The Impact of Presence on Learning Transfer Intention in Virtual Reality Simulation Game

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Abstract
The three-dimensional (3D) virtual reality content is widely used for educational and training purposes, and there has been interest in how virtual reality environments influence users’ learning effect. Analyzing survey data collected from a game play, this study examined how presence in a 3D virtual reality car driving simulation game impacts players’ learning transfer intention through flow, arousal, and enjoyment. Using structural equation modeling, the results showed that presence was positively associated with flow and arousal, which in turn contributed to an increase in enjoyment of the game. The enjoyment played a significant role in elevating the players’ learning transfer intention. These results provide an understanding of the psychological mechanisms behind the impact of presence on learning transfer intention in a 3D virtual reality driving simulation game. Limitations and implications of the study are discussed in greater detail.

Keywords
virtual reality, presence, flow, arousal, enjoyment, learning transfer

Introduction
Virtual reality (VR) technology has been used for educational and training purposes (Loup-Escande et al., 2017). This technology has shown the potential to influence users’ learning outcomes, such as learning transfer, which is the transfer of skills and knowledge acquired in one context to another context or situation (Mayer et al., 2011). VR car driving simulation content is designed to simulate a real vehicle, allowing users to learn driving skills and knowledge in a virtual environment (Burkhardt et al., 2016). VR car driving simulation programs are safe, and cost-effective as an educational tool for novice drivers (Lemieux et al., 2014).

However, there is little research regarding the influence of VR car driving simulation content on users’ learning transfer—especially among novice drivers. Previous studies have suggested the psychological mechanisms behind the impact of VR content on learning by considering the characteristics of VR technology. For example, because VR technology imitates a realistic environment in which users conduct a particular task (Huang et al., 2010), they can experience immersion (Pallavicini et al., 2019), arousal (Felnhofer et al., 2015), and/or enjoyment (Shin et al., 2019), which may in turn improve their learning.

This study explores how the use of a VR car driving simulation program facilitates users’ learning transfer intention. In this study, we use a 3D VR driving simulation game, with which users can experience realistic driving performance using interface devices, to explore the psychological mechanisms underlying VR technology use. More specifically, we analyze data from game play to examine how the sense of presence in a 3D VR environment influences learning transfer intention through the mediation of psychological factors, such as flow, arousal, and enjoyment. Figure 1 shows our proposed model, in which users’ levels of presence (generated by the 3D VR car simulation program), flow, and arousal can serve as factors influencing the enjoyment of the simulation program, and which may in turn be associated with their learning transfer intention. As a result, this study may improve the understanding of the psychological process behind the impact of a 3D VR car driving simulation game on learning transfer intention, along with significant practical implications for VR driving simulation games.

Background
Presence, Flow, and Arousal in Drivers of VR Simulation Games
The application of 3D VR technology to computer games, using interface devices such as HMDs and steering wheels.
Presence refers to a psychological state (or a subjective perception) of being transported into a virtual or technology-mediated setting (Minsky, 1980; Narciso et al., 2019). The 3D VR technology helps individuals to expand their human sensory and cognitive processing systems, eliciting a stronger sense of presence owing to the enhanced vividness and interaction of the technology (Weibel et al., 2008). In the context of VR game environments, presence also indicates the extent to which players perceive that they are inside the game world when manipulating controls and characters (Ho et al., 2017).

It is known that presence can influence users’ psychological outcomes (Lombard & Ditton, 1997). For example, past research has shown that presence is positively associated with flow in virtual game play (e.g., Weibel et al., 2008) and in virtual educational environment (e.g., Rodriguez-Ardura & Meseguer-Artola, 2016). Flow refers to a state of increased psychological immersion and energized focus on the task performed by an individual (Csikszentmihalyi, 1990). Because presence takes users to a virtual realm in which they can focus on their actions and feel more connected to the task, they are more likely to feel immersed in the activity (Rodriguez-Ardura & Meseguer-Artola, 2016). From this perspective, it has been suggested that presence can serve as a significant antecedent to flow (e.g., Cheng et al., 2014; Novak et al., 2000). On the basis of this consideration, we propose the following hypothesis:

**Hypothesis 1 (H1):** Presence will be positively associated with flow.

In addition to flow, it has been suggested that presence is also related to arousal (Lombard & Ditton, 1997). Arousal refers to the psychological or physiological state of being activated or awoken in response to a certain stimulus (Jeong & Biocca, 2012). In particular, psychological arousal is described as an individual’s perception of the extent to which they are excited or stimulated to respond (e.g., Novak et al., 2000).

