Cinematic Lighting and Emotional Expression of Virtual Characters

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Supervisor: Rachel McDonnell

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Cinematic Lighting and Emotional Expression of Virtual Characters

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Cinematic lighting can create an atmosphere and enhance the emotions of the characters. This project focuses on how lighting affects the emotional expression of 3d virtual characters. A set of perceptual experiments are designed to investigate the effects of light color, shadow intensity and realism of the characters. White, yellow and blue lights are used to represent different color temperatures. The recognition of the emotion, emotion intensity and genuineness of the emotion are used to measure the participants' responses. Shadow intensity and realism are proved to have effects on recognition, intensity and genuineness of emotion. And they affect the perception differently according to different kinds of emotions. The result doesn't show that the provided light colors have effects on emotional expression. Future work like running the experiments with more different light colors is needed.

Key Words and Phrases: Character Lighting, Emotion, Perception, Genuineness

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Chapter 1

Introduction

This chapter is an introduction to the rest of the paper.

Chapter 2 provides background on cinematic lighting and the connection between lighting and emotions. And it states related work about lighting and virtual characters' emotional expression, detailing why light color, shadow intensity and realism are considered factors in the experiment. Section 3 presents the design of the experiment, including what lighting conditions, characters and emotions were used, and how I set up the measurements. Chapter 4 describes the implementation of the experiment, including experiment settings, stimuli creation and the measurement scales. Chapter 5 discusses the evaluation method and results. Finally, chapter 6 draws conclusions and discusses future work.

Chapter 2

State of the Art

2.1 Background

2.1.1 Cinematic Lighting

Lighting is one of the most important and powerful tools in film-making [Grodal (2005)]. Cinematic lighting refers to the process of controlling of both natural and artificial light sources in a scene. It includes manipulating both the intensity and color temperature of the light sources, as well as setting up cameras to control the intensity of the light that reaches the sensor.

Lighting is fundamental because it helps to create mood and atmosphere for the film. It guides the audience's eyes and reflects the mood of the characters. Cinematic lighting is also widely used in animated films. Hengtaweesub (2017) proved that cinematic lighting affects the 3D animated scenes' emotional impact and story in detail.

2.1.2 Lighting and Emotions

Poland (2015) proved that different lighting conditions receive different levels of emotional responses from the audience. They proposed that high-key lighting will cause audiences to feel higher levels of positive emotions like happiness or humor. However, a film in low key will cause more feelings of suspense and mystery, etc.

More specifically, Melo and Paiva (2007) studied lighting's effect on creating emotions for virtual characters. And Wisessing et al. (2020) designed perceptual experiments to examine if brightness and shadow intensity affect the emotion expression of the characters. They rendered a controlled set of stimuli varying in key-light brightness and shadow intensity, and proved that brightness and shadow have some effects on the emotion intensity and appeal of the virtual characters.

2.2 Closely-Related Projects

This thesis focuses on the emotion expression of virtual characters under different lighting conditions. According to Wisessing et al. (2020), I designed perceptual experiments to record participants' response. They applied different brightness and shadow intensity to virtual characters to see how these factors affect the characters' appeal and emotions. Based on that, I also researched light color's effect on emotion expression, and considered it as a variance to examine in the experiment.

In this research, different light colors and shadow intensity were applied to 4 characters. Instead of appeal, I added genuineness of the facial expression as a measurement. In the next sections, related research about these factors is stated.

2.2.1 Colors and Emotions

Early research [Hemphill (1996) and Mahnke (1996)] already showed that colors have an impact on human's emotion and feelings. For example, according to the experiment of treatment room lighting from Han and Lee (2017), blue and red lights strengthen the mood states of depression, anger and confusion compared to yellow light, and emotions of vigor-activity like happiness and humor were rated with higher scores under yellow light. But research from Wexner (1954) showed that blue color has been associated with comfort and security. And the experiment of Mahnke (1996) proved that red has positive impressions such as active, warm, and passionate. Some evidence shows that these different effects of colors may be culturally-based. In all nations, black and red are seen as the colors of anger. Black represents fear and red represents jealousy. However, Germans connected envy and jealousy with yellow, Americans connected envy with black, green and red, and Russians saw envy as black, purple and yellow [Hupka et al. (1997)].

