



Exploring the Use of Light and Colour to Detract and Enhance the Plot of 3D Rendered Scenes

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Lighting and colour play an essential role in the 3D rendered scene. Besides its roles in illuminating the objects, it helps create the mood, directs the audience's eye, creates visual interest and most importantly, creates an illusion of believability in the mind of the viewers that help them engage with the scene. Whereas lighting has a depth to reveal the 3D impression, so it can be out from the background; unfortunately, it is hard to obtain a good lighting due to many concerns that influence the lighting results, such as the light source, its direction, and intensity. This work intends to illustrate how to use a lighting base as ambient displays, combine it with its initial function, to define what forms of interaction are best suited to pass on a message and create a secure emotional connection between the audience and the scene. Different variations of light and colour were applied to the rendered scene to quantify the saturation of the independent factors as well as to observe their effects to work out whether the variations can change the connected emotions and plot of the original scene. The experiments were conducted on 400 participants. As a result, it became evident that the light and colour does control the feelings of the viewers, both elements are complex and varied enough to require further investigation into how they should be monitored. Moreover, the process of lighting is influenced by the taste of the designer.

Keywords:

Lighting techniques; Lighting effects; Colour preferences; Colour types; Colour effects; Render Passes.



1. Introduction

Light surrounds us, whether within an enclosed environment or outside in open spaces. It affects visibility, health and well-being and it can influence a person's effective mood. An emotional state refers to the feelings, emotions and attitudes which one experiences, and it can be influenced by many environmental factors such as sounds, smells or light. Colour can also influence the person and can be associated with emotions and events. For example, blue can remind people of the sky and feel relaxation and red can prompt people of love and blood.

Thus, lighting plays an essential role in a 3D rendered scene. It helps create the mood, directs the audience eye, creates visual interest and most importantly, creates an illusion of believability in the mind of the viewers that help them connect with the story of whatever they are watching. On the other hand, colour is considered to be an important trigger of our feelings and senses. "Colour vision and our emotions are connected because both are processes of the right hemisphere and colour preferences are wired into our brains from selection" (Freiders et al, 2012). From multicultural aspects, colours have different meaning such as green with envy, purple with passion. As well, there is a common culture that associates red with love, white with purity and black with death (Freiders et al, 2012). Palmer et al., mentioned "some colours send an "approach" signal while others send an "avoid" signal. These signals are "deeply ingrained natural colour signals" that have improved survival of early humans" (Palmer et al, 2010).

This research illustrates how light and colour can affect the mood of the scene by detracting from or enhancing the plot. Also, it demonstrates how to use a lighting technique to pass on a message and create a strong emotional connection between the audience and the scene. A further aim is to discover how light and colour heighten the emotional engagement and enhance the overall interactive experience. How does our cognition of light and colour affect our feelings? Different techniques and different variations of light and colour were applied to observe, what forms of interaction are best suited to pass on a message and create a secure emotional connection between the audience and the scene. To get the desired results, many points have been verified while working on the project, such as quality; is the lighting harsh, or soft; direction, where is the light source? What angle? Contrast; the intensity, the brightness, and saturation measures brightness of colour.



The rest of this paper is organized as follows: Section two looks at the state of the art and background of light and colours characteristics. The methodology of this work and a detailed explanation of each experiment are presented in section three. Section four provides a comprehensive discussion about the implementation of different experimental techniques that are used in this research. Where the analysis of this work are explained in Section five. Finally, the conclusion and future directions for our work are presented in Section six.

2. Literature Review

Light is everywhere and is probably the first thing we experience as we enter the world. The most important categorization of light in creating 3D rendered scenes is the division between direct light and artificial light. Direct light is the light available to set the scene; it can be daylight, moonlight, streetlight, or interior lighting. Artificial light is light that enables the design controller to achieve a specific purpose in the scene. The most significant characteristics of light are brightness, colour, and temperature (Gallardo, 2001). Light that is visible to the human eye is the part of the electromagnetic spectrum, comprised of different wavelengths, which are recognized as different colours. The longer wavelengths are perceived as red, and the shorter ones as violet (Gallardo, 2001).

