

Comparison of the Effect of Control Mapping on Players' Presence in Different Environments

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Summary

During the last few years, virtual reality has been undergoing a small renaissance as it is gradually becoming a common technology. This has opened the topic of control mapping, as the classic setup of keyboard and mouse is unsuitable for use with head-mounted displays. This research explores how control interface – directional natural mapping (DualShock 4), realistic tangible natural mapping (steering wheel Thrustmaster T150 RS Force Feedback) and incomplete tangible natural mapping (Playstation Move) alters our sense of presence when playing on TV and with HMD. Results indicate that incomplete tangible natural mapping and realistic tangible natural mapping offers a generally greater sense of presence; however, the increase in presence is platform independent as the difference in presence was similar under both conditions (TV and HMD).

Keywords: virtual reality, presence, flow, controller mapping

1. INTRODUCTION

With the renaissance of virtual reality in recent years, more attention has been paid to phenomena such as immersion or presence. One of the first to address this topic was Jonathan Steuer, who defined presence as a feeling of being in a different environment than we actually are.¹ He defined two criteria of the quality of the sense of presence – vividness, and interactivity. Vividness is expressed by the number of senses that virtual reality has an effect on and how well they are stimulated (e.g. image resolution). Interactivity consisted of three aspects – response rate, number of stimuli, and the way of mapping. By mapping (control), we understand the transfer of real-world motion to the virtual one. As Steuer further writes, mapping ranges from totally unrelated (e.g. giving written instructions to perform

¹ Steuer, Jonathan. Defining Virtual Reality: Dimensions Determining Telepresence. *Journal of Communication*, Volume 42, Number 4, 1992, 73-93.

a given task) to natural (i.e., 1:1 motion transfer). This idea was further developed by Paul Skalski and Ron Tamborini², who divided the ways of natural mapping into four categories from the least natural way of control to the most natural:

- **Directional natural mapping** – there is a link between the VR motion direction and the location on the controller (the relationship between the directional arrows and the motion in the game)
- **Kinesic natural mapping** – our body movement is scanned and transmitted to the virtual world (e.g., Microsoft Kinect)
- **Incomplete tangible natural mapping** – control through the motion controller that allows us to transfer the motion to the virtual world, but this controller is universal and acts as a representation of various objects
- **Realistic tangible natural mapping** – control that realistically copies elements in virtual reality (for example, pedal wheel or arcade gun pistols)

Skalski and Tamborini supported their categorization with practical research in which they explored the influence of control over the presence and enjoyment of playing on the monitor – specifically, they compared a classic gamepad (directional mapping) with Wii Remote (incomplete tangible mapping) in a sports golf game and a keyboard (directional mapping) with a steering wheel (realistic tangible mapping) in the Need For Speed Underground game.³ Both experiments confirmed that incomplete and realistic tangible mapping has a positive impact on presence and enjoyment. Similar results were also provided by Ki Joom Kim's study, which confirmed the effect of realistic tangible mapping on presence as well as arousal.⁴ Another study was conducted by Daniel Shafer, in which he compared incomplete tangible natural mapping (Razer Hydra controller) against the keyboard, both on the monitor and in VR.⁵ His results showed that presence was larger in VR than on the monitor, but as for control, the respondents labeled the keyboard as a more natural way of control than the Razer Hydra, which is in contradiction with Skalski's assumptions. Daniel Shafer pointed to Vorderer's work which mentioned the factor of users being used to a particular way of control – even if control is more natural, users may not perceive it that way and need a certain amount of time to adapt to it because they are used to another system.⁶

² Skalski, Paul - Tamborini, Ron - Shelton, Ashleigh et al. Mapping the road to fun: Natural video game controllers, presence, and game enjoyment. *New Media & Society*, Volume 13, Number 2, 2010, 224-242.

³ Ibidem.

⁴ Kim, Ki Joon - Sundar, Shyam, S. - Shelton, Ashleigh et al. Can Interface Features Affect Aggression Resulting from Violent Video Game Play? An Examination of Realistic Controller and Large Screen Size: Natural video game controllers, presence, and game enjoyment. *Cyberpsychology, Behavior, and Social Networking*, Volume 16, Number 5, 2013, 329-334.

