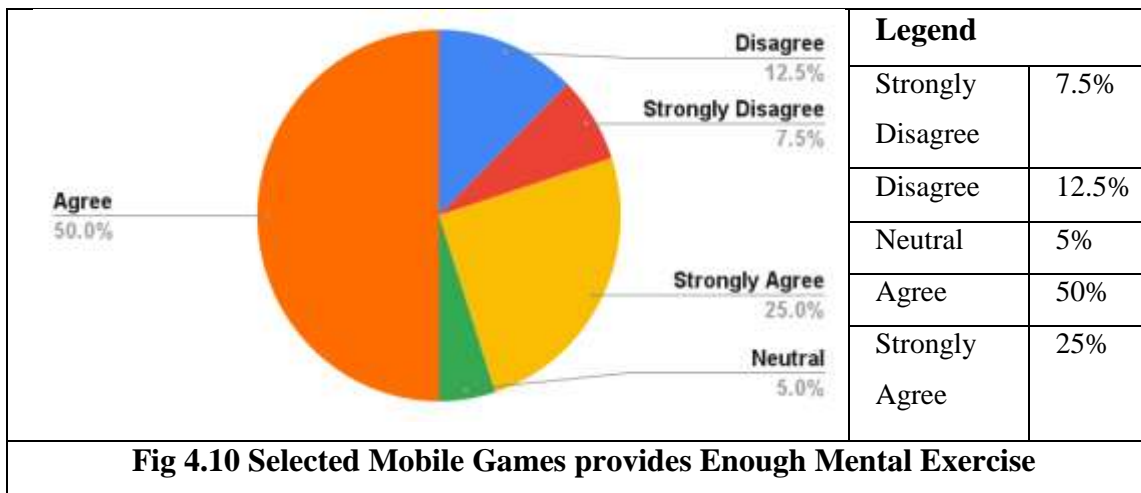
Mobile games should be entertaining in order to provide a fun time to elder adults. A question was asked to investigate that the selected mobile games were entertaining for elderly users. Only 17.5% of the participants agreed that mobile games are source of entertainment. 2.5% of the respondents responded strongly agree, 7.5% responded neutral, 50% responded disagree and only 22.5% responded strongly disagree. Figure 4.11 illustrates the results.

Legend	
Strongly Disagree	22.5%
Disagree	50%
Neutral	7.5%
Agree	17.5%
Strongly Agree	2.5%

Fig 4.11 Selected Mobile Games are Entertaining
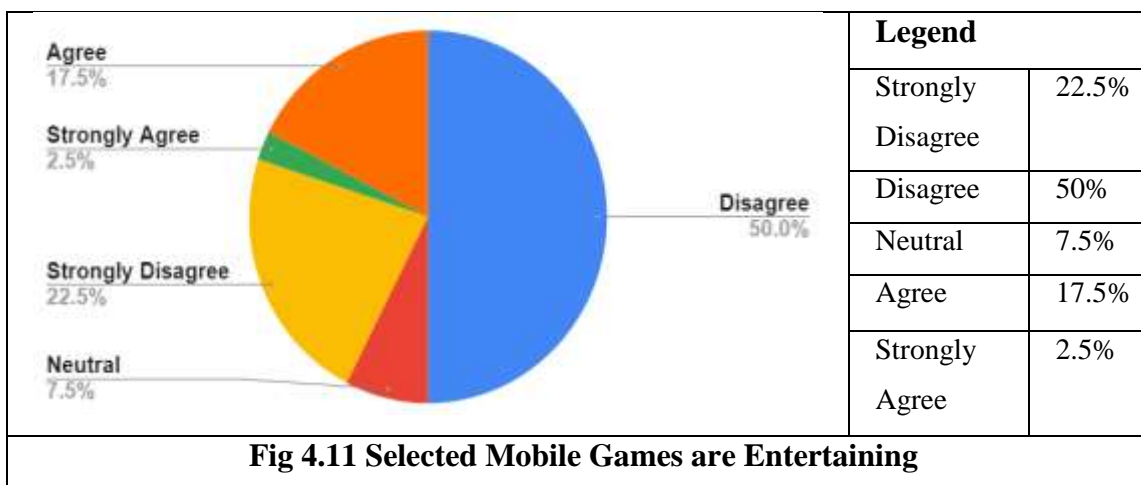
Tasks of mobile games should be thrilling and challenging in order to help elder adults in their brain training. Majority of the participants responded that tasks of the selected games are not thrilling and challenging. 60% of the respondents responded disagree, 30% responded strongly disagree, 2.5% responded neutral, 2.5% responded agree and 5% responded strongly agree. Figure 4.12 illustrates the results.

Legend	
Strongly Disagree	30%
Disagree	60%
Neutral	2.5%
Agree	2.5%
Strongly Agree	5%

Fig 4.12 Thrilling and Challenging Game Tasks
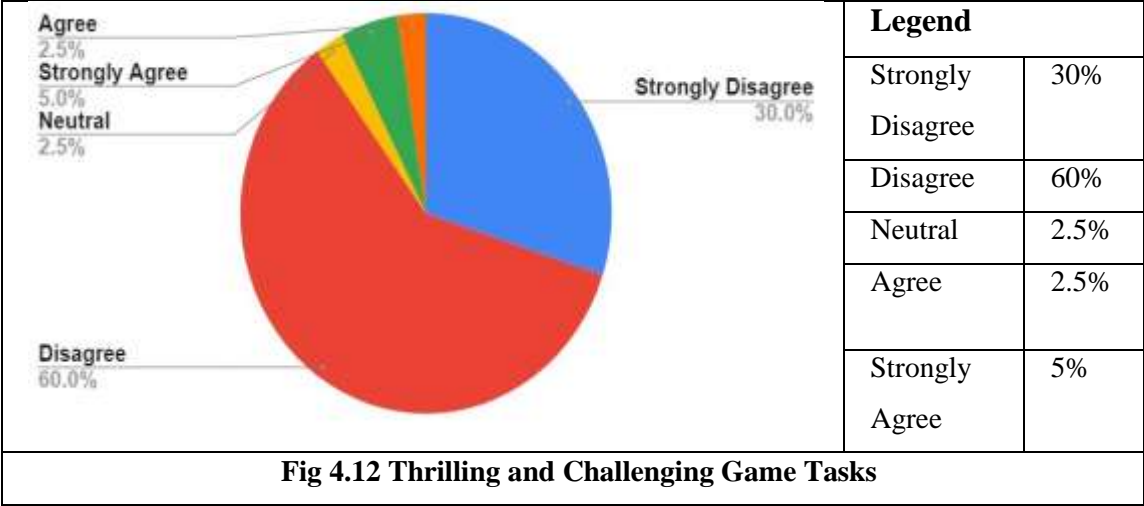
Game flow is an essential aspect of usability. When playing mobile games, it is important that the player is intensely absorbed in the game. 52.5% participants responded that they did not feel intensely absorbed in the games. Results of figure 4.13 shows that 25% of respondents responded strongly disagree, 15% responded neutral, 5% responded strongly disagree and only 2.5% respondents responded disagree.

Legend	
Strongly Disagree	25%
Disagree	52.5%
Neutral	15%
Agree	2.5%
Strongly Agree	5%

Fig 4.13 Player is Absorbed in the Game
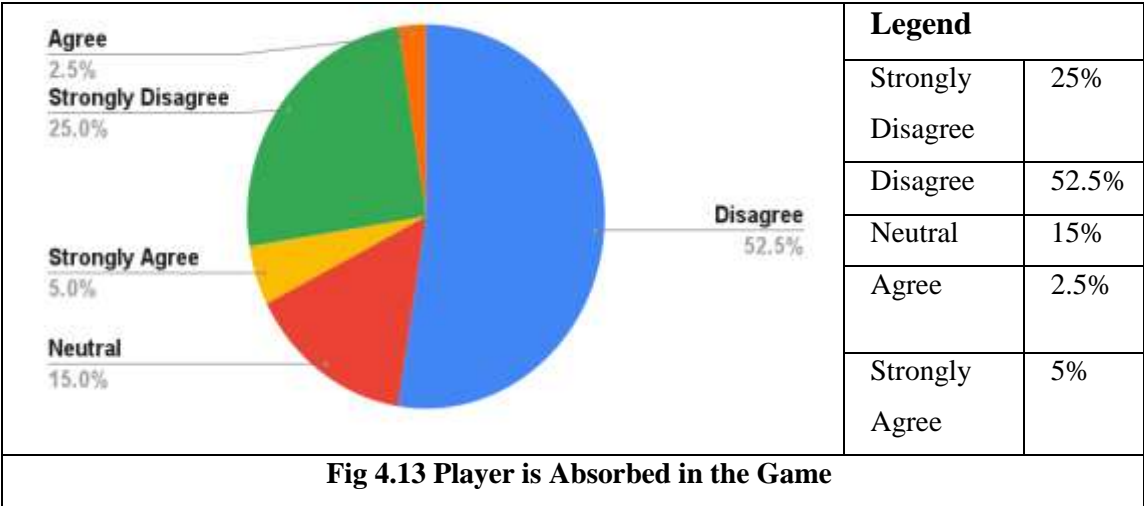
It is important that players should have a feeling of control while playing Mobile games. 62.5% participants responded that they did not have a feel of control while playing the mobile games. Results of figure 4.14 shows that 20% of respondents responded strongly disagree, 7.5% responded neutral, 7.5% responded strongly agree and only 2.5% respondents responded agree.