There are a number of controllable factors that affect the psychological and emotional state of the viewer. Colour, light intensity and distribution are the most effective factors used to influence the viewer. Colour is considered to be the key for generating the mood and directing the emotion of a scene. Hues and saturation used in the scene are aids to convey what the scene is about, or to direct the emotions of the audience. Light intensity is the amount of transferred light or brightness and it can range from a dim glow to shining lights; while distribution refers to the physical location of the lights, and relates to the number of lights in the scene, their types, and beam size. The location plays a huge role because it defines how the objects in the scene will be lit. Placing the light at a suitable angle and location will affect the way it casts light on to the object, helping to shape it and create more engagement with the scene (Calahan, 2000). Moreover, Colour characteristics can be expressed in three visual aspects: brightness, saturation and hue (Fairchild, 2013). Brightness or lightness is the perceived amount of light, making a difference between bright and dim. Saturation can be defined as the visual sensation of colour appearing to be more or less chromatic. Hue is related to the controlling wavelength of the



visible spectrum (Fairchild, 2013), and the differentiation between colours by name, such as yellow, green and so on.

From the beginning of cinema production, cinematographers and producers have been using lighting effects. Even though these lighting effects were not essential, there was a need to create a specific mood. At the inception of the 20th century, the film industry focused as much as possible on illuminating actors in the most favourable way. A noticeable return to using natural light was marked in the World War II, which gave movies a more realistic and powerful look (Sikov, 2009). A key technique used by cinematographers to light the scene is the Lighting Key. There are two kinds of lighting keys. The high key uses shining illumination to give the scene a more realistic and natural impression, this manner achieves better recognition for the objects in the scene. The low key uses shadows and pools to establish feelings of suspense or mystery. Another technique used to introduce an atmosphere of tension and anxiety is "High Contrast Lighting" which utilises bold, black streaks. This style also creates many shadows, which can convey an atmosphere of worry (Sikov, 2009).

There is much evidence that various lights and colours in different spaces might affect the viewer's psychological mood (Laike, 2006). A study found that a positive mood is created with a luminance under 2000 lux. and more than 300 lux (Laike, 2006). There is a model proposed to discover "in which mood, visual performance and decision making strategy are affected by the visual environment and compete for mental processing capacity" (Calahan, 2000). The mood shift for men was strongly positive for "bright" conditions and almost zero for "dim" conditions, while women respond in the opposite direction (Laike, 2006).

Light shortage can influence natural physiological performance (Kuller, 2002). There is a relationship between daylight and mood called "Seasonal Affective Disorder (SAD)". This can happen in countries far from the equator during the winter months. It can make people feel sad, reduce activity, social withdrawal and depressed. In fact, there is a technique adopted by specialists to help many common disorders associated with SAD, called "Light Therapy" which uses daylight and coloured light to treat some mental illnesses (Kuller, 2002). Despite the fact that light can be powerfully effective in a psychological situation, it also has a dexterous way to evoke feelings and emotion. One of the most key characteristics of light is its intensity. "Higher levels of lighting generally produce cheerful effects and stimulate people to alertness and activity,



whereas lower levels tend to create an atmosphere of relaxation, intimacy and restfulness" (Gallardo, 2001).

Colour is always paired with a light, and it plays an enormous function in tuning the mood. For instance, the crimson light of a fire instantly warning us of danger. The warm orange glow of candlelight enhances the feeling of relaxed, romantic and comfortable mood. The shining yellow light from the sun supply us energy for the day (Shin et al, 2015). It has been claimed that pulsing light with a quick dissonant rhythm is not the only way to get our attention; flashing light with a high frequency "long wavelength" can influence our attention and make us feel excited or anxious. For that, "the use of strobe lights in haunted houses and contrast that with the constant illumination on flags and public buildings, which connotes stability and strength" (Shin et al, 2015). Additionally, focused and diffused light can influence our mood strongly. Knez in his research illustrated that diffuse light comforts us and softens our facial expression and relieves tensions. In contrast, hard focused light makes the objects seen in a sharp and strict way, which might make us feel nervous, anxious and uncomfortable (Knez, 2001).

Response to colours might be individual and due to associations, as a red colour may comfort someone, while causing stress and discomfort for another (DeLong et al, 2013). One explanation suggests that the human is affected by different colours that reach the "hypothalamus" which controls the nerve centre and body functions; the wavelength for each colour differs with the intensity; in turn this influences us in various ways. Colour may cause a reaction in the vascular system; this might be shown through feelings and emotions.