⁵ Shafer, Daniel, M. - Seibert, Jonmichael - Shelton, Ashleigh et al. Control mapping in virtual reality: effects on spatial presence and controller naturalness. *Virtual Reality*, Volume 22, Number 1, 2018, 79-88.

⁶ Vorderer, Peter. Interactive entertainment and beyond. In *Media entertainment: The psychology of its appeal*. Zillmann, Dolf - Vorderer, Peter (eds.). Mahwah: Lawrence Erlbaum Associates Publishers, 2000.

2.HYPOTHESIS

The main aim of this work is to broaden the previous research and explore how we perceive ways of mapping on classical television and in virtual reality. Based on the previous studies, we decided to explore three aspects - flow (which replaces the enjoyment and arousal of the past studies), presence, and naturalness of control. The research will consist of two experiments – in the first one, we will compare directional mapping with realistic, tangible mapping on TV and in VR under the assumption that realistic, tangible mapping helps to achieve a higher sense of presence, flow and naturalness of control in VR than directional mapping. Therefore, we assume that the difference in observed values for the examined two ways of control will be greater in virtual reality than on the classic display. The second experiment will compare directional natural mapping with incomplete tangible mapping in the virtual reality environment. Despite the inconsistency of the previous results, we assume that incomplete tangible mapping will provide higher values for all the variables monitored.

3.METHODS

3.1.Participants

The total number of participants was 44 (35 males and 9 females). Twelve of them had never tried VR, 32 had tried it at least one time. Participants were randomly divided into two groups. During the first experiment group A was playing with DualShock 4 (directional natural mapping - DNM), and group B was playing with steering wheel Thrustmaster T150 RS (realistic tangible mapping controller – RTNM). During the second experiment group A used DualShock (DNM) and group B used PlayStation Move Controller (incomplete tangible natural mapping – ITNM). Each participant visited the testing lab two times (the interval between the sessions was at least three weeks). During one session they were playing on television, and during the second they were playing in VR. The order of sessions was randomized (half of the participants played first in VR and the second half played first on TV) to eliminate its possible effect.

3.2.Game and Controls

For the first experiment, the racing game *Gran Turismo Sport* was chosen. The game was played on a PlayStation 4 PRO with PS VR. The primary reason for choosing PlayStation instead of another VR platform was its low price and easy operation. The primary aspect of the selected genre was the possibility of using two natural mapping options – directional (gamepad) and realistic tangible (steering wheel). The main aspect in the selection of the game was to achieve similar gameplay experience in VR and on TV. However, there were some differences between the platforms – except significant graphics downgrade in VR there was only one AI opponent on the track compared to 20 opponents on TV. Also, the option of 3DoF movement in the car was present in VR. Participants played one race on the Dragon Trail track with a Ford Focus (automatic transmission, beginner difficulty). The race was approx. 6 minutes long. The sound was provided through headphones with the same volume settings for each test.

For the second experiment, *Until Dawn: Rush of Blood* was chosen. The participants played the second level of the game (approx. 6 minutes long) at medium difficulty. *Until Dawn* is an FPS game where players go through a haunted house in a carriage (player movement is limited to 3DoF) and weapons are held in both hands. The task is to shoot at targets and objects that attack you. With PS Move, the player has two controllers (one in each hand) and each controller represents a gun that is held in your hand. With DualShock there is only one controller that represents both guns, so the main difference between the two mapping options is that it is not possible to aim your weapons individually with the DualShock controller.

3.3. Measured variables

Presence, flow, and perceived naturalness were assessed and complemented with video recordings of every session. The questionnaire consisted of three parts:

- The Igroup Presence Questionnaire⁷
- Flow Questionnaire⁸
- A set of questions focused on the controller mapping experience

The Igroup Presence Questionnaire (IPQ) is a scale for measuring the sense of presence experienced in a virtual environment (VE). It was constructed using a large pool of items and two survey rounds with approximately 500 participants. The questionnaire is divided into three subscales (Spatial Presence, Involvement, and Realism which are independent to each other) and one general factor "Sense of Being There" which has a connection to all three factors, especially "Spatial Presence." However, for this experiment, we decided to use only the questions related to the spatial presence and sense of being there.