Legend	
Strongly Disagree	20%
Disagree	62.5%
Neutral	7.5%
Agree	2.5%
Strongly Agree	7.5%

Fig 4.14 Player have Feeling of Control
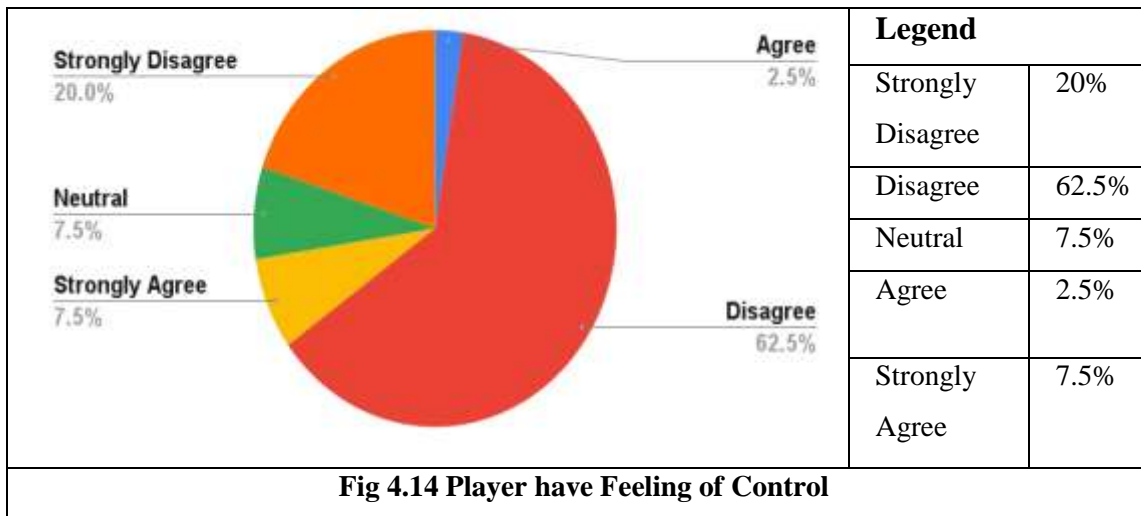
Respondents were asked to tell which mobile game they enjoyed the most. Results of figure 4.15 show that most people like the Match 3D puzzle game. 90% of the participants responded that they liked Match 3D game, 7.5% like Dots game and only 2.5% of the respondents like Tetris game. The results depict that majority of the elderly adults enjoyed Match 3D puzzle game due to its simplicity, ease of use and entertaining missions.

Legend	
Match 3D	90%
Dots	7.5%
Tetris	2.5%

Fig 4.15 Most Liked Mobile Game
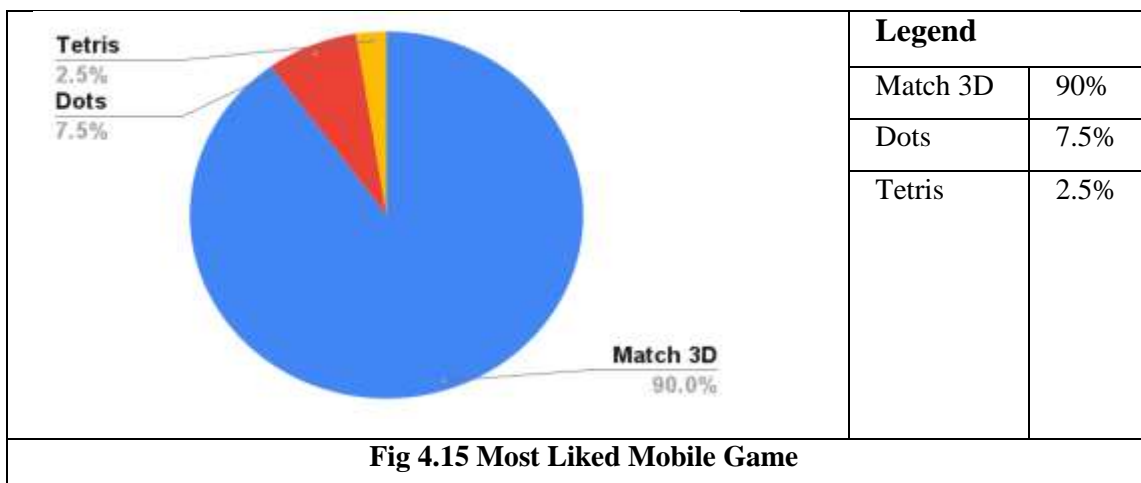
4.2. Development of Prototype of Mobile Game for Elderly People

This section gives details of a prototype application developed based on the feedback received in our initial survey on a sample set of mobile games being played by elders. A brief discussion on the tools used to develop the prototype of mobile games is presented. Moreover, design principles followed in the development of the prototype are also discussed.

In a previous study an activation mobile game for elderly people was developed and the experiences of elder users were evaluated. The usability evaluation of game was conducted by three groups of elderly people. Majority of elderly people provided positive feedback and challenge faced by elder people was related to controller of game which was difficult to handle [41]. A prototype of bowling mobile game was developed for elderly persons. The prototype of a game is implemented by following the iterative methodology of development. The user feedback was recorded which indicated that users need more practice to play this bowling game. The challenges faced by elder users include insufficient guidelines and difficulty in controlling the cursor with the help of mouse [42].

The design of mobile exergame for elder adults was provided in a study. The purpose of the game was to overcome the inactive lifestyle of elderly people and to provide them with entertainment. With the help of this game elderly people were able to improve their fitness and cognitive abilities. Five prototypes of games were evaluated, and results showed that elderly people playing mobile games are healthier and possess better cognitive abilities [43]. Architecture of mobile game was presented, specifically designed to improve the health conditions of elder adults. In this game elder users give their responses to quizzes and provide their feedback. This game is good for brain training and improves the decision power of elderly people. The difficult part of the game was its higher levels which comprised of very difficult questions [44].

Four different mobile games were designed specifically for brain training of elder adults. These games were evaluated and the effect of the game on elder adults was observed. Results of experiments showed different effects of brain training mobile

games on different age groups. Interfaces of mobile games have great impact on willingness of elder adults for playing mobile games. Elderly people respond slowly to the games having complex interfaces as they face difficult in understanding those games. Simple and easy interfaces of mobile games are more preferred for elder adults to improve brain training [45].

4.2.1. Prototyping in General

Prototyping is a major part of mobile game development. Prototyping is a process in which the game developers create a model of mobile game or some modules of the game. The prototyping can be used to conduct testing of new games or an idea of games that the developers consider as fun for the players. This help developers to test whether an idea of new game is acceptable by the players in practice as it is rough sketch of the game without spending too much effort on graphics and audio [46].

There are various types of prototyping to create the prototypes of different kinds, for example, physical, video, digital, visual and software prototyping. These different kinds of prototyping could all be used in the same project for creating prototypes of different modules. The important thing to be considered while developing prototype that developers should not create prototype of whole design but only important aspects that are necessary for the users [47].

Digital prototyping was used to develop the prototype mobile game for elderly people. Various aspects of games were tested through digital prototyping, for example how the controls of game work, how a player would act in a certain situation. Digital prototyping involves game mechanics, aesthetics of games, visual elements, touch controls, responsive user interface and best tools to develop the prototype mobile game for elderly people [46].

4.2.2.   Tools Used

To develop a prototype mobile game for elderly adults Unity Engine was used. In Unity engine different GameObjects and scenes are developed. The second tool used to script the programming language C# was MonoDevelop IDE. This tool is used with Unity Engine and is the main tool for developers working in Unity Engine [48].

4.2.2.1.   An Overview of the Unity Engine

Unity Engine is a tool used by developers for game development. Unity game development engine is a powerful tool, easy to use and is available free of charge. Unity Engine versions used in the development of the game prototype was Unity 2020.3.8f1. Unity Engine comprises of five different components which includes Hierarchy, Project, Scene, game and inspector. These are also known as views of unity which are used for developing games. Figure 4.16 demonstrates the default window of empty Unity project [48].

Fig 4.16 Default window of the Unity Editor

Project browser comprises of all the assets related to the existing game project such as audio, images, textures, scenes and scripts. Hierarchy displays a list of all the objects of the game which are used in the current project [48]. Every object of the hierarchy is displayed in the scene view, and they can change their movement to left, right and can be rotated. To preview the developed game in unity Engine the game view is used. In this view the game is previewed exactly how the players will view the game. All the components attached to the GameObject of the current game are displayed in the

Inspector View. All the scripts created in Unity are opened and edited in MonoDevelop IDE [49].

4.2.3.   Game Idea for Elder Adults

Different approaches are required to design mobile games for elder adults as compared to designing games for young adults and children. This is because elderly adults have special demands as players of mobile games. Traditional methods of developing games do not consider the age-related needs of elder adults. Challenges and motivational factors identified in this research can help in developing a prototype of mobile games that is more appropriate for elder adults.

We selected the Matching Puzzle Game as our prototype application based on feedback from elders as the majority enjoyed the puzzle game. In this game users must have to identify similar images. The game design is kept simple and easy for elder adults.

4.2.4.   Design of the Matching Puzzle Game

A simple and easy design is used to develop the prototype of Puzzle Game. The goal of game is to swap the pieces of puzzle till there is one more similar puzzle. When a match of puzzle is made, those tiles are removed, and empty spaces are displayed. This lets players memorize similar puzzle pairs and make possible combinations. The Puzzle game comprises of three levels and these levels contain 6-30 images and elder players need to identify similar images in each level and match them together. Images are of different shapes and vehicles. Figure 4.17 shows the conceptual design of Matching Puzzle game prototype.
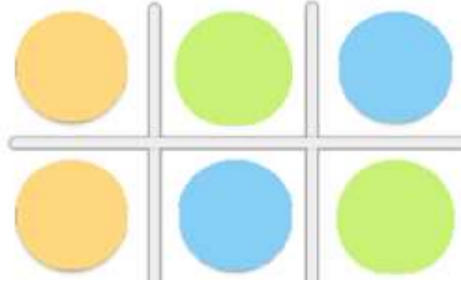
Fig 4.17 Conceptual Design of Matching Puzzle Game Prototype

4.2.5. Setup

The setup of Matching Puzzle game starts out with placing out the Puzzle Tiles on the Game Board. To create Matching Puzzle game in Unity Engine the following steps were followed:

- First a board is created that contains puzzle tiles.
- Puzzle tiles are selected and deselected with the mouse clicks.
- Adjacent puzzle tiles are identified.
- Just click or tap on puzzle tiles.
- A match of 2 similar puzzle tiles is detected.
- A pair of matched puzzle tiles is filled with empty tiles.

