The association between immersion experiences and visual attention distributions in a learning game context

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Introduction

In recent years, many studies have confirmed the positive influences of digital games on learning. Gameplay provides players with game immersion, a graded experience that delineates the degrees of involvement, might be more appropriate to describe gameplay. According to Brown and Cairns (2004), the game immersion experience consists of three stages, namely engagement, engrossment, and total immersion. By using construct validity approaches, including both exploratory and confirmatory factor analyses, Cheng, She, and Annetta (2005) verified the hierarchical structure of game immersion experience. Moreover, empirical evidence has also indicated that game immersion is a dynamic process over time, such that the player becomes more immersed in the game as time passes (Cheng, Lin, She, & Kuo, 2017). Attention is essential to game immersion. The more attention invested, the more the player is immersed in the game. Self-report measures are generally used to investigate flow or immersion experience in most of the previous studies; however, what remains substantially unclear is the way the player distributes his/her attention while immersed in the game. Therefore, this study attempted to increase our understanding about the association between immersion experiences and visual attention distributions in a learning game context by using eye-tracking techniques.

Methods

A total of 79 undergraduate and graduate students (52 males and 27 females, aged 19-25 years old) with science majors participated in this study. They were asked to play *Humunology*, an educational game for learning about immune defence, by themselves for two hours, and the eye-tracker recorded their eye movements during their gameplay. A scientific knowledge assessment (17 multiple-choice questions) was performed as pre- and posttest and a game immersion questionnaire (23 items) was administrated to the participants as the posttest.

The preliminary eye-tracking measures were computed, and further analyses were performed using MATLAB. Five areas of interest (AOI) were defined in this study (Figure 1):

- **Main scene area (S)** :
  Shows where the player generally deployed his/her immune characters to combat the invasive pathogens.
- **Energy area (E)** :
  Shows where the player can use a certain amount of energy.
- **Character selection area (C) :**
  Shows where the players can select the player characters.
- **Timer zone (T) :**
  Shows the time left for the player to fight the pathogens.
- **Mission area (M) :**
  Shows the additional missions/tasks the player must accomplish to earn a better rank.

Figure 1 Screenshot of *Humunology* showing five AOIs.

Results

The results revealed that students who were more immersed in playing *Humunology* paid more attention to and invested more mental effort in processing information in areas related to player characters (Table 1). Moreover, they learned from playing *Humunology*, yet their counterparts who were not so immersed did not (Table 2).

Table 1
The profiles of cluster analysis and the results of independent *t*-tests showing the differences between the two clusters.

	Cluster 1 (N=31) Low immersion/ Low visual attention distribution		Cluster 2 (N=48) High immersion/ High visual attention distribution			
	Mean	SD	Mean	SD	*t*	Cohen's *d*
Engagement	3.430	.632	3.963	.559	3.930**	.906
Engrossment	2.189	.757	3.461	.641	8.019**	1.845
Total immersion	1.984	.684	3.289	.719	8.024**	1.850
AOI-S MFD	.297	.020	.318	.018	4.674**	1.117
AOI-E MFD	.281	.047	.304	.044	2.210	.509
AOI-C MFD	.298	.043	.334	.036	3.938**	.926
AOI-M MFD	.283	.026	.297	.033	1.999	.460
AOI-T MFD	.233	.100	.249	.146	.522	.123

**p<.001; MFD: Mean fixation duration.

Table 2
The results of paired *t*-tests showing the differences in science learning outcomes for Clusters 1 and 2.

		Pretest		Posttest		*t*	
	N	Mean	SD	Mean	SD	(post-pre)	Cohen's *d*
Cluster 1	31	12.900	3.091	14.100	2.343	2.228	.403
Cluster 2	48	12.730	2.583	14.500	2.352	5.589**	.807

**p<.001

Conclusions

The finding provided supporting evidence that when the players are immersed in the game to the extent that they empathize with the characters and believe that they are actually in the game (Cheng et al., 2015), they do invest more mental effort in processing information about the player characters. By collecting eye movement data, the research not only supported Jennett et al.' s (2008) findings, that players who were more immersed in the game focused more on game-related components, but further revealed that the player characters are the elements the players were mentally processing.

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