The 3D VR is designed to evoke arousal among users (Bae et al., 2012). As Heeter (1992) suggested that intensified presence in media may induce a higher level of arousal, presence in 3D VR also can contribute to the promotion of arousing experiences among users owing to the vividness of the virtual environments. Vividness indicates the capability of a media technology to generate a representationally rich mediated environment (Steuer, 1992). Because the vividness of media serves to expand one’s sensory breadth and depth in a mediated environment (Steuer, 1992), it improves the sense of presence (Lombard & Ditton, 1997), which may in turn contribute to eliciting users’ arousal response to the media stimulus. Indeed, an experimental study showed that participants who felt presence in a virtual environment displayed a heightened level of arousal (Malbos et al., 2012). On the basis of this consideration, we present the following hypothesis:

**Hypothesis 2 (H2):** Presence will be positively associated with arousal.

**Enjoyment as a Resulting Factor of Flow and Arousal**

Enjoyment has been considered an important aspect of VR content, including VR game play (Decock et al., 2014; Makransky et al., 2019). In particular, game programs are designed to be enjoyable to motivate users to continue to play games or to learn (Giannakos, 2013). Moreover, as Hartmann et al. (2010) argued that enjoyment can occur when users move to alternate mediated settings that are more entertaining (Ho et al., 2017), VR environments may...
influence the sense of enjoyment by providing highly realistic or exciting experience with novel visual or auditory stimuli (e.g., H. G. Lee et al., 2013).

Prior research has shown that flow and arousal are associated with enjoyment (e.g., Csikszentmihalyi, 1990; Sweetser & Wyeth, 2005). Indeed, experimental research found that participants who reported a greater level of flow were more likely to have a greater feeling of enjoyment about a game (Limperos et al., 2011). Moreover, arousal is considered an essential element in inducing pleasurable moods or positive experiences (Zillmann, 1991). For example, Janicke and Ellis (2013) found that individuals with a higher level of arousal were more likely to experience greater enjoyment during 3D game play. In this regard, it is anticipated that flow and arousal are positively related to enjoyment of the game. On the basis of this consideration, the following hypotheses are proposed:

**Hypothesis 3 (H3):** Flow will be positively associated with enjoyment.

**Hypothesis 4 (H4):** Arousal will be positively associated with enjoyment.

**Learning Transfer Intention as a Consequence of Enjoyment**

VR technology has the potential to affect users’ learning (Thompson et al., 2018). In particular, learning transfer is considered a significant learning outcome when observing the effects of learning in a virtual environment (e.g., McComas et al., 2002; Moskaliuk et al., 2013). Learning transfer refers to the ability to extend and apply knowledge and skills acquired in one context to new contexts or situations (Mayer et al., 2011). Moreover, as behavioral intention indicates that an individual plans to perform a particular behavior (Andrews et al., 2010), learning transfer intention can be suggested as one’s behavioral plan that will apply skills obtained in one setting to another setting. Furthermore, previous studies have shown that intention significantly predicts actual behavior (Swaim et al., 2014), indicating that people with a stronger intention to perform a certain behavior are more likely to engage in the behavior.

People increasingly use media technology—such as VR—to learn a certain task, and this technology plays an important role in inducing them to apply their skills and knowledge to the real world, which indicates that people integrate the acquired skills and knowledge into everyday life. Thus, it has been suggested that the commonality between a learning environment and an actual task situation produces greater transfer of learning (Enos et al., 2003). Because VR technology provides a highly realistic simulation environment, it may help users to more readily apply skills and knowledge experienced in the virtual setting to real world situations. For example, the use of VR content designed to educate children in safely crossing an intersection helped them learn a pedestrian safety skill and improve street crossing behavior, which in turn transferred to real world behavior (McComas et al., 2002). In the area of medical education, the use of VR surgical simulation contributed to improvements in operating skills, including a reduction in errors, with surgical trainees making steady progress throughout a surgical operation (Seymour et al., 2002). Moreover, learning transfer saves considerable amounts of time and effort, because it enables individuals to apply the knowledge and skills learned in an educational environment to similar situations. It is likely that people can transfer driving skills and knowledge learned from a 3D VR car driving simulation game to a real driving situation on a road in a convenient and safe manner.