4.2.6. Starting the Puzzle game

Development of prototype started by selecting the canvas which was a portrait mode. Switch the build settings of Unity Engine to Android. A few steps followed to start the development of prototype are mentioned below:

- **Animations:**

In Unity there is a 2D Animation package that allows you to add animations to Sprites. All the needed animation for the Puzzle game were applied by opening Window menu and clicking "Animation".

- **Audio:**

Unity contains the sound effects and music required for any game. Audio files can also be imported in the Unity Project. There is an option to play, pause and stop the audio. Audio for Puzzle game was added by opening Window menu and clicking "Audio Source".

- **Prefabs:**

GameObject is stored in Prefab asset type along with all its components and properties. A button Prefab is an aspect that enables the players to interact with the button. In Matching Puzzle game button prefab is created named Puzzle Button. This button is used to create scripting events when it is clicked.

- **Scenes:**

In Unity Scenes holds all the content of the game. They are assets that comprise of the menu and all other parts of the game. For Matching Puzzle game there is a single scene of Main Menu that contains all the contents of game.

- **Scripts:**

Scripts folder contains all the scripts used in Matching Puzzle Game. Scripts of Matching Puzzle Game include Puzzle Game Controller, Puzzle Game Saver, Puzzle Level Controller Scripts, Puzzle Menu Controller Scripts and Puzzle Music Controller.

4.2.7. Design Principles

Table 4.1shows design Principles followed to implement the prototype of Matching Puzzle game.

Table 4.1 Design Principles of Mobile Game Prototype

Sr.No	Design Principles	Sources	Implemented in Selected Games	Implemented in Developed Prototype	Parameters Validity
1.	Easy to use navigation	[50]	✓	✓	Understandability
2.	Easy to perceive		✗	✓	Understandability
3.	East to touch screen		✓	✓	Easy Operation
4.	Easy to Interactk		✗	✓	Understandability
5.	Color set for older adults		✓	✓	Easy Operation
6.	Recognizable icon set		✗	✓	Easy Operation
7.	Simple interface		✗	✓	Easy Operation
8.	Communication	[51]	✓	✓	Easy Operation
9.	Player equipment and game space visualization		✗	✓	Easy Operation
10.	Information model criteria		✓	✓	Mental Exercise
11.	Evaluation		✗	✓	

12.	Episodic Memory	[52]	✘	✓	Mental Exercise
13.	Processing Efficiency		✘	✓	Game Flow
14.	Reaction Time		✘	✓	Game Flow
15.	Visualization of Game Space		✘	✓	Game Flow
16.	Customization		✘	✓	Easy operation

4.2.8.   Creating the Game Board

To create the game board for Matching Puzzle Game a game object is created, and it is named as PuzzelGameManager. The PuzzelGameManager will be responsible for creating the game board and keeping the puzzles slots. Next step was to locate the PuzzelGameManager.cs under Scripts\Puzzle Game Controller in the Project window. Drag that PuzzelGameManager.cs file and dropt it onto the PuzzelGameManager game object in the Hierarchy window. Figure 4.18 shows the initial Game Board of Matching Puzzle game. This game Board is the Main Menu of the Matching Puzzle Game. The icons used demonstrate the three different types of Puzzles used in the game.

Fig 4.18 Game Board of Matching Puzzle game

4.2.9.　　　　Adding Puzzle Slots

Next step is to add Puzzle slots under Sprites\Puzzle Game Controller\CreatePuzzle in the Project window. PuzzelGameManager is selected in the Hierarchy window and size of the Puzzle Sprites is changed in the inspector window. Each Puzzle sprite is dragged into the empty slots. Sprites are images of three different types of puzzles used in the Matching Puzzle Game. Figure 4.19, figure 4.20 and figure 4.21 show puzzle slots of different types of puzzles used in the game.
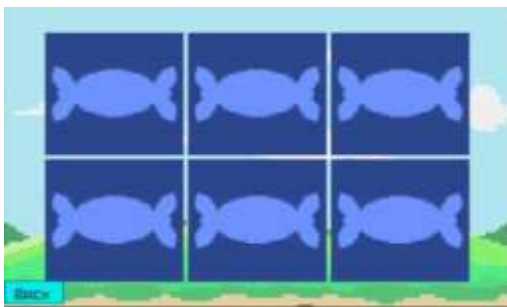

Fig 4.19 Puzzle Slots for Type 1 Puzzles

Fig 4.20 Puzzle Slots for Type 2 Puzzles

Fig 4.21 Puzzle Slots for Type 3 Puzzles

4.2.10.　　　　Adding Levels to Matching Puzzle Game

Most important step in developing game prototype was adding different levels. Each type of Puzzle consists of five different levels which can be unlocked once a player has completed the previous level successfully. To add levels three script files named LevelLock, LevelSelect and StarsLocker were created under Scripts\Puzzle Level

Controller Scripts. Figure 4.22, figure 4.23, figure 4.24 and figure 4.25 show different levels of different Puzzle Types of Matching Puzzle Game.
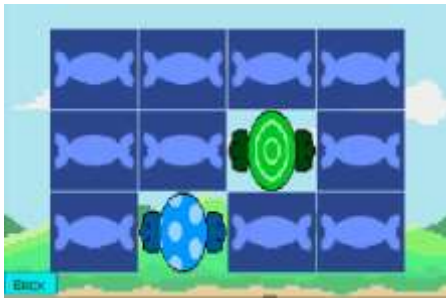

Fig 4.22 Level 2 for Type 1 Puzzles
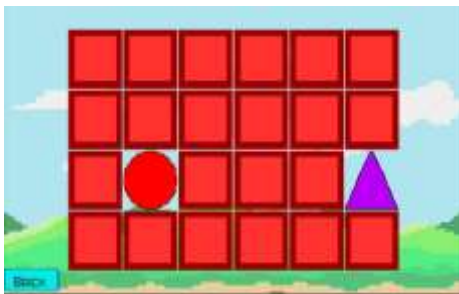

Fig 4.23 Level 3 for Type 2 Puzzles
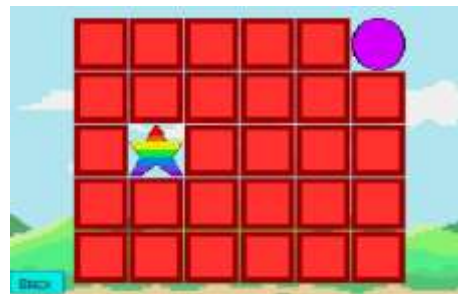

Fig 4.24 Level 4 for Type 3 Puzzles

Fig 4.25 Level 5 for Type 3 Puzzles

4.2.11.   Gameplay

The Matching Puzzle game starts by showing the Main Menu to the player. Three different icons are shown on the screen which shows the type of Puzzle. Players can select the type of puzzle they want to play. After selecting the puzzle type Level Board will be displayed which contains five levels for every puzzle type. Except level 1 all other levels will be locked. If the player successfully completes the first level, then the second level will be unlocked, and the same process repeats for other levels. Player must make a similar combination of puzzles by clicking on any two puzzle slots. If the pair of puzzles selected is similar than those puzzle tiles will be removed, and empty spaces will be displayed. On completing all the possible combination of Puzzles the player will be taken to the next level of the game. Figure 4.26 shows the Level Board

that contains the locked levels and figure 4.27 shows the Level Board containing unlocked levels.


Fig 4.26 Level Board of Locked Levels

**Fig 4.27 Level Board of Unlocked Levels**

4.3. Post-Study Survey

Post-Study survey was the second round of the survey in which 46 participants participated. Each participant was of age 50 or above. Questionnaire prepared for post-study survey comprises 33 questions out of which two were preliminary questions. Five questions were about general usability, and the remaining questions were addressing the usability parameters of our proposed framework. In the post-Study survey each participant was asked to play the developed prototype of Matching Puzzle game first and then complete a questionnaire. Different responses were collected from different participants.
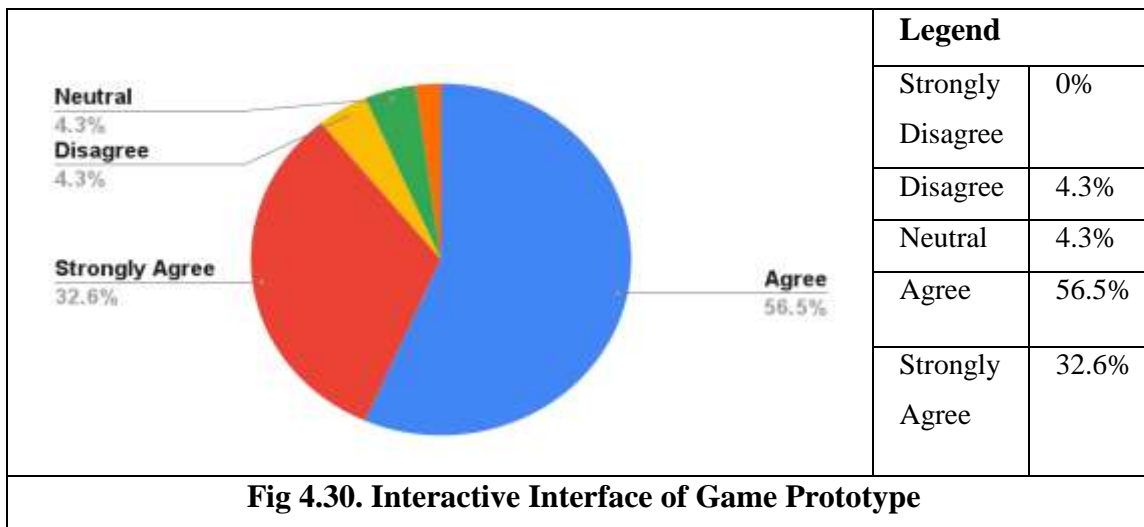
After the completion of second round of survey, responses of participants were analyzed.78.3% of the participants were between 50-60 age range,21.7% were between 61-70 age range. The result for the age range of participants is shown in Figure 4.28.

