ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

IMPACTS OF SENSORY VISUAL EFFECTS ON GAMERS' SPATIAL EXPLORATION BEHAVIOR

M.Sc. THESIS

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ALGISAL GÖRSEL EFEKTLERİN OYUNCULARIN ÇEVRESEL KEŞİF DAVRANIŞLARI ÜZERİNE ETKİLERİ

YÜKSEK LİSANS TEZİ

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Bülent Koray Öz, a M.Sc. student of ITU Graduate School 529191004, successfully defended the thesis entitled **"IMPACTS OF SENSORY VISUAL EFFECTS ON GAMERS' SPATIAL EXPLORATION BEHAVIOUR"**, which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To the gaming community,

FOREWORD

Visual effects are inseparable elements of today's computer games. They bring life to the games. They provide visual realism, and are strong tools to transfer emotions. Visual effects take computer games to another level. Besides, visual effects are a strong medium to communicate with the gamers. Visual effects have been studied for a long time, but there is not enough research about how visual effects are perceived by the players.

This thesis aims to enlighten the game developers' way into more intelligent visual effect designs. It investigates the relation between visual effects and the players. Sensory visual effects have been specifically studied, and their impact on the players' spatial exploration behavior was analyzed.

My dear advisor Prof. Dr. Hatice Köse guided me through all the stages of this thesis. I would like to thank her for all her assistance and understanding. Also, I would like to thank all the participants in the experiment process for their support and time. Lastly, I am grateful to my family who are always there for backing and encouraging me.

June 2022

Bülent Koray ÖZ
Computer Engineer

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ABBREVIATIONS

URL	**:** Uniform Resource Locator
REST	**:** Representational State Transfer
API	**:** Application Programming Interface
JSON	**:** Javascript Object Notation
ID	**:** Identity Number
PMG	**:** Procedural Map Generation
UE	**:** Unreal Engine
GIS	**:** Geographic Information Systems
PCG	**:** Procedural Content Generation
NPR	**:** Non-Photo-Realistic

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IMPACTS OF SENSORY VISUAL EFFECTS ON GAMERS' SPATIAL EXPLORATION BEHAVIOR

SUMMARY

Visual effects are the basic visual elements that build virtual universes and computer games. How a scene will be perceived by the player, which emotions will be triggered, and the general theme of the game can be determined by visual effects. Visual effects have different meanings in computer games than the film and the photography industries. In the film and the photography industry, the manipulations on the camera lens or the visual adjustments made through a computer on the images form visual effects. On the other hand, in the game industry, the entire game environment is created virtually by a computer. Therefore, visual effects in computer games are visual elements with additional features. Visual effects in computer games are classified under 3 classes. Lighting effects are used to illuminate scenes and create shadows. Environmental effects allow real-world natural events to be simulated in the game environment. Finally, sensory effects define how the game environment will be perceived. These effects originate from the structure of the human visual system or camera lenses in the real world. Sensory effects have a great role in the formation of the perception of reality in games. There are two types of reality in games. One is perceptual reality and the other is photo-realistic reality. Perceptual reality is based on the characteristics of the human eye, and the scene is designed so that it can be seen with the human eye in real life. When photo-realistic reality is adopted, the created virtual environment is designed as if it is being watched by a camera. Effects such as blur, vignetting, dirty lens, and flare are sensory effects. Transferring the emotions such as pain and stress experienced by the character in the games to the player and making the player understand the depth in virtual reality games are some of the examples that are implemented thanks to sensory visual effects.

As mentioned above, sensory visual effects are important game elements that determine the mode and convey emotions in games. Although the structures of these visual effects have been studied in detail, the impacts of the effects on the players have not been systematically studied enough. In this thesis, the effects of sensory visual effects on the players are examined. In particular, the unconscious effects of sensory visual effects on the players were investigated. Whether the players are aware of the effects, the recognition of the effects and their effects on decision-making mechanisms are taken as research points.

While investigating the effects of sensory visual effects on the conscious and unconscious decisions of the players, the spatial exploration mechanics in the games were used. When people enter a new environment in real life, they first begin to explore and learn about the environment in its entirety. This exploratory behavior occurs instinctively and reflexively. Exploration mechanics are also used in most computer games. In the examination of unconscious decisions made by the players depending on the visual effects, the help of spatial exploration behavior was taken due to its

reflexive nature. In the developed game, the relationship between sensory visual effects and exploration behavior was investigated.

Two games were developed within the scope of this thesis. Both games are developed using the Unreal Engine game engine. First of all, it was necessary to determine a data collection technique that can be considered as a game, and quantitative data can be collected from the players without interfering with the gameplay. A preliminary study was conducted to identify and test such a technique. The first game was developed within the scope of this preliminary study.

In the second game developed, the impacts of visual effects on the exploration behavior of the players were examined. In this game, an environment consisting of rooms connected to each other by doors has been created. The rooms are designed as a virtual museum. The players were asked to roam freely in this virtual museum, and to examine the works of art and to explore the museum. The artwork images in the museum were taken from the New York Metropolitan Museum. In order to provide the task mechanics for the developed data collection technique, in addition to these physical artworks, digital artworks were added to the museum. The player was asked to identify and collect these digital artworks while visiting the museum. In this way, both the player was encouraged to explore the museum as much as possible and the active interaction of the player in the game was measured. In addition, the game map is created during the game by using the procedural map generation technique so that the player can move freely. In this way, the player's exploration movement is not limited depending on the game map design and unbiased results are obtained.

In this study, 4 perceptual visual effects were selected, namely blur, vignette, chromatic image distortion and noise, to investigate their effects on players. These effects are the effects that are stated to affect the emotions of the players in previous studies and are commonly used in games. The selected effects are assigned to the rooms. The effects of the sensory visual effects are examined while exploring the game environment and doing the given tasks.

During the test, participants first fill out a preliminary questionnaire. Afterwards, the participants were directed to the developed game. All necessary instructions are given on the game screens. No outside input or direction has been made. Participants were asked to play the game for at least 5 minutes. Finally, the participants were asked to fill out a final questionnaire. In the last survey, qualitative data on game experience and effects were collected. In addition to the qualitative data obtained through the questionnaires, quantitative data such as how long they stayed in which affected room and interacted with which artworks in which room during the game were recorded. These quantitative and qualitative results collected after the test were evaluated both among themselves and mutually.

13 people participated in the tests conducted within the scope of this thesis. All of them have successfully completed the testing processes. In the postsurvey, 84.6% of the participants stated that they wanted to play the game again. The game was found to be fun with a rate of 76.9%. In addition, the majority of the participants had no trouble understanding how to play the game. These results show that the developed program is a successful game. When the data obtained as a result of the experiments and surveys are examined, it is seen that the sensory visual effects have different impacts on the players according to the game experiences of the players. When both spatial exploration behavior and in-game interaction were examined for experienced and inexperienced players, contradictory results were obtained. Visual effects have

negatively affected spatial exploration behavior in experienced players. These players spent less time in rooms with visual effects than in rooms without effects. On the other hand, less experienced players have longer visit times in rooms with visual effects than in reference rooms. When the results were analyzed in terms of in-game interaction and success in the game, the opposite result was obtained. While the in-game interaction of players in both groups increased in the effects rooms, experienced players had higher success in the given task. Less experienced players' success decreased significantly in the visual effects rooms. The unconscious effects of the visual effects on the players' decisions were also examined through in-game interaction and spatial exploration behavior data. When the data of the players who stated that they did not see a visual effect in the post-survey was inspected, it was seen that those players also behaved similarly with other players. This shows that players are affected by these effects even if they do not notice or realize that they see visual effects. Conscious use of visual effects when designing game scenes can help to indirectly guide players in a certain way. When the impacts of the effects used in the game were examined, it was seen that the players clearly noticed and recognized the blur, vignette and chromatic chromatic aberration effects. They had difficulty recognizing the noise effect. In contrast, they spent time in rooms with the most noise effects. Blur was the least popular effect, while experienced players showed the worst performance with the vignetting effect.

ALGISAL GÖRSEL EFEKTLERİN OYUNCULARIN MEKANSAL KEŞİF DAVRANIŞLARI ÜZERİNE ETKİLERİ

ÖZET

Görsel efektler sanal evrenleri ve bilgisayar oyunlarını oluşturan temel görsel elementlerdir. Bir sahnenin oyuncu tarafından nasıl algılanacağı, hangi duyguların tetikleneceği ve oyunun genel teması görsel efektlerle belirlenebilir. Görsel efekt kavramı bilgisayar oyunlarında ve film/fotoğraf sektöründe farklı anlamlara sahiptir. Film/fotoğraf sektöründe kamera ile elde edilen görüntülerin üzerinde direkt lense yapılan müdahaleler veya bilgisayar yardımı ile yapılan etkiler görsel efektleri oluşturur. Buna karşılık oyun sektöründe oyun ortamının tamamı bilgisayar ile sanal olarak yaratılır. Dolayısıyla bilgisayar oyunlarında görsel efektlerden kasıt özel anlamları olan görsel oyunlardır. Bilgisayar oyunlarında görsel efektler 3 başlık altında sınıflandırılır. Aydınlatma efektleri sahnelerin aydınlatılması ve gölge oluşumu için kullanılır. Odada ampülden yayılan ışık veya doğada güneş ışınlarının yansıması ile gölge oluşumu bunlara örnek olabilir. Çevresel efektler gerçek dünyadaki doğa olaylarının oyun ortamında simüle edilebilmesini sağlar. Suyun akışı, kar ve yağmur gibi doğa olaylarının simülasyonları çevresel görsel efekt sınıfındadır. Son olarak algısal efekler ise oyun ortamının nasıl algılanacağının tanımlanmasını sağlar. İnsan görme sisteminin yapısından veya gerçek dünyada kamera lenslerinden kaynaklanan efektlerdir. Oyunlarda gerçeklik algısının oluşmasında algısal efektlerin rolü büyüktür. Oyunlarda benimsenen iki tip gerçeklik olgusu vardır. Biri algısal gerçeklik, diğeri foto-realistik gerçekliktir. Algısal gerçeklik insan gözünün özelliklerini temel alır ve sahne, gerçek hayatta insan gözü ile görülebilecek şekilde tasarlanır. Foto-realistik gerçeklik benimsendiğinde ise yaratılan sanal ortam bir kamera ile izleniyormuş gibi tasarlanır. Efektler yerleştirilirken lens efektleri de kullanılır. Blur, vinyet, kirli lens ve parlama gibi efektler algısal efektlerdir. Oyunlarda karakterin yaşadığı acı ve stres gibi duyguları oyuncuya aktarmak ve sanal gerçeklik oyunlarında derinlik algısını oyuncuya hissettirmek algısal görsel efektlerin oyunlara sağladığı etkileşim zenginliklerindendir.

Yukarıda bahsedildiği gibi algısal görsel efektler oyunlarda modu belirleyen ve duygu aktarımını sağlayan önemli oyun unsurlarıdır. Bunun yanında bu görsel efektlerin yapıları detaylı olarak incelenmiş olsa da efektlerin oyuncular üzerindeki etkileri sistematik olarak yeterince incelenmemiştir. Bu tezde algısal görsel efektlerin oyuncular üzerindeki etkileri incelenmiştir. Özellikle algısal görsel efektlerin oyuncular üzerindeki bilinçdışı etkileri araştırılmıştır. Oyuncuların efektlerin farkına varıp varmadığı, efektlerin tanınırlığı ve karar verme mekanizmalarına etkileri araştırma noktaları olarak alınmıştır.

Algısal görsel efektlerin oyuncuların bilinçli ve bilinçdışı kararlarına etkileri araştırılırken oyunlardaki mekansal keşfetme mekaniği kullanılmıştır. Gerçek hayatta canlılar yeni bir ortama girdiği zaman öncelikle ortamı bütünüyle keşfetmeye ve öğrenmeye başlar. Ortamdaki canlı-cansız unsurları ve onların davranışlarını anlamaya çalışır. Bu keşfetme davranışı içgüdüsel ve refleksif olarak gerçekleşir.

Keşfetme mekaniği bilgisayar oyunlarının da çoğunda kullanılır. Oyunların başlarına eğitim seviyeleri yerleştirilir ve oyuncunun oyunun kurallarını kavraması sağlanır. Mekansal keşfetme davranışı ise genel keşfetme davranışı ile aynı doğrultuda, oyuncuların oyun ortamını öğrenmesini kapsamaktadır. Oyuncuların görsel efektlere bağlı olarak verdikleri bilinçdışı kararların incelenmesinde insan doğasından gelen refleksif yapısı sebebiyle mekansal keşfetme davranışından yardım alınmıştır. Geliştirilen oyunda algısal görsel efektlerin keşfetme davranışı ile ilişkisi incelenmiştir.

Bu tez kapsamında 2 tane oyun geliştirilmiştir. Her iki oyun da Unreal Engine oyun motoru kullanılarak geliştirilmiştir. Öncelikle, hem oyun sırasında oyun akışını bozmadan oyunculardan nicel verilerin toplanabileceği hem de oyun olarak kabul edilebilecek bir veri toplama tekniği belirlemek gerekmekteydi. Bu şekilde bir teknik belirlemek ve test etmek için bir ön çalışma yapılmıştır. İlk oyun bu ön çalışma kapsamında geliştirilmiştir. Geliştirilen oyunda her seviye başında oyunculara bir görev verilip görev yapılırken gerekli veriler oyun akışı bölünmeden yazılımsal olarak toplanmaktadır. Ancak görevler hem istenen verilerin üretilmesi sağlanacak şekilde tasarlanmalı hem de oyuncunun toplanan verilerden haberi olmamalıdır. Belirtilen teknik ile hem veri toplama süreci oyunlaştırılmış oluyor hem veriler test akışı bölünmeden toplanmış oluyor hem de veriler yazılımsal olarak toplandığı için insan etkisi minimize edilmiş oluyor. Yapılan ön çalışmada farklı bir çalışmadaki test süreci burada tanımlanan veri toplama tekniği ile tekrarlanmış ve oyun kabul sonuçları incelenmiştir. Ön çalışma sonucuna göre toplanan veriler ile önceki çalışmanın sonuçları örtüşmektedir. Bu durum verilerin doğru toplandığını göstermektedir. Bunun yanında oyun kabul sonuçlarında önemli bir artış görülmüştür. Ön çalışma kapsamında test edilen veri toplama tekniği başarılı olmuştur.

Geliştirilen ikinci oyunda görsel efektlerin, oyuncuların keşfetme davranışı üzerindeki etkileri incelenmiştir. İlk oyunda test edilen teknik kullanılarak veri toplanmıştır. Bu oyunda birbirine kapılar ile bağlı odacıklardan oluşan bir ortam hazırlanmıştır. Odalar mümkün olduğunca sade tasarlanıp, sanal bir müze olarak dizayn edilmiştir. Oyunculardan hem hazırlanan bu sanal müzede serbestce dolaşıp sanat eserlerini incelemeleri hem de müzeyi keşfetmeleri istenmiştir. Müzedeki sanat eseri görselleri New York Metropolitan Müzesi'nden alınmıştır. Müzeden çoğunlukla tablo ve portre görselleri seçilmiştir. Geliştirilen veri toplama tekniğindeki görev mekaniğini sağlamak için ise bu fiziksel sanat eserlerine ek olarak bilgisayar ortamında oluşturulmuş dijital sanat eserleri de müzeye eklenmiştir. Oyuncudan müzeyi gezerken bu dijital sanat eserlerini belirleyip toplaması istenmiştir. Bu sayede hem oyuncu müzeyi olabildiğince fazla keşfetmesi için teşvik edilmiş hem de oyuncunun oyunda ne kadar aktif etkileşimde olduğu ölçülmüştür. Ayrıca oyuncunun serbestçe dolaşabilmesi için oyun haritası prosedural harita üretme tekniği kullanılarak oyun sırasında oluşturulmaktadır. Bu sayede oyuncunun keşfetme hareketi oyun haritası tasarımına bağlı olarak sınırlandırılmamış ve önyargısız sonuçlar elde edilmiştir.

Bu çalışmada oyuncular üzerindeki etkileri araştırılmak için blur, vinyet, kromatik görüntü bozulması ve gürültü olmak üzere 4 tane algısal görsel efekt seçilmiştir. Bu efektler daha önceki çalışmalarda oyuncuların duygularına etki ettiği belirtilen ve oyunlarda yaygın olarak kullanılan efektlerdir. Seçilen efektler, oyun ortamını oluşturan odalara atanmıştır. Oyuncuların oyun ortamını keşfederken ve verilen görevleri yaparken bilinçli ve bilinçdışı olarak aldığı kararlarda bulundukları odalardaki efektlerin etkileri incelenmiştir. Odaların tasarımına bağlı olarak her oda tipinde birbirinden farklı sayıda sanat eseri bulunmaktadır. Seçilen efektler odalara

atanırken her efekt için ortalama olarak aynı sayıda sanat eseri bulunması sağlanmıştır. Kullanılan prosedural harita oluşturma algoritması her oda tipinin kullanılması olasılığı aynı olacak şekilde tasarlanmıştır. Ayrıca sanat eserleri de her yeni oda yaratılışında rastgele şekilde seçilerek yerleştirilmektedir.

Test sırasında katılımcılar öncelikle bir ön anket doldurmaktadır. Bu ön anket ile her katılımcıdan demografik veriye ek olarak görsel sanatlar ve oyun sektörü ile olan yakınlık dereceleri ve oyun oynama deneyimi bilgileri alınmaktadır. Sonrasında katılımcılar geliştirilen oyuna yönlendirilmiştir. Gerekli bütün yönergeler oyun ekranlarından verilmektedir. Dışarıdan bir girdi veya yönlendirme yapılmamıştır. Katılımcılardan en az 5 dakika olmak üzere oyunu oynamaları istenmiştir. İlk 5 dakika sonunda oyun ekranında istedikleri zaman oyunu sonlandırabilecekleri bir buton belirmektedir. Katılımcılar ortalama 10,4 dakika oyunda kalmışlardır. Son olarak katımcılardan bir son anket doldurmaları istenmiştir. Son ankette ise oyun deneyimi ve efektler ile ilgili nitel veriler toplanmıştır. Hem çoktan seçmeli hem de açık uçlu sorular ile oyunun anlaşılır olup olmadığı, eğlenceli olup olmadığı gibi bilgiler alınmıştır. Ayrıca katılımcılara oyun sırasında hiç görsel efekt fark edip etmedikleri sorulmuştur. Görsel efekt fark ettiğini belirten katılımcılardan gördükleri görsel efektleri açıklamaları istenmiş ve çoktan seçmeli sorular ile hangi efektleri gördükleri sorulmuştur. Anketler ile alınan nitel verilere ek olarak oyun sırasında hangi efektli odada ne kadar kaldıkları, hangi odada hangi sanat eserleri ile etkileşime girdikleri gibi nicel veriler kaydedilmiştir. Test sonrası toplanan bu nicel ve nitel sonuçlar hem kendi içlerinde hem de karşılıklı olarak değerlendirilmiştir.

Bu tez kapsamında yapılan testlere 13 kişi katılmıştır. Hepsi test süreçlerini başarıyla tamamlamıştır. 9 katılımcı deneyimsiz, az deneyimli veya orta düzeyde deneyimli bilgisayar oyuncularıdır. Son ankette katılımcıların %84,6'sı oyunu tekrar oynamak istediklerini belirtmişlerdir. %76,9 oran ile oyun eğlenceli bulunmuş. Bunlara ek olarak katılımcıların çoğunluğu oyunun nasıl oynanılacağını anlamakta zorlanmamış. Bu sonuçlar geliştirilen programın başarılı bir oyun olduğunu göstermekte. Yapılan testler ve anketler sonucunda elde edilen veriler incelendiğinde, duyusal görsel efektlerin oyuncular üzerinde oyuncuların sahip olduğu oyun deneyimlerine göre farklı etkileri olduğunu görülmektedir. Deneyimli ve deneyimsiz oyuncular için hem keşif davranışı hem de oyun içi etkileşim incelendiğind birbiriyle zıt sonuçlar elde edilmiştir. Efektlerin, deneyimli oyuncularda mekansal keşif davranışını olumsuz etkilediği görülmüştür. Bu oyuncular görsel efektli odalarda efektsiz odalara göre daha az süre geçirmiştir. Öte yandan, görsel efektli odalarda daha az deneyimli oyuncuların ziyaret süreleri referans odalarına göre daha fazladır. Sonuçlar oyun içi etkileşim ve oyunda başarı açısından incelendiğinde ise tam tersi bir sonuç elde edilmiştir. Her iki gruptaki oyuncuların da oyun içi etkileşimi efektli odalarda artmış olsa da, deneyimli oyuncular verilen görevde daha yüksek başarıya sahipken, daha az deneyimli oyuncuların başarısı görsel efektli odalarda önemli ölçüde azalmıştır. Efektlerin oyuncuların kararlarındaki bilinçdışı etkileri de yine oyun içi etkileşim ve mekansal keşif davranışı verileri üzerinden incelenmiştir. Yapılan son ankette görsel efekt görmediğini belirten oyuncuların, görmediklerini söyledikleri efekt olan odalardaki verileri incelendiğinde o oyuncuların da diğer oyuncularla benzer davranışlarda bulundukları görülmüştür. Bu durum oyuncular görsel efektleri görmese veya gördüğünü fark etmese dahi bu efeklerden etkilendiğini göstermektedir. Oyun sahneleri tasarlanırken efektlerin bilincli kullanımı oyuncuları dolaylı olarak belirli şekilde yönlendirmeye yardımcı olabilir. Oyunda kullanılan efektlerin özel olarak etkileri incelendiğinde ise oyuncuların blur, vinyet ve kromatik renk sapması

efektlerini net bir şekilde fark edip tanıdıkları görüldü. Gürültü efektini ise tanımakta güçlük çektiler. Buna karşılık en çok gürültü efekti olan odalarda vakit geçirdiler. Blur en az sevilen efekt olurken, deneyimli oyuncular en kötü performansı vinyet efektinde gösterdi.