The Flow Questionnaire is a self-report scale. It consists of 10 items such as "I do not have to strive to concentrate," "The right thoughts/movements come very naturally" and "I feel I have the process under control." Respondents express their level of agreement with each item on a zero to six scale. The average score was established for each respondent in order to access his or her level of flow experienced during the game. Questions focused on controller experience examined whether the players found control natural. Altogether we measured four aspects:

- Spatial Presence
- Sense of Being There
- Flow
- Naturalness of Control

⁷ Igroup presence questionnaire (IPQ) overview. *Igroup.org – project consortium* [online] 2016 [cit. 2.2.2019]. Available at: <<http://www.igroup.org/pq/ipq/index.php>>.

⁸ Vollmeyer, Regina - Rheinberg, Falko. Motivational effects on self-regulated learning with different tasks. *Educational Psychology Review*, Volume 18, Number 3, 2006, 239-253.

All the questionnaires used a zero to six scale where zero indicated complete disagreement and six complete agreement.

3.4.Procedure

The experiment took place at the MysLab at Charles University in Prague from March to June 2018. At the beginning of the first session, every participant filled in an introductory questionnaire. Then they played Gran Turismo Sport, and after the game, they filled in presence/flow/control questionnaire. When attending the VR session, they also played second game Until Dawn: Rush of Blood. After finishing the second game, the participants filled in the questionnaire once again.

3.5.Data Analysis

All the data were collected in Google Forms with possible answers ranging from 0 (Very Low) to 6 (Very High). All the data were collected and analyzed in Jamovi software. For analysis, Repeated Measure ANOVA was used – comparing two groups of respondents (with/without sound) with repeated measures TV / VR.

4.RESULTS

4.1.Comparison of the Effect of Controller Mapping on TV and VR (Directional X Realistic Tangible)

Using Repeated Measure ANOVA, we analyzed data from the questionnaires (See Tab. 1). For all measured variables, except for flow, Directional Natural Mapping (DNM; DualShock 4) showed lower values than Realistic Tangible Natural Mapping (RTNM; Thrustmaster T150 RS). Similarly, VR showed higher values than TV in most of the measured variables except flow. These results confirm the previous studies that VR provides a greater sense of immersion (with $p < 0,001$ for both spatial presence and sense of being there). The effect of the platform on flow and perceived naturalness could not be proven as $p = 0.061$ (flow) and $p = 0,089$ (naturalness of control). On the other hand, the effect of controller mapping greatly affects perceived naturalness of control with $p = 0.019$ on TV and $p = 0.003$ in VR, but its effect on presence and flow could not be proved as p values between directional and realistic mapping ranged from 0.156 to 0.961. However, analyzing the interaction between platform and controller mapping, flow is the only variable that showed a significant effect (see Fig. 1). The different controllers influenced flow only while playing in VR and not while playing on the screen. For all other measured variables, the interaction was not significant, meaning that the effect of controllers was not different for different platforms (VR x TV).

Gran Turismo								
	DNM TV Mean (SE)	RTNM TV Mean (SE)	DNM VR Mean (SE)	RTNM VR Mean (SE)	DNM X RTNM (TV) <i>p</i>	DNM X RTNM (VR) <i>p</i>	Platform TV X VR <i>p</i>	Platform * Mapping <i>p</i>
Spatial Presence	3.33 (0.168)	3.54 (0.167)	4.00 (0.168)	4.35 (0.167)	0.825	0.473	< 0.001	0.568
Sense of Being There	2.85 (0.286)	3.05 (0.283)	4.05 (0.286)	4.43 (0.283)	0.961	0.783	< 0.001	0.717
Flow	4.55 (0.208)	4.53 (0.206)	4.53 (0.208)	5.15 (0.206)	1.000	0.156	0.061	0.046
Naturalness of Control	3.00 (0.365)	4.34 (0.363)	3.30 (0.365)	4.89 (0.363)	0.019	0.003	0.089	0.605