Legend	
50-60	78.3%
61-70	21.7%
71-80	0%
81-90	0%

Fig 4.28. Age range of Participants in Post-Study Survey
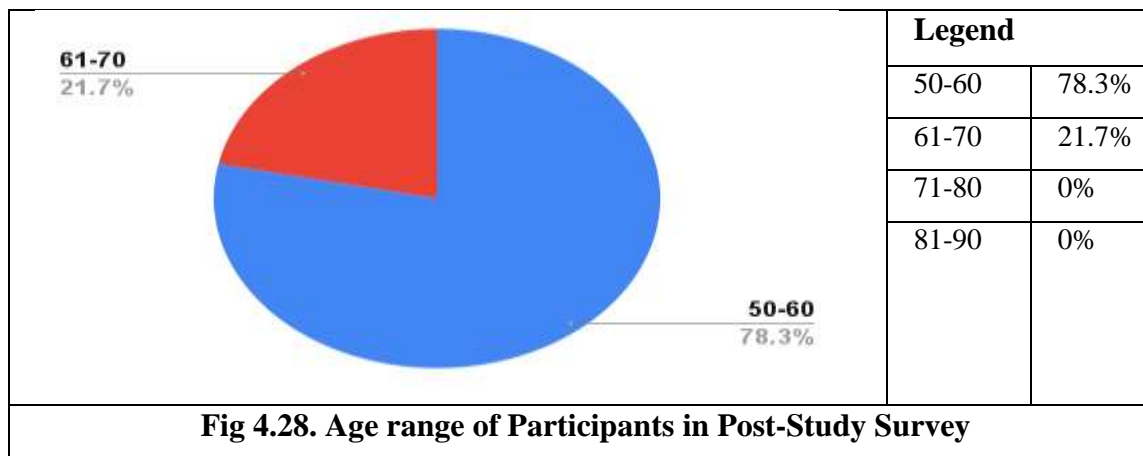
The prototype of Matching Puzzle game should be easy to start as it is specifically designed for elder adults. 65.2% of the participants responded that they find it easy to start the game. 26.1% responded very easy and 15% responded neutral to start the game. Only 2.2% of the respondents pointed that they faced difficulty to start the games.0% of the participants responded very difficult. The results are shown in Figure 4.29.

55

Legend	
Very Easy	26.1%
Easy	65.2%
Neutral	6.5%
Difficult	2.2%
Very Difficult	0%

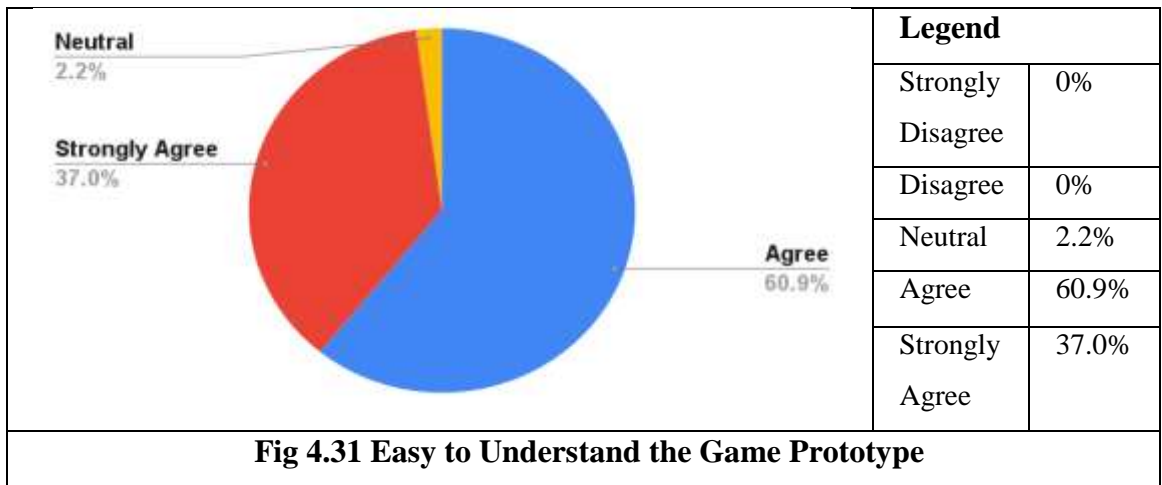**Fig 4.29. Easy to Start the Game Prototype**
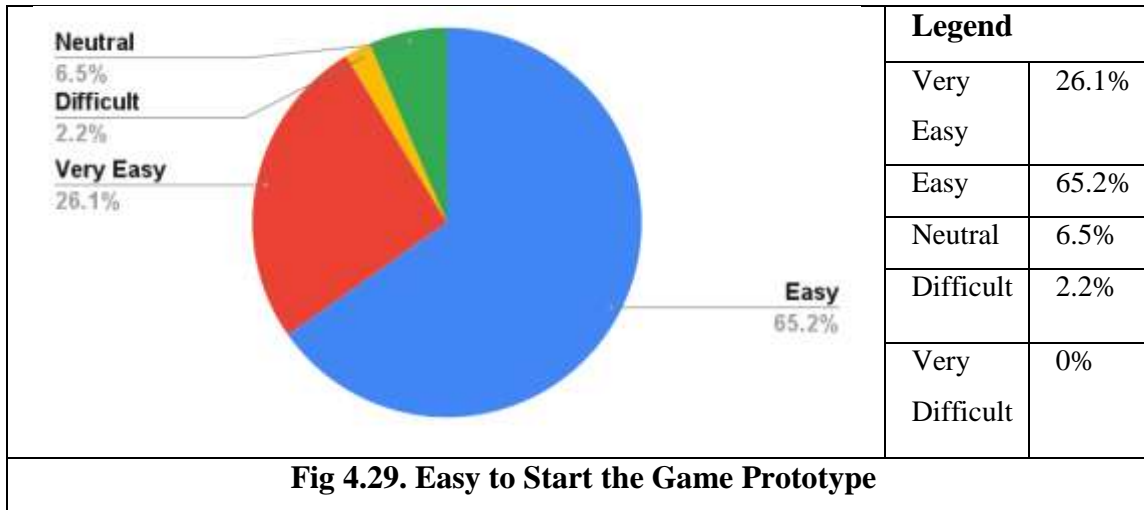
Interface of the prototype is kept simple and interactive so the elder adults can easily understand the game. A few questions were asked about the parameter of understandability in the second round of survey. 56.5% of the participants agreed that the interface of Matching Puzzle game is interactive. The statistics of Figure 4.30 shows that 32.6% of respondents responded strongly agree,4.3% responded neutral and 4.3% responded disagree.

Legend	
Strongly Disagree	0%
Disagree	4.3%
Neutral	4.3%
Agree	56.5%
Strongly Agree	32.6%

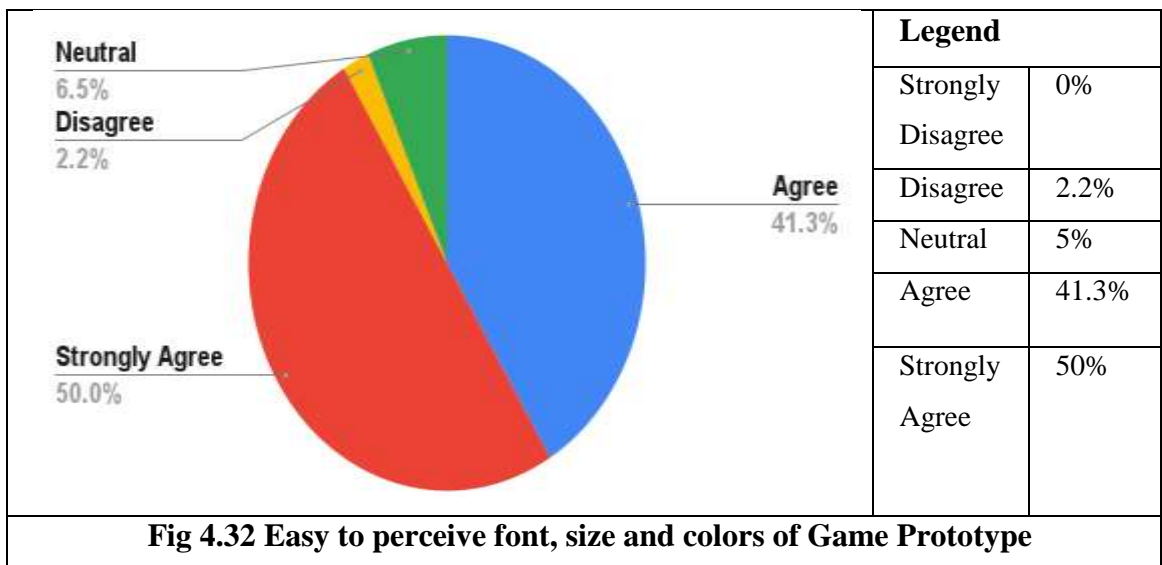**Fig 4.30. Interactive Interface of Game Prototype**