1. INTRODUCTION

The history of computer games starts in the early 1970s with the arcade games. The very first successful example of those games is Pong. It was published by ATARI in 1972. Since then, the computer game industry grew significantly. Nowadays, with the effect of the Covid-19 pandemic, gaming became one of the most popular and reachable entertainment activities, which made this industry grow inevitably. It is estimated that there were 2.7 billion game players worldwide in 2020. Furthermore, the computer gaming industry reached US$ 179.7 billion by an increase of 20 % compared to 2019 [1].

Today, computer game graphics are way beyond their starting point thanks to enhancements in graphics hardware. They increased the realism in games dramatically. Modern graphic cards provide the multi-pass rendering ability which enables computer game programmers to write their shaders and create post processing effects. Post-processing effects brought photorealistic scenes with them. All of these graphical improvements brought virtual and real worlds closer. Gamers also appreciate these advancements. It is stated in Zhang and Hu's work that visual special effects are the main means that attracts the players [2].

Visual effects are an inseparable element of digital visual arts. Visual effects help to provide not only realism but also magical phenomena. It provides perfect tools to mimic natural and environmental elements in virtual worlds that are created in digital art and makes it possible to bend physical world rules to create imaginary realism. Using this tool, artists may trigger different emotions in the audience. The oldest and most well-known examples of visual effects are seen in movie production. In movie production, visual effects enrich the narrative and storytelling [3]. Hasrul also stated that visual effects help to construct a nonlinear narrative and improve intractability. On the other hand, visual effects are adopted by the computer game industry on a whole different level. Visual effects indicate all graphic elements in computer games [4]. They are base game elements to reflect a real or artistically designed world.

With the word real or realism, mostly, its being photo-realistic is meant in the game industry. There are two types of realism in visual arts, perceptual realism and photo-realism. Mostly, the art style and the theme of a game are designed as if the player looks at the virtual world behind a camera lens. Therefore, visual effects are created in order to reflect that kind of realism. One important tool that helps to create such realism is post-processing effects. Post-processing effects are often mentioned as sensory effects. These effects are handled in a separate phase during the normal rendering pipeline. It is an image processing procedure. In addition to image processing, extra information like depth values and normal images are used [5]. These effects can change how the scene is perceived dramatically. Post-processing effects include blur, contrast, color grading, depth-of-field, motion blur, vignette, and many more. Raud explains the photo-realism feature of computer games in his study [6]. He examined the perceived realism in his study. He used lens flare, bloom, noise, grain, and depth of field sensory effects. In one of his experiments, a participant stated about post-processing effects that 'without post-processing effects, the world looks frozen'. Besides, these effects are used to stimulate desired emotions during the game. For example, chromatic aberration and color grading are used to simulate pain, and anxiety is visualized by blur and saturation [7]. Jeong et.al. investigated sensory realism in their paper [8]. They considered both visual and audial cues. They found out that visual sensory realistic effects such as realistic blood color in computer games result in increased aggression in the real world. It is also stated because of this real-world effect of computer games with realistic imagery, some games are rated as *adult games*. Having a deeper understanding of visual effects' emotional and cognitive impacts on the audience/player is necessary and provides game designers with a powerful tool to enrich visual digital arts.

Another important game design element is exploration. When a person enters a new environment, he/she starts trying to understand the environment. Not only its geographic features and location but also all of its elements such as other living beings, culture, and resources are new to that person. The basic instinct here is survival. This learning, experimenting, and understanding process is called spatial exploration. The spatial exploration behavior is also seen in computer games and virtual environments. Basic exploration patterns in both worlds resemble each other. The similarities of real-world and virtual world exploration behavior of people are detaily explained by

Nielsen in his study [9]. On the other hand, he explains that computer games clear out crucial consequences that may occur during exploring the real world. Virtual environments provide a safe space to experiment and explore, fast feedback to take action, and opportunity to alter decisions. By acknowledging mentioned differences, game designers try to interpret these exploration behaviors in order to create better game design patterns. For example, in a study [10], believable AI agents that autonomously explore the environment were proposed. They worked on creating believable exploration algorithms that replicate human behaviors using time utilization, traveling distance, map coverage, and goal achievement as indicators. Another application area of exploration patterns is procedural map generation and specifically, procedural dungeon generation. It is basically an algorithmic game environment generation process. On starting up, a base map is generated. Then, PMG algorithms take user input and generate maps during runtime using randomized processes. These algorithms will be explained in detail in the following sections. In role-playing games, dungeons are the game environments where users wander around and do tasks. Therefore, procedural dungeon generation algorithms are required to yield meaningful maps in order to provide fun games, and applying the learned exploration behaviors to those algorithms brings a big advantage. Most of the current PMG algorithms focus on geometrically map generation and generation of gameplay-related objects whereas a significant portion of the game environment is non-player characters, decorations, lighting, music, and visual effects [11-13].

1.1 Research Questions and Purpose of Thesis

This research has started with a single question: How do visual effects affect players in computer games? Initially, it is aimed to be able to define a set of rules that game designers can use as creating computer games. The rules would direct designers to use visual effects in a more intelligent way. During the research process, visual effects were analyzed first. It was found that post-processing effects are the ones that provide realism, impact emotions, and may change players' decisions consciously or unconsciously. The main purpose was to be able to stir a certain idea or emotion unconsciously. As the research goes deeper, it was seen that the impacts of visual effects on the players are not well-researched areas. Then, exploration behavior during the gameplay started to investigate because it is a natural and instinctual act. Its being

instinctual helped to investigate unconscious decisions made during gameplay and made it possible to detect visual effects' impacts on taken decisions. Also, visual effects and exploration behavior were not researched together before. Additionally, most of the studies found in both post-processing and exploration behavior topics evaluated only qualitatively [6,10,14,15]. In order to detect unconscious decisions, eliminate the human factor and validate both methods with cross-checking, both qualitative and quantitative evaluations were used.

As explained above, the scope of the thesis has evolved during the research process. This project tries to find valid answers to the following research questions.

- How do post-processing visual effects affect spatial exploration behavior during gameplay?
- Do players notice post-processing visual effects?
- Do players recognize post-processing visual effects?
- How does the experience level of the player affect the impact of post-processing visual effects on the player?
- Do post-processing visual effects result in an unconscious decision?
- How do post-processing visual effects change players' interaction during the game?
- How do qualitative and quantitative results relate?

On the other hand, this thesis mainly focuses on the impact of post-processing visual effects. Therefore, it does not specifically intend to find answers to any problems, but it may lead to future research, on the following specific topics.

- Procedural map generation algorithms
- Visual effects other than selected post-processing effects

1.2 Literature Review

As stated before, Yang, Yip, and Xu define visual effects in computer games as all graphic effects. According to their article [16], visual effects are the base elements of computer games that are used in order to implement real or artistic environments, objects, and physical and non-physical phenomena. On the other hand, they stated that

graphic effects used for special purposes are meant by visual effects in computer game production. In the article, technical background is firstly explained, then visual effects in computer games are classified according to their characteristics. Three classes are introduced, global illumination effects, environmental effects, and sensory effects. Example visual effects on these classes with their computation state, flexibility, and computational complexity features are given in Figure 1.1 which is taken from the article.

Table 1. Classification of visual effects and techniques in computer games.

Computation stage	Global illumination effect	Environmental effect	Sensor effect	Flexibility	Computational complexity
Precomputation (offline)	Irradiance, shadow, color bleeding, precomputed radiance transfer (PRT), ambient occlusion (AO), irradiance volume	Skybox	None	Static scene	Scene complexity and level of detail
Object space (real-time)	Shadow, reflection, refraction, AO	Fog, sun shaft, smoke, fire, water, clouds, rain, snow, explosions	Motion blur	Dynamic scene	Scene complexity, level of detail, and screen resolution
Screen space (real time)	Refraction, color bleeding, SSAO, SSDO	Fog, sun shaft, rain, snow, heat distortion	Depth of field, motion blur, bloom, glare, afterimage, tone mapping, color correction, lens distortion, vignetting, chromatic abbreviation, film grain, night vision, thermal vision	Dynamic scene	Screen resolution only

Figure 1.1: Visual effect classification.

Global illumination effects are lighting effects. Lighting features that are constituted from single or multiple complex resources are calculated. Ambient, specular, and diffuse light are the most common lighting features. Environmental effects simulate atmospheric events such as fog, snow, clouds, and explosions. Particle systems are one of the most commonly used tools to implement these effects. Sensory effects result from the characteristics and motion of sensors. These effects simulate the human visual

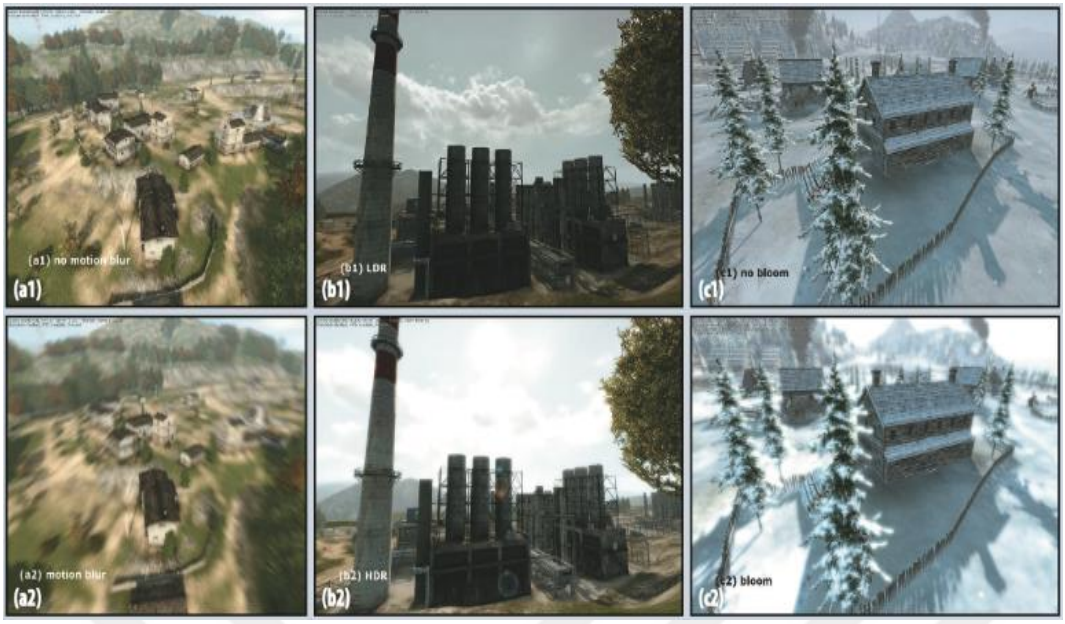

Figure 1.2: Sensory effect examples.

system and cameras. Examples of sensory effects can be seen in Figure 1.2. Also, Yang et.al. state that visual effects increase realism in computer games. Interaction with the player in games is in most cases only provided by visual stimuli. In the absence of other senses, visual effects have great importance in triggering emotion in players. Misztal et.al. conducted a study [17] on 102 games that included 67 visual stimuli. They mentioned that most people process emotions through visual means and they said that they can be used to manipulate the emotions or perceptions of the players in the games. For example, by using visual effects such as blur, color and lighting changes, it is possible to change the gamer's point of view as if it is a cat's view. However, with the right effect design, it has been practiced that a sense of empathy can be developed in serious games in the medical field. As a result of their research, they developed a guiding system in which the meanings of visual stimuli that can be used in computer game design are matched.

Buhler, Misztal, and Schild have worked on VR sickness in their paper [18]. VR sickness is motion-sensitive sickness experienced in a VR environment. It results from conflict between the human vestibular system and experienced virtual movement. Buhler et.al. tried to overcome this sickness using visual effects and stated that either FOV was reduced or unnatural moves were invented in other related studies. They invented two new visual effects whose names are the Dot effect and the Circle effect. These effects can be seen in Figure 1.3.

Figure 1.3: Left: Circle effect, Right: Dot effect.

Their aim is to reduce effective optical flow. The dot effect employs white small dots on the screen and those dots move in the opposite direction which player moves with doubled speed. On the other hand, the Circle effect uses two cameras. One is regular while the other one stands still during the character's navigation. Both images blend on top of each other as the regular one is on top and centered. Both effects are active when the character is moving forward because VR sickness affects the gamer on active movement. As a result, Buhler et.al. found that Circle and Dot effects do not show significant performance differences but a small positive effect. Misztal, Carbonell, Zander, and Schild [7] have strongly emphasized that visual effects were broadly investigated not only in the computer game industry but also movie industry. Otherwise, the impacts of these virtual effects on gamers/audiences were not analyzed as much. It is still not known whether or not these effects have an expected impact on people. In order to understand the impact of visual effects, they have studied vignetting, image noise, chromatic aberration, color grading, and blur. These effects are shown in Figure 1.4.

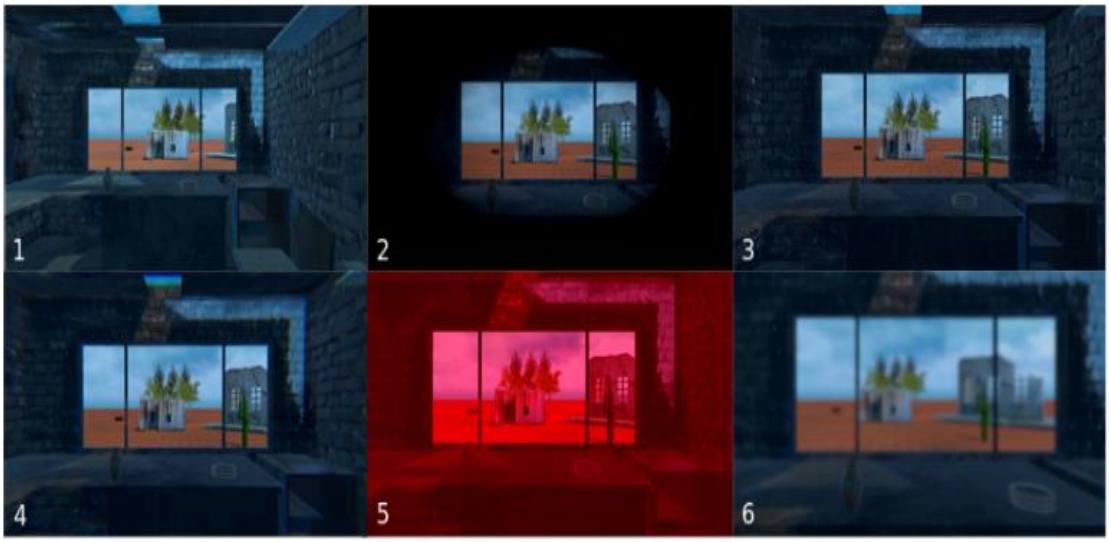

Figure 1.4: Left Top to Right Bottom: no effect, vignette, image noise, chromatic aberration, color grading, blur.

They investigated these effects' effects on stress perception, perceived presence, and simulator sickness. An action game scene is designed to test these effects. Participants experienced the game with no effect in addition to aforementioned 5 effects. Misztal et.al reported that used effects intensified stress perception without negatively affecting perceived presence and without increasing simulator sickness. Cidota et.al. developed a game that is used for the rehabilitation of people with motion disorders. They have tried to increase depth perception using visual effects. Fade and blur effects were used. Cidota et.al. [16] investigated results in both AR and VR environments. They found that AR has negative performance at both effects in comparison with no effect. On the other hand, Fade and blur effects increase test success in a VR environment.

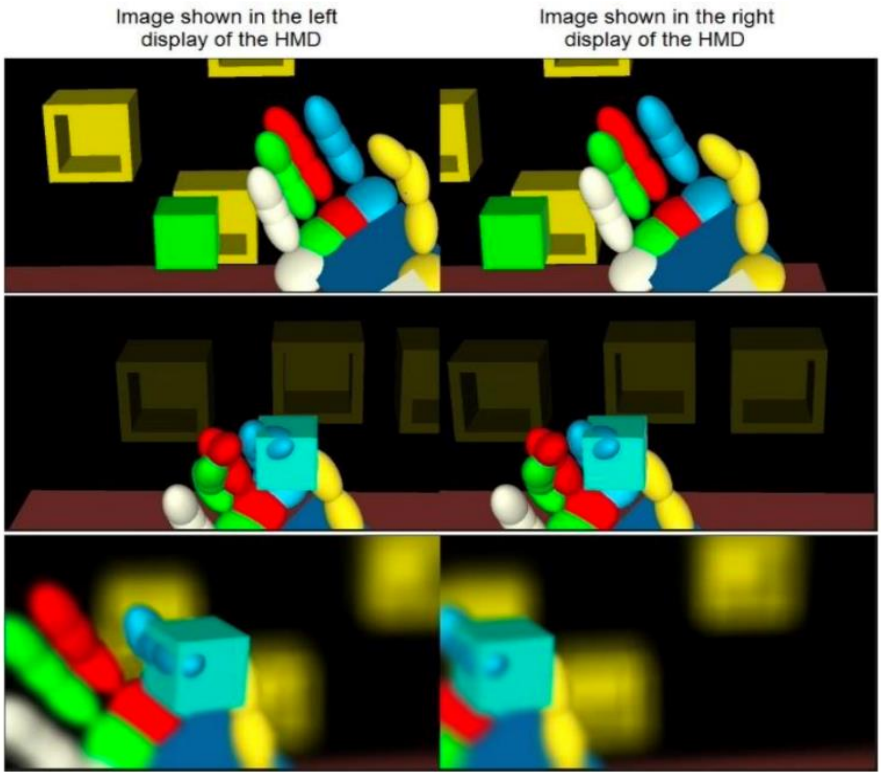

Figure 1.5: Top-Down: no effect, fade, blur.

Sennersten and Craig have studied [19] visual elements' impact on attention in FPS computer games. They emphasized that understanding the cognitive and emotional characteristics of gameplay and visual effects' effects have importance. They started the research with three hypotheses, diagonal cuing, look then shoot and shoot closest first. The first hypothesis says that the diagonal shape and position of the gun directs gamers' attention. The second hypothesis suggests that gamer looks toward enemy before shooting. The third one says the gamer shoots the closest enemy first. They developed an FPS game to investigate these three hypotheses and designed a route. As a result, Sennersten and Craig state second and third hypotheses hold while the first hypotheses do not.

All of the studies introduced so far worked on photorealistic post-processing effects. On the other hand, sensory visual effects are not limited to those effects. Magdics et.al studied on non-photorealistic post-processing effects [20]. They emphasized that modern game engines have ready-to-use plugins in order to implement photorealistic effects, but game designers need to create non-photorealistic effects from scratch. Even though there is less support for NPR effects, their importance is not less than photorealistic ones. Magdics et.al explains their importance by stating that shape and thickness of contour lines of the objects in the scene can trigger different emotions.

Also, lighting and shadows help players to understand scene geometry and depth perception. Apart from lightning and contour lines, colors may set the mood. They exemplify the effect of colors on the mood. Brown and dark blue create a dramatic mood. Green and dark blue can be used for suspense, and orange and red indicate violence. Colors are another significant research area. This topic is widely adopted by game production. For example, Sauvaget et.al emphasizes colors' importance by stating that they should not be chosen randomly [21]. They contain different meanings and may lead to misunderstandings. Also, they stated it is even more important to set the colors on the scene when people with vision problems play the game. Joosten, Lankveld, and Spronck worked on the relation between colors and emotions [22]. They investigated arousal, valence, and dominance values that the colors trigger. They used light blue for surprise, dark green for fear, yellow for joy, and red for anger. They created a map with 5 rooms. Four of them are designed with mentioned colors as ambient light while the remaining room has neutral ambient color. Players started in the first room and are asked to find the key in order to switch to the next room. In between each room, they are asked to select the appropriate options from self-assessment manikin questionnaire. In the end, they state that lighting attaches the player to the game emotionally. Also, they found out arousal results are higher in the red-colored room than in the blue colored room. Geslin, Jegou, and Danny also worked on the relation between colors and emotions [23]. They stated that there is a lot of research on this topic, but there is no agreement on their having positive or negative effects. Besides, it is said that there is a correlation between color, hue, saturation, brightness and arousal, valence, and dominance. Using the correlation, they created a circumflex color model. The model can be seen in Figure 1.6 below. They aim to provide a guide that shows the relation between colors, emotions, and movement speed. It can be inferred from the model that in less saturated environments, valence is low and fear is denser. As the movement speed increases, arousal also increases simultaneously.