There are several models found to measure and describe emotions based on the behavioural or cognitive response of a person. One of these models is the OCC model "Ortony, Clore and Collins (1988)". This model describes a hierarchy that categorizes twenty-two emotions by type. It contains three branches: First, emotions based on the succession of events such as joy and pity, secondly, actions of agents like pride and reproach, and finally, aspects of objects like love and hate. Furthermore, some branches of the hierarchy join to form compound emotions, which are defined as, "emotions concerning the consequences of events caused by actions of agents" such as gratitude and anger. These concepts (events, actions, and objects) are also usually used in the agent model (Steunebrink et al, 2009). Strauss et al., in their effort to discover why people like a specific colour, specialists have tended to focus on evolution. The main approach considers that people "like colours that are tied to things that are healthy and promote survival." for



instance, a blue sky indicates calm weather, which might lead to the interpretation that blue is a favoured colour across cultures. On the other hand, dark yellows and oranges may indicate toxins, such as rotting food. As might be expected, there is thus a preference for rejecting these hues around the world (Strauss et al, 2013).

Specialists are also obtaining different results, such as a preference for red among women. One of the experiments involved presenting slide shows of coloured objects to a group of people. The researchers found that some people might perceive positive associations like delicious strawberries, and in contrast green images were associated with unpleasant things like slime. In the same context, others saw unpleasant red things such as blood, but they felt satisfied with an association of nice green trees. Subsequently, the National Academy of Sciences reported that "people preferred whichever colour has been linked to the positive images they saw, whether red or green" (Palmer et al, 2010).

3. Methodology and Experimental Design

The aim of this research is to find how to use a lighting base as ambient displays, combine it with its initial function, to define what forms of interaction are best suited to pass on a message and create a secure emotional connection between the audience and the scene. How light and colour heighten the viewer's emotional engagement and enhances the overall interactive experience. Besides that it tries to find how does our perception of light and colour provoke feelings? Moreover, how can light and colour influence the emotions perceived by different cultures? By using "Three Points" lighting and colour correction techniques in the creation of the scene, different variations of light and colour were applied to enable observation of the effects in order to work out if the variations could change the effect on emotions evoked by the plot of the original scene. Obtaining the desired results entailed verifying many points while working on the project, such as light quality, light angle and direction, and the difference between the brightness of the shot and colour saturation (the contrast).

At the beginning of developing the media project, it was important to find the most effective tools to begin creating the scene. This project used Autodesk Maya Software to create 3D rendered scenes, including creating the lighting environment. Adobe Photoshop was used for UV Texturing. Nuke and Adobe After Effects software for colour correction and visual effects. In addition, the author models and online 3D model was used to create the scenes. These are the

most essential software products in the 3D industry. The media product of this project has focused on psychological and practical aspects. Two virtual environments have been created (Indoor and External), each environment having two different lighting circumstances; the aim is to get to a stage that can simulate a real scene with the appropriate psychological atmosphere for each one.

3.1 External Environment

The appearance of an external scene depends on a multiplicity of features: viewing geometry, scene structure and reflectance, illumination (sunlight, moonlight, stars, and street light), atmospheric conditions (clear air, fog, rain) and weathering of materials. Throughout the time-scale of the scene, these features change, altering the way it appears. This description covers a wide range of daylight and night conditions which are used in the scene to interact with actual scene depth. This scene has been shot in two different lighting states. The next part will illustrate the lighting setting for each 'external' shot.

3.1.1 Lighting setting: Scene One

Choosing a particular time of the day to capture the scene was very difficult. The distribution of environmental illumination on a scene produces a wide variety of scene appearances. Generally, marked effects include shadows, colours of sunrise and sunset, and lighting from stars, moon, and streetlight at night (Narasimhan et al, 2002). To maintain the neutrality of the scene, day time 'early morning time' has been selected. The human visual system depends on illumination in the scene to understand the scene reflectance and appearance correctly (Knez, 2001). As a result, rendering a scene with convenient illumination is crucial for realism in a 3D rendered scene. Considering the various sources of illumination available for any external scene, direct illumination primary source 'Sun Direction' or 'Physical Sun and Sky' was used. As mentioned before, colour is an important trigger of our feelings and senses. Colour correction and grading is the final step in making any scene, being used to make special effects more realistic and palatable, as shown in the figure 2.

3.1.2 Lighting setting: Scene Two

This scene used same setting for the first one, but with a different lighting concept. it presents a dark and stormy night as shown in figure 3.