Colors are also represented in temperature terms such as "warm" or "cool", according to the dominant wavelength of the color. Cool colors like blue, green and purple are seen as quiet and peaceful, and warm colors like red and yellow are considered stimulating and active [Ballast et al. (2013)]. I decided to use warm and cool to represent different light colors, and add normal (white) light as a middle value. A perceptual experiment from Shahidi et al. (2021) use red, blue and white lights to test the effect of color temperature. Previous research shows blue and red both depression and anger [Han and Lee (2017)]. Instead of red light, I use yellow light to represent warm light, since it received more emotions like active and hopeful [Mahnke (1996)].

2.2.2 Emotion Genuineness

Facial expressions often come from genuine emotion and remembered events [Dawel et al. (2017)]. For example, someone displayed a sad expression because something bad happened, or someone laughed because they heard a hilarious joke. But in some situations, we can see people acting or posing expressions, like smiling in a school photo without feeling any real happiness. In this case, their facial expressions look fake and we don't actually feel any emotion from them. Tinwell et al. (2011) ran an experiment to test the familiarity and human-likeness of emotional characters. They found that fear, sadness, disgust and surprise are more uncanny (less familiar and human-like), but anger and happiness have less noticeable uncanniness. And in the research of Dawel et al. (2017), they applied a neutral-midpoint scale to measure the participants' responses to genuineness. Their scale starts from –7 (completely fake) to +7 (completely genuine), with a neutral midpoint at 0, which means don't know. So scores above 0 indicate genuine emotion, and those below 0 are treated as fake. Their perceptual experiments showed some connections between different emotions and genuineness. So I decided to use genuineness as a measurement in this research, and see if lighting conditions have some effects on genuineness.

2.3 Summary

The perceptual experiment from Wisessing et al. (2020) showed that brightness and shadow intensity can affect the emotion intensity and appeal of the characters. Based on the research about color and emotions, I added light color as a new factor to test in my perceptual experiment. And I used genuineness as a new measurement according to Dawel et al. (2017). I was also interested in the impact of characters' realism on emotion perception. Previous research like MacDorman et al. (2009) shows that different levels of realism affect human-likeness and attractiveness of the virtual characters.

Therefore, I hypothesized that light color, shadow intensity and realism can affect the emotion expression of virtual characters. I presented a large number of stimuli to the participants and used recognition, intensity and genuineness as measurements for this perceptual experiment. The perceptual experiments showed that both shadow intensity and realism have effects on emotion expression, including the new measurement genuineness. However, our data showed that light color didn't have significant effects on these measurements.

Chapter 3

Design

This chapter is about how I designed the experiment. I was interested in how lighting conditions can affect the perception of the characters' emotions. The main factors I was going to test were: light colors, shadow intensity, emotions and the realism of the characters. Therefore, I needed to render out stimuli of the characters in different emotions, under controlled lighting conditions. All the stimuli would be displayed to the participants, and they needed to rate the stimuli according to the provided measurements.

3.1 Characters and Emotions

For characters, I decided to use 4 characters of different gender (female and male) and races (black and white). All the characters were made using the Metahuman feature of Unreal Engine, as Figure 3.1 shows.

(a) Ada (b) Bryan (c) Pia (d) Ettore

Figure 3.1: The 4 Characters used in the experiments

I chose 5 emotions to test in the experiments: neutral, happiness, sadness, anger and fear. Jack et al. (2014) proposed that emotion communication is comprised of 4 basic emotions: happiness, sadness, fear and anger. And I added a neutral expression based on this theory. I wanted to test if realism could also affect the perception of emotions, so I set up 2 levels of realism for the characters.

Figure 3.2 shows characters with different emotions and levels of realism.

(a) Happy, high realism

(b) Sad, high realism

(c) Happy, low realism

(d) Sad, low realism

Figure 3.2: Character Pia with different emotions and levels of realism

To exclude the effects from the character itself, I set up the same haircut for characters in same gender. Also, all the characters were wearing the top with same shape and color.