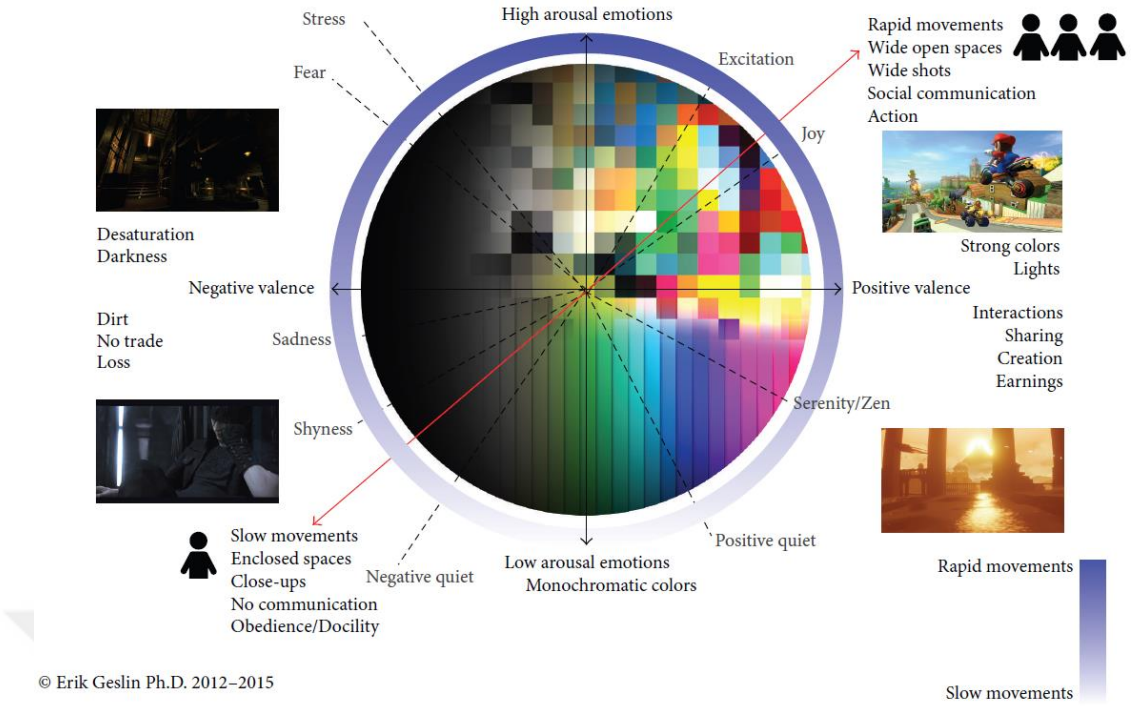

Figure 1.6: Circumplex model for color scripting.

Exploration is an important game mechanic that almost all games include. It is discovery-based activity. It may be in the form of exploring the environment, learning the rules of the game world, or identifying non-player characters. One of the most common types of the exploration mechanic in computer games is spatial exploration. There are games both building the game mechanics on top of spatial exploration and using the spatial exploration supplementary feature. Spatial exploration may include mapping environments, collecting bonus items, and discovering locations. Si et.al tried to understand human exploration behavior in virtual environment in their study [24]. Firstly, they defined the exploration behavior in games. They strongly emphasize that spatial exploration behavior is not researched enough, and the topic is essential in order to design better games. They classified players according to exploration patterns. They defined three factors that typically affect the behavior. The factors are gender, weekly gameplay time, and real-life navigation abilities. During the experiments, they collected both qualitative and quantitative data. By collecting both types of data, their study comes forward with its reliability. As a result, they managed to form for classes. The classes are wanderers, seers, pathers, and targeters. They defined the classes in terms of players' geographic exploration patterns, and they took into account only their map coverage and their sensitivity to geographic elements like high and low areas, walls, and corners. They did not consider other spatial elements like nonplayer

characters, decorations, lighting, visual effects, and sounds. Most of the participants were placed in targeters or seers, but it is also stated that players do not belong to one single class. They may also have minor characteristics. Besides, the characteristics that each player presents change between games. Another factor that Si et.al. investigated was gender. They found correlations between gender and game experience, so there was no clear result on gender effect. There are other studies in-game production literature that works on gender effects. For example, Wauck et.al. also investigated the relation between spatial exploration behaviors and gender [25]. Initially, they analyzed commercial games in terms of spatial exploration mechanics. Then, They created an experiment game that consist of two modes as exploration and construction. As a result, they found out that there are differences in spatial exploration behaviors between genders and pointed out that game designers should take into consideration these differences. They also state that games that require spatial exploration use first-person view.

As stated before, procedural map generation and procedural dungeon generation are popular game content generation topics. Designing a virtual game environment is very delicate. It defines players' game experience. Therefore, applying a sensitive approach to the algorithmic map generation processes is a must. Virtual map designing should also benefit from spatial exploration behavior patterns. Biggs, Fisher, and Nitsche studied wayfinding patterns within algorithmically created game environments [26]. They said that while creating the map, besides how the pieces will be placed, how the players will understand and interact with them is also very important. They measured how much the players are sensitive to placements of the gameplay elements. They merged two different architectural algorithms. They concluded that players are highly sensitive to the placements of the gameplay elements.

Drachen et.al. offers to utilize spatial exploration behavior in another way in their paper [15]. They state that a player's overall experience from a game is highly related to exploration experience in the game. Therefore, they offer to analyze the spatial exploration patterns for user-oriented game testing. It is highlighted in the paper that this type of game analysis is largely unexplored even though its potential. Playtesting, usability testing, ethnographic methods, and surveys are mentioned as broadly used user-oriented game testing methods. The current state of the game user research

methods were investigated by Desurvire et.al. [27]. They listed game testing methods below.

- Think-Aloud
- Rapid Iterative Testing and Evaluation (RITE)
- Heuristics
- Playtesting
- A/B Testing

All of the mentioned methods by Drachen et.al's study and Desurvure et.al.'s study are qualitative methods. On the other hand, using spatial exploration patterns as user-oriented game testing methods provides a quantitative point-of-view.

2. METHODOLOGY

In this section, applied methodology in order to find valid answers to questions that forms this project is going to be described. Firstly, development tools that are used for game and backend application development will be defined. Later, developed games for the preliminary test and main test will be explained in detail. Data collection techniques and applied pre-survey and post-survey will be described after developed games.

2.1 Development Tools

For the testing processes of this project, two computer games and one backend application were developed. Because computer games and server-side backend applications are different platforms, development tools that are required by both platforms differ significantly. The following subsections were formed in a way that explains the tools used in both platforms.

2.1.1 Game Engine Selection

Game engine selection is the foremost step of game development. Computer games consist of different subsystems such as user-interface systems, physics engines, particle systems, rendering engines etc. Implementing all of these required systems from scratch needs too much time and effort. In order to overcome this issue, game engines are heavily used in today's game development processes. While some game studios create their game engine, there are some commonly used game engines. Some of the well-known engines are Unreal Engine, Unity3D, and Cryengine. These engines provide ready-to-use components that developers need to create computer games. In addition to the previously mentioned subsystems, some of these engines also have cross-compile capabilities. The cross-compile capability gives developers a chance to ship their games to different platforms with small changes such as mobile platforms, game consoles, and VR/AR. Another massive advantage of using widely known game

engine is the big community supporting them. The community that is gathered around these game engines helps every developer, from beginner to experienced, while creating their games. Game developers can discuss issues in these community's online and offline channels. With these communities, issues are solved faster and more efficiently. Also, some of the game engines have their online stores. There are ready-to-use components, plug-n-play feature packs, game assets, and much more in those stores. It is possible to find both free and priced items in the stores. Using the stores, it is not required to create everything from scratch.

Each game engine has a subset of the mentioned features and many more, so each game engine has advantages and disadvantages compared one to another. In the scope of this thesis, two of the most used game engines were compared, Unreal Engine and Unity3D.

Table 2.1: Unity and Unreal Engine game engine comparison

	Unity	Unreal Engine
Developed by	Unity Technologies	Epic Games
Programming Languages	C#, Bolt	C++, Blueprint
Graphics	Provides the same features as UE using plugins. Underperforms compared to UE	AAA quality, Post Processing, Material Editor, Physically-Based Rendering, Global Illumination out of the box.
Community	Has 295000 members in subreddit.	Has 165000 members in the subreddit
Platforms	25+ leading platforms	Supports as many platforms like Unity. But Unity is more powerful on mobile platforms.
Learning Curve	Suitable for beginners	Hard to learn

Unique Features	2D, animation	AI, Graphics, Network, Blueprint
Target Users	Indie developers	AAA studios
Asset Store	Has its asset store and marketplace	Has its asset store and marketplace

The above Table 2.1 shows the basic comparison of the two game engines. Even though each engine has its own unique upsides, both of them are widely used in the game production industry. Choosing which one to use is a hard decision and requires use case-specific analysis. Both engines have a strong community, multi-platform support, rich documentation, and asset store. Unreal Engine is the best in terms of graphics. It is preferred by AAA studios. Several AAA games have been developed with UE. It has built-in networking and visual scripting support. Unity provides these features with 3rd party plugins. On the other hand, Unity has better performance on mobile platforms. Unity has been supporting AR and VR for a longer time, so it is a more robust system in that area. Also, it has a bigger community, and it is dominating the indie gaming industry.

By accounting for all of the two game engines' advantages and disadvantages, Unreal Engine has been chosen for this thesis. This thesis mainly focuses on visual effects. Therefore, UE's being the best at computer graphics was an important factor. In addition to its advanced graphics and visual effect tools, UE marketplace has more high-resolution ready-to-use assets. Also, UE provides great visual scripting functionality via Blueprints. Blueprints have shortened the developing process significantly.

2.1.2 Backend App

In this project, one backend application was developed. It is used in order to remotely gather and save players' gameplay data such as total playtime. Details about the collected data will be given in *Collected Data* section under *Developed Test Game* section. How and where the application is used and it is data flow will be explained in

Data Collection section. Used technologies in the backend application will be described in the following subsections.

2.1.2.1 Golang

Golang is a programming language. The backend application was implemented using Golang. It was created in 2007 by Robert Griesemer, Rob Pike, and Ken Thompson as an internal Google project. Since it is published publicly, it has been adopted by the technology world. It is widely used by today's leading technology companies such as Google, Twitter, Meta, Netflix, and many more. It is used in cloud and network services, command-line interfaces, web development, development operations, and site reliability [28]. Because of its high adoption rate, a strong community has formed around the language.

2.1.2.2 Postgresql

Postgresql [29] is an open-source relational database management system. It is being developed for more than 30 years. It has a strong open-source community. It runs on all major operating systems and can be extended with several plugins. In addition to its being robust, easy to use, fault-tolerant, and scalable architecture, it can be enhanced with custom data types and functions.

In this project, Postgresql is used in order to keep experiment data. The information that is sent to the backend application through REST API is kept in the Postgresql database.

2.1.3 Plugin and Packages

2.1.3.1 Procedural Level Generator

Procedural Level Generator is an Unreal Engine package. It is an implementation of procedural map generation algorithm. It is the foundation of the random map generation feature of the proposed game. How the algorithm works and how it is used in this project will be explained in the following sections. The package includes code pieces, example maps, levels, and a detailed documentation. It has 3 important components: world generator, door generator, and levels. Its generator components are customizable via parameters without diving into code. The package is reachable on Unreal Engine Marketplace [30].

2.1.3.2 Art, Fashion, Automotive Galleries, and Showcases

This is another Unreal Engine package available on Unreal Engine Marketplace. It is a rich collection of assets, maps, materials, and textures that helps to create a showcase and gallery environment. It has 134 meshes and high-quality texture sets. Also, there are realistic postprocessing volume assets. One can easily create a photorealistic gallery atmosphere using these ready-to-use assets. In this project, collectible objects' materials and static environment objects are created using this package [31].

2.1.3.3 VaREST

VaRest a well-known Unreal Engine editor plugin. It helps to manage server-side communications. It provides modules in order to handle REST queries. The package also provides JSON object handling. It does not require any C++ code. All of the query management including creating request body and headers and handling responses is done via blueprints. An example HTTP request is given in Figure 2.1 [32].

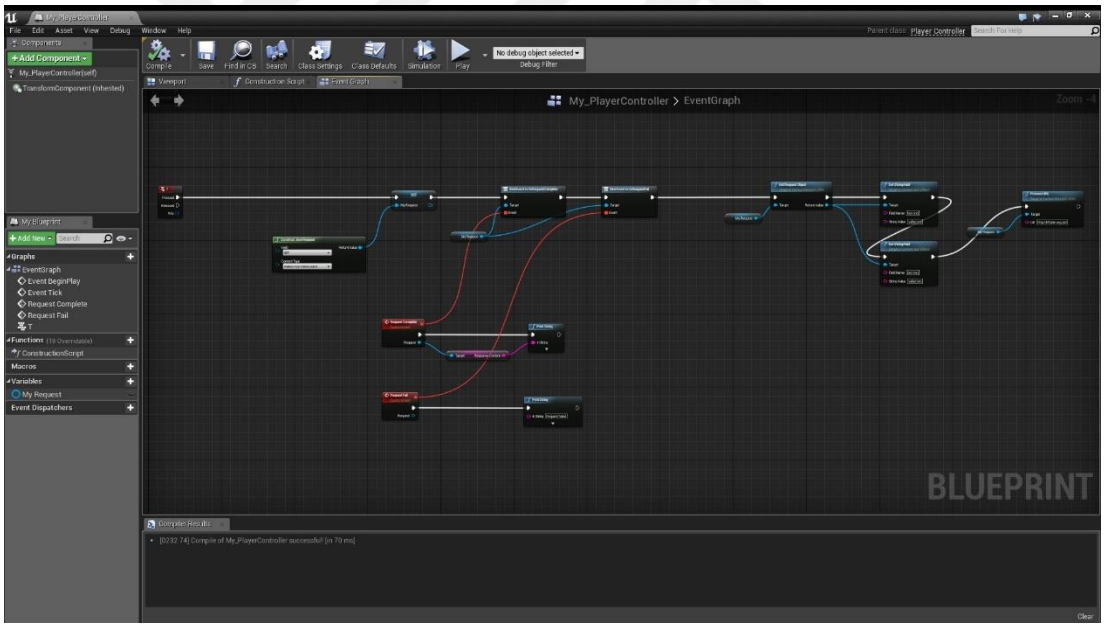

Figure 2.1: An example image of a visual scripting with VaRest plugin on Unreal Engine.

2.1.3.4 Chi

Chi is the only major plugin/package used in this project for backend development. It is a router package for building Go HTTP services. It is licensed under MIT License, so it is a fully open-source package. Chi project's main purpose is to create a neat

solution to create REST API servers. It is robust, lightweight, fast, and maintainable. It is also highly customizable with middlewares [33].

2.2 Preliminary Work

This thesis mainly aims to explore visual effects' conscious and unconscious impacts on the players in computer games. To be able to measure their impact, it is needed to develop a technique that includes gamification elements and helps to collect conscious and unconscious action data. This preliminary study aimed to define and validate such a technique. The designed game in order to collect such data uses a quest mechanic. Players are given a task at the beginning of each level. The tasks are designed in a way that players' actions produce the needed data while they are doing the task. The main purpose remains hidden. Players play the game without knowing the hidden purpose. Therefore, needed unconscious data will be collected without any bias. Then, conscious data will be collected via questionnaires.

To validate the explained technique, Hirai and Kaoru's studies [34,35] will be used. The aim of the first project [34] is to generate a visual effect dictionary in order to be able to express a word visually. They tried to form a relation between object - word(adjective) - visual effect. They used commonsense knowledge as a base and combined it with Natural Language Processing techniques. For the experiment, glowing, disturbed, moisture, dynamic, and floating visual effects were created and they were applied on to fruit, warm food, cold food, car, and ball objects. As a result of the experiment, they expected to form the relation such that an image of a word can be correctly represented by a visual effect and an object. During the experiment, each participant watched total of 76 videos then, answered 122 questions by selecting one "can recall", "can somewhat recall", "do not know", "cannot very much recall" and "cannot recall". In the succeeding study [35], a game was developed to enhance the experiment procedure by Hirai and Sumi. Firstly, the participant is asked to verify the object image if it is proper and recall the noun at a game level. After the participant's verification, an object image with a visual effect is shown and participant is asked if the effect recalls the adjective. The more answers overlap with commonsense knowledge the more participant earns attack points and kills the enemy. In the experiment, each participant played the game 3 times. In terms of creating object - word(adjective) - visual effect relation and dictionary, results were overlapping with

the first study's results. The first study [34] has found some strong relations such as the delicious apple-glowing effect, warm food-steam effect, and new object-glowing effect. Same as the first study, the second study resulted in some strong object-effect relations such as delicious dish-spicy effect, delicious dessert-powder effect, and delicious fruit-shiny effect. On the contrary, most of the participants found the game "hard to use" by 67.5%.

2.2.1 Game Details

The developed game in the previous study [34] was criticized as being not understandable. Participants stated that game mechanics were set too complex in order to be able to represent common sense knowledge during the game. Also, the implementation style of visual effects made them hard to identify. Therefore, a new data collection game is developed by redesigning gamification elements and visual effects. At the same time, the outputs of the game are kept unchanged because the main focus is to evaluate gamification success.

2.2.1.1 Gamification Elements

In the previous game [34], a 2D environment is used and the camera point of view is designed as if a platform game. As can be seen in the Figure 2.2, the player character and the enemy are in the top one-third area.

Figure 2.2: Question screens of the game from the previous study.

Larger portion of the screen is reserved for the question and answer buttons. This layout may lead players not to be able to make connections between game mechanics. Also, one of the participants said that the attack mechanic is not understandable.

In this study, the main difference between the game developed and the previous one is adopting 3D environment. The game is developed in 3D environment using Unreal

Engine, and the game is designed in first-person view. The Player's presence is aimed to increase. Also, the Question and Answer mechanic was removed and replaced with picking. At each level, the player is asked to pick some objects that are matching with a description. For example, "Collect delicious fruits". The player starts going around the scene and collects fruits that look delicious to them. At the beginning of the game, the purpose of the game is explained with text, then the quest of each level is given to the player at the start. After the player starts to the level, there is not any text on the screen that can distract player. The player can freely go around the scene and do the given quest. In addition to picking, quest, and level mechanics, point and time mechanics are added to the game. For each level, the player has 100 seconds to finish the task. Objects have unique points that are calculated according to commonsense. If the object-adjective-visual effect relation is matching with commonsense, the object has higher point. When the player finishes the given task, the level's point is calculated using the collected objects' total points and remaining time. In Figure 2.3, Figure 2.4 and Figure 2.5, scenes from gameplay can be seen. Using these gamification elements, player's understanding of the game mechanics, presence perception and attention time is aimed to increase.

Figure 2.3: Preliminary game introduction screen.

Figure 2.4: Preliminary game level explanation screen.

Figure 2.5: Preliminary game gameplay screen.

2.2.1.2 Effects

As the game is developed in a 3D environment, objects and effects are also designed in 3D. Same as previous game, steam, shiny, spicy and powder visual effects are implemented. While Figure 2.6 shows the effects and Figure 2.7 shows a scene with effect applied object that were implemented in the previous game, Figure 2.8 shows new effects and objects.

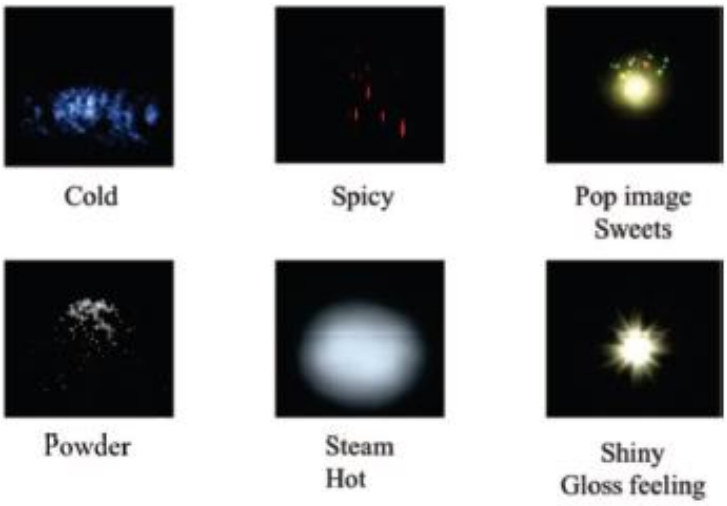

Figure 2.6: Visual effects from the previous game.

Figure 2.7: Game scenes with objects and effects from the previous game.

Base design of the effects are kept same as much as possible on purpose because the image that is used in the original study for created dictionary is aimed to keep unchanged.

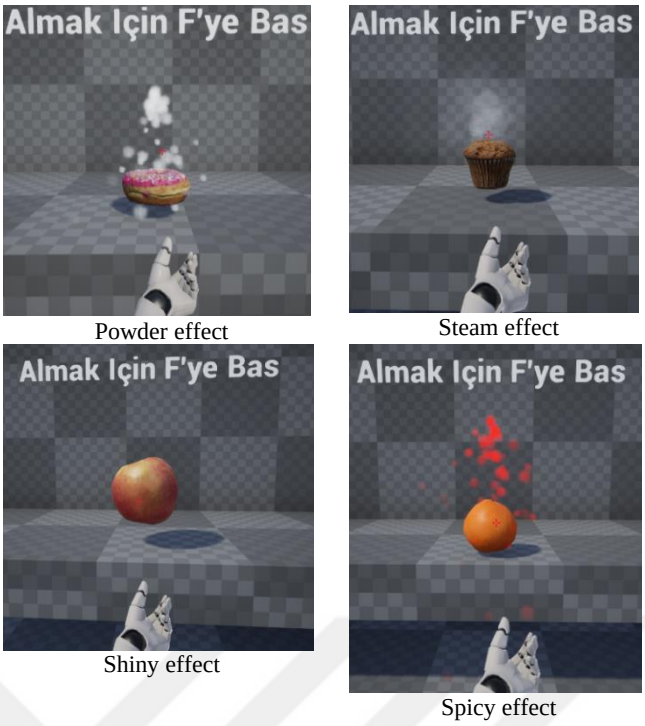

Figure 2.8: Designed visual effects and object examples from developed game.