Tab. 1 - Gran Turismo. Source: Author's archive

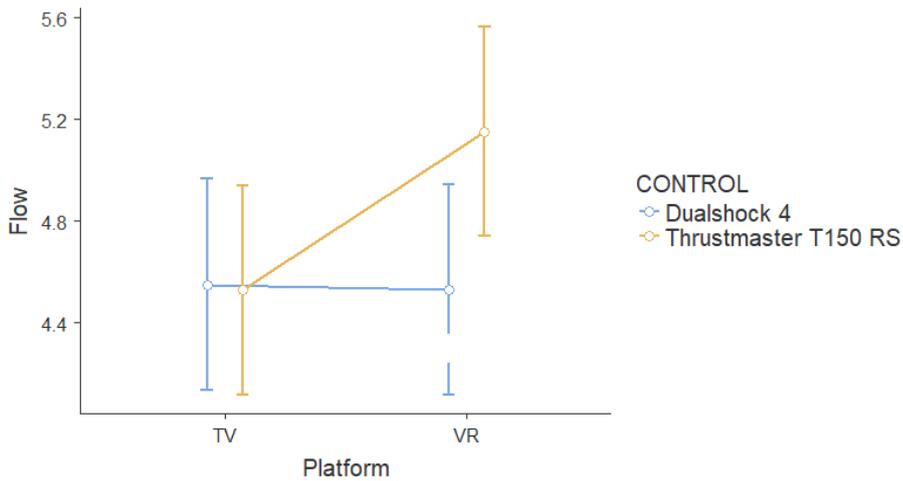


Fig. 1 - Flow. Source: Author's archive

4.2. Comparison of the Effect of Controller Mapping in VR (Directional X Incomplete Tangible)

ANOVA with fixed factor Controller Type was used in the second experiment. The results (see Tab. 2) show that directional natural mapping (DNM; DualShock 4) provided lower values in all monitored variables than incomplete tangible natural mapping (ITNM; PlayStation Move) as we expected. However, the only difference in flow was statistically significant with $p = 0.023$. Other variables' p was from 0.055 to 0.410.

Until Dawn: Rush of Blood			
	DNM Mean (SE)	ITNM Mean (SE)	DNM X ITNM p
Spatial Presence	4.18 (0.123)	4.55 (0.115)	0.055
Sense of Being There	4.25 (0.305)	4.74 (0.284)	0.247
Flow	4.36 (0.191)	4.98 (0.178)	0.023
Naturalness of Control	4.57 (0.240)	4.84 (0.224)	0.410

Tab. 2 - Until Dawn. Source: Author's archive

5. CONCLUSIONS

In congruence with the previous studies, we confirmed the influence of platform on the player's presence and the influence of controller type on perceived naturalness of control. We were not able to fully confirm that different mapping options enhance our presence as the results were not statistically significant. However, there is a clear trend that supports this hypothesis and given the previous evidence, we believe that it would have been confirmed if more respondents had participated. Regarding the primary hypothesis, we were not able to confirm that differences between the directional mapping and realistic tangible mapping are bigger in VR than on TV. Only one measured variable – flow – showed significant platform-controller interaction, while differences in presence and naturalness of control were almost the same on both platforms. This result is surprising given the high conceptual similarity between presence and flow.⁹

⁹ Michailidis, Lazaros - Balaguer-Ballester, Emili - He, Xun. Flow and immersion in video games: The aftermath of a conceptual challenge. *Frontiers in Psychology*, Volume 9, 2018.

In our second experiment, we compared the effect of incomplete tangible mapping and directional mapping in virtual reality, expecting that incomplete tangible mapping will provide a greater sense of presence, flow, and perceived naturalness. Even though all of the measured variables showed higher values with incomplete tangible mapping, only in the case of flow, the difference was statistically significant. We presume that it is a similar situation as in the first experiment: with a larger number of respondents, we would have obtained more convincing data. However, more interesting is the comparison with the previous study by Daniel Shafer that claimed that players perceived the Razer Hydra controller as less natural than the mouse and the keyboard. This could be explained by the game that Shafer used in his experiment, as *Half-Life 2* was not designed for use in VR with motion controllers. On the contrary, the game used in our research – *Until Dawn: Rush of Blood* – was created specifically for VR technology, and it is optimized to provide the best experience with motion controllers. Using a more appropriate game thus provided results that support Steuer's theory of interactivity.

For further research we would like to have a full comparison of incomplete tangible control on both platforms; however, at the time of this experiment, we were not able to get the content on PlayStation 4 that would allow such experiment.

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