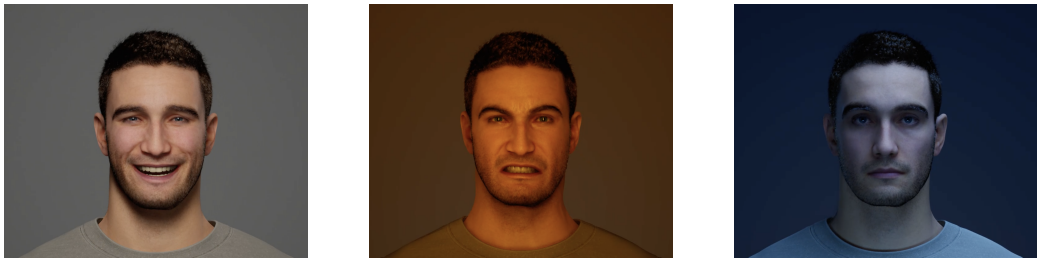
3.2 Lighting Conditions

The controlled lighting conditions are light color and shadow intensity.

For light colors, I wanted to test how color temperature affects the emotion perception. So I chose yellow light and blue light to represent different color temperature (warm and cool). Also, I chose a white portrait light to see as normal light. So the light color set was normal light, warm light and cold light, as Figure 3.3 shows.

To exclude other factors, the scene is always the same, with a white wall behind the characters. The colors displayed on the screen were only reflection of the controlled lights.

As for shadow intensity, I considered it as with and without shadow, to make a marked difference between the 2 levels of realism, as Figure 3.3 shows.



(a) Normal light (b) Warm light (c) Cool light

(d) Without shadow (e) With shadow

Figure 3.3: The controlled lighting conditions in this experiment. (a) to (c) are under 3 colors of lights, (d) and (e) are in different shadow intensity.

3.3 Measurements

I set up 3 measurements for the stimuli. The participants needed to answer 3 different questions accordingly.

- **Recognition**: Each stimuli has a label of emotion. This measurement is to see if the participants can recognize the emotions correctly.
- **Intensity**: The participants rated the intensity of the emotions according to the given scale (the details are discussed in the next chapter). This measurement is to see if the lighting conditions can make the emotions stronger or weaker.
- **Genuineness**: The participants rated the emotions between genuine and fake according to the given scale (the details are discussed in the next chapter). This measurement is to see whether the participants perceive the emotions as genuinely felt or faked.

3.4 Summary

In summary, the details of the factors are shown in Table 3.1.

Light Color	Normal, Warm, Cool
Shadow Intensity	With shadow, Without shadow
Character	Ada, Bryan, Pia, Ettore
Emotion	Neutral, Happiness, Sadness, Anger, Fear
Realism	High, Low

Table 3.1: Factors of the experiment

Between-subjects Experiments

Since the stimuli were generated in 3 different colors of light, I decided to use the between-subjects (or between-groups) design for this variance. In a between-subjects study design, different groups of participants test different conditions, so that each person is only exposed to a single condition. In opposite to between-subjects, within-subjects (or repeated-measures) study design let the same group of participants test all the conditions.

Between-subjects experiments minimize the learning and transfer across conditions. For example, if the participant finished the experiment of one condition, they are more knowledgeable about the whole process. They might be more efficient or make choices they think we are expecting in the experiment of the next condition, which will be very different from the first. Light color is a new variance to test in this perceptual experiment, so between-subjects will be more accurate. Besides, there were 240 stimuli for the whole experiment, which is too many for one participant to finish. They might be tired and leave inaccurate results.

Therefore, there were 3 groups of participants. Each group viewed all the stimuli under one color of light. The other factors were used as within-subjects variances. In other words, participants in one group needed to rate the stimuli of all characters and emotions and all levels of shadow intensity and realism.

Chapter 4

Implementation

4.1 Stimuli Creation

The appearance of each character was normalized (haircut, clothing and background). And all the facial expressions are controlled to be the same. They were all lit in cinematic lighting setup with controllable light colors and shadow intensity.

Stimuli for the online experiments are rendered out as high-resolution images. To avoid different perception caused by low resolution, the participants were required to experiment on a monitor or laptop.

4.2 Experiment Settings

There were 3 experiments of different light colors, assigned to 3 groups of participants. According to Table 3.1, there were 80 stimuli in each experiment: 4 characters (Ada, Bryan, Pia, Ettore) x 5 emotions (neutral, happiness, sadness, anger, fear) x 2 levels of realism (high, low) x 2 levels of shadow intensity (with, without).