2.2.2 Results and Analysis

An experiment is conducted with 6 people. All explanation and instructions about the game is given by the game itself using on screen texts. Any extra explanation is not given to the participants before starting to play. Each person firstly played the game ones. Then, a questionnaire is conducted in order to investigate participants' motivations.

- Did you have any visual effects that properly represented "delicious"?
- Do you want to play the game again?
- Was the game setting interesting?
- Was the game easy to use?
- What kind of functions would make this system more interesting?
- How often do you play computer game?

Participants answered the questions in 5-point scale. Except the last question, questions are taken from the previous study. Last question is added to investigate the relation between understanding gameplay and game experience. Also, while players are playing the game collected objects at each level and remaining time is collected automatically.

2.2.2.1 Object-Adjective-Visual Effect Relation Results

The game is constituted of 3 levels. At each level, player collects delicious objects of fruits, vegetables and bakery, respectively. Each level has 4 different objects of given class. For example, first level has apple, mandarin, pear and avocado. The object and effect combinations that overlays with commonsense have 5 point. Others have 0 point. Each participant played each level ones. In the first and second levels, strong relation between fruit and shiny effect and vegetable and shiny effect formed. In the third level, both powder and steam effects have 4.3 average point.

As a result, strong relation between objects and visual effects for delicious adjective formed. By 4,5 average, fruit-shiny effect has strongest relation. For the bakery objects, both powder and steam effect have 4.3 average and lastly vegetable and shiny effect has 4 average. As it can be seen from the resulting averages, relations with high importance are found.

2.2.2.2 Game Acceptance Performance Results

At the end of the experiment, each participant asked the questions given in the beginning of this section. First 5 questions were directly taken from the previous work in order to provide same scaling to measure performance of the game. Last question was added to questionnaire to be able to understand how experienced gamers' opinions differ from the less or not experienced ones. 3 of the participants answered the last question as "never" while 1 answered "sometimes" and other two participants answered as always. This shows that majority of the participants are not experienced gamer. "Was the game setting interesting?" and "Was the game easy to use?" are other important questions for this research. By 66,6% of the participants answered "Agree" the first one and except 2 unexperienced participants, everybody answered second question as "strongly agree". Those two unexperienced participants also answered as "agree". On the other hand, all participants finished the last 2 levels a way faster than first one by 25 seconds difference. The completion times also shows that the game is easy to learn.

2.2.2.3 Analysis

In this pre-work, a data collection game developed. By analyzing the obtained results, it can be said that a promising data collection technique has developed. Firstly, all of

the participants answered the question “Do you want to play the game again?” as agree or strongly agree. Also, it was stated that the game is easy to learn. These results show the game has better game acceptance performance than the original one. In terms of the Object-Adjective-Visual Effect relation results, the game was successful, too. Strong relations found with the rates 4 out of 5 and above. These results correlate with the original game’s results. Success in both game acceptance and forming object-adjective-visual effect relations shows that the proposed data collection technique has better performance.

2.3 Proposed Test Game: Rooms

2.3.1 Game Design

Rooms is a discovery game. It is a standalone PC game. It has first person view and it is designed as a virtual museum. Art pieces taken from the Metropolitan Museum of Art are showed in this virtual museum. The art pieces are mostly paintings. There are also several pieces that are photographs of physical works such as statues and architect-designed furnitures. In addition to these art pieces, digital art works are presented in this virtual museum. On the Figure 2.9, there are one example for each artwork type. The game consists of rooms. The game starts in a room. Players need to go around the museum, see the art pieces and explore the environment. As the player explore further, the museum expands continuously. It is an infinite museum. At the beginning of the game, players are told that they should go around the museum and pick the digital art works. There is also a hidden aim of the game.

Figure 2.9: Left: Painting collectible object example. Right: Digital art collectible object example.

Each room in the game is applied different sensory virtual effect. The players are not informed about the virtual effects before they play the game. While they play the game their all actions and interactions with the game objects are logged. According to their actions, it is aimed to interpret effects of the virtual effects on discovery behavior of the player. Total play time, collected objects, their locations and many more are logged. Four different sensory virtual effects are matched with room types. Whole game map is build with the combination of this room-effect matchings. Each time the game is played, the game map is created dynamically and randomly; therefore, each player plays in different map. The collectible objects are also placed dynamically. The dynamic and random creation of the game map provides unbiased environment. Map creation algorithm, used effects, room-effect matchings, room selection, collectible object selections and collected data will be explained in detail in following sections.

2.3.2 Gameplay Flow

The game has three levels. First and last levels are informative levels while the second level is where main gameplay and interaction is on. Details of these levels will be given in the following section.

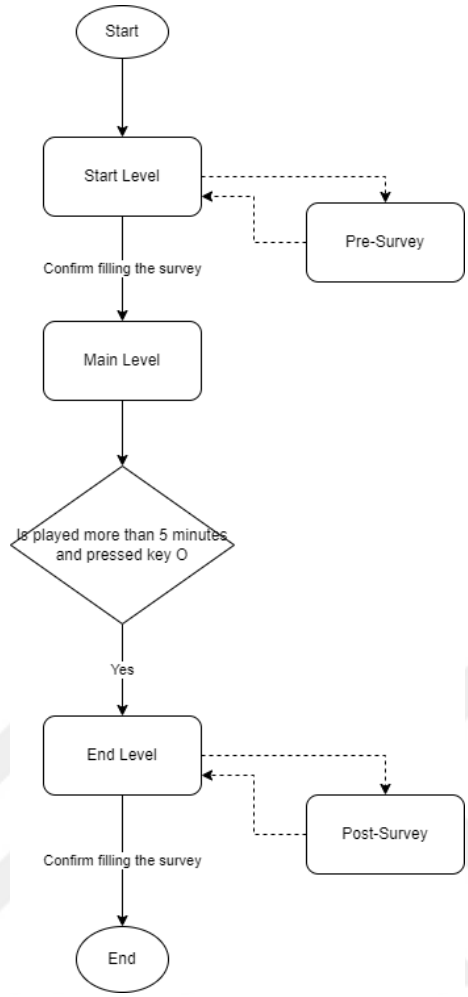

Figure 2.10: The game room's gameplay flowchart.

Figure 2.10 shows the gameplay flow. Start Level welcomes the player. It asks them to fill the presurvey. When they approve that they finished the presurvey by clicking to the start button, game switches to Main Level. After a quick loading sequence, player character is spawned and game starts. The game must be played at least 5 minutes. When 5 minutes passes, player may end game by pressing to key O on keyboard, or continue playing as long as they want. End Level also asks player to fill the postsurvey. The game ends just after players approve filling the survey.

2.3.3 Levels

2.3.3.1 Start Level

Start level is the initial level of the game. It is a fully informative level. There is not any gameplay element. There are a short introduction to game and a start button. This level directs the participant to pre survey and makes sure that he/she has completed the survey. Also, game id is written on this screen. Game id value is used to match

game data with surveys and provides anonymity. How the level look is shown on the Figure 2.11.

Figure 2.11: A screenshot from the Start level.

2.3.3.2 Main Level

The main level is where all game play elements are on. Firstly, a loading screen is brought up during generating the initial map after switching to this level. When the initial map is created, the game starts and main screen layout appears. On this layout, there is a time counter on the upper left corner. Once the counter hits to zero, a text appears that informs the player about finishing the game. The gameplay flow and map creation procedures are explained in their own sections. Different screen layouts in this level are shown on Figure 2.12.

Figure 2.12: Example layouts from Main Scene.

Main level is where dynamic game map is generated as mentioned before. In addition to this, Other dynamically generated gameplay elements and produced data are created in this level. Following actions are handled in this level:

- Procedural Map Generation
- Creating painting and digital art materials,
- Randomly picking created materials and placing them to collectible canvases,
- Placing effects to created rooms,
- Time calculation,
- Score calculation,
- Player action logging.

Player action logging refers to collected numeric data during gameplay. The data collection will be explained in *Collected Features During Gameplay* section in detail.

2.3.3.3 End Level

End level is an informative level like start level. Both of the levels' designs look similar. It shows total score and game id. Thanking message to the participant is also shared there. End level reminds participant to fill post survey. Layout of this level can be seen on Figure 2.13.

Figure 2.13: A screenshot from End Level.

2.3.4 Environment

2.3.5 Collectible Objects

The game contains two different type of collectible objects. The game's gamification element was built on top of these objects. As explained in *Game Design* section, Players are required to differentiate objects according to their object type; therefore, the items should be similar enough to challenge players while avoiding confusing them too much. To be able to provide needed behavior, paintings and digital arts were selected as object types. How and where the objects were picked will be explained in following subsections.

2.3.5.1 Paintings

Painting is the first object type used in the game. By painting, art pieces that are created using paint and brush on a canvas were meant at the beginning. Because the map is planned to be endless, a large number of paintings was needed. Selecting all paintings one by one would take too much time. Therefore, initial intention was to find some

kind of database, folder with bunch of paintings or a service. It was found that there are some web services that provides images of different paintings through a REST API. Harvard Art Museum, the Metropolitan Museum of Art and The Art Institute of Chicago are some of the museums that have such service. Also, Artsy API, deviantArt API and Behance API are independent online service examples. Artists from all over the world can upload their own art pieces to those platforms and sell them. These API's help third-party developers to get images from the platforms and develop their own services.

After a comparison process, the Metropolitan Museum of Art's web service is decided to use for this project. It was the easiest to use and the most comprehensive with its filters. Retrieving images from the web service is two step process. Firstly, image identification numbers are gathered from page at "https://collectionapi.metmuseum.org/public/collection/v1/search" with *"painting"* and *"hasImage*" filters. Then, image information that also includes image URL is fetched from the page at "https://collectionapi.metmuseum.org/public/collection/v1/objects" using image ID's. The first query gathers all image IDs that matches with given filters, and the second query is needed to send for each image individually.

At the first version of the game, images was not stored statically. All of the images was downloaded and created during initialization process between Start Level and Main Level. This downloading process requires one query for retrieving all image Ids and one query for each image. Because of queries' response time, texture and material creation time, game initialization duration grew exponentially with increasing painting time. Initialization durations with used image counts are given on below Table 2.2. 18 minutes for around 300 images was not acceptable. Therefore, another solution was found. All images fetched and saved in advance using small scripts written in Golang and Python. Then, these images were transferred to Unreal Engine and corresponding textures were created. During the game initialization only dynamic material generation remained. With this change, initialization duration was reduced to a couple seconds. The downside of this solution was increasing game size. It increased to 5 GB.

Table 2.2: Game initialization durations for different number of images.

# of Images	Initialization Duration
20	23.75 seconds
50	1 minute 33.73 seconds
100	4 minutes 59.46 seconds
295	18 minutes

At the final version of the game, 293 images labeled as painting. These images consist of mostly paintings as described at the beginning of this section. Also, there are hand-drawn illustrations and photographs of different 3-dimensional art pieces such as architect-designed furnitures. An example for these exceptional images is shown belove Figure 2.14.

Figure 2.14: An example to exceptional painting objects.

2.3.5.2 Digital Arts

Digital arts are artistic products that are created using computers or other digital media. While choosing the digital art pieces, it was important to not to confuse the player too much and make them focus to images more than they focus environment. Because main and hidden objective of the game was to make players discover the environment. They should go around easily, and experience the atmosphere and effects. Thus, digital

art images were selected in a way that they stand out as digital easily. Firstly, a web service was also tried to find for digital arts. But, there was not needed for a web service to find digital arts because only 20 digital art images were used in the game. On the other hand, these images require individual attention to make sure they are good fit for the game. These images were picked from Deviant Art online art platform one by one. The list of the links for the digital art image is given in APPENDIX A.1.

2.3.6 Effects

This project focuses on sensory visual effects. They are also called postprocessing effects. There are lots of postprocessing effects that are used in game production. Vignette, chromatic aberration, image noise(grain), color grading, depth of field, motion blur and bloom are the ones that are found during literature reviews. In the Mitzal and friends' work [7] vignette, chromatic aberration, color grading, noise and blur were investigated in terms of their relation with stress perception. Also, they are the most used postprocessing effects in computer games. Because of their importance in game production, this project limits its scope with these five effects.

In the early versions of this project, the specified five effects have been implemented. Before finalizing the developed game and starting to experiments, a small preliminary trial has been done. In this trial, 3 people played the game. Purpose of this trial is to determine minimum time limit and test if the implemented effects are visible enough. The time part will be explained in following sections. During the development processes, there were unstructured comments that stated noise effect was not noticable. Because of these comments, a small trial has conducted in order to optimize effect designs. As a result of the trials, intensities of blur and noise effects were increased. Also, color grading was removed from the project. Color grading noticed by all 3 participants, but it was realized as darkness. This perception resulted from the environment design. As it can be seen on the Figure 2.15 below, the environment is indoor and designed like space station. General design elements impacted the perception of the color grading effect. Later, it was found out color grading is the one that is the most sensitive to surroundings.

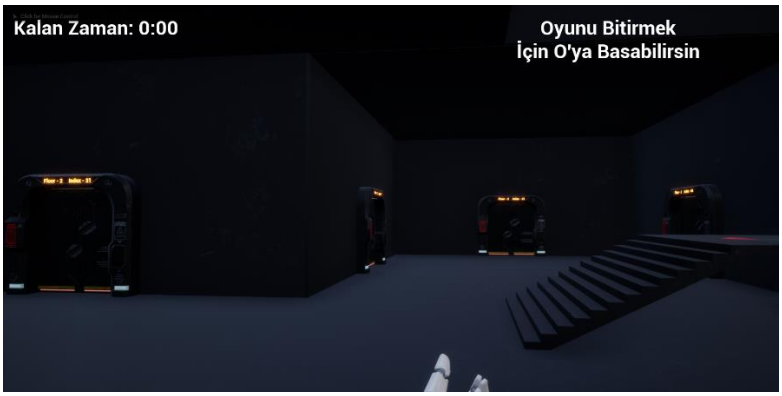

Figure 2.15: Indoor game environment design.

2.3.6.1 Chromatic Aberration

Chromatic aberration originally is an optical effect. It is seen on photographs and movies.It is caused by lens dispersion and occurs when used lens cannot make all wavelengths of the incoming light focus to the same position on focal plane. As a result of chromatic aberration, bending of colors around the edges of the objects where there is dark-white transition is created.

In computer game production, designers use this effect to create photorealism to the game. There is not any other meaning or known impact on the player. Also, there is not any consensus in the gaming community about this effect. Its being under researched also make this effect a good candidate for this thesis.

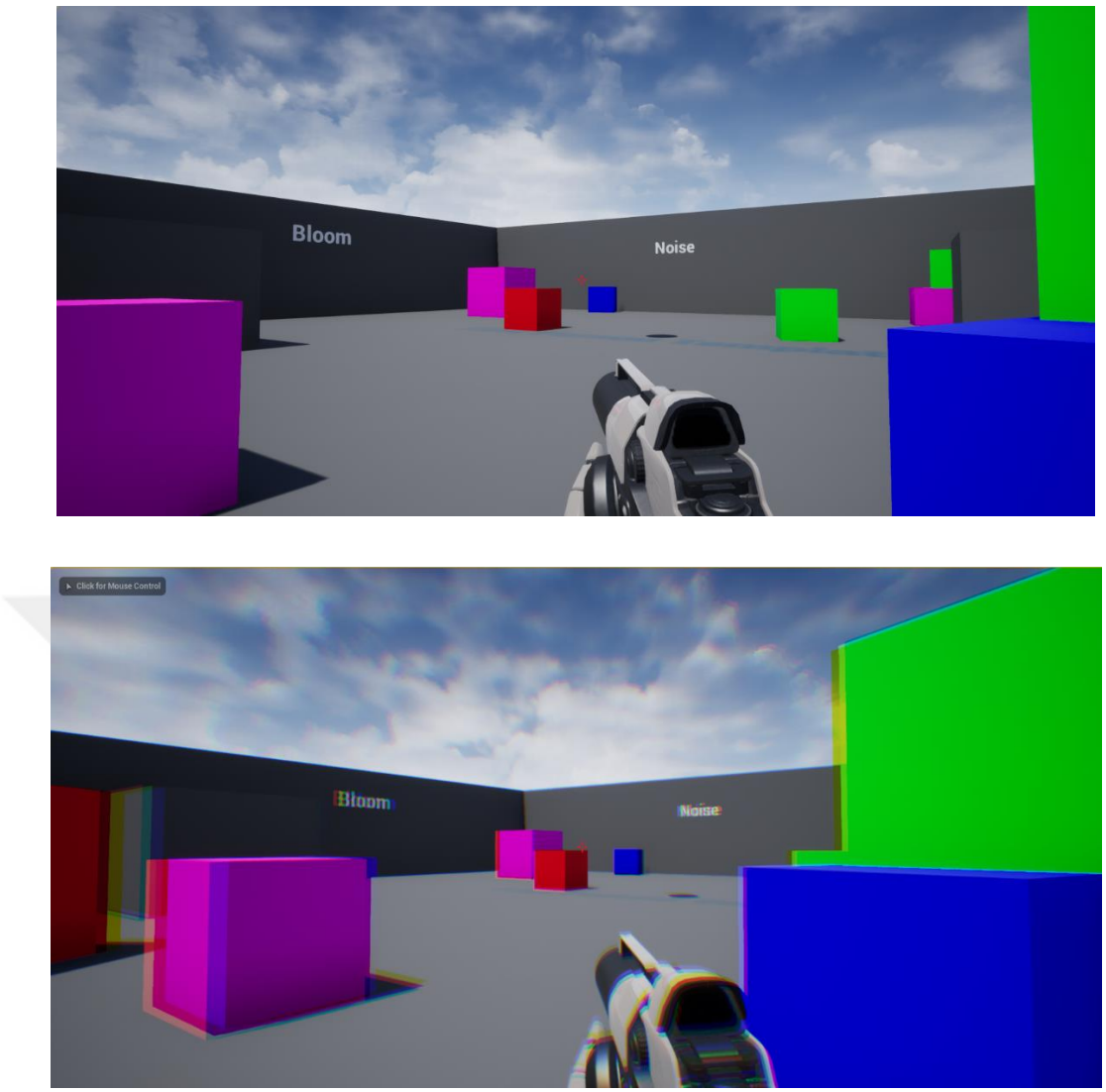

Figure 2.16: Top: A game scene that chromatic aberration effect is off. Bottom: A game scene with chromatic aberration effect.

On the Figure 2.16, two images from the game when chromatic aberration is on and off are given. It is visible that there is light diffraction around the boxes. Also, used post-processing volume settings in order to implement chromatic aberration can be seen on Figure 2.17.

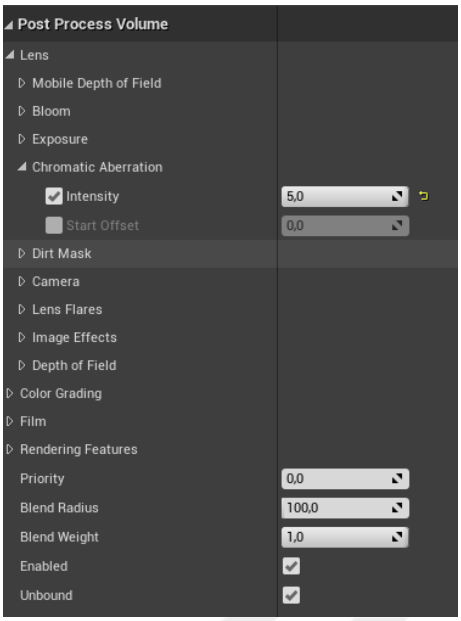

Figure 2.17: Chromatic aberration effect's implementation settings.

2.3.6.2 Blur

Blur is an effect that results from depth of field. Blur is applied to the objects according to their distance to the focal plane. It is used to draw players' attention to a specific place or object. Also, because of using a pinhole camera system, all game objects seem with sharp details. With this all-sharp image, players would not have a cue about the depth of the objects. The blur effect is used in order to eliminate this side effect of pinhole camera systems [36]. Used depth of field settings can be seen in Figure 2.18.

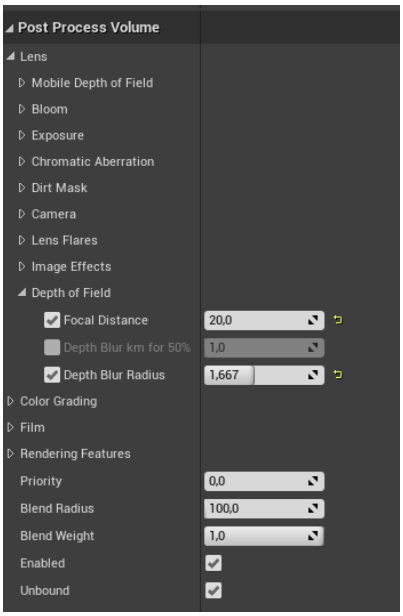

Figure 2.18: Blur effect's implementation settings.

2.3.6.3 Noise

Noise is sometimes referred as a dirt mask. It is applying a filter onto a camera or lens. It adds different features to the game depending on the design, density, and color of the filter. Therefore, it has variety of use cases. It can be used as a bloom dirt mask and brightens up the bloom. It is used to indicate health damage in action games. It simulates a war camera look. Also, it creates more impressive HDR effect and simulates camera imperfections.

In this project, the noise effect has been implemented with Perlin noise. Plutchik stated in his work [37] that the yellow color increases the joy perception. In order to provide more pleasant and enjoyable gaming experience, the noise filter was painted to yellow. The effect's design can be seen on the Figure 2.19 below.

Figure 2.19: Noise effect design.

