A Study of Players' Experiences during Brain Games Play

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Abstract. Much of the experience of videogame players remains hidden. This paper presents an empirical study that assesses the experience of 50 participants (i.e. 25 children and 25 adults) during brain games play. Results from the empirical study show a number of significant correlations among diverse kinds of players' experiences (i.e. engagement, enjoyment, anxiety, usability, adaptability and noninvasiveness). It is further identified by the study that the similarities and differences exist among the experiences of children and adults. Consequently, the observations of presenting study provide an insight against the experience of players during brain games play, which was previously unknown. Besides, we exploit these insights to successfully narrow down the complexity of user feedback process for brain games playing activity.

Keywords: gamification, experiences, smart assessment, children, adults.

1. Introduction

Various questions arise when we talk about the experience of videogame players. Why do players of one generation like some videogames while the others don't? Which are the elements required by the players of a specific generation to accept the videogame? What are the similarities and differences among the players' psyche of different generations that reflect upon their perception towards videogames? In this paper, we present an empirical study to seek answers to some of these critical questions. However, the focus of presenting study is limited to the experience of two generations (i.e. children and adults) in brain games play. The term "brain games" refers to the category of videogames that are specifically designed to enhance the mental fitness of players. Besides, these games (e.g. [13, 25, 38]) also contain specific content, dynamics, and mechanics that determines their effects on the brain [4].

Nonetheless, in order to investigate both generations' (i.e. children's and adults') experience an empirical study has been carried out in two-fold, a brain games play and questionnaire based feedback (see Figure 1). In the first fold of an empirical study, participants have been asked to play with the *"BrainStorm"* game suite (see Figure 2), which contains three brain games. Subsequently in the second fold, they have been requested to provide their feedback on the gameplay activity, by filling out a questionnaire. A questionnaire was compiled to cover four aspects of players' engagement (i.e. immersion, presence, flow and absorption), two aspects of players' emotion (i.e. enjoyment and anxiety) as well as usability, adaptability and noninvasiveness of the players. A questionnaire based feedback data has been statistically analyzed to study the experience of the players during *"BrainStorm"* gameplay. An understanding of players' experiences has been further exploited to successfully position the videogame assessment measures (i.e. engagement, enjoyment, anxiety, usability, adaptability and noninvasiveness) in relation to each other. Besides, a hypothesis has been tested that whether the positioning of videogame assessment measures in relation to each other support in narrowing down user feedback process, which will lead to broad scale assessment with less measurement efforts. The results of an empirical study support the argument.

Fig. 1. Flow diagram of an empirical study

The presented study makes a number of contributions. First of all, to the best of our knowledge, this is a first attempt to analyze the experience of players (i.e. children and adults) during brain games play activity. Secondly, a current study reports significant correlations among the different experiences (i.e. engagement, enjoyment, anxiety, usability, adaptability and noninvasiveness) of the players. Thirdly, it identifies the similarities and differences among the experience of both generations. Finally, it exploits the above insights to narrow down a user feedback process.

Fig. 2. Main user interfaces of *"BrainStorm"*

2. Definitional Issues

There exists a theoretical framework [32] that serves to define the "experience" of videogame players; however, in the presence of previously existing 250 state-of-the-art publications elaborating the multidimensional perspective of players' experiences, the framework concludes itself as groundwork. It is complex to cover all the attributes of players' experience (i.e. associated in major or minor extent), as the term has been casually used several times to measure the diverse aspects of players that include emotions [18, 26], usability [33-34], pleasure [22], fun [16], motivation [23] and playability [14, 39]. Thus, no definitional agreement certainly exists regarding how to comprehensively model the experience of players during the gameplay activity [32].

In this paper, the term "experience" refers to those personal states of players during the game playing situations that have been observed under the ongoing study. These observed personal states include players' engagement, enjoyment, anxiety, usability, adaptability and noninvasiveness. We explain these terms as follows.

2.1. Engagement

Engagement implies a general involvement of the players in videogames; however, it further technically includes "immersion", "presence", "flow" and "absorption", which can be understood as representing a continuation of ever-deeper engagement while playing videogames [20]. Their explanation is stated as follows.

Immersion. Immersion is a term used to define the capability of a videogame to induce a feeling in the player of actually being a part of it [46]. Immersion has also been considered to measure the experience of getting engaged in a gameplay activity while keeping some consciousness of one’s surroundings [1, 41].

Presence. Presence is a term employed to describe the awareness of being inside a virtual environment [27, 29, 36, 44]. Another term "spatial presence" has been proposed [46] to describe the awareness of being integrated into a mediated environment. Unlike previous formulations, this definition includes both, a new media (e.g. videogames) as well as conventional media (e.g. books).

