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Exploring the Impact of AR Games on Attention Concentration in Middle Childhood Children: A Demonstration Using Merge Cube as an Example

Siwei Kong

Anhui International Studies University, Anhui, Hefei, 230000, China
Email:siweikong36@gmail.com

Abstract:

Online games, like cookies and candy, have gradually become a part of the life of school-age children, and have a certain impact on their psychology and behavior. Middle childhood children are transitioning from understanding their external behavior to understanding their internal quality. During this period, self-concept, higher-order emotions, and personality have gradually formed. What are the psychological motivations for primary school students to be addicted to virtual scenes of online games for a long time? What kind of impact would it have on their psychology and behavior? This article took the mechanism of scene mapping in children's online games as the starting point to sort out the constraints and effects of virtual scenes constructed by existing Merge Cube games on children themselves. The experimental results showed that 77.85% of people believed that AR (Augmented Reality) games had a positive impact on children; 14.56% of people believed that AR games had a negative impact on children; 7.59% of people believed that AR games had no impact on children.

Keywords: AR Games, Middle Childhood Children, Attention Concentration, Merge Cube

1. Introduction

With the development of informatization, electronic products are becoming increasingly popular. Young children have also learned to operate various electronic products proficiently. Meanwhile, various virtual things, especially virtual games, have had a significant impact on children. Some children have become addicted and play virtual games every day. Therefore, in the context of the information age, what effects have virtual games had on children's physical and psychological development? How should parents, educators, and society guide children to use virtual games correctly? This article explores the role of virtual games in children's physical and psychological development through research, and proposes specific guidance strategies. The healthy growth of children is not only related to individual development, but also to the quality of future society's population and even the development of the nation. At present, the use of high technology in children's play environments in China is still rare. Therefore, this article hopes to provide some reference for future related research by exploring and expanding this issue.

This article introduces the unique experience brought by AR mobile games and Merge Cube and then it introduces the analysis of factors influencing learning behavior investment under the influence of games and multiple regression analysis. Finally, a summary of the entire article is made.

2. Related Works

Experts have long conducted specialized research on the impact of AR games on various aspects of students. Ullah M discussed the roles of virtual reality, artificial intelligence, and augmented reality games in science education such as physics, as well as the positive and negative aspects of games in science education, and the overall attitude towards the use of serious games in education [1]. Cheah I systematically commented on the incentives concerning players when playing digital games. Based on a study of publishing tendencies, he identified and explored six main motivational topics (immersion and fluency, gratification and emotion, escapism, social interaction, identity, and goal orientation) [2]. Lee J compared the effects of augmented reality mobile games and print games on student engagement and foreign language learning attitudes based on game based learning and problem-based learning. Qualitative data showed that if EFL (English as

Foreign Language) teaching was carried out according to the principles of game based learning and problem-based learning, students can maintain a high level of participation and positive attitude [3].

Sharma S studied the effect of interactions between different types of gamers on their emotional identity, destination image, and choice of game destination. The results showed that the cognitive image in the game further confirmed a positive correlation with emotional and connotative images [4]. Amanatidis N reviewed AR (Augmented Reality) in the field of education, focusing on specific research questions regarding the effective use of AR in education and the use of AR games in everyday classrooms [5]. Kleftodimos A provided cultural heritage knowledge about prehistoric lake settlements through gamification and storytelling. The evaluation results indicated that these two virtual reality applications have achieved good results in terms of usability, student satisfaction, and educational practicality [6].

Hassan S A introduced children's educational games based on augmented reality technology, and it was expected that such an interactive project would greatly improve children's learning abilities [7]. Nordin N introduced an AR board game called REV-OPOLY that can help with learning. The research results showed that students had a significant improvement in all tests before using REV-OPOLY [8]. Park J investigated the effects of augmented reality's stimulus content, space, time, and human interaction on children's pleasure and sustained behavioral intentions. He provided a theoretical basis for the positive effects of multiple contextual perceptions on the game experience in AR games, as well as the effects of four types of contextual perceptions on game enjoyment, game performance, and behavioral intentions in augmented reality contexts [9].