2.3.6.4 Vignette

Vignette effect is one of the effects that game production industry adopts from photography. It is basically darkening on the corners of the frame. There are different types of vignette. It may result from the used lens naturally. It can be produced by used specific devices, or it can be added in the post-processing phase of the production.

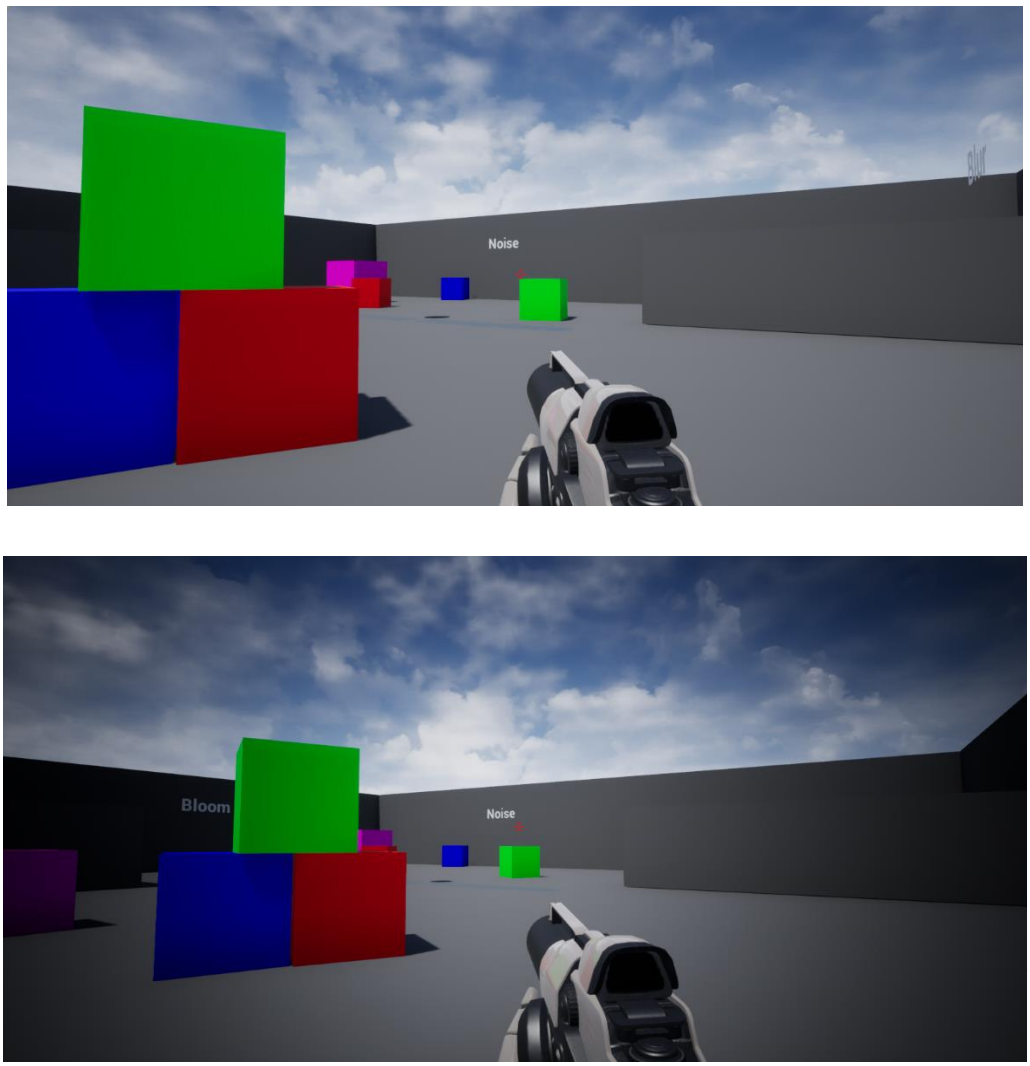

Figure 2.20: Top: A game scene without vignette effect. Bottom: A game scene with vignette effect.

On the Figure 2.20, same view with and without vignette can be seen. It is used in games in order to draw players' attention to the center of the frame from the corners. Also, the effect is used to point out critical health situations. Because of its darkening corners, it may be added to the scene to create a claustrophobic theme. In Figure 2.21 below, vignette settings can be seen.

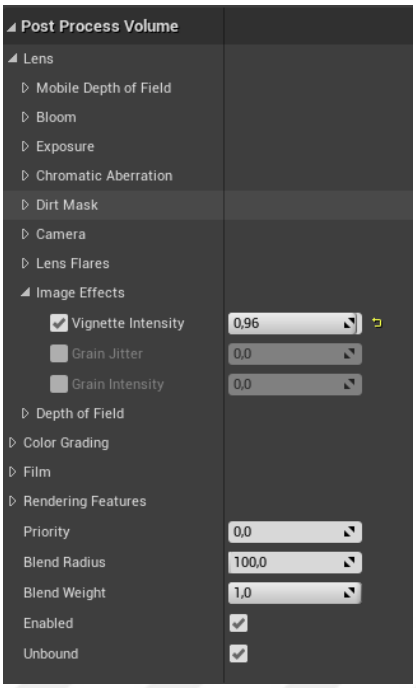

Figure 2.21: Vignette effect's implementation settings.

2.3.7 Mechanics

2.3.7.1 Player Interaction and Game Controls

In terms of player interaction and game control, Rooms game has a simple design. The main interaction happens through paintings and digital arts. With given collecting task, it is ensured that players would not stay in one room and stare one corner until the time is over. Because exposing to the visual effects is a hidden interaction element and what the game tries to inspect, players should go around the rooms and experience the visual effects. As mentioned before, the game has a first-person view. It was chosen in order to make player experience effects more closely. Instructions about gameplay and game controls are given as plain text messages on screen. Common practice is applied when designing game controls. To move the character around, WASD keys and mouse is used. In addition to moving the character, players use F key to pick a collectible and O key to finish the game. There is help text in the game to assist the player for picking and finishing game controls. These help texts can be seen on Figure 2.22.

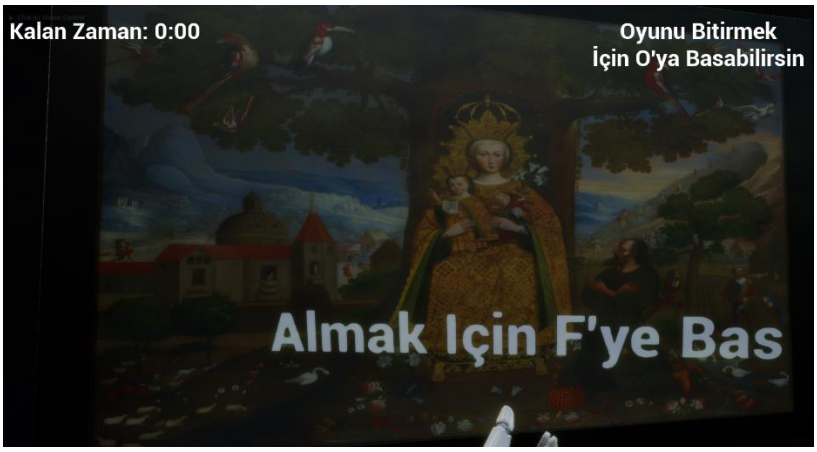

Figure 2.22: On screen helper texts.

2.3.7.2 Scoring

Scoring is another gamification element used in this game. The function in order to be used to calculate score can be seen on Figure 2.23. The inputs of score function are the number of seen digital arts, the number of collected digital arts and the number of collected paintings. Maximum possible score is 1000, and the minimum possible score is 50. Firstly, 1000 is multiplied by the ratio of collected digital art objects and seen digital art objects. If all seen digital art objects are collected, this part yields 1000. Then, number of collected painting objects is subtracted from the multiplication result. If overall result is less than 50, the score is set to 50 in favor of not having a negative score.

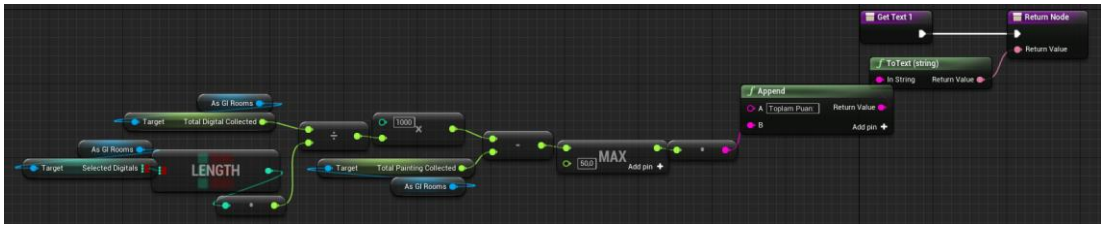

Figure 2.23: Score calculation function.

The aim of having a scoring mechanism in this game is to provide a comparable result and success feeling to players. It gives players an indicator to compete on. It is a strong gamification element because it helps the game to be accepted as a game by players. As the score mechanism's aim in this game is about increasing game perception, the score calculation function is not included any input about effects. It only calculates players' success on their given quest. Therefore, the score does not directly answer any research question of this project.

2.3.7.3 Time Management

Time constraint is not applied strictly during the game. There is only a minimum time rule. Players should play the game at least 5 minutes. It is enough time to see all of the effects. When the game begins, a countdown of 5 minutes starts and the remaining time is shown on the upper left corner of the screen. After 5 minutes, players are free to choose either to end the game or continue playing endlessly.

As stated in *Effects* section, a small preliminary study has been done. In that study, the minimum time limit tried to be finalized. Players played the game with minimum of 5-minute configuration. All three participants played for more than 5 minute voluntarily. After their play, their opinion about the time asked. They stated that the 5-minute rule was not restricting. Also, all three participants has visited rooms with each effect type.

2.3.7.4 Map Creation

2.3.7.4.1 Procedural Map Generation

Procedural map generation basically refers to the algorithmic game environment creation process in games. It is a subtopic of procedural content generation. Therefore, procedural content generation should be explained as beginning. PCG is an algorithmic game content generation process that includes randomization or pseudo-randomization [12]. There are several different methods. These methods are classified according to the content type created, user inputs and the algorithm strategy. Also, they are examined according to speed, reliability, controllability, expressivity and diversity and, creativity and believability. They take human-generated contents as seeds, and merge them with randomization, player inputs during game and processing power. These PCG processes have been used since 1980s [11,13]. Modern computer games contain a lot of more content types than older ones. As the randomized content generation algorithms help to provide the increasing demand of modern games' content need, not all content types can be generated procedurally or accepted as procedurally generated. Software tools that create dungeons for action-adventure games, new weapon creation algorithm in a shooter game that take player's inventory and player's habits as input, generating complete and playable board games, game engine middleware that creates and places new environment objects like trees, vegetables, buildings, and creating game maps are the ones that are accepted as

procedurally generated contents. On the other hand, AI that plays a board game or game world generation tool that does not take any automatic action are not examples of procedural content generation software.

The most important reason to use PCG algorithms is to use human power in a most productive way possible. As it said before, modern games contain high volume of game contents. Providing the need manually is not possible, so PCG algorithms are employed. Other reasons can be listed as

- storage optimization
- creating endless games
- generating personalized game content for each player
- utilization of unexpected designs that randomization brings

In the scope of this thesis, specifically procedural map generation algorithms were studied. Because the main focus is identifying players' responses to visual effects, it was crucial to provide them an environment that they can explore and experience freely. In order to provide such a boundless environment, PMG algorithms were preferred to create endless game map.

Procedural map generation algorithms have a long history. Very early implementations of PMG algorithms are seen in the game Rogue [38,39], and their usage has increased since. The Elder Scrolls 2: Daggerfall and Diablo are other early examples. No Man's Sky is a modern example. Games may require maps with different designs. One may need labyrinthine indoor building that room-like spaces linked through corridor while other may need endless outdoor environment with buildings or nature items like hills, grasslands, trees. In that variety, procedural generation of dungeon stands out. Dungeons are labyrinthic environments with challenges, quests and rewards.They are mostly seen in role playing games and adventure games. Current PMG algorithms are very good at real time dungeon generation, but they need to provide a broader control over the generation process [13]. They require algorithms that provides not only randomized, explorable, unexpected maps but also structured control. These generation processes also include non-player characters, decorations, gameplay related objects and effects etc. Most of the researches in this area focuses on spatial generation of these maps instead of mentioned game contents. Some of well-known and

researched algorithms are space partitioning, agent-based dungeon growing, cellular automata, grammar-based dungeon generation, genetic algorithms [11]. The needed PMG algorithm by this thesis resembles to dungeon generation algorithms by this means. It should take into consideration visual effect, and collectible object placements.

A unique PMG algorithm was not implemented specifically for this project as its main focus is visual effects. Procedural Level Generator plugin mentioned in a previous section was integrated to the game developed as PMG algorithm implementation. The plugin creates a labyrinthine environment constituted by predefined rooms. The algorithm takes the predefined rooms as nodes, and merge them by their creation points. When the game started, an initial map is created. Then, while the player proceeds in the environment, new rooms are added automatically. Rooms are joint together by their doors. The algorithm classifies the nodes under four types: starting rooms, standard rooms, transition rooms and important rooms. The entry point of the map is chosen from starting rooms. For each room creation, firstly the room type then the next room is chosen from the list. To provide equal chance for each room to be produced, all rooms are added to starting and standard room lists. Important room list was left empty. Transition rooms are double-layer rooms. Only one double-layer room was designed and left without any visual effect in order not to manipulate test results. Besides, the algorithm was modified in a way that it includes collectible object and effect placement randomization.

2.3.7.4.2 Room Selection

The map of this game is created by the PMG algorithm. As explained in the previous section, this algorithm is given nodes. Then, these nodes are attached together continuously according to given parameters as a certain event occurs. Therefore, an endless map is produced.

This game’s nodes are rooms. Room set was formed by matching room designs with effects. Room set contains below rooms.

- 1x1Blur
- 2x2Noise
- 3x3Blur

- BossChromaticAberration
- BossReferance
- INoise
- LVignette
- RoodChromaticAberration
- TVignette
- TReferance

The matching process of rooms and effects will be explained in the following section. Each room has doors and door generators. When a room is generated, the door generators in that room decide the succeeding rooms. They make randomized calculations and decide if there will be a room behind a door or not. If it is decided not to place a room behind a door, the door is removed and a plain wall remains. After deciding to creation of a door, the room should be chosen. Room choosing algorithm is given on Figure 2.24. As it can be seen on the Figure 2.24, room selection is also randomized and chance of each room's being chosen is equal.

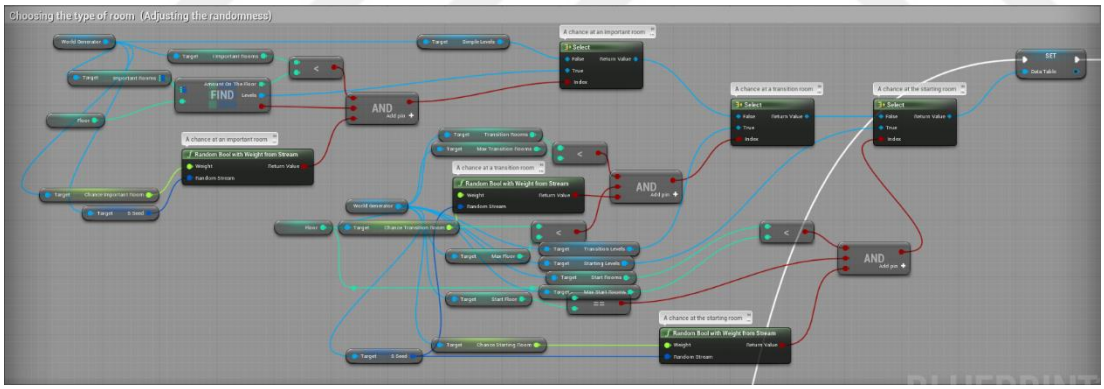

Figure 2.24: PMG algorithm's room choosing function.

The room decision and choosing algorithm is also part of the used PMG package. The package's door generation flow was altered in order to place collectible objects in the place of removed doors. By this alteration, number of possible objects in each room was increased. Besides, the possibility of occurence of long empty walls was eliminated.

2.3.7.4.3 Effect-Room Matching

As explained in *Effects* section, this study focuses on four sensory visual effects. To be able to classify and investigate impacts of these effects, effects were matched with rooms. At the *Procedural Map Generation* and *Room Selection* sections, dynamic map generation algorithm was explained. Thanks to used algorithm, probability of each room's occurence in each session is same. The number of object that each room contains is proportional to the size of the room. In order to make sure that each effect covers approximately equal space, the effects were assigned to the rooms in the way that total collectible object number exposed to each effect would be equal to each other.

Table 2.3: Room type - Collectible Count - Assigned Effect matchings.

Room Type	Collectible Count	Assigned Effects
1x1	4	Blur
2x2	15	Noise
3x3	24	Blur
Boss	12	Chromatic Aberration and Reference Room
I	8	Noise
L	10	Vignette
Rood	12	Chromatic Aberration
T	12	Vignette and Reference Room

On the Table 2.3 above, Each rooms' collectible counts and their assigned effects are given. Deriving from collectible counts, 3x3 room is the biggest and 1x1 is the smallest. Also, it should be noted that, these given number are the maximum possible collectible counts. Some spots on rooms are interchangeable with doors. When map generation algorithm places a neighor room, doors are created on intersecting points instead of collectible objects. L2 room is a transition room. It connects two floors with

stairs, so no effect is assigned to this room. Along with the four under researched effects, two rooms are labeled as reference. These rooms have no effect. The data collected there will be used as base line values. Below Table 2.4 shows total collectable object counts for each effects and reference rooms. All effects except blur contain 23 collectibles on average. Blur effect was assigned 4 extra collectibles because the map generation algorithm uses 1x1 room as filler room and this room mostly has 1 collectible and 3 doors.

Table 2.4: # of collectible objects for each effect.

Effect Type	Collectible Count
Blur	28
Chromatic Aberration	24
Noise	23
Vignette	22
Reference Room	24

2.3.7.4.4 Digital Art Selection

As explained before, there are two types of collectible objects in the game. Digital arts constitute the small part of all collectible objects. During the creation of the each room, collectible objects' texture that are in the specific room are randomly picked from the texture pool. Every room has an actor that deals with the object selection. Actors are base class of all game objects in Unreal Engine. They have 3D transformations. They can be added meshes, sub objects, trigger boxes and many more on them. Their behavior can be customized with code. They can be created and destroyed via code. Camera, static meshes, interactable objects are examples for an actor. The custom actor that selects the collectible objects is *Painting Selector*.

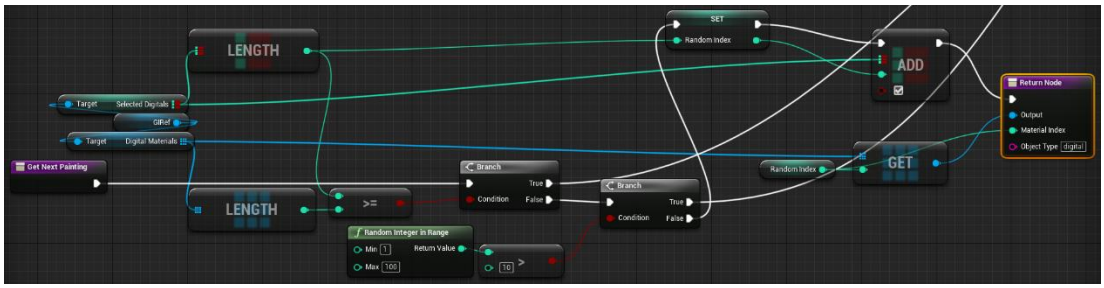

Figure 2.25: Digital art selection part of the collectible selection function.

Painting Selector gets painting and digital art pools and already selected ones for each type. Also, it has access to collectible object slots in each room. Then, it walks through each collectible object slot and picks a random number between 1 and 100. If the number is less than 10 and there is any unassigned digital art texture, a digital art texture is assigned to the slot. To be assigned texture is selected from the pool and is set to the collectible object slot. The explained code flow can be seen on Figure 2.25. There are two white lines that goes up on the upper right-hand side. The remaining part of these lines are on Figure 2.26, and this figure shows picking procedure of painting objects. This procedure will be explained in following section.

2.3.7.4.5 Painting Selection

Paintings are the vast majority of the collectible objects in the game. Painting objects also give the infinity feeling in the game. There are almost 300 textures in painting texture pool. Painting object are randomly picked from this pool until the all are used. If the game still continues, they are started over to be picked.

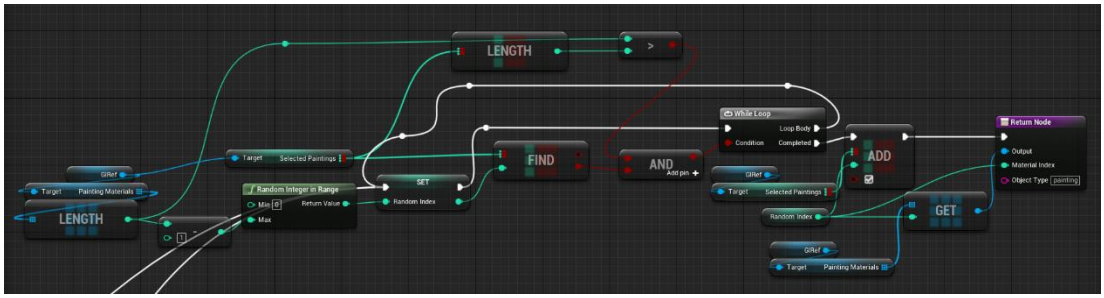

Figure 2.26: Painting selection part of the collectible selection function.