While designing the Matching Puzzle game it is ensured that this game should be understandable by the elder users. 60% of the respondents agreed that the Matching Puzzle game was easy to understand. Results of figure 4.31 shows that 37% of
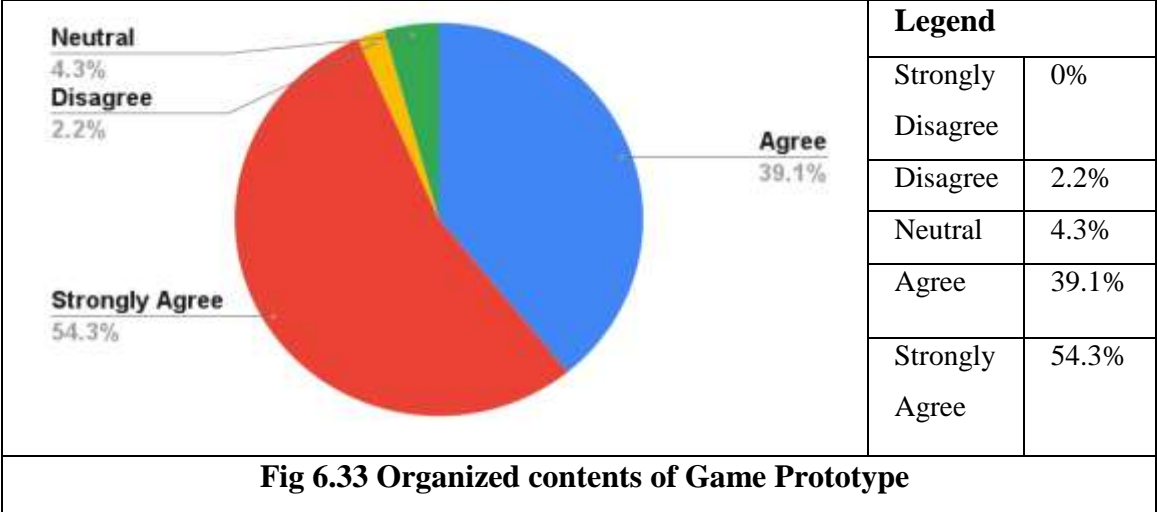
respondents responded strongly agree and 2.2% responded neutral. No participant responded disagree and strongly disagree.

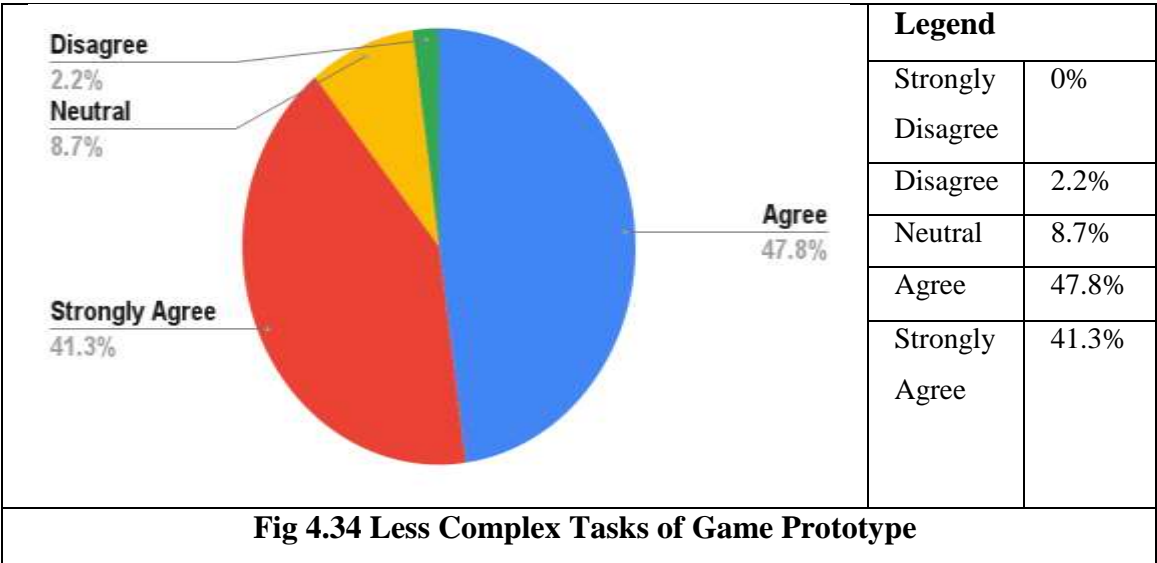|	Legend	
	Strongly Disagree	0%
	Disagree	0%
	Neutral	2.2%
	Agree	60.9%
	Strongly Agree	37.0%
Fig 4.31 Easy to Understand the Game Prototype		

In the design of prototype, color set used comprises of mixing with blue, green and dark colors. Light color including white was avoided for clear understanding. Font size used is clear enough to be readable by the elder adults.50% participants strongly agreed to easily perceive the font, size and colors of the prototype. 41.3% respondents responded agree,5% responded neutral and 2.2% responded disagree. Results are shown in Figure 4.32.

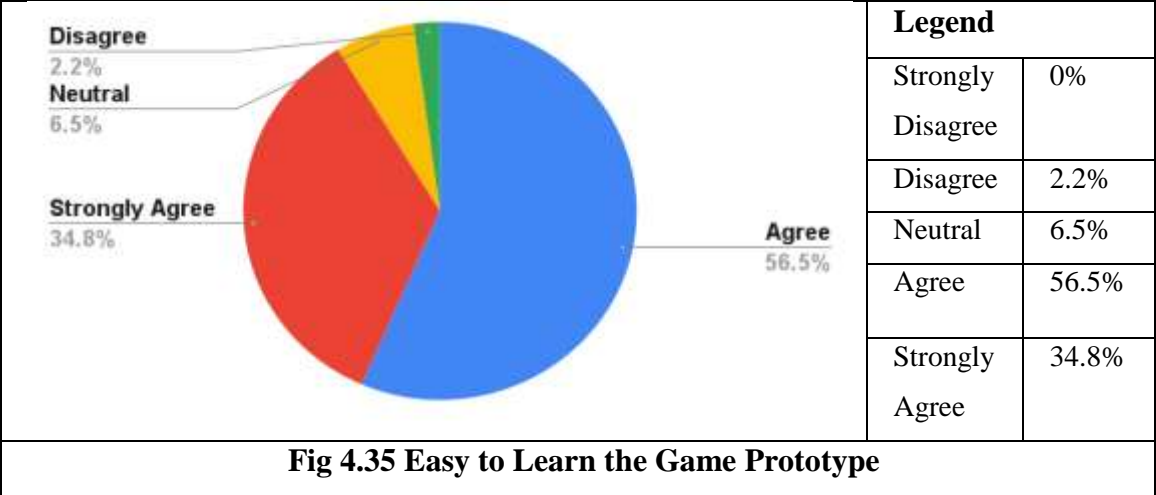|	Legend	
	Strongly Disagree	0%
	Disagree	2.2%
	Neutral	5%
	Agree	41.3%
	Strongly Agree	50%
Fig 4.32 Easy to perceive font, size and colors of Game Prototype		

54.3% participants strongly agreed that content of Matching Puzzle game prototype is organized in proper manner. 39.1% respondents responded agree, 4.3% responded neutral, 2.2% responded disagree and not even a single participant responded strongly disagree. Results are shown in figure 4.33.

Legend	
Strongly Disagree	0%
Disagree	2.2%
Neutral	4.3%
Agree	39.1%
Strongly Agree	54.3%

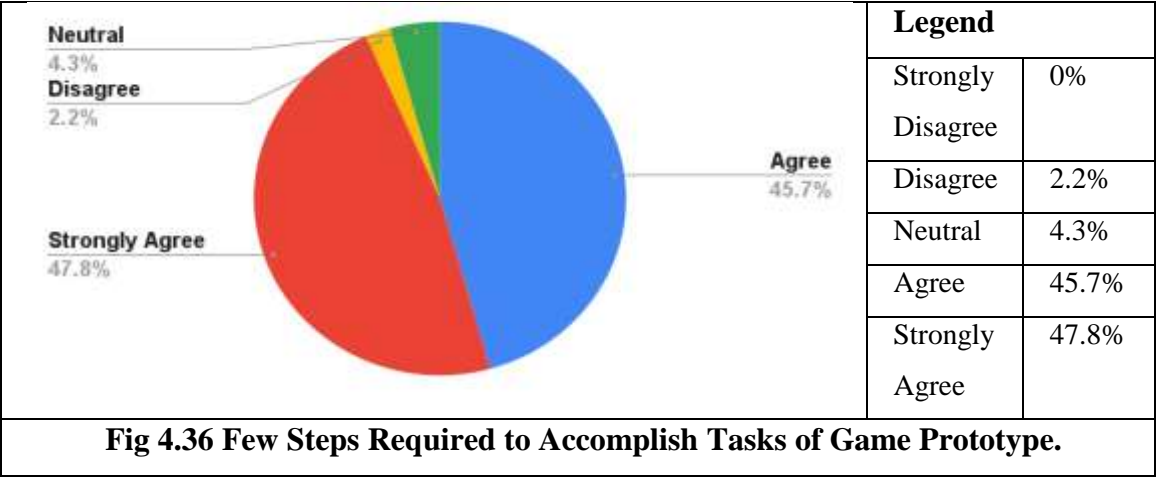**Fig 6.33 Organized contents of Game Prototype**

47.8% participants agreed that tasks of Matching Puzzle game prototype are less complex and 41.3% of the participants strongly agreed to this question. Statistics in figure 4.34 shows that 2.2% of the respondents responded disagree, 8.7% responded neutral. This shows that most of the respondents find the tasks of Matching Puzzle game prototype less complex.