Flow. Flow is a term utilized to express the feelings that occur when a balance between skill and challenge is achieved to perform an activity [8, 30-31]. Therefore, flow also includes a feeling of being in control, being one with the activity, and experiencing time distortion.

Absorption. Absorption is a term that describes the total engagement in a present experience [19]. Unlike immersion and presence, and like flow, being in a state of absorption induces a modified state of consciousness. In this modified state there is a separation of feelings, thoughts, and experiences and effect is less accessible to consciousness [17].

2.2. Enjoyment

Enjoyment is a term that describes the positive emotions of an individual in general. The definition of enjoyment during a gameplay activity was previously fuzzy [43] and not well differentiated from other potentially related perspectives [32]; however, recently it is defined as a multi-dimensional construct, made up of entertainment, challenge, competence, (minimum) frustration and one's interest [10].

2.3. Anxiety

Anxiety is an emotion that describes one's worriedness, nervousness, or uneasiness. It is also characterized by an unpleasant state of inner turmoil, often accompanied by the nervous behavior [40]. Similarly, the anxiety of a player during the gameplay activity refers to its unpleasant mood often take place due to the unanticipated gameplay experience.

2.4. Usability

Usability is not a characteristic that exists in any absolute sense; however, it can be best summarized as one's appropriateness towards the purpose [3]. ISO 9241-11 suggests that a usability measurement should cover effectiveness, efficiency and satisfaction. Likewise, the usability of a videogame refers to the effectiveness, efficiency and satisfaction w. r. t. its context.

2.5. Adaptability

Adaptability is a broad term that describes one's ability of being flexible to fit in changed circumstances. In just the same way, the adaptability of a videogame refers to the characteristics of being acceptable by its diverse target users [15].

2.6. Noninvasiveness

Noninvasiveness is a term commonly used in medical sciences in order to refer a certain treatment that is performed without cutting a body or putting something into the body [45]. Likewise, in the field of videogame interaction, noninvasiveness refers to a technique that achieves its goal without having any visible or tactile interaction with its target user [24].

3. Experiments and Data Collection

The empirical study has been carried out with children and adults, respectively, which includes an activity of brain games play and questionnaire based feedback. In total 50 participants, equally distributed as 25 children and adults have been recruited to voluntarily take part in the designed study. The recruited children (i.e. 15 male and 10 female) have been reported as 8 to 9 years old with the mean age of 8.7 years, whereas the adults (i.e. 13 male and 12 female) were 30 to 45 years of age with the mean age of 33.4 years. The recruitment process has been carefully made based on the adequate gameplay experience of the participants (i.e. habitual to gameplay, at least once a week).

To perform the gameplay activity, we employed *"BrainStorm"* that includes *"Picture Puzzle"*, *"Letter and Number"* and *"Find the Difference"* brain games. *"BrainStorm"* is the game suite that was previously developed for noninvasive cognitive capabilities assessment. However, a functionality of the brain games of *"BrainStorm"* is as follows. In *"Picture Puzzle"* brain game, an image of famous and/or historical personalities or places show on the screen, and the player has to choose its correct name among the different options (see Figure 3(a)). A core mechanism of *"Picture Puzzle"* requires player attention to receive the data from a visual source and passes it to the short-term memory, short-term memory then processes it and retrieves its correct information by communicating with the long-term memory.

Fig. 3(a). User interface of *"Picture Puzzle"*

Whereas in *"Letter and Number"* brain game, an incomplete sequence of letters or numbers show on the screen, and the player has to analyze its pattern and complete the sequence by selecting a correct option among the given options (see Figure 3(b)). A core mechanism of *"Letter and Number"* requires player to perform information visualization, articulation, analysis and decision making based on their personal understanding.

Fig. 3(b). User interface of *"Letter and Number"*

Moreover, in *"Find the Difference"* brain game, two similar images show on the screen, and the player has to find six differences between both images (see Figure

3(c)). A core mechanism of *"Find the Difference"* requires player to select the relevant information and filtering out the irrelevant information from a visual space by using spotlight [11] and zoom-lens [12] models.