The initial part of the texture selection algorithm is explained in the previous section. First step in the painting selection part is picking a random index from the painting texture list. The index finding process continues until an unused texture is found. If all textures are used before, first picked random index is approved. Then, the selected

texture is set to a collectible object slot. Figure 2.26 shows the painting object selection part of the algorithm.

2.3.8 Collected Features During Gameplay

While the player plays the game, some numeric data was collected. The data represents how the player interacts with the object within the game. It was used to make connection between player's in-game decisions and the effects that they experienced. Another use case of the collected data is to identify if players are aware of the visual effects. By comparing the numerical data and the answers each player has given to the pre and post surveys, it is aimed to distinguish players' conscious and unconscious choices. Collected numerical data can be listed as follows:

- Total gameplay time
- Visit duration and count for each room
- Visit duration and count for each effect
- Collectible type for each collected item
- Number of collected items for each collectible type
- Room and effect type that are each item collected from
- Number of painting and digital art that is presented to the player in each effect
- Number of collected object for each effect and room

Data was collected programmatically without any human interference. The technique and the tool that was used to collect data will be explained in detail in following section, and the interpretation of the data will be shared at *Results* section. An example of the collected data from a player can be found in APPENDIX A.2.

2.4 Data Collection

Data collection is one of the most important phase during a testing process. Data collection technique should provide a robust data flow, be easily applicable during the experiment process, and yield unbiased results. Therefore, while designing the data collection process, it is prioritized to eliminate any human factor.

During the experiment, two types of data was collected: numeric gameplay data and surveys. Surveys were applied through an online survey service without any intervention from any researcher. All instructions were given on the survey itself. On the other hand, numeric gameplay data was collected automatically while the player plays the game. He/She was not informed beforehand to make sure the data is not biased. After the game finishes, collected data stored directly by the game itself. To store the data, two approach were followed simultaneously.

2.4.1 Local Log File

The whole numeric data is collected in Main Level. Collected data is kept in memory during the gameplay in this level. Once the player finishes the game and switches to the End Level, data is saved to a log file that is in the local file system. The format of the file is designed in order to distinguish different data types. Different information is written to seperate line. Each line in the file starts with the unique game ID, so one single file can include different players' data. A small portion of the log file can be seen in Figure 2.27.

```
7458-5 Mar 2022 23:24:29
Created digitals:20
7458-116_8197-painting-vignette-T-5 Mar 2022 23:11:50
7458-ballerina_822-digital-noise-l-5 Mar 2022 23:12:28
7458-dreams_7297-digital-referance-boss-5 Mar 2022 23:14:50
7458-28_8151-painting-chromatic_aberration-boss-5 Mar 2022 23:15:52
7458-futuristic_city_1112-digital-noise-l-5 Mar 2022 23:16:47
7458-solace_6138-digital-chromatic_aberration-boss-5 Mar 2022 23:17:47
7458-T-vignette-5 Mar 2022 23:11:22-0:39
7458-1x1-blur-5 Mar 2022 23:12:02-0:04
7458-l-noise-5 Mar 2022 23:12:06-0:25
7458-T-vignette-5 Mar 2022 23:12:31-0:10
7458-l-noise-5 Mar 2022 23:12:42-0:33
7458-boss-referance-5 Mar 2022 23:13:15-0:54
7458-T-vignette-5 Mar 2022 23:14:10-0:12
7458-l-noise-5 Mar 2022 23:14:22-0:23
```

Figure 2.27: A small part of the log file.

2.4.2 REST API Integration

In addition to the local log file, a server side backend application was developed. The application runs on a cloud server, and it is always available. It is reachable remotely, so the data also can be collected and stored remotely. While saving the data to the local file, it is also sent to the application. This feature provides both ability to carry out the whole experiment remotely and backup data storage.

The application serves as a REST API. It was implemented using GO. As a database solution, Postgresql relational database was used. Both GO and Postgresql was explained in *Development Tools* section. When the data collection finishes, whole data is converted in to a JSON object of the required format from the backend application. JSON is a data format that computer programmes and web services use to interact with each other. Then, the formed object is sent to backend application through provided endpoint. As the data reaches to the application, it is read and stored in the database.

2.5 Surveys

Two surveys were applied to the players. The players filled out one survey before playing the game and another survey after playing the game. Purpose of the surveys is collecting demographic information about players, their subjective and conscious opinions about the game and effects. At the beginning of the both survey, game id value is required to enter. It is used to match survey results with collected numerical data. Also, it helps to anonymize whole process.

2.5.1 Pre-Survey

Pre-survey starts with detailed description. The description includes story, objective, mechanics and little tips about the game. It mostly consists of demographic data such as age. Apart from demographic data, players' computer game playing habits and their relation with visual arts are gathered. Lastly, eye health status is questioned.

Players' relation with visual arts and computer games affects their perception of visual elements; besides, more experienced gamers tend to behave differently comparing less experienced ones [6]. Eye health might also affect recognition of visual elements. Therefore, having these information might result in more accurate results. Pre-survey questions can be seen on the APPENDIX A.3.

2.5.2 Post-Survey

Post survey is longer than the pre survey.This survey focuses on mostly how players perceive the effects and their feelings about the game. It consist of four sections. There are mostly open ended questions and one question with 5-scale Likert agreement ratings that ask players to evaluate overall game. Last question asks if the player has realized any visual effect. If the player chooses 'NO', the survey ends. Otherwise, it

continues with the second section. Second section has 3 open ended questions about players' experiences with effects. Third section questions if the player recognizes the visual effects. There are videos for six different visual effects, and players are asked to select the ones that they have seen in the game. Two of these effects are added for control purposes. After they choose the effects, they indicate their feelings about each effect by selecting from predefined options. Last section has only one question and it opens a space for players to express their general comments about the whole process. Post-survey questions can be seen on the APPENDIX A.4.

3. EXPERIMENT AND RESULTS

3.1 Experiment

3.1.1 Experiment Procedure And Setup

When designing the experiment procedure, eliminating all side effects that may cause any form of bias was prioritized. Because the project investigates gamers' unconscious behaviors, they were shared as less information as possible prior the experiment. They were told they would play a computer game that requires them to go around in an virtual museum and accomplish a task. Also, all instructions about the game was given through written descriptions on the game's start page and pre survey.

Table 3.1: Expriment computer configuration.

Component Name	Component Description
CPU	Intel(R) Core(TM) i7-7700K CPU @ 4.20GHz
GPU	NVIDIA GeForce GTX 1080
Memory	16 GB
Screen	27"IPS, QHD, 144Hz, 1ms, 2560x1440

All experiments have taken place in the same place. No remote experiment session was done. To play the game, participants were taken into a room where there are only the participant and one researcher. The participant was only an observer. He did not make any comment during the experiment. The experiment computer's configuration is given in Table 3.1. After the participant sit at the computer, game, pre and post surveys welcomed him/her. Firstly, they read the brief description on the start page of the game, and they filled out the pre survey. At the beginning of the survey, there is a

detailed explanation. Then, they started to play the game. Almost all of the participants tried to ask questions about game controls, aim of the game and the effects, but none of the questions were answered. Finally, end level directs them to post survey. When the post survey finishes, the experiment is finalized. After a participant is finished the experiment, aim of the game, research questions and collected data are explained to them. Figure 3.1 shows the experiment setup.

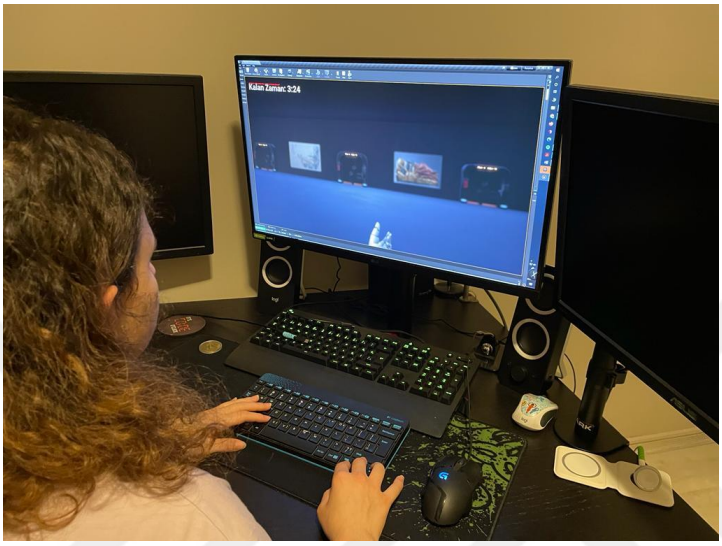

Figure 3.1: Experiment Setup.

3.1.2 Participants

Total 13 people participated to the experiment. Any kind of initiative was not given to participants. They were played voluntarily. Gender distribution was uniform. Most of the participants were between 22 and 25 year old. Detailed age distribution can be seen on Figure 3.2.

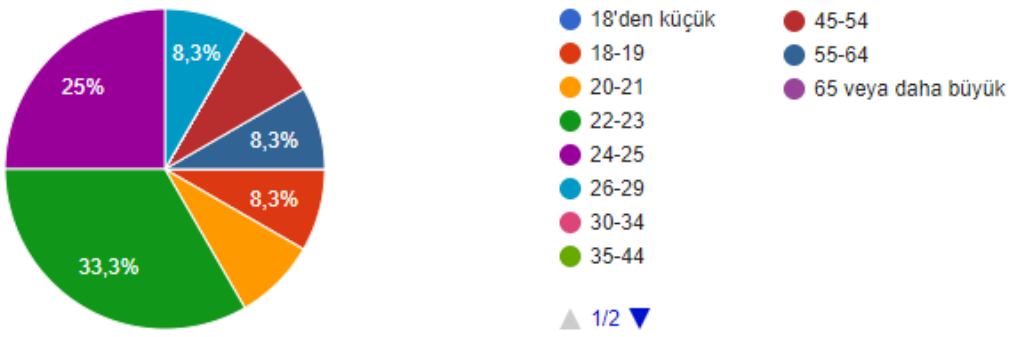

Figure 3.2: Age distribution of the participants.

3.2 Results

During the experiment, both qualitative and quantitative data have been collected. Qualitative data collected through pre and post surveys. Quantitative data collected during the game play. Qualitative data set mostly includes players' subjective comments and opinions about the game. Also, they are asked to describe their experience with the effects and if they notice any visual effect. On the other hand, quantitative data set contains numerical data about all of the actions players have taken during the game. Detailed explanation about the data sets is given at their respective subsection in *Methodology* section. As the data were analyzed separately, derived features were also created by combining them. Besides, qualitative and quantitative results analyzed comparatively in order to detect unconscious decisions that the players have taken. The collected data and obtained results will be given in this section, and detailed discussion about how these results answer the research questions of this thesis will be in the following section.

Game acceptance indicates if the players have consensus on the developed software's being a playable game with all of its mechanics, design, gameplay items and gamification elements. The post-survey results were used in order to measure game acceptance value. There were 5-point Likert scale questions. Questions and answers that reflects the game acceptance are given on the Table 3.2.

Table 3.2: Post-survey results that reflect game acceptance

Question	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
I want to play the game again.	3	8	2	0	0
I found the game fun.	3	7	2	1	0

%84,6 of the participants answered the first question as agree or totally agree. Also, answers to the second question were agree or totally agree by the rate of %76,9, and there was no totally disagree. These results indicate that the software is a complete game.

Participants' relations in visual arts, their game experience, and visual health status information are collected in the pre-survey. All participants have relations with visual arts as hobbyists through computer games except one participant. Their game experience data is mapped into three classes, high, moderate, and low, according to their playing game frequencies. A summary of game experience data can be seen in the Table 3.3. Also, 11 of 13 participants stated that they have some sort of visual impairment, but all of them used either glasses or contact lenses to fix the impairment.

Table 3.3: Game experience distribution of the participants.

	High Experience	Moderate Experience	Low Experience	No Experience
Total number of participants	4	2	5	2

In the post-survey, participants have asked about their overall experience during the gameplay. This was prior to the visual effect specific questions. One of the experienced participants said that he would expect a more complicated quest, and another one said he did not feel successful. On the contrary, most of the participants stated the game was easy to learn and fun. Also, both experienced and less experienced participants were described the blur effect without specifically asking. They mentioned that the blur effect was disturbing. In the post-survey, only 2 participants declared they did not notice any effects. Remaining 11 participants have asked to describe the visual effects they have seen. Participants described the blur effect again. Additionally, chromatic aberration effect was described as a colorful frame around the images by several participants. One participant also said he can recall darkened areas around the corners and a yellow fog. These depictions match with the vignette effect and noise effect, respectively. Lastly, they asked to select the visual effects that they have seen during the game in the post-survey. They are provided videos of a game scene with and without effects for each effect. On the Table 3.4, Table 3.5, and Table 3.6 below, the summaries of given answers to each effect related question can be seen. The answers

were classified according to the participants' experience level. The effect related questions in the post-survey also contain bloom and color grading sensory visual effects as control values. It can be seen on the tables that bloom effect make the participants confuse the most.

Table 3.4: High experienced participants' answers to questions about visual effect experience.

	Bloom	Blur	Vignette	Chromatic Aberration	Color Grading	Noise
Seen	3	4	4	1		2
Not Seen				1	4	1
Not Sure	1			2		1
I identified artworks easier in the rooms with this effect.	1		1			
I explored more comfortably the rooms with this effect.	1		1			
This effect prevented me to focus.	1	3	1			
It was easier for me to be aware of my surroundings in rooms with this effect.	1					
Rooms with this effect were more interesting.	1					

I avoided being in the room with this effect.		3				
This effect helped me feel inside the game.	1		1			

Table 3.5: Moderate experienced participants' answers to questions about visual effect experience.

	Bloom	Blur	Vignette	Chromatic Aberration	Color Grading	Noise
Seen		2	1	2		1
Not Seen	1		1		2	
Not Sure	1					
I identified artworks easier in the rooms with this effect.						
I explored more comfortably the rooms with this effect.						
This effect prevented me to focus.						
It was easier for me to be aware of my surroundings in rooms						

with this effect.						
Rooms with this effect were more interesting.						
I avoided being in the room with this effect.						
This effect helped me feel inside the game.						

Table 3.6: Low experienced participants' answers to questions about visual effect experience.

	Bloom	Blur	Vignette	Chromatic Aberration	Color Grading	Noise
Seen	2	5	1	4		
Not Seen	1		2		3	3
Not Sure	2		2	1	2	2
I identified artworks easier in the rooms with this effect.	1			1		
I explored more comfortably the rooms with this effect.	1		1			

This effect prevented me to focus.	1	5		1	
It was easier for me to be aware of my surroundings in rooms with this effect.	1		1	1	
Rooms with this effect were more interesting.				2	
I avoided being in the room with this effect.		2		1	
This effect helped me feel inside the game.	1			1	1

The above tables show the qualitative data about participants' experience with the visual effects. In addition to the data collected via surveys, quantitative data collected during the gameplay. Exploration behavior needed to be measured in order to understand its relation with visual effects. It was measured using the participants' visit counts of the rooms and visit durations. Visit duration and visit count data were collected. Then, visit durations per person, visit counts per person and visit durations per visit values were calculated from the collected base data. Also, these calculated features were classified according to experience levels. The quantitative data is given on the Table 3.7, Table 3.8, and Table 3.9.

Table 3.7: Visit durations per person of effects.

	Overall	High Experienced	Moderate Experienced	Low Experienced
Reference	82,69	82,75	43,5	100,28
Noise	150,23	105,25	95,5	158,57
Blur	158,07	130,5	182,5	166,85
Vignette	135	132,5	135,5	136,28
Chromatic Aberration	103,92	97,25	50	123.14
Average	125,98	109,65	101,4	137,02

Table 3.8: Visit counts per person of effects.

	Overall	High Experienced	Moderate Experienced	Low Experienced
Reference	5,15	6	3	5,7
Noise	6,61	10,7	3,5	4,8
Blur	14,7	21,2	10	12,2
Vignette	7,8	10	7	6,8
Chromatic Aberration	6,1	9,7	2	5,2
Average	7,1	11,5	5,1	7

Table 3.9: Visit durations per visit of effects.

	Overall	High Experienced	Moderate Experienced	Low Experienced
Reference	16	13,8	14,5	17,5

Noise	22,7	9,7	27,2	32,6
Blur	10,7	6,1	18,2	13,5
Vignette	17,2	13,2	19,3	19,8
Chromatic Aberration	16,8	9,9	25	23,3
Average	15,5	9,4	19,8	19,5

Another important feature that shows the participant's in-game activity is their interaction with the collectible objects. The given task was differentiating paintings and digital artworks. Participants were required to collect the ones that they think they are digital artworks. Table 3.10 shows the average numbers about interactions with the collectible objects for reference room and effected rooms. The number are given per person.

Table 3.10: Participants interaction data with the artworks in the game. Numbers are given per person.

	Collected	Correct	Wrong
Reference	1,03	0,67	0,35
Noise	1,67	1,07	0,60
Blur	1,22	0,59	0,63
Vignette	1,91	1,23	0,67
Chromatic Aberration	1,51	0,57	0,94
Average	1,47	0,83	0,64

Table 3.11 also shows the interaction with the collectible objects. The data in this table is filtered according to participants' answers to effect related questions on post-survey. Collected object numbers for the participants who states that they did not see the effect during the game are given on this table. For example, 2 participant stated that they did not see any blur effect in the game. These two people collected total 8 collectible objects from the rooms with blur effect, and 3 of them was correct. Average collected

object from the rooms with blur effect for 2 participant is 4 and average correct object value is 1,5. The values on the first row belongs to the ones that informs that they did not see at least one effect.

Table 3.11: Interaction data of the participants who informs that they did not see the effect.

	Collected	Correct	Wrong
Reference	1	0,5	0,5
Noise	2,2	0,5	1,6
Blur	4	1,5	2,5
Vignette	2,6	1,4	1,2
Chromatic Aberration	4,5	2	2,5
Average	1,9	0,82	1,07

3.3 Discussion

This project mainly aims to find a relation between the exploration behavior of the player and sensory effects. In order to be able to define the problem in a more structured way, it has been divided into sub-questions. These questions defined the scope and leaded the research process. The results obtained are interpreted in the light of these research questions.

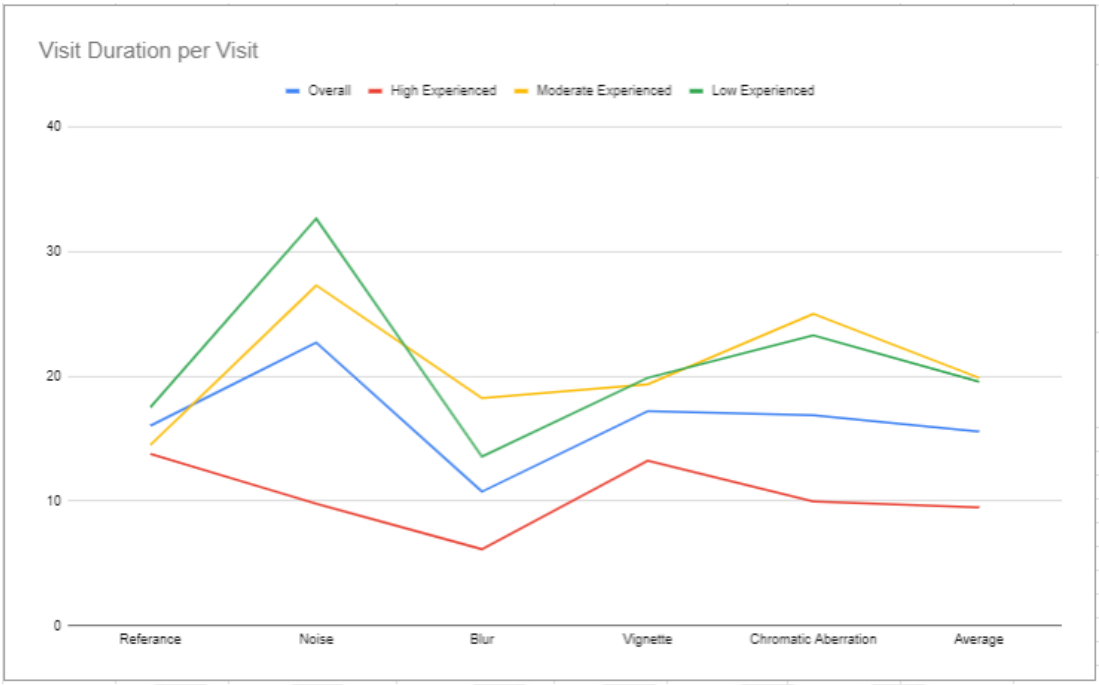

Figure 3.3: Average visit duration per visit.

The first research question is how visual effects affect exploration behavior during the gameplay. On the Figure 3.3, average visit duration per visit data is given as graph. This graph shows how much time participants spent in each room in average. It can be clearly seen that there are big differences on the time spent between effects. Overall average difference is almost 10 seconds between noise and blur effects while blur is the least time spent effect and noise is the most time spent effect. Visit durations for vignette and chromatic aberration effects are closer to each other. Also, average duration is higher than the reference values for low and moderate experienced participants. On the other hand, high experienced participants' visit durations for all effects are less than the reference values. This may indicate that high experienced participants are negatively affected in effected rooms. High experienced participants also spent less time during the game. The impact of game experience can also be seen between visual effects. Less experienced participants are more sensitive to the visual effects. Visit duration differences are bigger for low and moderate experienced participants. All of these implications answer perfectly the first question. Blur is the least favored and time spent visual effect while noise is the most. Vignette and chromatic aberration effects have similar impact on exploration behavior. Low and moderate experienced players are affected by visual effects positively in average. The difference that depends on the gameplay experience also answers the fourth research question which is how game experience level impact the effects of the visual effects.