Hou H T designed a set of board game models based on interactive reality and constructed a novel multidimensional three-dimensional model including cognitive model, metacognitive model and peer model based on it. It was found that there was no significant difference in academic achievement between the experimental group using the game teaching method and the control group using conventional textbooks [10]. Jin Y explored the interactive storytelling of different user interfaces in AR based on head mounted displays and its impact on user presence, narrative engagement, and reflection. The experimental results showed that head mounted displays had a significant statistical advantage in creating a sense of presence for users without experience in 3D role-playing games [11]. Shiau W L applied the "stimulus-organism-response", "information-system" model and "cognitive matching" theory to the "real" and "virtual" levels, and examined the "matching" and "response" in both "real" and "virtual" situations. It was found that game information quality, game system quality, virtual attributes and other factors had a significant positive effect on cognitive and emotional matching [12].

Zhao D investigated students' reactions to game based learning as part of programming courses. The results indicated that all students benefited greatly from using games in the teaching process [13]. Bahagia B found that online learning has both positive and negative effects on student gaming behavior. The results indicated that in online learning, students participate in playing games, leading to laziness, lack of discipline, and entering online classrooms. Students' behavior also becomes aggressive and negative due to losing games [14]. Sadeghpour M explored the impact of using game based tasks in EFL classrooms on virtual interaction among Iranian students. The research results indicated that the use of games can improve student interaction in online language classrooms. These results had a beneficial impact on language teachers and textbook developers to improve virtual interaction among EFL students through different game technologies [15]. The above research on the impact of AR games on the attention concentration of middle childhood children is not in-depth enough.

3. Methods

3.1 *Unique Experience Brought by AR Mobile Games*

AR technology has had a huge impact on games. Compared to traditional games, AR games can provide players with more realism and experience and stronger interactivity, and greatly improve the fun and gameplay of the game, allowing more people to join the game. AR technology processes this information through computers and then integrates it with other information to present it in the virtual reality world that users can see. Human senses are diverse, including touch, smell, hearing, and sight. AR can maximize human perception and provide a multi sensory interactive experience, allowing people to see real scenes, hear sounds, and touch textures, effectively integrating the real environment with virtual objects. In real games, because the camera of the game cannot be fixed in a single shot or screen, it changes according to the user's perspective. Therefore, users not only operate through the screen, but also enter the real scene, interact and communicate well with the game content, and become a member of the game, providing users with a better experience.

3.2 *Merge Cube*

Merge Cube is a cube based on augmented reality tech-

nology that can be used in conjunction with smartphones or tablets to provide an immersive AR experience [16-17]. The characteristic of the Merge Cube is that it has a unique visual effect that allows users to see 3D virtual objects or scenes on the cube. By rotating, moving, and touching the cube, users can interact with the virtual objects. The Merge Cube can be used for various AR games, educational applications, and entertainment experiences. In terms of gaming, users can play various interesting AR games through the Merge Cube, such as building, solving puzzles, shooting, and other types of games. In terms of education, Merge Cube can be used for teaching and learning, helping students understand various concepts and knowledge more intuitively, and improving learning interest and effectiveness [18].

The emergence of Merge Cube provides users with a new AR experience, allowing them to experience the virtual world more immersively. At the same time, it also provides developers with an innovative platform to design various interesting and practical AR applications. Overall, Merge Cube is an innovative AR technology product that can bring users a richer and more interesting augmented reality experience [19-20].

4. Results and Discussion

4.1 *Factors Influencing Learning Behavior Engagement under the Influence of Games*

Based on the evaluation questionnaire of learning behavior under the influence of the Merge Cube game, data was collected through a questionnaire survey. Three classes in a primary school in A city who had used the Merge Cube game were distributed, and a face-to-face survey method was adopted. The questionnaire was collected on-site. A total of 225 questionnaires were distributed, and 208 were effectively collected, with an effectiveness rate of approximately 92%. This article used SPSS 24.0 statistical analysis software to measure the reliability of the questionnaire.