Previous research has suggested that enjoyment is associated with learning outcomes (e.g., Iten & Petko, 2014; Jin, 2011). For example, students who enjoyed mathematics lessons were more likely to be interested in the subject and show improved performance (Schukajlow & Rakoczy, 2016). In the context of a game, people who have enjoyable game experiences were more likely to have a higher level of knowledge acquisition (Giannakos, 2013). Enjoyment during gameplay tends to encourage users to put forth more effort to learn the game, which may in turn result in higher achievement (Baek & Touati, 2017). Likewise, it is likely that players who enjoy a 3D VR car driving simulation game exert a greater level of learning performance, particularly for learning transfer intention. On the basis of this consideration, we propose the following hypothesis:

**Hypothesis 5 (H5):** Enjoyment will be positively associated with learning transfer intention.

**Methods**

**Participants, Apparatus, and Procedure**

To examine the relationships among presence, flow, arousal, enjoyment, and learning transfer intention, the study analyzed data collected from 3D VR car driving simulation game play at a large private university in the Gangwon Province of South Korea during 2 weeks in April 2015. Participants (N = 100) were recruited from undergraduate students who are novice drivers holding a driving license. The sample included 50 male and 50 female students. Participants were asked to sign a written informed consent before participating in the study. All participants received a small amount of compensation for their participation.

Our game play research relied on the playtest method (Davis et al., 2005). This method is a new approach for gathering systematic and quantitative information about users’ perceptions of games using survey methodology (Davis et al., 2005). In this method, participants play a specific game for a limited time and then complete a series of survey questions regarding their gameplay.
The 3D VR car driving simulation environment was generated by the Oculus Rift Development Kit 2, a personal computer, and a Logitech G27 Racing Wheel. Oculus Rift is a VR headset with a high-resolution (960 × 1080 pixels per eye) display and a wide field of view. The Oculus Rift headset creates a 3D VR space while exposed to VR content and provides head-tracking technology for enhancing VR realism. The personal computer used was a high-performance desktop coupled with an HDMI graphics card. HDMI enables the high-speed transmission of digital audio and video data to a compatible display device, such as the Oculus Rift headset. The Logitech G27 Racing Wheel is an electronic steering wheel designed for driving simulators and games. The G27 Racing Wheel is packaged with a steering wheel, a set of foot pedals for acceleration and braking, and a gear stick, allowing users to drive a simulated car by manipulating the steering wheel, pedals, and gear shifts.

The 3D VR car driving simulation game used in our research was City Car Driving (developed by Forward Development). The game is designed to simulate real automobile settings, including the car cockpit, windows, and fractional force, and resembles the atmosphere of a real road setting, including the traffic flow, traffic lights, traffic laws, pedestrians, and weather conditions. Moreover, because City Car Driving is compatible with the Oculus Rift display and the Racing Wheel control, the driving simulation game allows players to feel the real-driving experience. Thus, the simulation game may be useful for novice car drivers learning driving skills and road traffic knowledge. During the driving simulation gameplay, the road conditions, the difficulty of the driving mission, the weather, the time of day, and the vehicle type were controlled to be the same for all participants.

The general purpose of the study was explained to participants, seated in the 3D driving simulator; they were given standard instructions on how to play the 3D VR car driving simulation game, including safe driving and avoiding reckless driving, and asked to play for a 10-min session. Following this, participants were asked to complete a variety of questions about their game experiences, including presence, arousal, flow, enjoyment, and learning transfer intention.