3.2 Indoor Environment

For internal experimental design, a 'Kitchen' environment has been chosen. The scene as illustrated in figure 4 represents a traditional kitchen with simple architectural details.

Axiomatically, the key to a good and effective interior lighting setting is the brightness, as this would make every element in the scene easy to see. However, the brightness alone is not enough to adjust a better lighting state. The contrast is considered to be significantly important for an interior lighting design; it makes the viewer feel more comfortable and avoid monotony. Ideally, the room should have several light and dark regions. In this work, each scene has been shot in two different lighting situations. The next part will illustrate the lighting setting for each 'indoor' shot.

3.2.1 Lighting setting: Scene Three

As shown in figure 5, the key light coming through the window, 'Sun Light', is presented by using 'Directional Light' rather than 'Physical Sun and Sky'; it represents an extremely distant light source. Rays cast from directional lights run parallel in a single direction from every point in the sky. Directional light is typically used to simulate direct sunlight; the 'Light Shape Colour' has been changed to light yellow. Furthermore, a 'Blue Spotlight' was added, to support the 'Directional light' simulation. In addition, two 'Point lights' were attached to the scene to make it more realistic and reliable. The scene has been completed via Adobe Photoshop. The render passes combined, different layer properties have been changed such as 'Reflection and Direct Irradiance'.

3.2.2 Lighting setting: Scene Four

The target of the lighting in this scene was to create a mysterious and frightening impression. The first attempt to lighten the scene as shown in the figure 6 was by using 'Moon Spot Light' where the light is coming through the window, this is 'the key light' in the scene, which means that shadows for the elements will be from this light, supported by 'candle light' placed on the table using a 'Point Light'; the candle light casts illumination outward in every direction from a single, infinitely small point in 3D space. The point light colour has been set as 'Orange Flame' to create a lighting contrast. For the candle spotlight, 'The Depth Map Shadow Attributes' used the 'Depth Map Shadow'. A third lighting source in the scene is a 'Point Light' to make it more visible, the settings of this source were limited to use the "Intensity" in a lower level.

4. Discussion and Results Analysis

This work proposes to illustrate how to use a lighting base as ambient displays, combine it with its initial function, to define what forms of interaction are best suited to pass on a message and create a secure emotional connection between the audience and the scene. Several lighting conditions and various colour temperatures were presented to assess the validity of the idea that light and colour heighten the emotional engagement of the viewer, thus enhancing the overall interactive experience. The experiments were conducted on 400 participants as demonstrated in table (1), who were from the UK and Jordan. The age of the participants ranged between 21 and 32 years with an average of 24 years. The questions were administered to the participants at three different times and online to collect the data together. However, none of the participants were involved in any light/colour perception research. A questionnaire consisting of fifteen questions about different lighting conditions, and how it influences their mood.

Of the first questions, "What is your favourite colour?" was closely tied to personality and culture. Next, to find what different colours mean in different cultures, the question given was "What colour makes you feel Happy, Scared, Comfortable, Curious, Sad?" respectively. Following that, three 'colour mood' catalogue was presented for each scene to find how the participants would respond to colours themselves, and not related to any elements. The later questions were relying on 'the generated scenes with different lighting situations', to find more about the viewer's experience with certain lighting conditions, and how it influences their emotion. Whereas, Colours contribute significantly to our feeling and senses. As an attempt to explain this observation, two methods have been chosen; Colour vision and human emotions. The questionnaire for this project contained questions to determine how colour and lighting influence a person's psychological and emotional response, by combining the two questions "What colours make you Happy, Comfortable?" and "How would you describe your feelings during and after viewing the following images?" for the first scene (External day light).

The following conclusion was reached: in the UK, the participants' first and second choices for colours that make them feel 'Happy and Comfortable' were 'Blue, and Orange', rates at 20% and 18% respectively. While, in Jordan, favoured 'Blue, and Green' ranging around 17%, 16% and 16%, 23% consecutively. As mentioned before the psychological aspect that derived from the first scene, was a comfortable and relaxed impression. The image has achieved the desired goal, and the 'Comfortable and Happy' impression has recorded 52% and 34% as the highest choices

for the participants from all participating countries. Furthermore, the same scene has recorded around 23% for a 'secure' impression. As a result, the general impression was positive. This was due to the use of 'Blue and Green' as the predominant colours in the scene. In addition, from the researcher's perspective it reinforced the previously proven observation as to how the amount of light can affect our mood and emotions; natural lighting and skylights have a relaxing effect on minds and emotions.