There were 3 question blocks in one experiment: recognition block, intensity block and genuineness block. Each block had the same question. One block contains 80 trials (80 stimuli). For each trial, the stimuli was displayed on the screen for 4 seconds, and then the question of this block showed on the next page.

The measurement scales of the 3 questions are as follows, in the order of recognition, intensity and genuineness block:

- **Which emotion did the character portray?** Participants chose one from the 5 labels displayed on the screen: Neutral, Happy, Sad, Angry or Fear.
- **How intense did the emotional expression look to you?** Participants rated

the intensity on a scale of [0 1 2 3 4 5 6 7 8 9] by moving a slider on the screen. 0 meant they thought there was no emotion at all, for example when they saw a neutral face. 1 to 9 represented how strong the emotion was, where 1 was weak and 9 was strong.

- **How genuine did the emotional expression look to you?** Participants rated the genuineness on a scale of [-7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7] by moving a slider on the screen. -7 represented they thought the expression was completely faked (posed or acted). +7 represented they thought the expression was completely genuine, and that the character actually felt the displayed emotion. 0 meant they couldn't tell or they were just guessing.

The 80 trials in one block were randomized to avoid fatigue at the end of the experiment. Same as the question blocks, I randomized the order of the 3 blocks to avoid the participants being always tired in the last block..

The structure of one experiment is as Figure 4.1 shows.

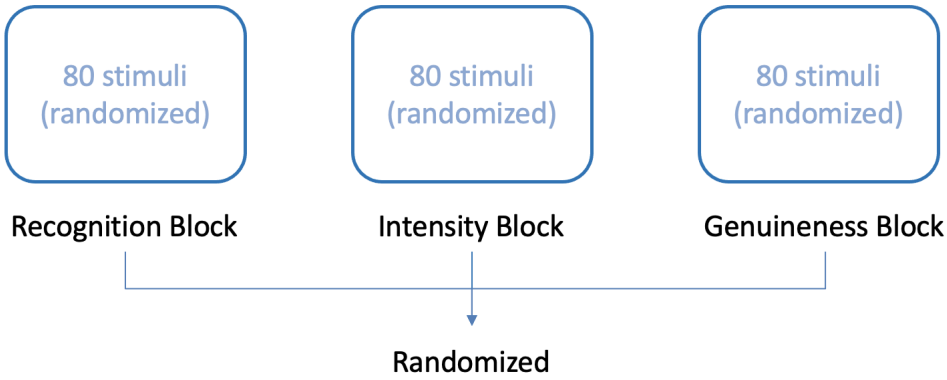


Figure 4.1: Structure of the experiment

Chapter 5

Evaluation

5.1 Methods

For the data of the recognition block, responses were converted into accuracy. When the answer was the correct label, it was recorded as 100%. Otherwise, it was recorded as 0%.

For the statistical analysis, I used Analysis of Variances (ANOVAs) to examine the results. Each ANOVA had the within-subjects factors *character* (4), *realism* (2), *emotion* (5) and *shadow* (2). Besides, light color is analyzed as a between-subjects factor since each light color was tested in a different group. I ran Mauchly's test for validating sphericity of the data:

$$\mathbf{F}(df, Error\_df) = F, \mathbf{p} = Sig.$$

when $\mathbf{p} < 0.05$, it's viewed as significant. If it's significant, the results with Greenhouse-Geisser correction applied will be marked with an asterisk *. As for post hoc analysis, I used Bonferroni correction for the comparisons.

For the summary of all significant effects and interactions with post hocs, see tables (From Table 6.5) in Appendix.

5.2 Main Effects

The main effects I wanted to examine were how different lighting conditions affect emotions. To focus on these effects, I averaged the results over the 4 characters, to remove the factors of characters (race and gender). In this case, the within-subjects factors were *realism* (2), *emotion* (5) and *shadow* (2).