Fig. 3(c). User interface of *"Find the Difference"*

It took participants 20 minutes (on average) to complete the gameplay activity on 19.5 inches touch screen, subsequently they were requested to provide their feedback on the event, by filling out the questionnaire (i.e. 5-level likert scale measurement). To collect feedback regarding the four aspects of players' engagement (i.e. immersion, presence, flow and absorption), Game Engagement Questionnaire (GEQ) [20] has been employed. To collect feedback regarding the two aspects of players' emotion (i.e. enjoyment and anxiety), 11 the most frequently used terms have been utilized [9]. Feedback on the usability factor of brain games has been collected by exploiting System Usability Scale (SUS) [3]. Besides, to collect feedback about the adaptability of the players and noninvasiveness of data collection, Adaptability, Social interaction, Children education and Noninvasiveness Questionnaire (ASCNQ) has been partly utilized. ASCNQ is a multidimensional construct that has been equally distributed for the measurement of its four aspects; therefore it doesn't affect the results if the questionnaire gets partially used. The designed terms of ASCNQ for the measurement of adaptability and noninvasiveness (i.e. 5-level likert scale measurement) respectively include T1:"The more time I spent in gameplay, the more I felt comfortable with *"BrainStorm"* environment." and T2:"I didn't feel while the gameplay that there is any data collection has been performed.".

Nonetheless, it has been assumed prior to the gameplay activity that children will face a certain level of difficulty in understanding the terms of employed questionnaires. As no appropriate questionnaire is publically available to measure the above stated aspects from the children; thus for the better understanding of employed questionnaires to the children, a short training session has been provided to the children in order to explain the meaning of each question to them.

4. Statistical Analysis

A statistical analysis has been performed on questionnaire based feedback data to analyze the experience of the players. In the initial phase of statistical analysis, Pearson correlation [6] has been applied to calculate the degree of correlation among the different experiences, where r ($-1 \leq r \leq 1$) indicates the direction and strength of the correlation. Whilst in the second phase, p-value has been calculated to demonstrate the significance ($p \leq 0.05$) of the findings [6]. It is well-known that the correlation doesn't imply causation, yet an approach has been used by the vast range of literature, which also includes a recently done research on *"StudentLife"* [37]. It is nearly impossible in a real world scenario to find the element(s) that has a causal relationship with the other element, as there always exist un(known/addressed) factor(s) that affects causality between the associated elements. Therefore, a reason behind the use of correlation technique was not to find the causal relationship but to understand the significance of one element in relation to the other, while acknowledging they are not causal. Apart from the correlation analysis technique, we further performed a regression analysis [7] on each significantly correlated dependent (i.e. "Y") and independent (i.e. "X") experiences, in order to develop their regression function (see Equation 1). The purpose of function development was to predict each dependent experience based on their significantly correlated independent experience(s) [35].

$$Y = constant + (a_1 * X_1) + (a_2 * X_2) + \cdots + (a_n * X_n) \quad (1)$$

In what follows, we draw the main observations of the presented study. 1) A number of significant correlations among the different experiences (i.e. engagement, enjoyment, anxiety, usability, adaptability and noninvasiveness) of the players (i.e. children and adults) have been found. 2) Similarities and differences among the experience of both generations have been identified. 3). A possibility to successfully predict players' experience, based on the other significantly correlated experience(s), has been validated (see Figure 4). Their details are as follows.

4.1. Correlation between Enjoyment and other Experiences

Table 1 shows a number of significant correlations between the players' enjoyment and other gameplay experiences. The stated results highlight a fact that an existence of immersion is not significantly relevant for children's enjoyment, as it does for adults; however, the importance of presence, flow and absorption over enjoyment are common among both generations. Besides, an impact of anxiety over enjoyment is also common and almost to the same degree among both generations. Thus, we hypothesized (i.e. H1) that an enjoyment of both generations depends upon their respectively correlated gameplay experiences. To analyze the hypothesis, we developed a regression function (see Equation 2 & 3) for each generation (i.e. children and adults) in order to estimate their predictive enjoyment. Subsequently, we calculated Root Mean Square Error (RMSE) (i.e. by using leave-one-out cross validation technique) between their actual enjoyment and predicted enjoyment. Results concluded that the correlated experiences are significant to predict an enjoyment of both generations (i.e. children (RMSE = 0.11) and adults (RMSE = 0.12)) (see Figure 4).

$$Enjoyment_{children} = 2.44 + (.24 * X_1) + (.19 * X_2) + (.33 * X_3) + (-.35 * X_4) \quad (2)$$

$$Enjoyment_{adults} = 2.32 + (.05 * X_1) + (.28 * X_2) + (.43 * X_3) + (-.19 * X_4) + (-.02 * X_5) \quad (3)$$

Table 1. Correlation of enjoyment with other gameplay experiences

Children				Adults			
ID	***Experiences***	***r***	***p-value***	***ID***	***Experiences***	***r***	***p-value***
-	-	-	-	X_1	Immersion	0.26	0.019
X_1	Presence	0.42	< 0.001	X_2	Presence	0.53	0.023
X_2	Flow	0.47	< 0.001	X_3	Flow	0.57	< 0.001
X_3	Absorption	0.46	< 0.001	X_4	Absorption	0.37	< 0.001
X_4	Anxiety	-0.30	< 0.001	X_5	Anxiety	-0.29	< 0.001

Note: "ID" w. r. t. the corresponding "experiences" of children and adults are referred in equation 2 & 3, respectively.