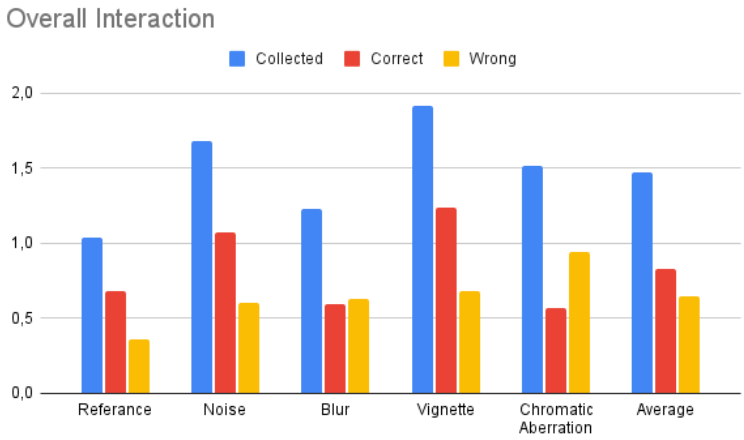

Figure 3.4: Participants' average interactions with collectible objects.

In order to understand the relation between visual effects and players' actions, change of their interaction level with collectible objects depending on the visual effects should be investigated. Figure 3.4 shows average collected object numbers, correctly collected object numbers and wrong ones for the reference room and the rooms with specified effects. It is seen on the figure that number of collected objects in the rooms with effect are higher than the reference room. Especially, vignette effect multiplied the interaction level by almost 2. The same interaction increasing behavior of the visual effects' is also seen when the object collection data is broken down to game experience levels. Figure 3.5 shows high experienced participants' number of collected objects and Figure 3.6 shows low experienced ones'. It is also seen that existence of the visual effects increases success rate for high experienced players. On the contrary, the success rate drops dramatically for low experienced players. In the reference room, both high experienced and low experienced players collected wrong objects more than correct objects. For all 4 sensory visual effects, high experienced players performance increased while low experienced players' dropped even more. High experienced players performed the worst in vignette effect while low experienced players performed the best in vignette and the worst in blur effect. These object collection results show that sensory visual effects extremely impact players' interaction behavior during the gameplay. Besides, these effects differ according to players' game experience levels.

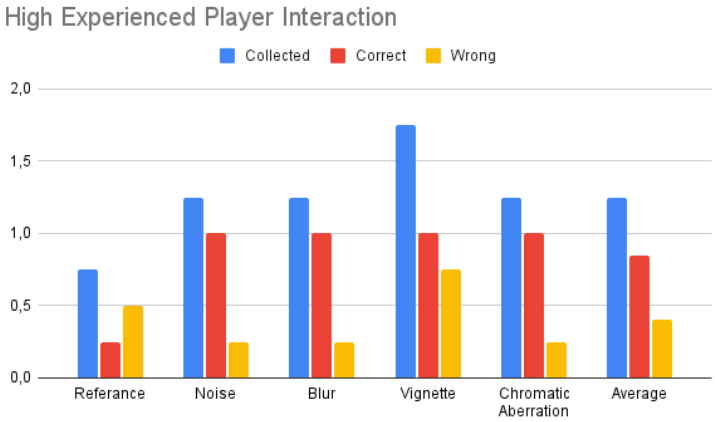

Figure 3.5: High experienced participants' average interactions with collectible objects.

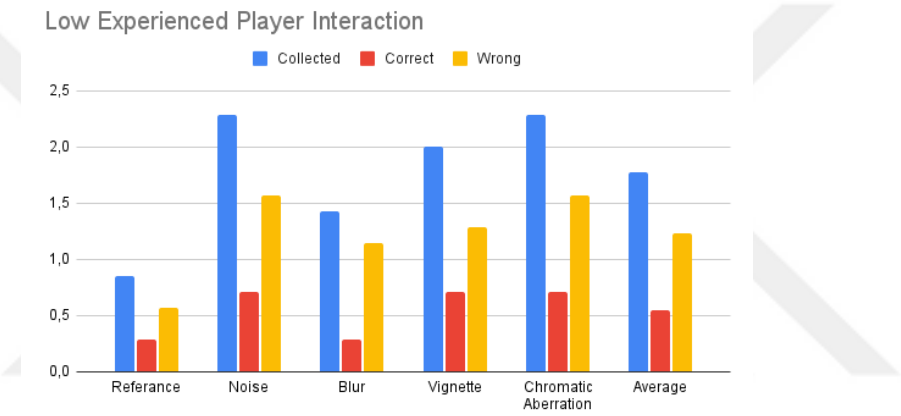

Figure 3.6: Low experienced participants' average interactions with collectible objects.

Another research question examines whether sensory visual effects result in any unconscious decision. Unconscious impacts of the sensory visual effect can be investigated in two ways in the scope of this thesis. Player's visit duration may indicate whether visual effects result in any unconscious behavior during exploration. On Figure 3.7, visit durations per visit for each visual effect is given. Also, data of the participants who informed they did not see the specified visual effect is shown on the figure. The visit data's structure for the *Did not See* group perfectly matches with the rest of the participants. This indicates that those group of the participants are also affected from the visual effect in the same way as others. The other indicator is interaction data. Same *Did not See* group of the participants' in-game interaction data is shown on Figure 3.8. It is also clear that their interaction behavior changes critically with the effects in the rooms. They collected many more objects in the effected rooms than the reference room, but success rate is not good. They collected slightly more

correct objects than wrong object only in the room with vignette effect. By designing the game environment carefully and placing the visual effects strategically, it is possible to manipulate how players explore and interact within the game.

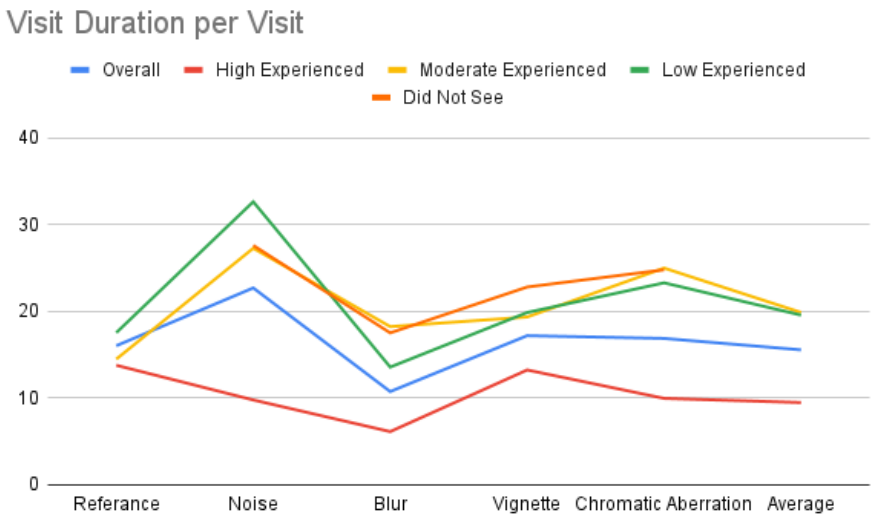

Figure 3.7: Participants' visit duration per visit including Did Not See group of the participants.

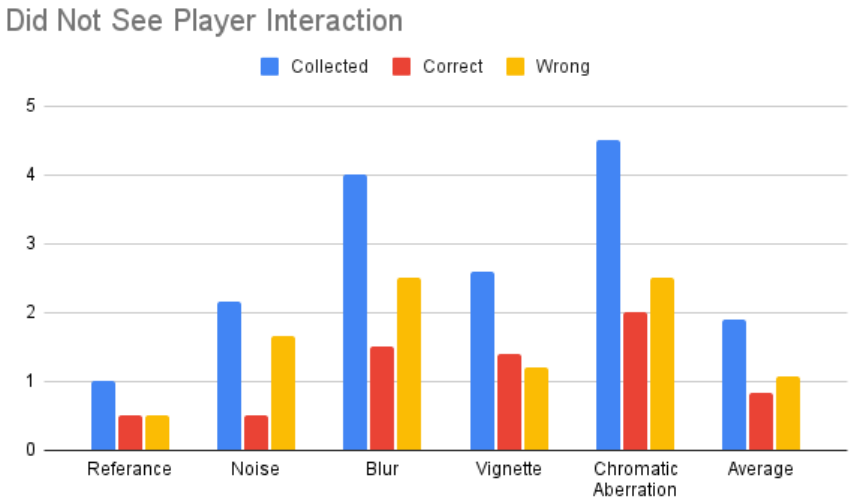

Figure 3.8: Interaction data with the collectible objects of the participants who state they did not see specified effect.

Table 3.12 shows the answers of the all participants' to the effect related questions. Total numbers of whether they have seen the effect in game and participants' feelings about the effects are given. All of the participants except 2 stated that they have seen at least one effect. This shows that players can notice the visual effects. Besides, blur effect was noticed by all of the participants. Vignette's notice rate is 54% and chromatic aberration's notice rate 63%. Noise is the only one that participants was

confused on. On the contrary, noise effect is one of the most liked and has best performance according to the quantitative results. Interesting point here is bloom effect. Bloom effect did exist in the game, but 81% of the participants indicated either they have seen the effect or not sure if they have seen it. This may result from the effect's design. It is a light glowing effect, and it can be mixed with other sensory effect. This condition should be researched further. Furthermore, some of the participants have described the chromatic aberration effect successfuly in the open-ended questions. All of these results shows that players can both notice and recognize the sensory visual effects.

Table 3.12: All participants' answers to questions about visual effect experience.

	Bloom	Blur	Vignette	Chromatic Aberration	Color Grading	Noise
Seen	5	11	6	7	0	3
Not Seen	2	0	3	1	9	4
Not Sure	4	0	2	3	2	3
I identified artworks easier in the rooms with this effect.	2	0	1	1	0	0
I explored more comfortably the rooms with this effect.	2	0	2	0	0	0
This effect prevented me to focus.	2	8	1	1	0	0
It was easier for me to be aware of my surroundings in rooms	2	0	1	1	0	0

with this effect.						
Rooms with this effect were more interesting.	1	0	0	2	0	0
I avoided being in the room with this effect.	0	5	0	1	0	0
This effect helped me feel inside the game.	2	0	1	1	1	0

The final research question asks whether qualitative and quantitative results relate and how they relate. While discussing all of the research questions in this section, both qualitative and quantitative results have merged most of the time. All quantitative results have investigated by classifying them according to game experience level. In addition to this, participants indicate that they avoided being in the rooms with blur effect on Table 3.12. Figure 3.7 confirms that behavior. Players spent the least time in the rooms with the blur effect.

4. CONCLUSION AND FUTURE WORK

Visual effects are one the essential visual elements of the computer games. They are the building blocks of the virtual environments that are created in the computer games. Visual effects provide the realism in virtual environments. Also, they help setting the mood in the game. Visual effects can be classified under 3 classes. This thesis focused on sensory visual effects. Those type of effects are used by the game designers use as a medium to interact with the players. Sensory visual effects are widely used to deliver a message to player, trigger an emotion on the player and manipulate them in the commercial games. Even though there are researches about the visual effects, their impacts on the players did not investigated systematically. This thesis tries to contribute to the computer game literature by filling this gap.

Sensory visual effects' impacts on the players' spatial exploration behavior were studied in this thesis. A 3D puzzle game has been designed and players' responses to the visual effects were investigated. Conscious and unconscious changes in their interaction with the in-game objects were inspected. Both qualitative and quantitative data have been collected during the experiments, and they were studied comparatively. Also, all of the collected data was analyzed by classifying them according to players' game experience levels.

Most of the participants stated that the designed game was easy to play and fun. This indicates that the game was well-designed for the thesis's purpose. All of the results show that sensory visual effects have different impact on the players according to their game experience. Most of the time their results are conflicting. Highly experienced players affected negatively by means of spatial exploration. Their visit time for the rooms with visual effects are less than the rooms without visual effects. On the other hand, the less experienced players' visit times increase in the rooms with visual effects. A similar but opposite behavior is seen when it comes to the interaction during the game. Highly experienced players have higher success on the given task while less experienced players' success decreased dramatically in the rooms with visual effects.

When the both interaction and room visit data are analyzed in terms of unconscious decisions, it is found that players who were stated that they did not see an effect behaved in the same way as others. This shows that players are affected by the visual effects unconsciously. In addition, it was seen that players noticed and recognized blur, vignette and chromatic aberration clearly. While players spent the most time in the rooms with noise effect, they have difficulties on recognizing it.

Outcomes of this thesis shows that visual effects have a great importance and power in computer game design. They are strong tools to transfer emotions to players and communicate with them. With all of this significance, it is a promising research area. This thesis tried to enlighten a small portion of it. In the future works, impacts of these effects on different game mechanics may be investigated. Similarly, different game genres can be tested. In addition, the effects used in this study can be designed again in a more realistic way by the help of a game artist. Procedural map generation is also an encouraging topic. How visual effects can be used more intelligently in procedural map generation algorithms may be studied.

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APPENDICES

APPENDIX A.1: Links to the used digital arts.
APPENDIX A.2: Content of the log file for one participant.
APPENDIX A.3: Pre-survey questions.
APPENDIX A.4: Post-survey questions.

APPENDIX A.1

Links to the used digital arts are given in below.

- https://www.deviantart.com/t1na/art/Meteor-shower-886772910
- https://www.deviantart.com/stasyasky/art/Eclipse-888627760
- https://www.deviantart.com/ryky/art/Light-884881441
- https://www.deviantart.com/antoinettestoll/art/Dreamhop-Music-commission-Somewhere-Nowhere-Deep-892756398
- https://www.deviantart.com/sylviaritter/art/Speedpainting-05112021-897040234
- https://www.deviantart.com/seven-teenth/art/Glitched-884855684
- https://www.deviantart.com/gydw1n/art/Dreams-886606798
- https://www.deviantart.com/g-hamm/art/Solace-banner-892240742
- https://www.deviantart.com/nanchoart/art/Ballerina-892873472
- https://www.deviantart.com/luetche/art/Auroramountain-888182836
- https://www.deviantart.com/omnifica/art/Winters-Pass-889280294
- https://www.deviantart.com/antonkurbatov/art/Gy-yl-s-Fingers-891680139
- https://www.deviantart.com/joyachannel/art/after-storm-894779158
- https://www.deviantart.com/parablev/art/Lost-Sky-888638682
- https://www.deviantart.com/victoria-graphiste/art/Futuristic-city-888673756
- https://www.deviantart.com/mailinartwork/art/Cloudy-parrot-886150395
- https://www.deviantart.com/jsraphael57/art/SMITE-Tombstone-Rider-Hachiman-891247179
- https://www.deviantart.com/arven92/art/Winter-Spirit-PATREON-REWARD-889471209
- https://www.deviantart.com/valerysazonov/art/Floating-rocks-893132914
- https://www.deviantart.com/laurolaposse/art/Valeros-885394663

