Designing the Flow State Experience Using Modern Digital Technologies

Eva Vidmar
Multimedia
Faculty of computer science
University of Ljubljana
Ljubljana, Slovenia
eva.vidmar2@gmail.com

Abstract

This article provides a brief overview of an extended Master's thesis and focuses on the use of modern digital technologies to design a multimedia environment aimed at inducing a state of flow in individuals. Flow is a psychological state characterized by deep immersion in an activity, leading to a loss of sense of time and external worries **[1]**. Exiting this state typically results in feelings of satisfaction and happiness. Achieving flow requires a balance between skills and challenges. Learning to attain this balance can help individuals improve overall, which is a key reason for this research. The main objective is to investigate whether flow can be achieved through the use of color light stimuli in a space that adapts in real-time to an individual's level of attention. This represents a preliminary step toward using technology to design spaces that stimulate individuals and facilitate the quicker and easier attainment of flow. An experiment was conducted to test whether such a space affects individuals' flow. Tetris was chosen as the central activity for the experiment. The findings indicated that color stimuli influenced the participants' physically measured attention, although no significant changes were observed in questionnaire responses or gameplay performance. Given that attention is a crucial factor in achieving flow, it can be partially asserted that participants experienced flow, though more reliable data would be necessary for further conclusions. These findings significantly contribute to the understanding of measuring and achieving flow through technology, representing an important advancement in this field.

Keywords

flow, optimal experience, user experience, digital interface, Tetris

1 Introduction

Historically, flow has been experienced by artists, athletes, and individuals with substantial practice. However, modern life, especially in technology-driven environments, necessitates new approaches to achieve this optimal state. This study investigates how real-time adjustments of ambient lighting, informed by physiological signals, can enhance flow experiences, offering a novel approach that builds on but goes beyond methods such as video games or Virtual Reality (VR). By integrating psychophysiology, user experience, and ambient intelligence, this research aims to leverage technology for meaningful improvements in well-being, productivity, and satisfaction.

Information Society 2024, 7–11 October 2024, Ljubljana, Slovenia

2 Theoretical Background

Inducing a flow state through technology poses complex challenges that require in-depth exploration of the neurocognitive aspects of flow and their relation to contemporary technologies. This understanding informs the design of technological solutions aligned with flow theory.

2.1 A Neurocognitive Perspective on Flow

Flow, characterized by deep focus and immersion, was first described by Mihaly Csikszentmihalyi, often referred to as the "father of flow" [1]. This state occurs when individuals find an appropriate balance between their skills and the challenges they face, allowing them to perform optimally with a sense of effortless control [1]. While initial resistance and sustained motivation are necessary to achieve flow, this state can occur even in unfamiliar tasks, although long-term practice may increase its likelihood [2]. Flow is often illustrated in a two-dimensional graph where it exists at the intersection of appropriate challenge and skill levels [1].

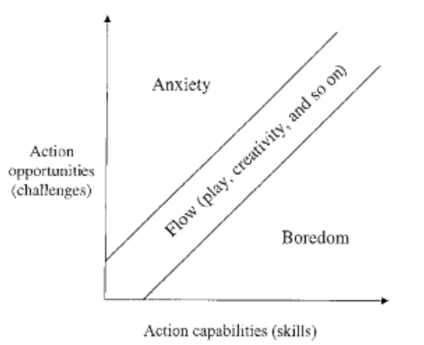

Figure 1: Graph representing occurrence of flow state [1]

Neuroscientific perspectives on flow suggest various underlying mechanisms. The transient hypofrontality hypothesis posits that during flow, activity in the prefrontal cortex decreases, reducing self-criticism and enhancing performance [3]. Alternatively, synchronization theory proposes that flow arises from synchronized activation across different brain regions, optimizing cognitive efficiency [4]. Both theories indicate that flow entails minimal energy expenditure in the brain.

Csikszentmihalyi's model outlines optimal conditions for flow, including clear goals, immediate feedback, and a balance between challenge and skill [1]. The concept of the autotelic personality—marked by intrinsic motivation and enjoyment—may enhance flow experiences but is not strictly essential for achieving it.

2.2 Flow in Technology: State of the Art

Various approaches have emerged to induce flow through technology. Traditionally, video games employed fixed difficulty levels, which often interrupted the flow experience [5]. Dynamic Difficulty Adjustment (DDA) algorithms now allow real-time modification of challenges based on player performance, as seen in games like Left 4 Dead [6], [7, p. 4], Affective computing enhances this by using emotional indicators, such as facial expressions, to fine-tune difficulty levels [6]. Jenova Chen’s game flOw exemplifies the integration of DDA with real-time adjustments to maintain flow [8]. Virtual Reality further immerses players, as evidenced by studies comparing VR to traditional 2D games and applications focused on meditation and relaxation [9], [10], [11]. Augmented Reality and multimedia art also contribute innovative avenues for inducing flow [12], [13].