Legend	
Strongly Disagree	0%
Disagree	2.2%
Neutral	8.7%
Agree	47.8%
Strongly Agree	41.3%

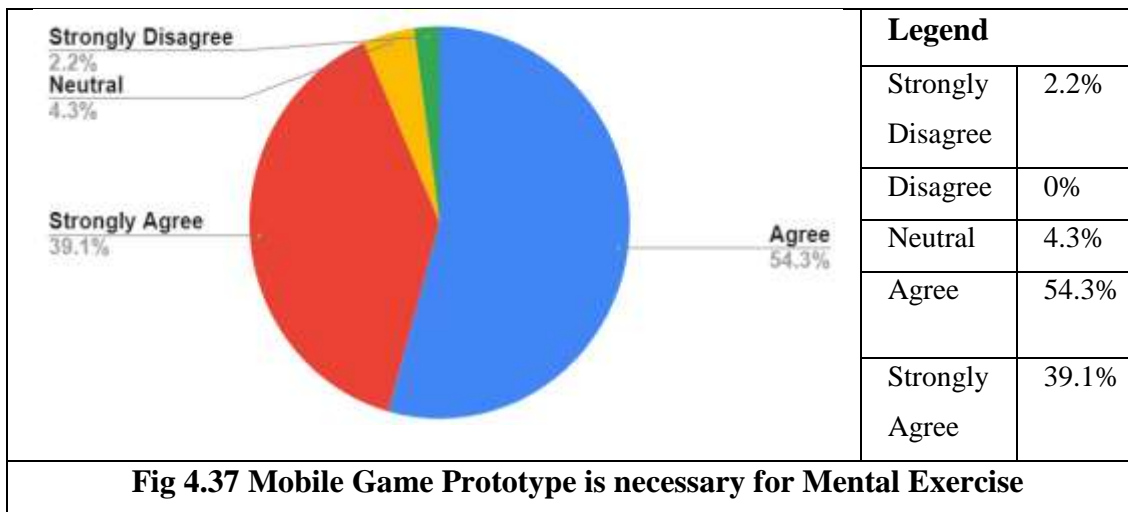**Fig 4.34 Less Complex Tasks of Game Prototype**

While designing the prototype of Matching Puzzle game it was ensured that game should be easy to operate specially for elder adults. To address the parameter of easy operation a few questions were asked in the second round of the survey which were based on categories of this parameter. Matching Puzzle game prototype is easy to learn. 56.5% participants agree that prototype is easy to learn.34.8% of the respondents responded strongly agree, 6.5% responded neutral and 2.2% responded disagree. Figure 4.35 illustrates the results.

Legend	
Strongly Disagree	0%
Disagree	2.2%
Neutral	6.5%
Agree	56.5%
Strongly Agree	34.8%

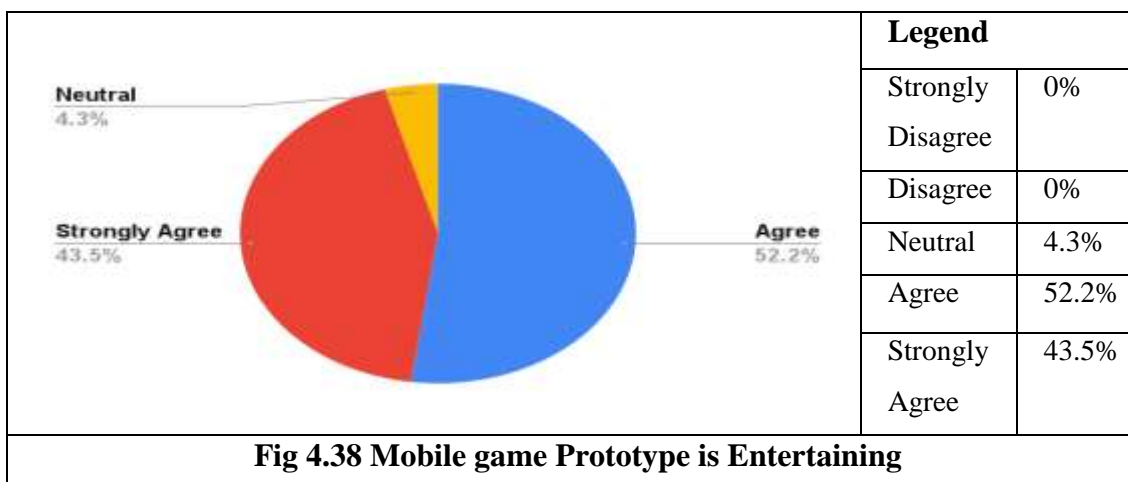**Fig 4.35 Easy to Learn the Game Prototype**

The design of Matching Puzzle game is kept simple and requires few steps to complete the game tasks. 47.8% of the respondents strongly agreed that Matching Puzzle game is simple, and few steps are needed to complete the game tasks.4.3% of the respondents responded neutral and 2.2% responded disagree. Figure 4.36 shows the results.

Legend	
Strongly Disagree	0%
Disagree	2.2%
Neutral	4.3%
Agree	45.7%
Strongly Agree	47.8%

**Fig 4.36 Few Steps Required to Accomplish Tasks of Game Prototype.**

Mental Exercise, which is another parameter of usability evaluation framework, was also considered while designing the prototype of Matching Puzzle game. Matching Puzzle game is a source of mental exercise for elder adults.54.3% of the participants agreed that Matching Puzzle game is essential for mental exercise. 39.1% of the respondents responded strongly agree, 4.3% responded neutral, 2.2% responded strongly disagree and not even a single participant responded disagree. Figure 4.37 illustrates the results.
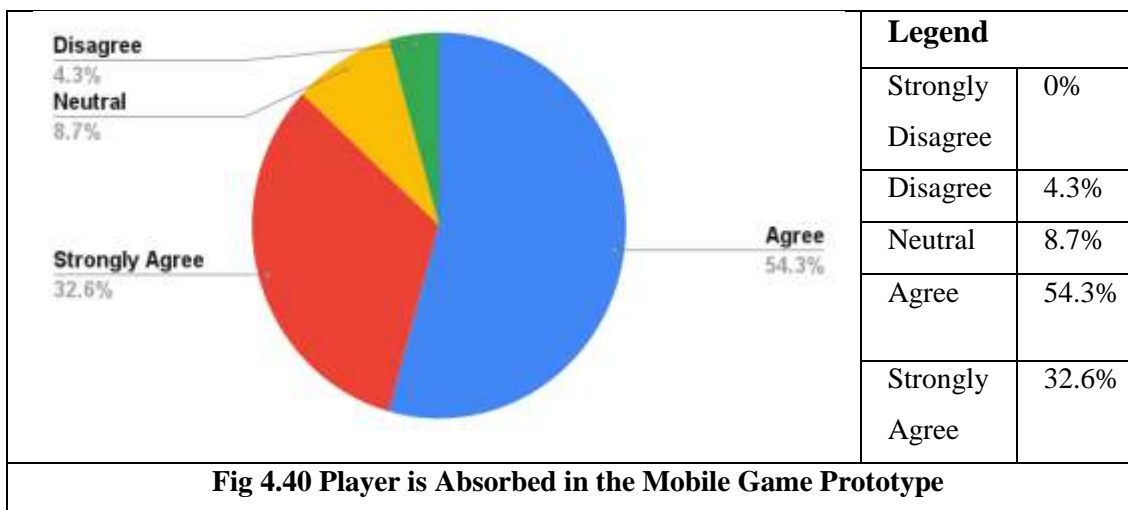
Legend	
Strongly Disagree	2.2%
Disagree	0%
Neutral	4.3%
Agree	54.3%
Strongly Agree	39.1%

Fig 4.37 Mobile Game Prototype is necessary for Mental Exercise

The developed prototype of Matching Puzzle game is entertaining in order to provide a fun time to elder adults.52.2% of the participants agreed that Matching Puzzle game is a source of entertainment. 43.3% of the respondents responded strongly agree, 4.3% responded neutral and none of the participant responded disagree strongly disagree. Figure 4.38 illustrates the results.

Legend	
Strongly Disagree	0%
Disagree	0%
Neutral	4.3%
Agree	52.2%
Strongly Agree	43.5%

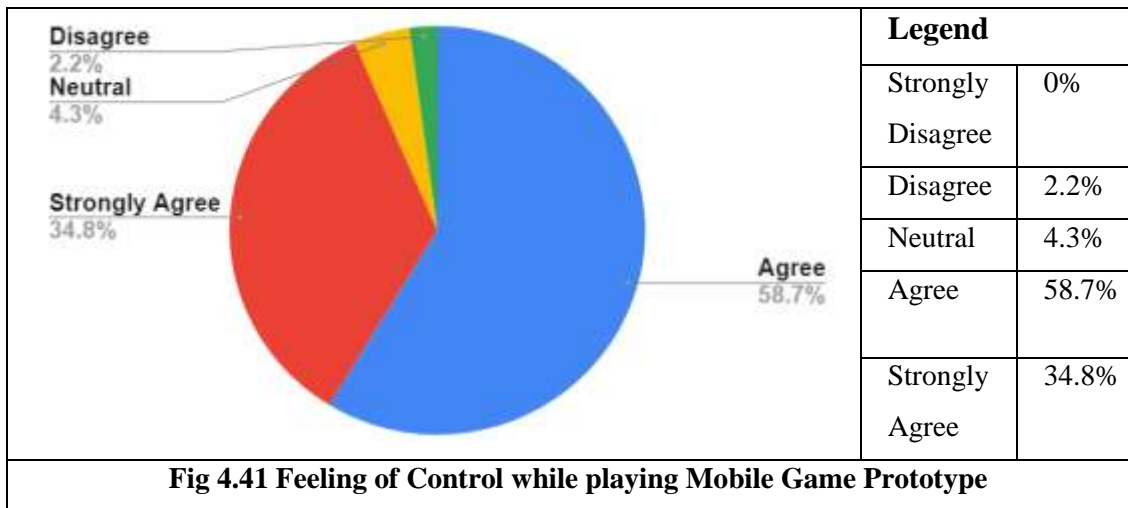**Fig 4.38 Mobile game Prototype is Entertaining**

The developed prototype of Matching Puzzle game has thrilling and challenging tasks in order to help elder adults in their brain training. Majority of the participants responded that tasks of the Matching Puzzle game are thrilling and challenging. 54.3% of the respondents responded agree, 37% responded strongly agree, 6.5% responded neutral, 2.2% responded disagree. Figure 4.39 illustrates the results.