APPENDIX A.2

```
3818-5 Mar 2022 22:38:49
Created digitals:20
3818-after_storm_5066-digital-vignette-L-5 Mar 2022 22:28:47
3818-126_6768-painting-blur-3x3-5 Mar 2022 22:30:58
3818-ballerina_548-digital-blur-3x3-5 Mar 2022 22:31:02
3818-deu2ooa_8064-digital-vignette-L-5 Mar 2022 22:33:27
3818-floating_rocks_6563-digital-vignette-L-5 Mar 2022 22:35:55
3818-dreams_2038-digital-vignette-L-5 Mar 2022 22:36:08
3818-futuristic_city_8033-digital-noise-2x2-5 Mar 2022 22:36:36
3818-glitched__7617-digital-noise-2x2-5 Mar 2022 22:36:43
3818-lost_sky_5256-digital-noise-2x2-5 Mar 2022 22:36:53
3818-winter_spirit__patreon_reward_5585-digital-referance-T-5 Mar 2022 22:38:17
3818-winters_pass_by_omnifica_depgd2e-fullview_4682-digital-referance-T-5 Mar 2022 22:38:24
3818-L-vignette-5 Mar 2022 22:28:32-0:42
3818-L2-transition-5 Mar 2022 22:29:14-0:07
3818-L2-transition-5 Mar 2022 22:29:22-0:05
3818-1x1-blur-5 Mar 2022 22:29:27-0:05
3818-3x3-blur-5 Mar 2022 22:29:33-3:18
3818-1x1-blur-5 Mar 2022 22:32:52-0:01
3818-T-referance-5 Mar 2022 22:32:53-0:12
3818-1x1-blur-5 Mar 2022 22:33:05-0:09
3818-1x1-blur-5 Mar 2022 22:33:15-0:06
3818-L-vignette-5 Mar 2022 22:33:21-0:16
3818-T-referance-5 Mar 2022 22:33:37-0:14
3818-1x1-blur-5 Mar 2022 22:33:51-0:09
3818-2x2-noise-5 Mar 2022 22:34:01-1:17
3818-L-vignette-5 Mar 2022 22:35:19-0:27
3818-L-vignette-5 Mar 2022 22:35:47-0:16
3818-L-vignette-5 Mar 2022 22:36:03-0:28
3818-2x2-noise-5 Mar 2022 22:36:31-0:35
3818-1x1-blur-5 Mar 2022 22:37:07-0:07
3818-1x1-blur-5 Mar 2022 22:37:14-0:05
3818-L-vignette-5 Mar 2022 22:37:20-0:06
3818-L2-transition-5 Mar 2022 22:37:26-0:05
3818-L2-transition-5 Mar 2022 22:37:32-0:03
3818-rood-chromatic_aberration-5 Mar 2022 22:37:35-0:23
3818-rood-chromatic_aberration-5 Mar 2022 22:37:58-0:10
3818-T-referance-5 Mar 2022 22:38:08-0:19
3818-L-vignette-5 Mar 2022 22:38:28-0:10
3818-1x1-blur-5 Mar 2022 22:38:39-0:03
3818-l-noise-5 Mar 2022 22:38:43-0:06
3818-vignette-13-3
3818-chromatic_aberration-8-0
3818-noise-16-0
3818-blur-20-1
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```
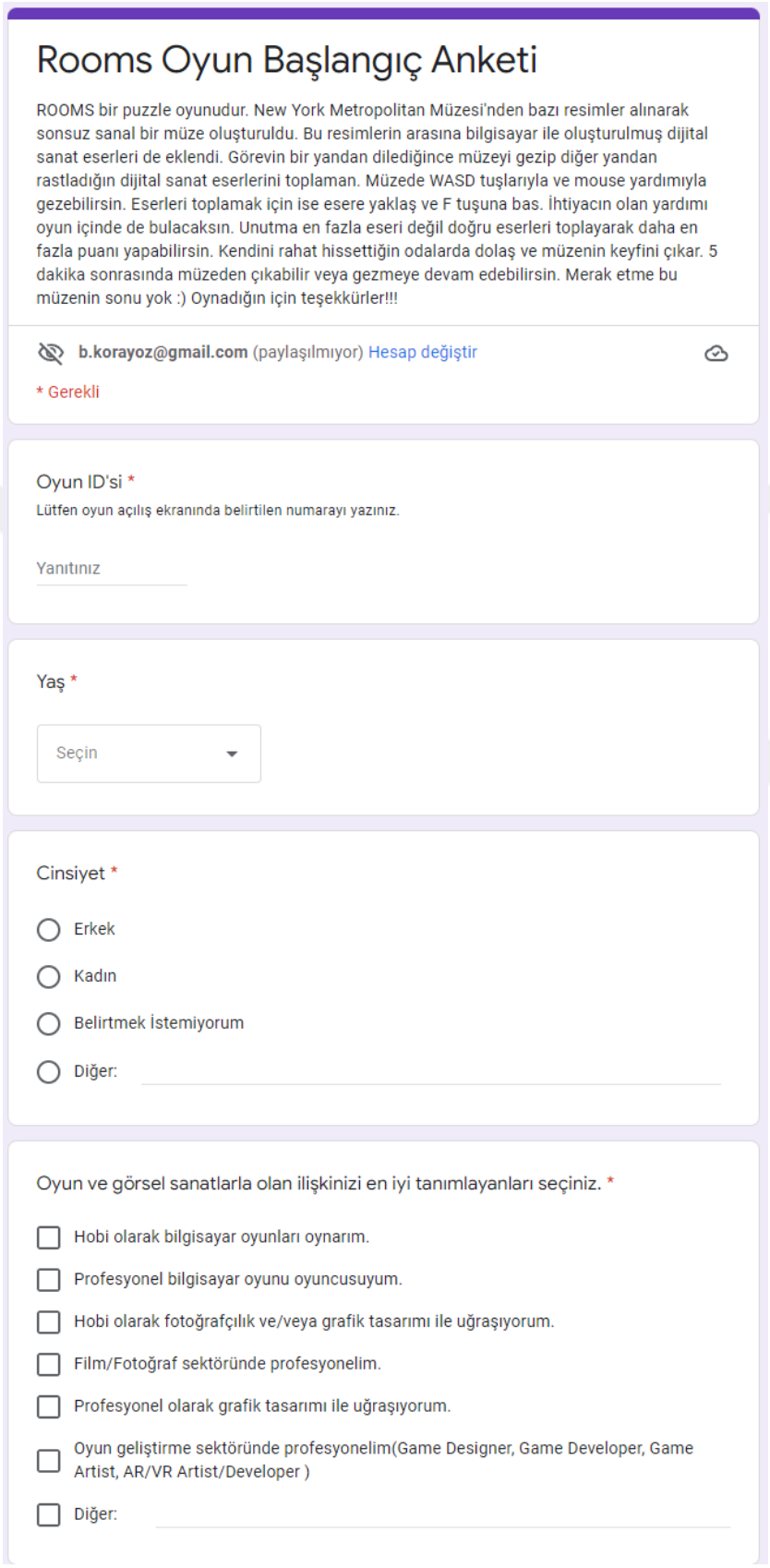

Figure A.2.1: Log file's content that was generated after one participant.

APPENDIX A.3



Rooms Oyun Başlangıç Anketi

ROOMS bir puzzle oyunudur. New York Metropolitan Müzesi'nden bazı resimler alınarak sonsuz sanal bir müze oluşturuldu. Bu resimlerin arasına bilgisayar ile oluşturulmuş dijital sanat eserleri de eklendi. Görevin bir yandan dilediğince müzeyi gezip diğer yandan rastladığın dijital sanat eserlerini toplaman. Müzede WASD tuşlarıyla ve mouse yardımıyla gezebilirsin. Eserleri toplamak için ise esere yaklaş ve F tuşuna bas. İhtiyacın olan yardımı oyun içinde de bulacaksın. Unutma en fazla eseri değil doğru eserleri toplayarak daha en fazla puanı yapabilirsin. Kendini rahat hissettiğin odalarda dolaş ve müzenin keyfini çıkar. 5 dakika sonrasında müzeden çıkabilir veya gezmeye devam edebilirsin. Merak etme bu müzenin sonu yok :) Oynadığın için teşekkürler!!!

b.korayoz@gmail.com (paylaşılmıyor) Hesap değiştir

* Gerekli

Oyun ID'si *

Lütfen oyun açılış ekranında belirtilen numarayı yazınız.

Yanıtınız

Yaş *

Seçin

Cinsiyet *

- Erkek
- Kadın
- Belirtmek İstemiyorum
- Diğer:

Oyun ve görsel sanatlarla olan ilişkinizi en iyi tanımlayanları seçiniz. *

- Hobi olarak bilgisayar oyunları oynarım.
- Profesyonel bilgisayar oyunu oyuncusuyum.
- Hobi olarak fotoğrafçılık ve/veya grafik tasarımı ile uğraşıyorum.
- Film/Fotoğraf sektöründe profesyonelim.
- Profesyonel olarak grafik tasarımı ile uğraşıyorum.
- Oyun geliştirme sektöründe profesyonelim(Game Designer, Game Developer, Game Artist, AR/VR Artist/Developer)
- Diğer:

Figure A.3.1: Pre-survey questions.

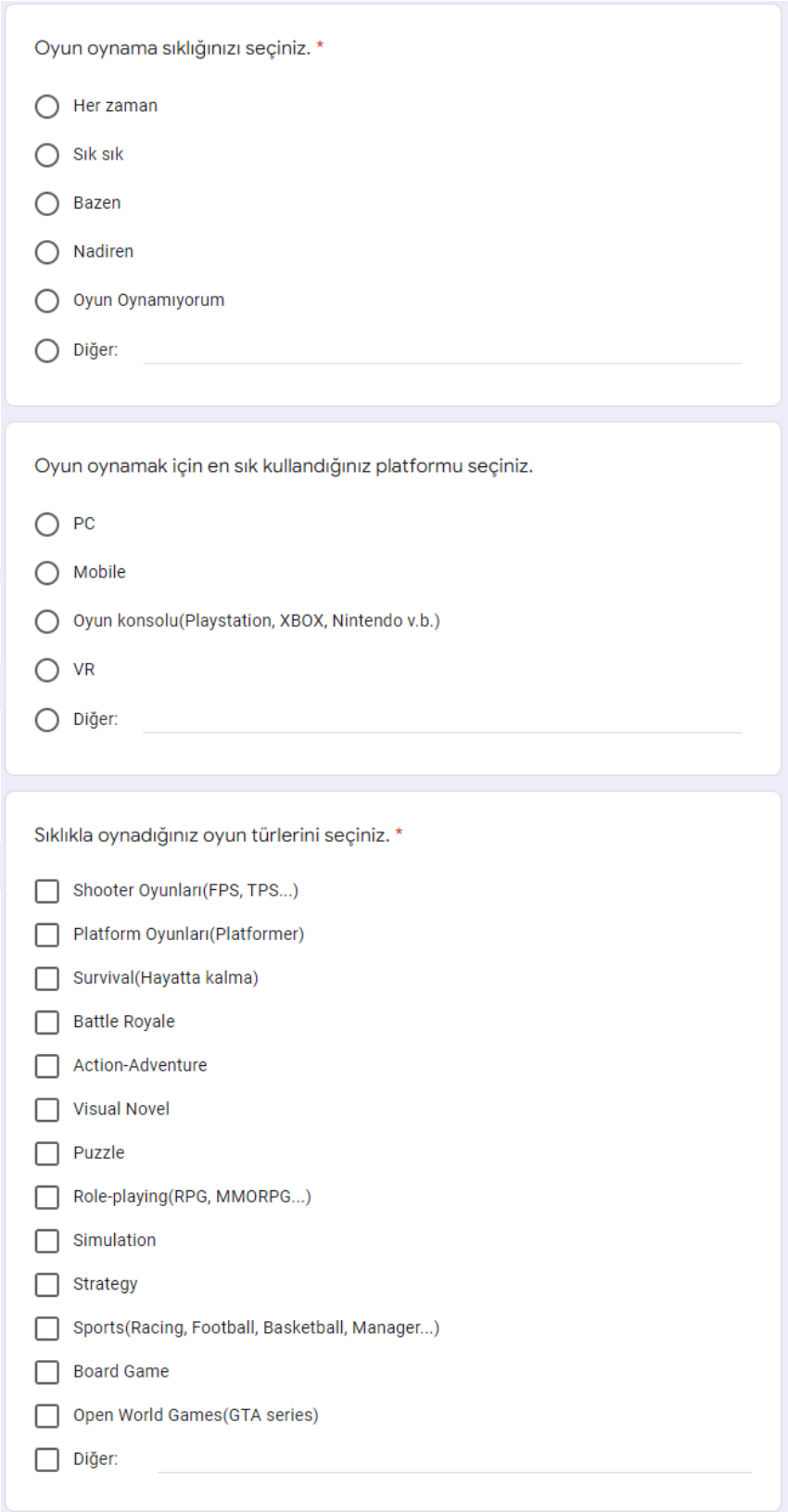


Figure A.3.2: Pre-survey questions continuing.

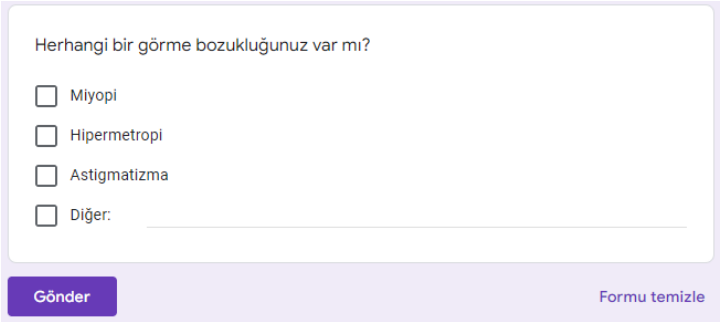


Figure A.3.3: Pre-survey questions continuing.

APPENDIX A.4

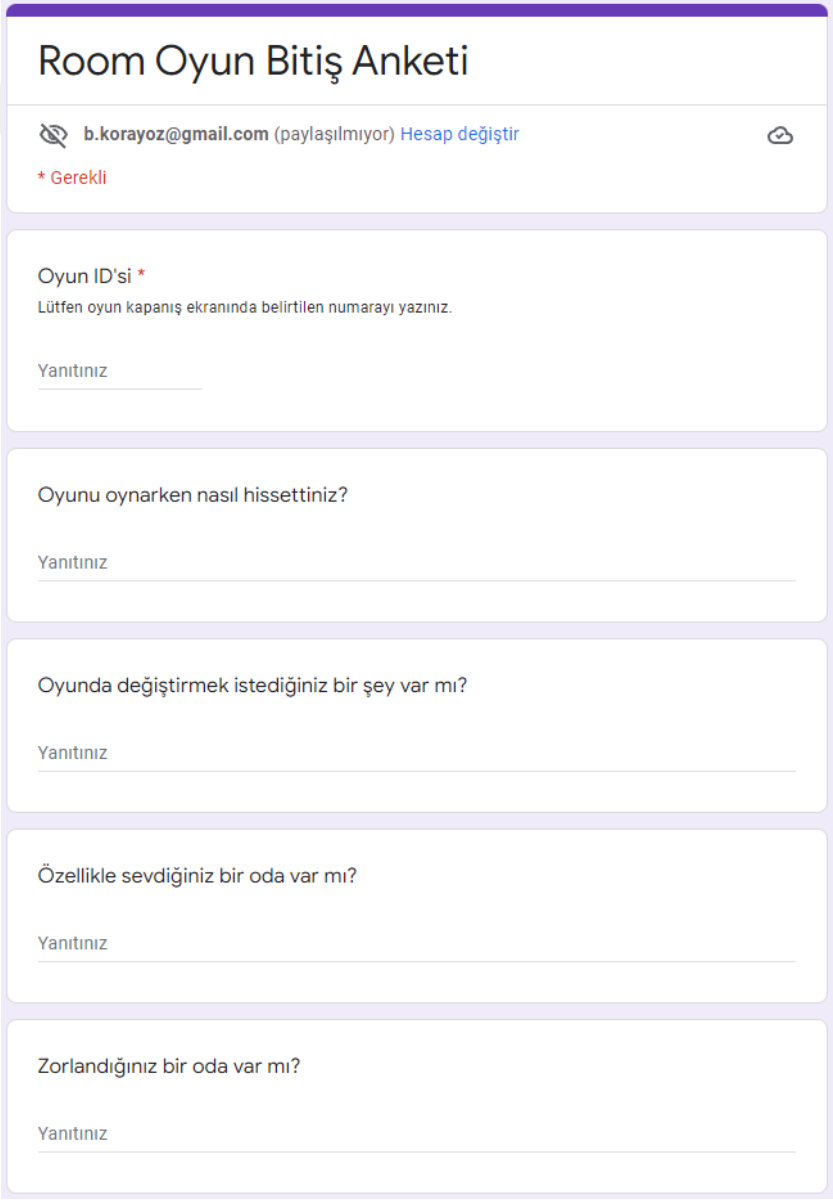


Figure A.4.1: First part of the post-survey questions.

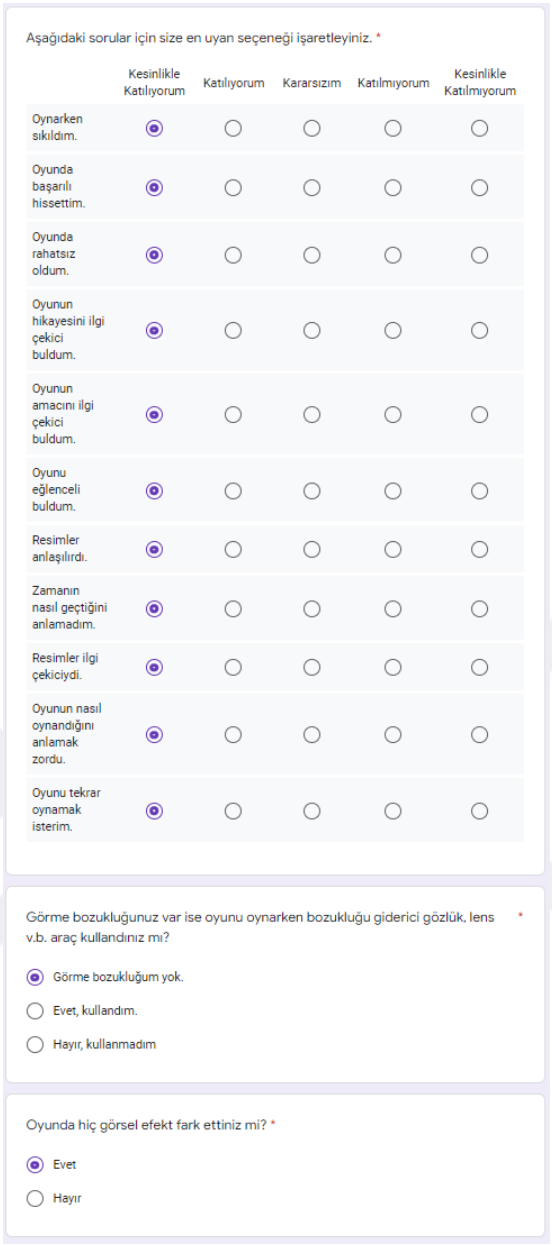


Figure A.4.2: First part of the post-survey questions continuing.

Efektler 1

Hangi efektleri gördünüz? Açıklayınız. *

Yanıtınız

Gördüğünüz efektlerden sizi rahatsız eden oldu mu?

Yanıtınız

Gördüğünüz efektlerden özellikle sevdiğiniz var mı?

Yanıtınız

Figure A.4.3: Second part of the post-survey questions.

Efektler 2

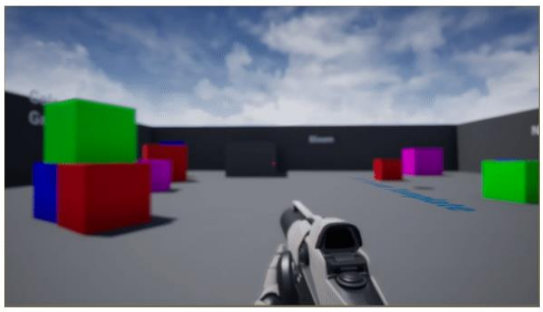
Aşağıdaki videodaki görsel efekt oyunda var mıydı? *

- ○ Efekti oyunda gördüm.
- ○ Kararsızım
- ○ Efekti oyunda görmedim.

Eğer önceki sorudaki efekti oyunda gördüyseniz, bu efekt oyun deneyiminizi nasıl etkiledi? Birden fazla seçenek işaretleyebilirsiniz.

- ☐ Bu efektin olduğu odalarda resimleri daha rahat ayırt ettim.
- ☐ Bu efektin olduğu odalarda daha rahat gezdim.
- ☐ Bu efekt odaklanmama engel oldu.
- ☐ Bu efektin olduğu odalarda çevremin farkına varmam kolaydı.
- ☐ Bu efektin olduğu odalar daha ilgi çekiciydi.
- ☐ Bu efektin olduğu odada bulunmaktan kaçındım.
- ☐ Bu efekt kendimi oyunun içinde hissetmeme yardımcı oldu.
- ☐ Diğer:

Aşağıdaki videodaki görsel efekt oyunda var mıydı? *



- ○ Efekti oyunda gördüm.
- ○ Kararsızım
- ○ Efekti oyunda görmedim.

Figure A.4.4: Third part of the post-survey questions.

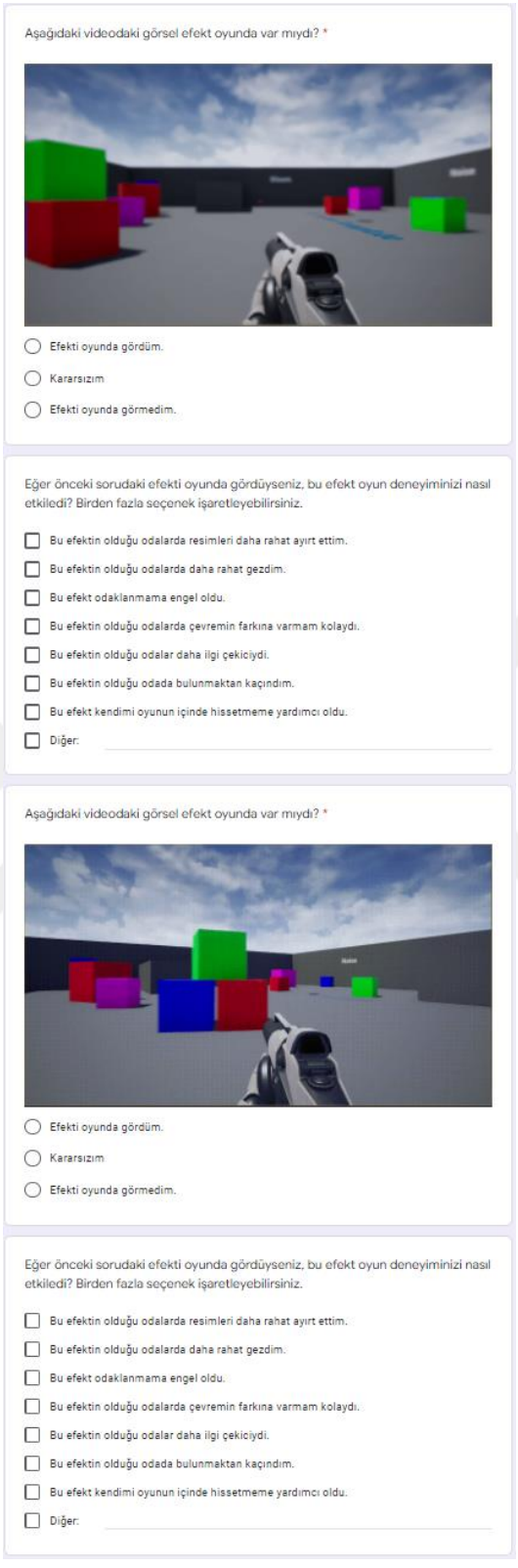


Figure A.4.5: Third part of the post-survey questions continuing.

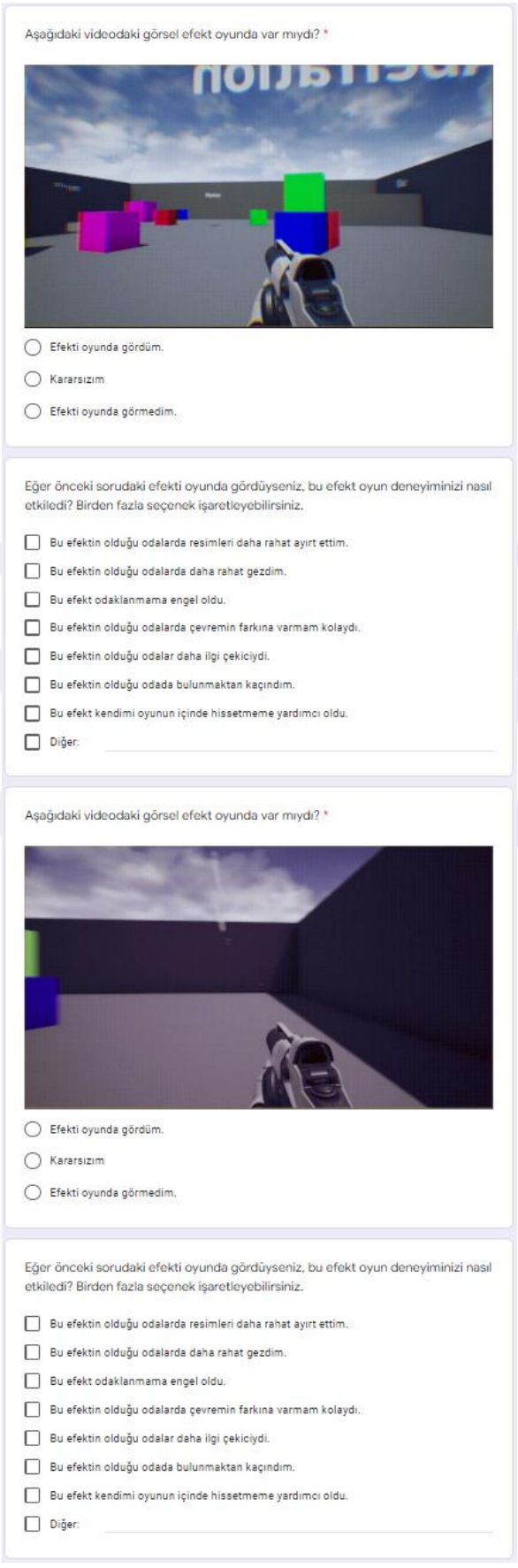


Figure A.4.6: Third part of the post-survey questions continuing.

Figure A.4.7: Third part of the post-survey questions continuing.

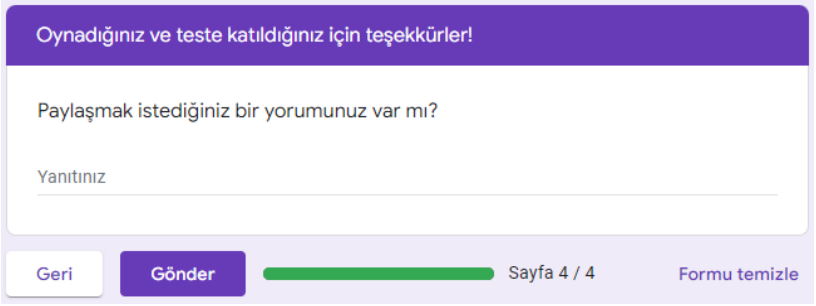


Figure A.4.8: Fourth part of the post-survey questions.

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- **Uluer P.**, **Köse H., Öz B. K., Aydınalev T. C., and Barkana D.** "Towards An Affective Robot Companion for Audiology Rehabilitation: How Does Pepper Feel Today?," 2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), Naples, Italy, 2020, pp. 567-572, doi: 10.1109/RO-MAN47096.2020.9223534.