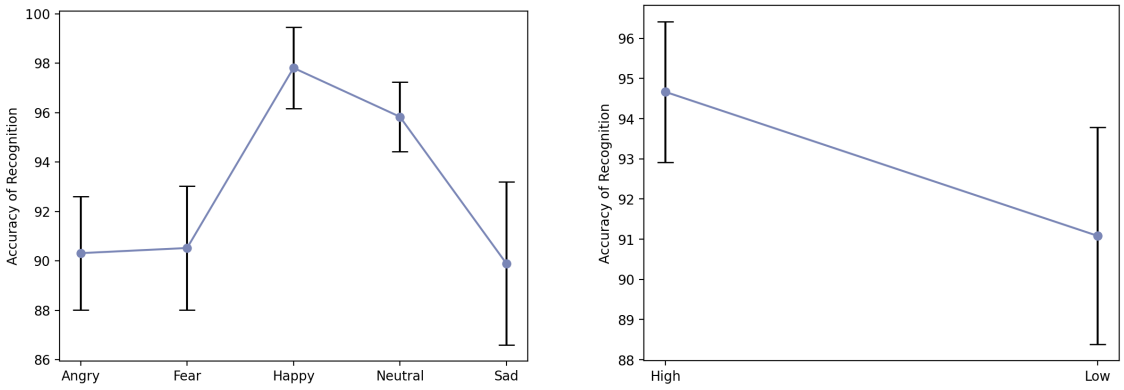
Recognition

Light Color	$\mathbf{F}(2,57) = 0.072$, $\mathbf{p} = 0.931$
Shadow	$\mathbf{F}(1,57) = 0.070$, $\mathbf{p} = 0.792$
Emotion*	$\mathbf{F}(4,228) = 11.704$, $\mathbf{p} < 0.001$
Realism*	$\mathbf{F}(1,57) = 15.596$, $\mathbf{p} < 0.001$

Table 5.1: Main effects of recognition: emotion and realism overall have effects on recognition of the emotions, but light colors and shadow don't have effects

According to Table 5.1, emotion and realism have effects on emotion recognition, but light color and shadow don't affect the recognition of the emotions overall. Figure 5.1 shows how these variances affect emotion recognition.

- **Emotion**: The participants had the highest accuracy (average: 97.81%) when recognizing happiness. Neutral also had a high accuracy (average: 95.83%). The recognition of anger (average: 90.31%), fear (average: 90.52%) and sadness (average: 89.90%) was less accurate.
- **Realism**: The characters in high realism were easier to recognize than those in low realism.



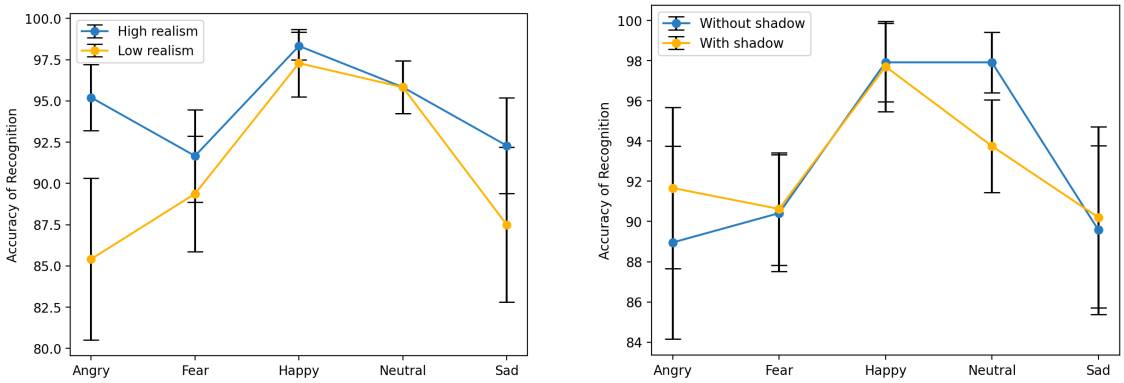
(a) Emotion

(b) Realism

Figure 5.1: The main effects of emotion recognition

Although shadow overall doesn't have an effect on emotion recognition, there is an interaction between shadow and emotion. I applied post hoc analysis to those interactions with $\mathbf{p} < 0.05$. The result showed that emotion $\times$ realism and emotion $\times$ shadow have some effects on emotion recognition, as Figure 5.2 shows.

- The recognition of anger had a significant difference between high and low realism. Anger was easier to recognize with high realism than low realism. Other emotions didn't have significant differences with different levels of realism.
- Although shadow didn't have an effect all the emotions, it affected the recognition of neutral expression. The participants recognized neutral faces without shadow better than those with shadow.