**Measures**

**Presence.** Presence was measured using a 5-point scale (1 = “strongly disagree,” 5 = “strongly agree”) by asking participants to rate their level of agreement with the following three statements: “During gameplay, I felt like the situation on the screen actually came towards me,” “I felt like I was seeing the traffic situation in the game from my real car seat,” and “I felt that the situation in the game seemed similar to my real situation” (Cronbach’s alpha = .75, M = 3.56, SD = 0.65). These statements were adapted and modified from earlier research (e.g., Kim & Biocca, 1997).

**Flow.** Flow was measured by asking participants to indicate their level of agreement with the following three statements on a 5-point scale (1 = “strongly disagree,” 5 = “strongly agree”): “I felt completely focused while in the game,” “Time really flew by when I was in the game,” and “I felt like all of my senses were engaged while in the game” (Cronbach’s alpha = .71, M = 3.99, SD = 0.63). These statements were adapted and modified from previous research (e.g., Faiola et al., 2013).

**Arousal.** Arousal was measured using a 5-point scale (1 = “strongly disagree,” 5 = “strongly agree”) by asking participants to report their level of agreement with the following three statements: “I felt stimulated when playing the game,” “I felt active when playing the game,” and “I felt lively when playing the game” (Cronbach’s alpha = .71, M = 3.45, SD = 0.70). These statements were adapted and modified from prior research (e.g., Liu et al., 2013).

**Enjoyment.** Enjoyment was measured using a 5-point scale (1 = “strongly disagree,” 5 = “strongly agree”) by asking participants how much they agree with the following three statements describing their enjoyment of the car driving simulation game: “I enjoyed playing the game,” “I would like to continue playing the game because I experienced pleasure,” and “I can play more because the game was fun” (Cronbach’s alpha = .80, M = 3.46, SD = 0.76). The measurement items were adapted and modified from earlier research (e.g., Ho et al., 2017; Lee, 2009).

**Learning transfer intention.** Learning transfer intention was measured using a 5-point scale (1 = “strongly disagree,” 5 = “strongly agree”) by asking participants how much they agree with the following three statements: “I plan to apply what I learned in the game to real driving,” “I am certain that I can apply what I learned in the game to real driving,” and “I will attempt to apply what I learned in the game to real driving” (Cronbach’s alpha = .80, M = 3.58, SD = 0.65). The measurement items were adapted and modified from previous research (e.g., Joo et al., 2011).

**Analysis**

Before running structural equation modeling, we performed a confirmatory factor analysis (CFA) using SPSS AMOS 21 software to investigate the measurement instrument constructs (i.e., three items for presence, three items for flow, three items for arousal, three items for enjoyment, and three items for learning transfer intention). The CFA revealed that all of the measurement instrument constructs consisted of the items that had factor loadings scores above 0.50 (e.g., Ho et al., 2017). To examine our hypothesized model (see Figure 1), structural equation modeling was conducted using SPSS AMOS 21 software to evaluate the measurement models.
and estimate the conceptual relationships (Arbuckle, 2012; Kline, 2011). We used the Maximum Likelihood estimation approach to estimate the unknown parameters in the model (Ho et al., 2017). The goodness of fit of the model was evaluated on the basis of a Root-Mean-Square-Error of Approximations (RMSEA) less than 0.06, Standardized Root-Mean-Square Residuals (SRMR) less than 0.08, Tucker–Lewis Indexes (TLIs) of 0.90 or greater, Comparative Fit Indexes (CFI) of 0.90 or greater, and chi-square statistics, which indicate that a nonsignificant value of chi-square is usually acceptable as evidence of a good model fit (Bentler, 1990; Worthington & Whittaker, 2006).

Results

The structural equation modeling analysis showed the following fit indices of the proposed model, $\chi^2 (85) = 108.18 \ (p < .05, \text{chi-square/degree of freedom ratio } = 1.27)$, RMSEA $= .05$, SRMR $= .08$, TLI $= .94$, and CFI $= .95$, which indicates a reasonably acceptable result (Bentler, 1990; Worthington & Whittaker, 2006). In addition, all of the factor loading values resulting from the analysis were greater than 0.5 and acceptable, confirming convergent validity (Field, 2005; Ho et al., 2017). Figure 2 presents the predicted (and standardized) paths and their statistical significance in the hypothesized direction. To simplify the model visually, we eliminated the measurement errors of all the variables in the figure.