In the other presentation of the same environment, 'External dark night', in 65% of all responses the participants experience of the lighting conditions and colours were considered 'Scary'. About 22% of UK participants found it 'worrisome', whereas amongst Jordanians, 14% considered it an interesting scene. In the same trend, the participants from both regions considered 'Black' as a colour making them feel scared in percentages of 39%, 29% and 23% of the UK, Jordan, respectively. Moreover, 'Black' is an absence of light, and that might cause a feeling of menace. In addition, 'Black' is considered a colour that makes the participants feel sad in each region separately. In the UK it recorded the same percentage as 'Brown' colour; 26%. Also in Jordan the percentage of 'Black and Brown' as a colour causing a sad impression is convergent; 28%, 27%.

On the other hand, the goal of lighting for the 'Internal dark' scene, was to create a mysterious and frightening impression. The result was slightly surprising, 32% of UK participants described the image as impression. The participants from Jordan described the first impression as sad at 31%, around 18% found it scary, and the unexpected consequence was 14% of the participants found it interesting and secure. 34% of the participants from other regions, considered the scenes sad, and 31% scary.

To analyse these consequences, and the colour mood in the scene, by looking for what colours make the participants feel scared, sad, and curious, it is obvious that 'Black' as a representative of sad and scary feeling, influenced the scene as it is represented by the shadows. Furthermore, as mentioned before night scenes may exaggerate fearful signs and enlarge fear responses. To explain why the participants felt the scene to be 'interesting', recorded as 12%, 14%, in the UK, Jordan, respectively. Considering which colour makes the UK responders feel curious, the results arrived at were Blue 28%, White 26%, and Orange 10%. From a scientific standpoint, this was achieved in the scene by the contrast between Blue and Orange, because Orange is the supplementing colour of Blue in 'The Colour Wheel' in (Custers et al, 010). On the other hand,



Jordan participant responses to which colours make them feel curious, were Black 16%, Red 19%, and Orange 13%. Once again, Orange colour achieved a contradiction in the scene, which sparked the participants' interest. In the same way as in the 'Internal daylight' scene, the lighting objective was to create an interesting and secure impression. This target has been achieved through the participants' choices from both participating countries, interesting 28%, comfortable 24.7% and secure 18.7%.

The purpose of this research is to study the impact of lights of different colour and intensity on the viewers of a constructed scene. Experiments, as explained above were conducted towards this goal. This section presents the results of the experiments by answering questions posed previously. What do the different colours mean for different cultures? There are common cultural connections about colours such as red with love, white with purity, and black with death. It is evident that we link colours with our emotions and this could be due to the fact that emotions and colour vision are both processes of the right hemisphere (De Bortoli et al, 2001; Jasper, 2014). As depicted in Table 2, each colour can represent a different feeling for this study audience.

In order to figure out how our experience of light and colour can affect our feeling, this work presents two scenes; each scene keeps the same elements but has two different lighting conditions. Light itself expresses different meanings; clarity, hope, comfort, truth, and guidance. In addition, Darkness represents adverse forces. As a result, in the external lighting scene, the viewers felt comfortable, happy and secure. In the contrasting scene, the external dark lighting has presented a dark and stormy night; the high contrast lighting creates many 'Black' shadows. The same scene with the same elements evokes feelings of fear and anxiety. The lighting in this situation represents a cool, melancholy atmosphere. Results analysis for each scene are illustrated in figures 7.

Furthermore, where the use of lighting was targeted to create a mysterious and frightening impression in the 'Internal dark scene', it has recorded a response as sad and scary; The presence of shadows and dramatically dark areas lead to that feeling. Thus, the role of lighting and colour to create that feeling cannot be ignored, because this can be proved by contrast with the 'Internal daylight scene', which kept the same elements, but with the change of the type of lighting, the participants consider the scene as interesting and comfortable, giving an impression of peacefulness to the viewer. As shown in figure 8.



Research in lighting, which this project confirms, shows that lighting and colours are intimately related. Literature indicates that lighting can influence emotions, mood and cognition as well as atmosphere and spatial impressions. As has been reported, lighting has become a key component of visual design, it can create a valuable emotional effect, and show the essential reaction to light and darkness in order to influence the viewer's response to narrative development. Light location and direction convey significant meaning because they affect the shadows, deep shadows can make a scene untrustworthy or conceal a host of horrors. By contrast, bright, diffused lighting can provide comfort and peace or create the impression of a holy feature, because of the harmony between the lighting and shadows.