Figure 2: Refik Anadol 2D projection Machine Hallucinations [12]

Our research identifies the use of ambient lighting as a promising yet under-explored method for inducing flow while engaging participants in a core activity, specifically Tetris. This game, created by Alex Pajitnov in 1985, has been extensively studied for its capacity to induce flow [14]. Players arrange falling blocks to form complete lines, receiving immediate visual feedback—key elements for maintaining flow. Research indicates that even brief sessions of Tetris can lead to flow experiences and reduced negative emotions [15].

2.3 Techniques for Flow State Measurement

Various methods exist to measure brain activity, with electroencephalography (EEG) being the most direct and commonly used. Functional Near-Infrared Spectroscopy (fNIRS) and Functional Magnetic Resonance Imaging (fMRI) provide insights into brain function, while Magnetoencephalography (MEG) offers high resolution of neuronal activity. However, these methods often involve expensive and less accessible equipment.

The MindWave Mobile 2, a consumer-grade EEG device, stands out for its ease of use, making it suitable for educational and entertainment contexts [16]. This device is ideal for our research due to its user-friendly nature, minimizing inconvenience for participants.

Figure 3: Mindwave Mobile 2 [16]

Flow state was traditionally measured through self-reporting instruments, such as the Experience Sampling Method (ESM) developed by Csikszentmihalyi [1]. Various questionnaires, including the Flow State Scale and Game Experience Questionnaire, have been developed to assess flow but rely on retrospective reporting. Alternatively, physiological measures may offer a more objective assessment of flow experiences.

3 Experiment: The Impact of Light on Flow State During Tetris Gameplay

This experiment investigated whether spaces incorporating adaptive technology could enhance user engagement. We compared standard Tetris gameplay to a version featuring color-changing lights that adjusted based on player attention, measured via the MindWave Mobile 2. The goal was to assess whether these technological enhancements positively impacted engagement and performance, specifically exploring if adaptive lighting improved attention, stabilized focus, and led to better gameplay results.

Drawing from Csikszentmihalyi's model, we recognized the importance of differentiating the environment in which flow activities occur. We aimed to create a highly engaging environment by designing a prototype of adaptive lighting for a dimly lit space.

For the experiment, we developed a color-changing light prototype controlled by the MindWave Mobile 2. The device measured brainwave activity during Tetris gameplay. We utilized an Arduino Uno microcontroller to interface with the MindWave Mobile 2 and control a 2-meter AdaFruit NeoPixel LED strip. The light's color adjusted based on attention levels, with red indicating low attention, blue indicating high attention, and white representing optimal focus. This setup aimed to evaluate whether adaptive lighting could influence players' attention and flow during the game.

Figure 4: The setup of light prototype behind laptop

The experiment was designed to compare Tetris performance with and without adaptive lighting. Participants played Tetris under both conditions, and their attention levels, measured via the MindWave Mobile 2, were used to adjust the light's color dynamically. Data on engagement, attention, and gameplay performance were collected and analyzed to determine the effectiveness of the adaptive lighting in enhancing flow.

Figure 5: Scenario of playing Tetris with lights

3.1 Results

Data were collected from the MindWave Mobile 2, which recorded attention and meditation levels during Tetris gameplay with and without adaptive lighting. We filtered data to focus on attention values from 5 minutes of gameplay, excluding values below a threshold of 10 and retaining the 300 most representative data points. A Shapiro-Wilk test confirmed normal distribution for both conditions. A paired t-test revealed significantly higher attention levels during gameplay with lights (p-value = 0.00032). Notably, attention levels were more stabilized with adaptive lighting, as evidenced by a smaller variance in attention scores compared to gameplay without lights.

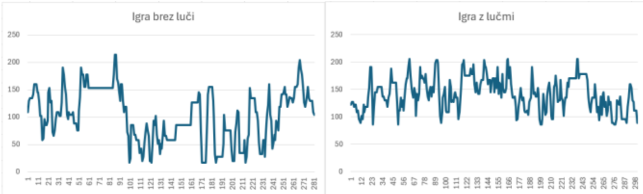

Figure 6: Attention levels of a player during gameplay without lights (left) and with lights (right)

For engagement, while the Shapiro-Wilk test confirmed normality, a paired t-test indicated no significant effect of lighting on engagement (p-value = 0.668). Tetris performance was assessed based on scores, with the group using lights achieving a higher average score (9377) compared to the no-light group (8979), though a Wilcoxon signed-rank test revealed no significant difference (p-value = 0.33).

Qualitative analysis of interviews with 40 participants identified seven key themes related to their experiences with the lighting: awareness of external stimuli, control and feedback, concentration, immersion, motivation, satisfaction, and pressure. Many participants reported feelings of pressure and stress, underscoring the challenges of achieving flow. Nonetheless, the lights were generally perceived as motivating, and some participants noted decreased awareness of their surroundings, aligning with theories regarding transient hypofrontality and reduced default mode network activity during flow [1].