It was hypothesized that presence is positively related to flow (H1). As expected, there was a significant and positive relationship between presence and flow ($\beta = .48, p < .01$). This finding indicates that participants who perceived a higher level of presence in the VR simulation game were more likely to experience flow. Thus, H1 was supported. The study also proposed that presence is positively related to arousal (H2). As expected, the finding revealed that presence was significantly and positively associated with arousal ($\beta = .33, p < .05$), indicating that participants who felt a greater presence in the VR driving game were more likely to elicit arousal response. Therefore, H2 was also supported.

It was stated that flow is positively correlated with enjoyment (H3). We found that flow was positively related to enjoyment ($\beta = .34, p < .01$), lending support to H3. This result shows that participants who reported a higher level of flow were more likely to have enjoyed the VR car driving game. Moreover, it was suggested that arousal is positively associated with enjoyment (H4). In support of H4, the analysis showed that arousal had a significant and positive relationship with enjoyment ($\beta = .48, p < .01$). This finding indicates that participants who reported a higher level of arousal were more likely to experience greater enjoyment during the VR driving game.

It was proposed that enjoyment is positively associated with learning transfer intention (H5). As expected, it was found that enjoyment was significantly and positively related to learning transfer intention ($\beta = .62, p < .001$). This result indicates that participants who enjoyed the driving simulation game were more likely to intend to transfer their driving skills and knowledge gained in the virtual environment to real driving. Thus, H5 was supported by the findings.

Discussion and Conclusion

Analyzing game play data derived from a 3D VR car driving simulation game, this study explored the relationship between presence, flow, arousal, and enjoyment and how these factors in turn influence players’ learning transfer
intention. The findings in the study supported our assumed hypotheses. Our analysis revealed that the enhanced sense of presence experienced when playing the VR driving simulation game was positively related to flow and arousal. Moreover, intensified flow and arousal contributed to attaining user enjoyment of the game. The study also found that enjoyment of the game was positively associated with players’ learning transfer intention. Finally, our study showed the significant indirect effects between presence and learning transfer intention through flow, arousal and enjoyment.

More specifically, sense of presence in the 3D VR simulation game was found to be associated with flow and arousal. Individuals who perceived a higher level of presence in the VR simulation game were more likely to experience flow and arousal. Previous research has also found that presence plays a considerable role in promoting flow in a virtual simulation setting (e.g., Cheng et al., 2014) and arousal in a VR environment (e.g., Malbos et al., 2012). Because the 3D VR driving game is designed to simulate real driving environments by using various interactive devices, such as a steering wheel set, the players could feel a sense of presence, which may in turn have resulted in greater immersion in the game. Moreover, as the players were exposed to the vivid game content derived from HD displays and a wide field of view using the VR headset, they were more likely to experience realistic gameplay in the virtual environment. The enhanced presence may help the players become aroused in response to the driving game stimulus.

We also found that flow and arousal were positively associated with enjoyment. The players who reported a higher level of flow and arousal were more likely to have enjoyed the car driving game. These findings are consistent with previous studies (e.g., Janicke & Ellis, 2013; Limperos et al., 2011) that enjoyment is increased by higher levels of flow and arousal. In particular, the findings could be explained by an increase in flow, which may make users concentrate deeply on the gameplay with loss of sense of time in the virtual environment, thereby facilitating enjoyment of the game. Moreover, because flow is intrinsically rewarding rather than relating to an external reward (Admiraal et al., 2011), the players in the flow state would seek more enjoyment of the game as an intrinsic reward. Moreover, as the players are excited or stimulated by the vivid and interactive VR technology of the driving game, they could experience more pleasure or enjoyment during the gameplay.