Another result this research has found, that there is a possibility to enable the viewers to feel a connection towards the scene. This has been achieved in all scenes, and the choices of viewers were converging. It is been demonstrated that the viewers respond to lighting according to three features, brightness; visual attraction; and complexity (Birn, 2006). Thus, in this project the responses to the 'external dark scene' were clear, the participants found the lighting conditions and colours 'Scary', as shown in figure 9.

5. Conclusion

Learning to light is learning to see, but this requires more than intense observation. The most difficult and most important aspect to learn is visualization. One must take into consideration the psychological aspects of lighting and colours and how these can influence the viewer. In addition, there is the capacity to imagine the final result in the mind before applying it in the software; and to be comfortable with what the tools can do. This study provides a better understanding of the impact of lighting on the perceived emotional atmosphere in an innovative environment. Lighting characteristics and interior qualities, including colours, brightness, and intensity were successfully linked to perceived atmosphere. This research showed how light and colour can affect the mood of the scene by detracting from or enhancing the plot. In addition, the research showed how to use a lighting technique to pass on a message and create a strong emotional connection between the audience and the scene, thus discovering how light and colour heighten the emotional engagement and enhance the overall interactive experience. How can they be used to influence understanding of the emotions for different cultures? Moreover, how does our cognition of light and colour evoke our feelings? Different techniques were used in this project, and different variations of light and colour were applied to observe the effects in order to work out if the



variations can change the connected emotions and plot of the original scene. To get the desired results many points have been verified while working on the project, such as, quality; is the lighting harsh, or soft; direction, where is the light coming from? What angle? Contrast; the intensity, the brightness of the shot and saturation measures brightness of a colour.

However, studying the effect of spatial distribution of coloured lighting on the current atmosphere, while keeping the scene brightness constant, could be quite challenging. In addition, animated lighting could also influence the atmosphere, for example to create thrilling atmospheres. Environments do not use a single coloured. Therefore, colour combination, could promote or reduce the perceived atmosphere. Additionally, it would be interesting to see if the natural light (daylight or moonlight) have an influence on the perceptible atmosphere but also on the suitability of a space. In this experiment there was light from outside, which it is a common factor in everyday life. However, natural lights are uncontrollable and therefore it could be poignant to invent daylight/moonlight to control impacts of outside elements like cloudiness or extreme sunlight.

Figures and Tables

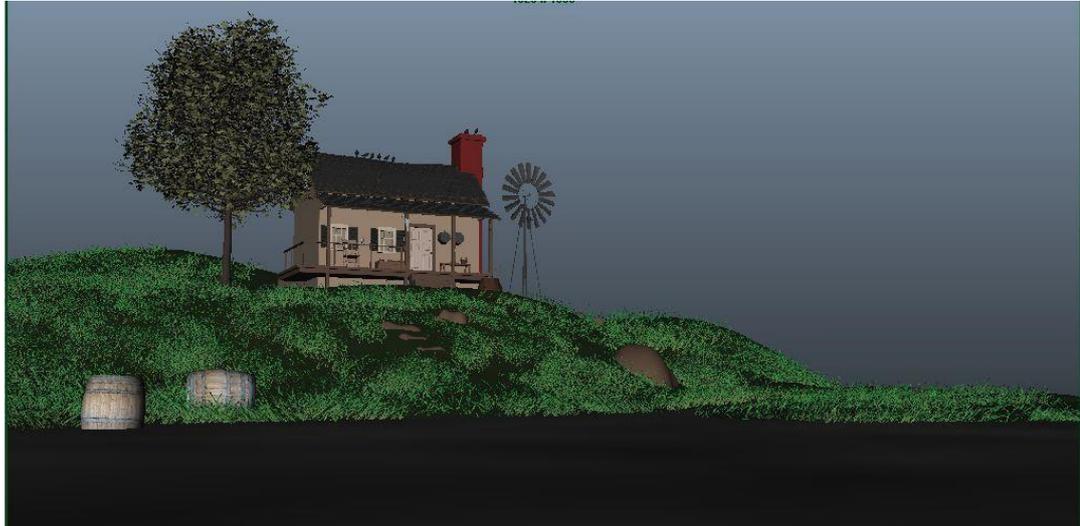


Figure 1. External environment design



Figure 2. External environment 'Day light' final result



Figure 3. External environment 'Dark light' final result.