Legend	
Strongly Disagree	0%
Disagree	2.2%
Neutral	6.5%
Agree	54.3%
Strongly Agree	37%

Fig 4.39 Thrilling and Challenging tasks of game Prototype
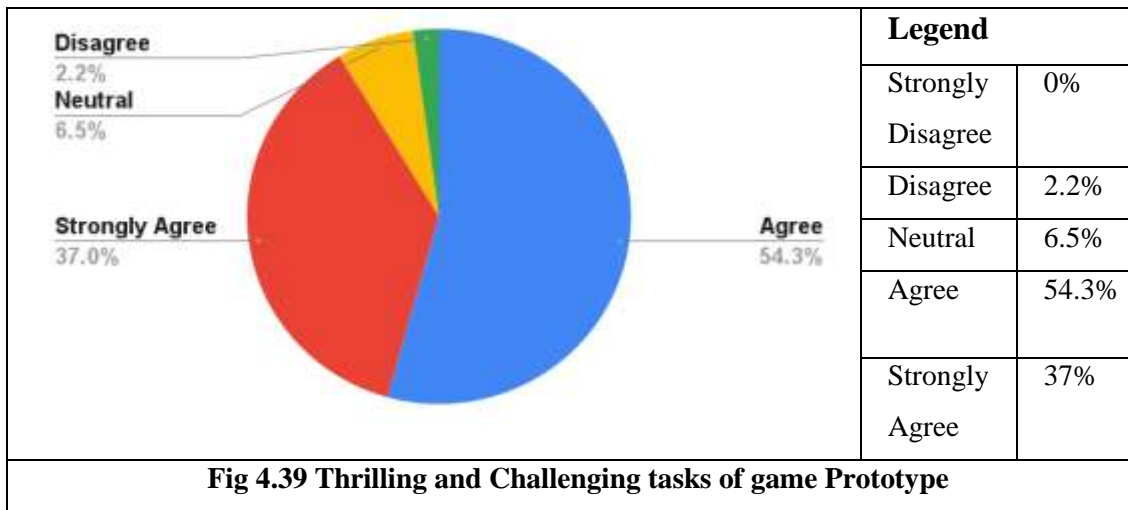
When playing Matching Puzzle game, it is important that the player is intensely absorbed in the game. 54.3% participants responded that they feel intensely absorbed in the Matching Puzzle game. Results of figure 4.40 shows that 32.6% of respondents responded strongly agree, 8.7% responded neutral and 4.3% responded disagree.

Legend	
Strongly Disagree	0%
Disagree	4.3%
Neutral	8.7%
Agree	54.3%
Strongly Agree	32.6%

Fig 4.40 Player is Absorbed in the Mobile Game Prototype

It is essential that elder adults should have a feeling of control while playing Matching Puzzle game. 58.7% participants responded that they have a feel of control while playing the Matching Puzzle game. Results of figure 4.41 shows that 34.8% of respondents responded strongly agree, 4.3% responded neutral and only 2.2% responded disagree.

Legend	
Strongly Disagree	0%
Disagree	2.2%
Neutral	4.3%
Agree	58.7%
Strongly Agree	34.8%

Fig 4.41 Feeling of Control while playing Mobile Game Prototype

Respondents were asked to tell what they like the most about the Matching Puzzle game. Most of the respondents enjoyed the game and found it an entertaining game. Some participants were happy about the interface, some about the simplicity and some about the cognitive benefits achieved by playing the game. Different responses were received from different participants about the game. Feedback from participants about is reviewed and it is analyzed that majority of the participants gave positive feedback. The results depict that majority of the elder adults liked the prototype of Matching Puzzle game due to its simplicity, attractive interface, ease of use and entertaining tasks.

4.4. Evaluation

There are various methods which are used to conduct usability evaluation of mobile games. The objective of these methods is to identify problems of usability and to improve usability of mobile games. Usability evaluation methods ensure that mobile games have user centered design (UCD).

After playing the selected mobile games in the first round of survey, participants were asked to fill in the questionnaire. After analyzing the results of the questionnaire, major problems of usability in mobile games are identified.

Table 4.2 Usability Problems Identified in Selected Mobile Games

Usability Problems Identified in Mobile Games		
Sr.No	**Problem Category**	**Key Issues**
1.	Understandability of mobile games.	Tetris game is not understandable and difficulty in playing other games as user interface is difficult to understand.
2.	Interface of the mobile games are not user friendly.	User interface of these mobile games are frustrating, unclear and difficult to understand
3.	Button and icons of the game are not visually perceivable.	Icons, images, buttons and size of text is very small.
4.	Aesthetics of the games are not good	Interface and color scheme of the game is not appealing due to which these games are unable to effectively involve the player.
5.	These games are not attractive and visually pleasing	Visual representations of games are difficult to interpret.
6.	Response to player's actions is not efficient.	Players face difficulty in interacting with the game due to slow response.
7.	The content of games is not	Players are unable to skip non playable

	properly organized.	content.
8.	Lack of guidelines which help players to play the games.	Does not provide enough documentation, guidelines and tutorials.
9.	These games are not entertaining.	Comprises of repetitive, boring tasks and no element of brain training in these games.

In the second round of the survey each participant was asked to play the prototype Matching Puzzle game first and then fill in a questionnaire. The results of the questionnaire were analyzed and problems of usability in the prototype of Matching Puzzle game were identified.

Table 4.3 Usability Problems Identified in Developed Prototype of Game

Usability Problems Identified in Developed Prototype of Game		
Sr.No	**Problem Category**	**Key Issues**
1.	Levels of the prototype are not improved.	The game comprises of only 5 levels and the existing ones should be further improved by making them more challenging.
2.	User feedback is not recorded.	There is no option for the player to provide proper feedback about the game.

4.4.1.   Comparison

By analyzing the results of the initial survey and post-Study survey we compare the relationship between them. During the design phase of prototype of Matching puzzle game; focus was on usability of game along with its content. All other parameters of our proposed framework should also be considered while developing a prototype of game specifically for elder adults.

The result of first round survey indicates that elder adults were not happy in playing the selected three games. But in the second round of survey elder adults enjoyed playing the prototype of Matching Puzzle game and gave positive feedback about the game.

Results in table 4.1 indicate that elder adults faced a lot of usability problems while playing the three selected games. But the results in table 4.2 show that only a few problems were identified by elder adults while playing the prototype of Matching puzzle game. Moreover, feedback of elder adults was collected about the developed prototype in which majority of the elder adults gave positive comments about the prototype.

Comparison of survey results verified that prototype developed gave better usability results and met the expectations of the elders as majority of the parameters proposed in our framework are fulfilled in this prototype. Those parameters include understandability, easy operation, mental exercise and game flow. The developed prototype of Matching Puzzle game is understandable, easy to operate, provides mental exercise, improves cognitive benefits and has better game flow. Table 4.4 shows comparison of survey results.

The overall analysis demonstrates that all parameters of usability proposed in our framework are essential to develop usable mobile games for elders. The verification of this fact will be helpful for the developers of mobile games in motivating them to consider all the usability parameters and the issues identified in the survey.

4.4 Comparison of Survey Results

Usability Parameter	Questions	Result Percentages of Initial Survey	Result Percentages of post-Study Survey
		% Agree	
Understandability	The interface of mobile game is interactive.	12.5	89.1
	The game is easy to understand.	10	97.9
	Font, size, colors are easy to perceive.	15	91.3
	Contents of game are organized in proper manner	12.5	93.4
	Tasks of the game are less complex.	12.5	89.1
Easy Operation	It is easy to learn how to use the game.	7.5	91.3
	Game is simple and requires few steps to accomplish tasks.	12.5	93.7
Mental Exercise	Mobile games are necessary for mental exercise.	75	93.4
	Mobile games are entertaining.	20	95.7
	Tasks of the game are thrilling and challenging.	7.5	91.3
Game Flow	When playing mobile games, I'm intensely absorbed in the game.	7.5	86.9
	While playing Mobile games, I have a feeling of control.	10	93.5

4.5. Conclusion

This chapter summarizes the results obtained from analysis of the initial survey and the post-Study survey. It graphically shows the percentages of all the data collected in both rounds of survey. Each graph illustrates the percentage of data taken as an individual question. The results of the survey helped in identifying the problems of usability in the selected games and in the developed prototype of game. Detail evaluation of results and comparison is also presented in this chapter.

Chapter 5

Conclusion and Future Work

In this chapter the results of the Thesis Project and some recommendations for future work are provided in the conclusion and recommendation section respectively.

5.1. Contributions

In this research usability evaluation of mobile games for elderly people was investigated in order to identify the mechanisms which are used for efficient usability evaluation of mobile games. To prove the significance of mobile games for elders benefits, challenges and motivational factors of playing mobile games for elderly people are identified in this study.

The aim of the research was to propose an effective usability evaluation framework for mobile games of elder adults. This aim is achieved by proposing usability evaluation framework for mobile games for elderly people. The proposed framework of usability evaluation is verified by user feedback collected from usability evaluation of three mobile games. The proposed framework of usability evaluation is implemented through developing a prototype mobile game for elderly people based on the feedback received in our initial survey. Design principles which can help in improving the usability of mobile games for elders are applied in the prototype developed. The prototype mobile game is verified by the user feedback to prove that the developed prototype of mobile games is suitable for elders and capable of enhancing usability for elderly people.