4.2. Correlation between Usability and other Experiences

Table 2 shows a significant correlation between the players' usability and anxiety, which is almost of same degree among both generations. Thus, we hypothesized (i.e. H2) that a usability of both generations depends upon their feeling of anxiety. To analyze the hypothesis, we developed a regression function (see Equation 4 & 5) for each generation (i.e. children and adults) in order to estimate their predictive usability. Subsequently, we calculated RMSE (i.e. by using leave-one-out cross validation technique) between their actual usability and predicted usability. Results concluded that the feeling of anxiety is significant to predict a usability of both generations (i.e. children (RMSE = 0.10) and adults (RMSE = 0.12)) (see Figure 4).

$$Usability_{children} = 3.65 + (-.21 * X_1) \quad (4)$$

$$Usability_{adults} = 3.83 + (-.26 * X_1) \quad (5)$$

Table 2. Correlation of usability with other gameplay experiences

Children				Adults			
ID	***Experiences***	***r***	***p-value***	***ID***	***Experiences***	***r***	***p-value***
X_1	Anxiety	-0.32	< 0.001	X_1	Anxiety	-0.29	< 0.001

Note: "ID" w. r. t. the corresponding "experiences" of children and adults are referred in equation 4 & 5, respectively.

4.3. Correlation between Adaptability and other Experiences

Table 3 shows a number of significant correlations between the players' adaptability and other gameplay experiences. However, unlike Table 1 and Table 2 where majority of the correlations were common among both generations, Table 3 demonstrates the diversity of perception among both generations regarding an adaptability of brain games. The stated results highlight a fact that the positive experience (i.e. enjoyment and (minimal) anxiety) of gameplay is significantly relevant for adults to be adaptive towards brain games; however, it is trivial for children. Nevertheless, the deeper aspect of engagement (i.e. absorption) is important for children's adaptability. Thus, we hypothesized (i.e. H3) that an adaptability of both generations depends upon their respectively correlated gameplay experience(s). To analyze the hypothesis, we developed a regression function (see Equation 6 & 7) for each generation (i.e. children and adults) in order to estimate their predictive adaptability. Subsequently, we calculated RMSE (i.e. by using leave-one-out cross validation technique) between their actual adaptability and predicted adaptability. Results concluded that the correlated experience(s) is significant to predict an adaptability of both generations (i.e. children (RMSE = 0.26) and adults (RMSE = 0.19)) (see Figure 4).

$$Adaptability_{children} = 1.73 + (.70 * X_1) \quad (6)$$

$$Adaptability_{adults} = 2.24 + (.42 * X_1) + (-.40 * X_2) \quad (7)$$

Table 3. Correlation of adaptability with other gameplay experiences

Children				Adults			
ID	***Experiences***	***r***	***p-value***	***ID***	***Experiences***	***r***	***p-value***
X_1	Absorption	0.38	0.010	X_1	Enjoyment	0.36	0.017
-	-	-	-	X_2	Anxiety	-0.35	< 0.001

Note: "ID" w. r. t. the corresponding "experiences" of children and adults are referred in equation 6 & 7, respectively.

4.4. Correlation between Noninvasiveness and other Experiences

Table 4 shows a number of significant correlations between the players' noninvasiveness and other gameplay experiences. Similar with Table 3, Table 4 also demonstrates the diversity of perception (i.e. to a certain level) among both generations regarding the noninvasiveness during brain games play. The stated results highlight a fact that an enjoyment is significantly relevant for children's noninvasiveness during brain games play; however, it is trivial for adults. Nevertheless, the deeper aspect(s) of engagement for children (i.e. immersion) and adults (i.e. flow and absorption) are also important in achieving noninvasiveness. Thus, we hypothesized (i.e. H4) that a noninvasiveness of both generations depends upon their respectively correlated gameplay experiences. To analyze the hypothesis, we developed a regression function (see Equation 8 & 9) for each generation (i.e. children and adults) in order to estimate their predictive noninvasiveness. Subsequently, we calculated RMSE (i.e. by using leave-one-out cross validation technique) between their actual noninvasiveness and predicted noninvasiveness. Results concluded that the correlated experiences are significant to predict a noninvasiveness of both generations (i.e. children (RMSE = 0.26) and adults (RMSE = 0.15)) (see Figure 4).