Figure 4. Indoor environment design



Figure 5. Indoor environment 'Day light' final result



Figure 6. Indoor environment 'Dark scene' final result

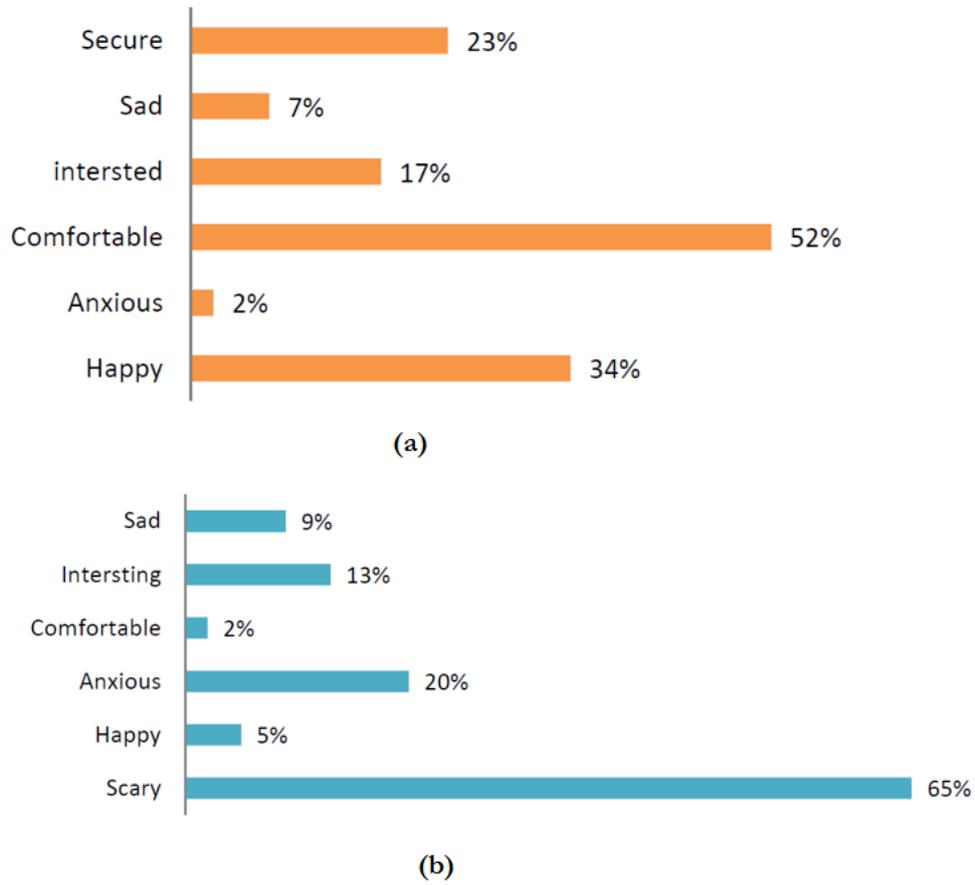


Figure 7. a) Results analysis of Scene 1 for both regions and b) Results analysis of Scene 2 for both regions