First of all, literature was investigated to find out nature and extent of most appropriate mechanisms used for conducting usability evaluation of mobile games. Chapter 2 provides a detailed overview of usability and common methods of usability evaluation. This chapter covers all the related work done in different stages and presents a clear

vision of our work. The literature investigated in this research provides useful findings regarding which mechanism was more effective for conducting usability of mobile games and which identified the largest number of usability problems in games. Several benefits, challenges and motivational factors of mobile games for elder adults are also presented. Few studies provide details of designing and developing prototypes of mobile games for elder adults. Chapter 3 presented justification of research design and methodology which helped to accomplish aims and objectives of this study. This chapter also discussed the technique that was used to collect and analyze data for conducting usability evaluation of mobile games. Mobile games selected for usability evaluation and criteria followed to select those games were also presented in this chapter. This chapter also presents all the details of the approach and architecture of proposed Usability Evaluation Framework. Design goal, parameters of the usability evaluation framework and its detailed architecture are described in this chapter. It was explained how this framework can be employed to achieve objectives of this research.

Chapter 4 presents the results of the survey conducted based on proposed framework of usability evaluation of mobile games for elderly adults. A survey was conducted in order to collect data from elder adults of age 50 or above. The survey conducted comprises of two rounds of Pre-Study survey and post-Study survey. After analysis, responses of all participants were examined, and results were reported in this chapter. Results of both rounds of survey analyzed the defined objectives of the study and problems of usability in mobile games reported by elder adults were also identified.

In the pre-Study survey 40 participants participated and each participant was asked to play the three selected mobile games first and then complete a questionnaire. After the completion of first round of survey, responses of participants were analyzed and problems of usability in the mobile games were identified. Based on feedback received from elder adults in the first round of survey and the problems of usability identified, a prototype of mobile game for elder adults was developed. In the second round of the survey each participant was asked to play the developed prototype of Matching Puzzle game first and then fill in questionnaire. The results of the

questionnaire were analyzed and problems of usability in the prototype of Matching Puzzle game were identified.

The results of this research show that mobile games are essential for elder adults as they are helpful in improving the mental health of elder adults. While designing mobile games for elderly people, focus should be placed on usability of games along with its content. All parameters of our proposed framework including understandability, easy operation, mental exercise and game flow should be considered while developing a prototype of mobile games specifically for elder adults.

The results of the first round of survey indicated that elder adults were not happy in playing the selected three games. This is because elder adults faced a lot of usability problems while playing the three selected games, results are indicated in table 4.1. While in the second round of survey elder adults enjoyed playing the developed prototype of Matching Puzzle game and gave positive feedback about the game. Feedback of elder adults as collected about the developed prototype which shows that majority of the elder adults gave positive comments about the prototype. The results in table 4.2 show that only a few problems were identified by elder adults while playing the prototype of Matching puzzle game.

Comparison of results of both rounds of survey verified that developed prototype of mobile game is best suited for elder adults as all the parameters proposed of our framework are fulfilled in this prototype. Those parameters include understandability, easy operation, mental exercise and game flow. The developed prototype of Matching Puzzle game is understandable, easy to operate, provides mental exercise, improves cognitive benefits and has better game flow. Overall analysis demonstrates that all usability parameters of our proposed framework are essential to conduct usability of mobile games for elder adults. The verification of this fact will surely be helpful for the developers of mobile games to consider all the usability parameters and the issues identified in the survey while developing a mobile game for elder adults. Overall quality of mobile games for elder adults is dependent on parameters of usability.

5.2.   Study Limitations

Few limitations identified in our research are mentioned below: -

- There is no option to keep track of number of attempts an older user input in the game prototype to guess the puzzle.
- The duration of the play sessions by older users was not estimated in the game prototype.

5.3.   Recommendations and Future work

In order to address the limitations that were identified in this research some recommendations are suggested for future work.

- A tracking list should be maintained to keep track of number of attempts an older user input in the game prototype to guess the puzzle and check if the new guess of users already exists in the tracing list.
- A session length metric should be maintained to record the amount of time older users spend playing game prototype. Session length metric will help to measure older user's engagement in game prototype.

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Annexure 1

Initial Survey on Usability Evaluation of Mobile Games for Elderly People

Category	Questions	Answers
Preliminary Questions	Are you male or female?	○ Male ○ Female
	What is your age range?	○ 50-60 ○ 50-60 ○ 71-80 ○ 81-90
	What is your occupation?	○ Serving ○ Retired ○ House Wife
	How often do you play Mobile games?	○ Daily ○ Weekly ○ Monthly ○ Never
	Have you had experience playing mobile games?	○ Yes ○ No
General Usability	How easy was it to start the game?	○ Very Difficult ○ Difficult ○ Neutral ○ Easy ○ Very Easy
	How easy was it to Play the game?	○ Very Difficult ○ Difficult ○ Neutral ○ Easy ○ Very Easy
	How easy was it to figure out the correct sequence of actions to take you to the next task?	○ Very Difficult ○ Difficult ○ Neutral ○ Easy ○ Very Easy
	How motivating was the game?	○ Not motivating ○ Slightly motivating ○ Very Motivating

	How were the game's graphics and layout?	○ Very Appealing	○ Appealing	○ Neutral	○ Not Appealing
Understanda bility	The interfaces of selected mobile games are interactive?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral	
	The selected mobile games are easy to understand?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral	
	Font, size, colors of selected mobile games are easy to perceive?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral	
	Contents of selected mobile games are organized in proper manner?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral	
	Languages used in selected mobile games like terms, phrases and symbols are easy to understand?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral	
	Tasks of the selected mobile games are less complex?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral	
Easy Operation	The selected mobile games have user friendly layout?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral	
	It is easy to learn how to use the selected mobile games?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral	
	Selected mobile games are simple and require few steps to accomplish tasks?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral	

	Both beginners and expert of the games can use them without any difficulty?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	Tasks of selected mobile games are attractive, relevant and clear to users?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
Mental Exercise	Selected mobile games provide mental exercise?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	Selected mobile games are entertaining?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	Tasks of the games are thrilling and challenging?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	The selected mobile games are good for brain training?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	I am satisfied with these games and it is fun to use them?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
Game Flow	When playing selected mobile games, I'm intensely absorbed in the game?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	While playing selected mobile games, I'm concentrated on the game?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral

	While playing selected mobile games, I feel detached from my surroundings?	○ Strongly Disagree ○ Disagree ○ Neutral ○ Agree ○ Strongly Agree
	While playing selected mobile games, I have a feeling of control?	○ Strongly Disagree ○ Disagree ○ Neutral ○ Agree ○ Strongly Agree
	My friends play and recommend mobile games to me?	○ Strongly Disagree ○ Disagree ○ Neutral ○ Agree ○ Strongly Agree
About Selected Games	What kinds of problems you encountered while playing the three selected mobile games?	[Open-ended question]
	Which games do you like the most?	○ Tetris ○ Dots ○ Match 3D
	I intend to play mobile games in the future?	○ Yes ○ No

Annexure 2

Post-study Survey on Usability Evaluation of Matching Puzzle Game Prototype for Elderly People

Category	Questions	Answers			
Preliminary Questions	Are you male or female?	○ Male	○ Female		
	What is your age range?	○ 50-60	○ 50-60	○ 71-80	○ 81-90
General Usability	How easy was it to start the game?	○ Very Difficult ○ Easy	○ Difficult ○ Very Easy	○ Neutral	
	How easy was it to Play the game?	○ Very Difficult ○ Easy	○ Difficult ○ Very Easy	○ Neutral	
	How easy was it to figure out the correct sequence of actions to take you to the next task?	○ Very Difficult ○ Easy	○ Difficult ○ Very Easy	○ Neutral	
	How motivating was the game?	○ Not motivating	○ Slightly motivating	○ Very Motivating	
	How were the game's graphics and layout?	○ Very Appealing ○ Not Appealing	○ Appealing	○ Neutral	
Understandability	The interface of Game Prototype is interactive?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral	
	The Game Prototype is easy to understand?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral	

	Font, size, colors of Game Prototype are easy to perceive?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	Contents of Game Prototype are organized in proper manner?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	Languages used in Game Prototype like terms, phrases and symbols are easy to understand?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	Tasks of the Game Prototype are less complex?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
Easy Operation	The Game Prototype has user friendly layout?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	It is easy to learn how to use the Game Prototype?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	Game Prototype is simple and requires few steps to accomplish tasks?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	Both beginners and expert of the Game can use Prototype without any difficulty?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	Tasks of Game Prototype are attractive, relevant	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral

	and clear to users?			
Mental Exercise	Matching Puzzle game provides mental exercise?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	Matching Puzzle game is entertaining?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	Tasks of the Matching Puzzle game are thrilling and challenging?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	This prototype game is good for brain training?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	I am satisfied with Matching Puzzle game and it is fun to use?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
Game Flow	When playing Matching Puzzle game, I'm intensely absorbed in the game?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	While playing Matching Puzzle game, I'm concentrated on the game?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	While playing Matching Puzzle game, I feel detached from my surroundings?	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral
	While playing Matching Puzzle game, I have a	○ Strongly Disagree ○ Agree	○ Disagree ○ Strongly Agree	○ Neutral

	feeling of control?	
	My friends play and recommend mobile games to me?	○ Strongly Disagree ○ Disagree ○ Neutral ○ Agree ○ Strongly Agree
About Game Prototype	What kinds of problems you encountered while playing the Matching Puzzle game?	[Open-ended question]
	What do you like the most about the Matching Puzzle game?	[Open-ended question]