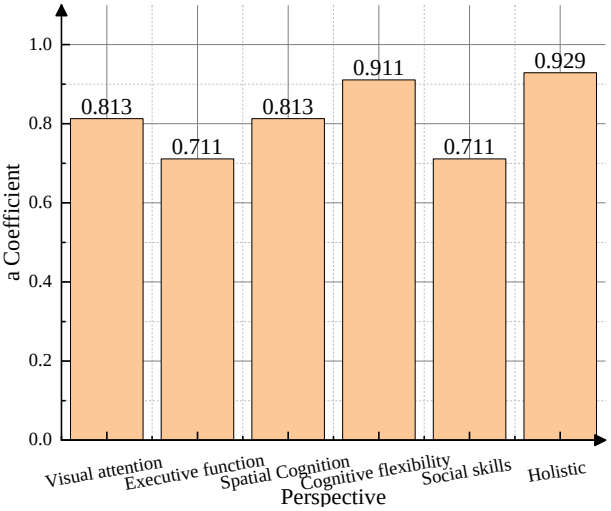

Figure 1. The a-coefficient of children's participation in various aspects of the Merge Cube game

The overall a coefficient of the questionnaire was 0.929, with a coefficient of 0.813 for visual attention, 0.711 for executive function, 0.813 for spatial cognition, 0.911 for cognitive flexibility, and 0.711 for social skills. The coefficients of a all exceeded 0.7, indicating that the questionnaire had good internal consistency.

$$KMO = \frac{\sum\sum_{i \neq j} r_{ij}^{\ 2}}{\sum\sum_{i \neq j} r_{ij}^{\ 2} + \sum\sum_{i \neq j} \alpha_{ij}^{\ 2}} \tag{1}$$

Here, r_{ij} represents the simple correlation coefficient, and α_{ij}^2 represents the partial correlation coefficient. Obviously, when $\alpha_{ij}^2 \approx 0$, $KMO \approx 1$; when $\alpha_{ij}^2 \approx 1$, $KMO \approx 1$. The value of KMO is between 0 and 1.

Table 1. Bartlett sphericity test

KMO Sample Suitability Quantity		0.77
Bartlett's test of sphericity	Approximate chi-square	89.7
	Degrees of freedom	14
	Significance	0.00001

From Table 1, it can be seen that the validity of the questionnaire was tested, and the KMO value of the questionnaire was 0.77, which was greater than 0.7. The significance of Bartlett's spherical test was 0.00001, which was less than 0.05, indicating good validity of the questionnaire.

4.2 *Multiple Regression Analysis*

In regression analysis, the t-value represents the degree of deviation of the regression coefficient from zero, that is, whether the influence of the independent variable on the dependent variable is significantly different from zero. In general, if the absolute value of t is greater than a certain

threshold (such as 1.96 or 2.58), the regression coefficient can be considered significant, that is, the influence of the independent variable on the dependent variable is significant. The standardization coefficient Beta is an indicator used to measure the degree of influence of the independent variable on the dependent variable. In statistics and regression analysis, the Beta coefficient represents the degree to which a change in the unit of the independent variable affects the dependent variable, without being affected by the unit and magnitude of the variable.

$$Beta = \frac{Cov(x, y)}{Var(x)} \quad (2)$$

Among them, Cov(X, Y) represents the covariance between the independent variable X and the dependent variable Y, while Var(X) represents the variance of the independent variable X.

According to SPSS 24.0, a significance test can be conducted to obtain the p-value. In general, $p<0.05$ indicates statistical differences; $p<0.01$ indicates significant statistical differences; $p<0.001$ indicates extremely significant differences. Multiple regression analysis is used to understand the impact of changes in various variables in the learning behavior engagement measurement scale on learning behavior engagement. The assumed influencing factors are set as independent variables and learning behavior investment as dependent variables. Regression analysis was performed using SPSS 24.0 statistical analysis software to obtain the results, as shown in Table 2.

Table 2. Analysis of learning engagement data

	Unstandardized coefficient		Standardized coefficient Beta	t	Significance
	Beta	Standard error			
Visual attention	1.145	0.319	0.01	5.12	0
Executive function	0.55	0.051	0.135	9.45	1
Spatial cognition	1.077	0.041	0.367	26.671	2
Cognitive flexibility	1.095	0.048	0.311	19.0556	3
Social skills	1.011	0.04	0.326	23.67	4

From Table 2, it can be seen that the standardized beta values of spatial cognition, cognitive flexibility, and social skills in games for the dependent variable of learning behavior investment were 0.367, 0.311, and 0.326, respectively, and the standardized coefficient Beta was also the highest. The above data fully demonstrated that spatial cognition, cognitive flexibility, and social skills had a significant positive effect on the dependent variable of learning behavior engagement.