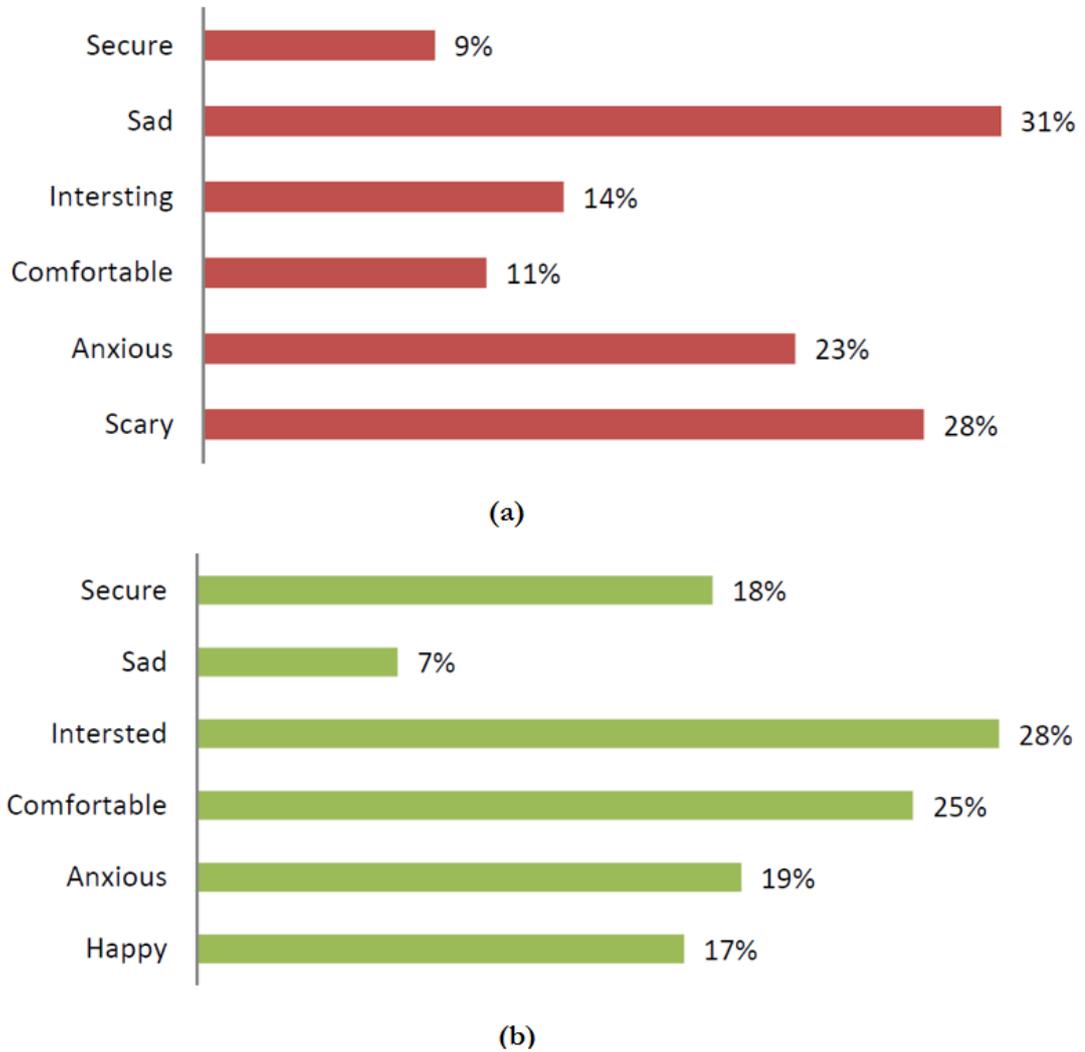


Figure 8. a) Results analysis of Scene 3 for both regions and b) Results analysis of Scene 4 for all regions

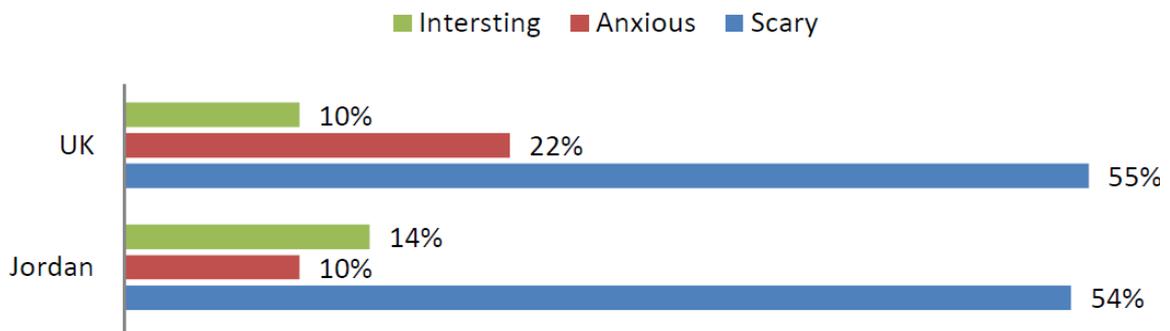


Figure 9. The participants' response to the 'external dark scene'

Table 1. Analysis of Participants

Country	Female	Male	Total
UK	110	90	200
Jordan	100	100	200

Table 2. Colours related feeling

Feelings Region	UK	Jordan
Happy	Blue 20%	Black 17%
Scared	Black 39%	Black 29%
Comfortable	Blue 34%	Blue 27%
Curious	Blue 28%	Red 195
Sad	Grey 28%	Black 28%

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