Interestingly, some participants reported not noticing the lights at all, suggesting a potential subconscious influence of flow on their experience. This observation could have affected the questionnaire results. In terms of color perception, red was described as stressful and distracting, while white and blue were regarded as pleasant, showing no significant difference between them.

4 Conclusion

This study explored the potential influence of external factors, specifically technology-based lighting, on the state of flow. While we observed increased attention levels during gameplay with lights, supporting the theoretical premise that flow involves synchronized neural networks related to attention and reward, our hypothesis remains unconfirmed. Qualitative interviews highlighted themes consistent with flow characteristics, such as immersion and motivation; however, the absence of statistically significant effects on engagement and gameplay performance indicates that further research is warranted. Future studies should involve larger, more diverse samples and consider additional metrics to assess flow states more comprehensively.

Overall, our findings offer valuable insights into integrating technology with flow theory, highlighting the potential for developing products that enhance focus and user experience. This research lays the groundwork for future innovations aimed at creating more effective tools for achieving optimal states of concentration and fulfillment in everyday life.

Acknowledgments

The research was conducted in collaboration with psychologist prof. dr. Andreja Avsec, who served as a co-supervisor of the thesis, and prof. dr. Gregor Geršak, an expert in psychophysiology and measurement, who acted as the primary supervisor.

References

[1] M. Csikszentmihalyi, ‘Flow: The Psychology of Optimal Experience’, 1990.
[2] O. de Manzano, T. Theorell, L. Harmat, and F. Ullén, ‘The psychophysiology of flow during piano playing’, *Emot. Wash. DC*, vol. 10, no. 3, pp. 301–311, Jun. 2010, doi: 10.1037/a0018432.
[3] FlowCode - Project Unity, *Transient Hypofrontality - FlowCode Lesson #7 / Flow state training*, (Jun. 26, 2020). Accessed: Nov. 11, 2023. [Online Video]. Available: https://www.youtube.com/watch?v=P5q5l47hGzY
[4] R. Weber, R. Tamborini, and A. Westcott-Baker, ‘Theorizing Flow and Media Enjoyment as Cognitive Synchronization of Attentional and Reward Networks’, *Commun. Theory*, 2009.
[5] S. Khoshnoud, F. Alvarez Igarzábal, and M. Wittmann, ‘Peripheral-physiological and neural correlates of the flow experience while playing video games: a comprehensive review’, *PeerJ*, vol. 8, p. e10520, Dec. 2020, doi: 10.7717/peerj.10520.
[6] M. Zohaib, ‘Dynamic Difficulty Adjustment (DDA) in Computer Games: A Review’, *Adv. Hum.-Comput. Interact.*, vol. 2018, p. e5681652, Nov. 2018, doi: 10.1155/2018/5681652.
[7] ‘Left 4 Dead on Steam’. Accessed: Jan. 13, 2024. [Online]. Available: https://store.steampowered.com/app/500/Left_4_Dead/
[8] ‘flOw’, Jenova Chen. Accessed: Nov. 24, 2023. [Online]. Available: http://jenovachen.info/flow
[9] ‘Virtual Reality and Flow: Discovering the Impact of Virtual Reality on Flow States’. Accessed: Nov. 24, 2023. [Online]. Available: https://www.novobeing.com/blog/virtual-reality-and-flow-exploring-virtual-realitys-impact-on-peak-performance
[10] TGC, ‘Flow’, thatgamecompany. Accessed: Nov. 24, 2023. [Online]. Available: https://thatgamecompany.com/flow/
[11] ‘Cosmic Flow: A Relaxing VR Experience on Meta Quest’, Oculus. Accessed: Jan. 14, 2024. [Online]. Available: https://www.meta.com/experiences/quest/3872076276162726/
[12] ‘Refik Anadol’, Refik Anadol. Accessed: Jan. 15, 2024. [Online]. Available: https://refikanadol.com/
[13] ‘Android Jones’, Android Jones. Accessed: Jan. 15, 2024. [Online]. Available: https://androidjones.com/
[14] D. Lora, A. Sánchez-Ruiz, and P. Gonzalez-Calero, ‘Towards Finding Flow in Tetris’, 2019, pp. 266–280. doi: 10.1007/978-3-030-29249-2_18.
[15] ‘Tetris: It could be the salve for a worried mind’, ScienceDaily. Accessed: Dec. 02, 2023. [Online]. Available: https://www.sciencedaily.com/releases/2018/10/181025084012.htm
[16] ‘MindWave Mobile 2 Quick Start Guide or User Guide / MindWave Mobile 2 / Knowledge Base - NeuroSky - Home Page Support’. Accessed: Mar. 28, 2024. [Online]. Available: http://support.neurosky.com/kb/mindwave-mobile-2/mindwave-mobile-2-quick-start-guide-or-user-guide