Table 3. Mean and standard deviation of descriptive scores

Variables	Title	Average value	Standard deviation
Playability	The game had the characteristics I was looking for in a game	3.33	0.872
	I understood how to achieve the goal of the game through the game	3.48	0.749
	The game was easy to play	3.86	0.719
	The game sends a clear message to me	4	0.839
Physical Activity Characteristics	The game inspired me	3.55	0.752
	The game has inspired me to play more outdoors.	3.53	0.807
	I feel like I'm working out more when I play this game	3.18	0.8
	I'll be more energized than usual in this game	3.02	0.733
Sensory properties	This game is unique in its graphics.	3.48	0.786
	The images in this game are very appealing.	3.09	0.791
	The images generated by the game are realistic and intuitive	3.54	0.883
	The virtual and real game screens are real.	3.19	0.874

Social properties	This game has allowed me to meet a lot of players.	3.38	0.85
	The game helps me to communicate with other players.	3.15	0.785
	This game gives me a feeling like all people are the same.	3.75	0.71
	This game gives me a sense of companionship.	3.53	0.739
Practical properties	This game is easy to play	3.55	0.717
	The quality of this game is good	3.71	0.842
	This game is simple	3.16	0.75
	The interface of this game is clear	4	0.84
Hedonic properties	This game is fun	3.43	0.873
	This game is very creative	3.86	0.892
	This game is very creative	3.74	0.851
	This is a very immersive game.	3.81	0.773
Emotional responses	This game makes me happy	3.07	0.812
	This game makes me satisfied	3.14	0.854
	This game makes me feel relaxed	3.07	0.837
	When I play this game, my personal information may be leaked	3.1	0.838
Risk perception	When you play this game, your location information may be leaked out	3.92	0.803
	There is a risk of traffic accidents if you play this game outdoors.	3.22	0.706
	Playing this sport outdoors reduces my perception of danger	3.83	0.767
Usage Behavior	I would gladly recommend this game to friends and associates	3.4	0.747
	I want to play it all the time	3.57	0.818
	I would like to participate in this game.	3.27	0.898
Evaluation Variables	Overall, I enjoyed the game	3.31	0.781
	I enjoyed the game	3.02	0.872
	This game appealed to me	3.95	0.815

Overall, the mean of each dimension was above 3 points, indicating that the respondents had a relatively high level of identification with each measurement variable. The average of the two descriptive features, “This game conveyed a very clear message to me” and “The interface of this game is very clear”, was 4 points. The Merge Cube game was designed for entertainment purposes, indicating that these two features were highly attractive to players and had a strong sense of identity.

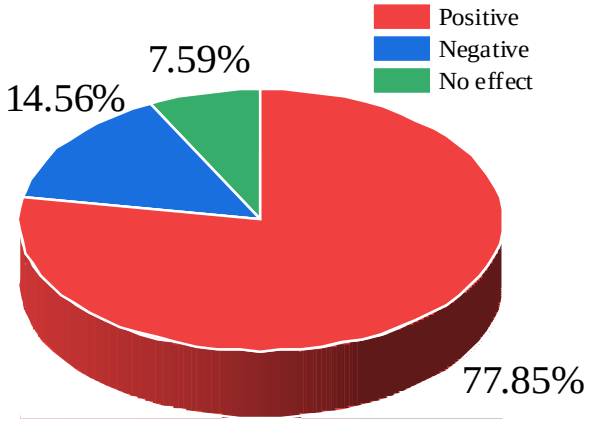

Figure 2. The impact of AR games on middle childhood children

From Figure 2, it can be seen that 77.85% of people be-

lieved that AR games had a positive impact on children; 14.56% of people believed that AR games had a negative impact on children; 7.59% of people believed that AR games had no impact on children.

5. Conclusions

With the continuous development of technology, AR technology has become an indispensable part of people's lives. AR games, as one of the applications of AR technology, are increasingly popular among children in their middle childhood. As an AR gaming device, the Merge Cube combines the virtual world with the real world, bringing children a brand new gaming experience. This article explored the impact of AR games on the attention concentration of middle childhood children, using Merge Cube as an example for empirical analysis. AR games have a positive impact on the attention concentration of middle childhood children. By attracting children's attention, enhancing the diversity and challenge of games, and promoting social communication and teamwork abilities, AR games can help middle childhood children better focus on games, thereby improving their attention concentration. Therefore, parents and educators can appropriately guide children to engage in AR games to promote their cognitive development and attention enhancement.

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