$$Noninvasiveness_{children} = 1.54 + (.45 * X_1) + (-.05 * X_2) \quad (8)$$

$$Noninvasiveness_{adults} = 1.87 + (-.13 * X_1) + (.74 * X_2) \quad (9)$$

Table 4. Correlation of noninvasiveness with other gameplay experiences

Children				Adults			
ID	***Experiences***	***r***	***p-value***	***ID***	***Experiences***	***r***	***p-value***
X_1	Immersion	0.38	0.048	X_1	Flow	0.23	0.020
X_2	Enjoyment	0.21	< 0.001	X_2	Absorption	0.41	0.016

Note: "ID" w. r. t. the corresponding "experiences" of children and adults are referred in equation 8 & 9, respectively.

5. Discussion

In view of theoretically defined players' experiences (i.e. in section 2), we elucidate the results of statistical analysis (i.e. stated in section 4) as follows. The results of statistical analysis indicate that in order to ensure an appropriateness of brain games in terms of providing an effective, efficient and satisfactory gameplay experience to the players (i.e. children and adults), it is significant that the games shouldn't stimulate the feeling of worriedness, nervousness, or uneasiness within the players (i.e. derived from Table 2). However, a balance between the challenged environment of brain games and players' skills make the gameplay experience more enjoyable, which eventually assist in reducing the feeling of worriedness, nervousness, or uneasiness. Besides, this balanced gameplay experience along with the associated positive emotions (i.e. enjoyment and (minimal) anxiety), successfully integrate players into the mediate environment of brain games as well as totally engage them in the gameplay activity (i.e. derived from Table 1). The experience of total engagement is also significant for children to accept the brain games, whereas it contradicts with the adults' psyche as positive emotions (i.e. enjoyment and (minimal) anxiety) are more likely required by the adults in order to accept the brain games (i.e. derived from Table 3). Nonetheless, in order to keep children unaware from the hidden goals of brain games play activity, it is necessary that they experience certain level of engagement along with the feeling of enjoyment; however, for adults this unawareness is more likely dependent on the balanced experience of gameplay as well as total engagement (i.e. derived from Table 4).

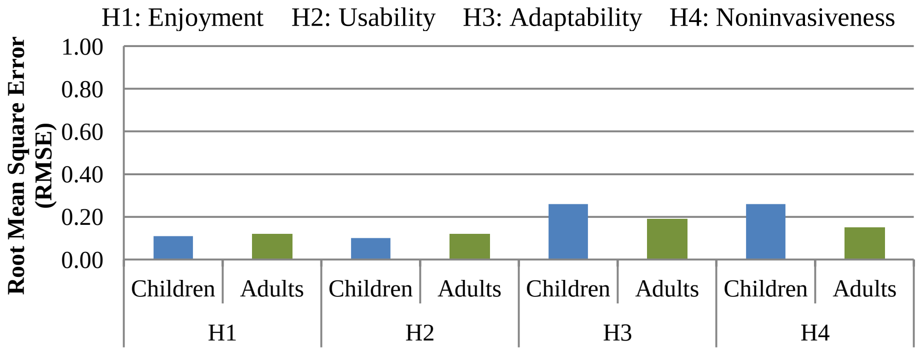

Fig. 4. Root Mean Square Error (RMSE) results of the predictions

6. Conclusion and Future Work

In this paper, we presented an empirical study on the experiences of children and adults during brain games play activity. We discussed a number of insights into behavioral trends, and importantly, correlations between players' engagement, enjoyment, anxiety, usability, adaptability and noninvasiveness. Consequently, the presented study attempts to provide an insight against the pressing questions, which were highlighted at the beginning of "Introduction" section of this paper. Besides, we exploited the insights to successfully predict players' enjoyment, usability, adaptability and noninvasiveness, which lead to broad scale assessment with less measurement efforts.

There exist several research studies that investigated the experience of players in terms of immersion [5], anxiety [28], usability [42] and flow [2, 21]; however, no scientific study employed brain games for the investigation of players' experiences. Subsequently, it is also evidenced that the experience of players differs w. r. t. the game genre [35]. The absence of literature on brain games' experiences as well as an individuality of genre-specific game experiences make the current empirical study first-of-its-kind as well as incomparable with the results of existing literature.

A future intent is to exploit the presented understanding of players' experiences in order to develop brain games design guideline, which will assist to achieve the exact goal (i.e. engagement, enjoyment, (minimal) anxiety, usability, adaptability and non-invasiveness) by targeting the corresponding aspects.

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