The study found that enjoyment of the 3D VR driving simulation game was positively associated with the players’ learning transfer intention. Individuals who enjoyed the driving simulation game were more likely to intend to transfer the driving skills and knowledge gained in the virtual environment to real driving. In particular, because novice drivers often tend to be stressed and anxious about driving (Y. C. Lee & Winston, 2016; Scott-Parker et al., 2012), enjoyment felt during the game could help the players who are novice drivers perceive that driving is enjoyable and fun, which may in turn result in a better car driving learning outcome. This suggests that enjoyment is a significant motivating factor for developing the intention of learning transfer of users. Moreover, because a high similarity between a learning setting and actual situations leads to improved learning transfer (Enos et al., 2003), the large commonality between the 3D VR driving simulation game and real driving conditions may help the players who are novice drivers have a stronger intention of transferring their skills and knowledge learned in the game to real driving. Thus, the 3D VR car driving simulation game can provide the opportunity for novice drivers to learn driving skills and knowledge in a convenient and safe way.

Finally, the sense of presence was found to have significant indirect effects on learning transfer intention through flow, arousal, and enjoyment. That is, the impact of the 3D VR driving simulation game on the players’ learning transfer intention was mediated by flow, arousal, and enjoyment. Previous studies have suggested that presence created by a VR environment has been associated with learning outcomes (e.g., Lee et al., 2010; Schrader & Bastiaens, 2012; Tichon, 2007). Our finding is consistent with the benefits of VR content, which improve sense of presence exerting educational or training effects on users. As a result, the 3D VR driving simulation game may serve as an effective educational tool by providing an enjoyable experience derived from flow state and arousal to help novice drivers.

Limitations and Suggestions for Future Research

This study has some limitations and suggestions for future studies. First, the cross-sectional survey data obtained from the experimental research were analyzed using structural equation modeling to examine the correlations among presence, flow, arousal, enjoyment, and learning transfer intention. Because of this, the results of the analysis need to be interpreted cautiously with regard to inferences of the directionality in the relationships among the factors. Nevertheless, our model was established within robust theoretical rationales between variables and the results of prior studies. Future research should consider using longitudinal data to establish causal links between variables.

Second, given that our study was not based on experimental design, there is no comparison group, such as a 2D car driving game group, for confirming the fact that participants experience presence in the 3D VR environment. However, our study does not claim that 3D VR environment is more effective than a 2D driving game or other media forms of learning effects. Rather, the study aimed to examine the psychological mechanism behind the influence of a 3D VR simulation game on learning transfer intention. Nevertheless, future research may consider using control or comparison groups for comparing between a 3D game group and another conditional game group.

Third, the study did not directly measure participants’ behavior such as their driving skills, learning transfer, or
physiological response in a real situation. Instead, we used self-reported measures to capture the arousal and learning transfer intention variables. Self-reported measurement can be constrained because it is sometimes susceptible to social desirability bias. Participants may respond with what they perceive to be appropriate responses, rather than revealing their true attitudes or behaviors. Nevertheless, our study used the playtest method, which is an efficient method for simultaneously measuring participants’ cognition, attitude, and perception. Future research should measure participants’ behavioral responses, such as driving skills, driving knowledge, heart rate, or skin temperature, by direct observation assessment in a real environment.

**Conclusion**

With these considerations in mind, this study contributes to an understanding of the psychological process behind the influence of a 3D VR car driving simulation game on the learning transfer intention of users. The results of the study showed that presence was positively associated with flow and arousal, which in turn increased enjoyment. Enjoyment played a considerable role in facilitating the learning transfer intention. This study has important theoretical and practical implications. From a theoretical perspective, our study demonstrated an integrated model for explaining how presence influences learning transfer intention in a 3D VR environment based on the psychological process. In considering the improvement of learning effects, we provide an empirical evidence that greater presence was positively associated with flow and arousal, which subsequently led to a higher degree of enjoyment. The practical implications of this study suggests that a 3D VR car driving simulation game can be used to apply driving skills and knowledge to real driving for educational or training purposes among novice drivers. In particular, because our study found that game enjoyment was positively associated with learning transfer intention, driving simulation game programmers need to focus more on improving player enjoyment when designing the game for educational or training purposes. Moreover, because the enjoyment was attained by the sense of presence through flow and arousal, 3D VR game programmers should design in a manner that enables players to experience a higher level of presence in their game, considering interactive devices, VR headsets, and high-resolution displays.

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