(a) Emotion × Realism

(b) Emotion × Shadow

Figure 5.2: The interactions between the variances of emotion recognition

Intensity

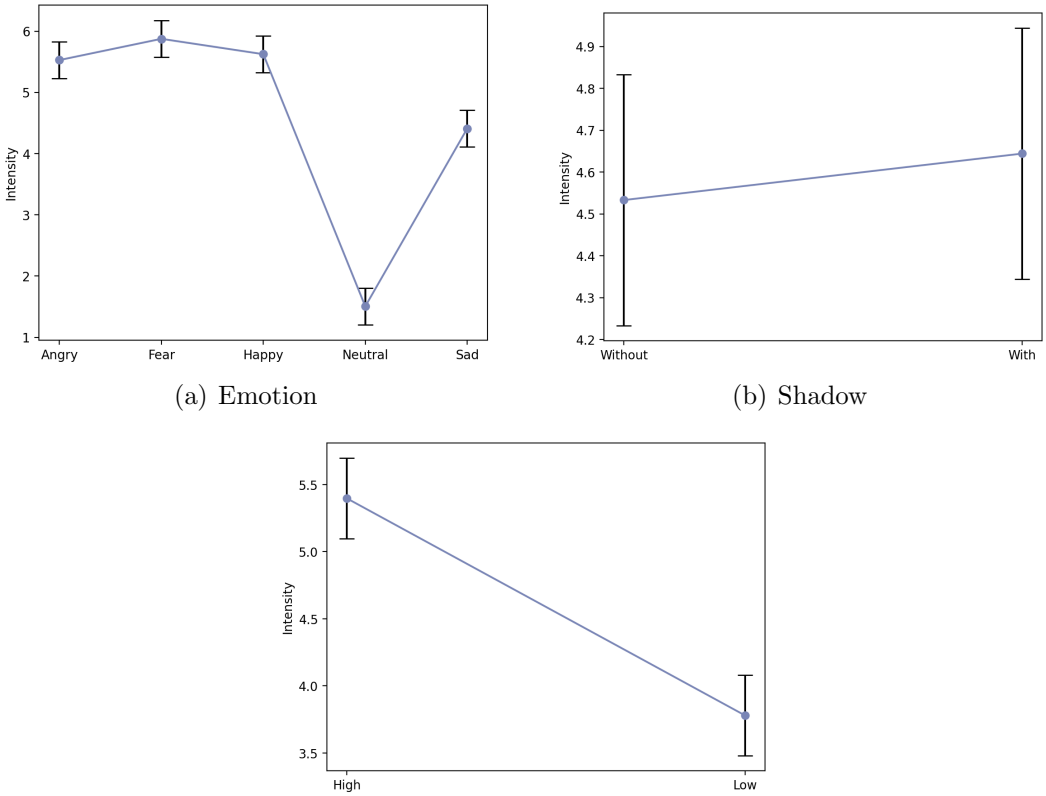
Light Color	$\mathbf{F}(2,57) = 1.068$, $\mathbf{p} = 0.351$
Shadow*	$\mathbf{F}(1,57) = 7.894$, $\mathbf{p} = 0.007$
Emotion*	$\mathbf{F}(4,228) = 137.137$, $\mathbf{p} < 0.001$
Realism*	$\mathbf{F}(1,57) = 243.395$, $\mathbf{p} < 0.001$

Table 5.2: Main effects of intensity: shadow, emotion and realism have effects on the emotion intensity

According to Table 5.2, shadow intensity, emotion and realism have effects on emotion intensity, but light color doesn't affect emotion intensity overall. Figure 5.3 shows how these variances affect the emotion intensity.

- **Emotion**: Fear (average: 5.875) was the most intense in the 5 emotions, and neutral (average: 1.505) is the least. The participants thought anger, fear and happiness were more intense, but sadness was less than the other 3 emotions.

- **Shadow intensity**: Emotions with shadow (average: 4.644) were more intense than those without shadow (average: 4.533).
- **Realism**: Characters with the high level of realism (average: 5.398) had more emotion intensity than those with the low level of realism (average: 3.780). The difference in this variance was significant.



(a) Emotion

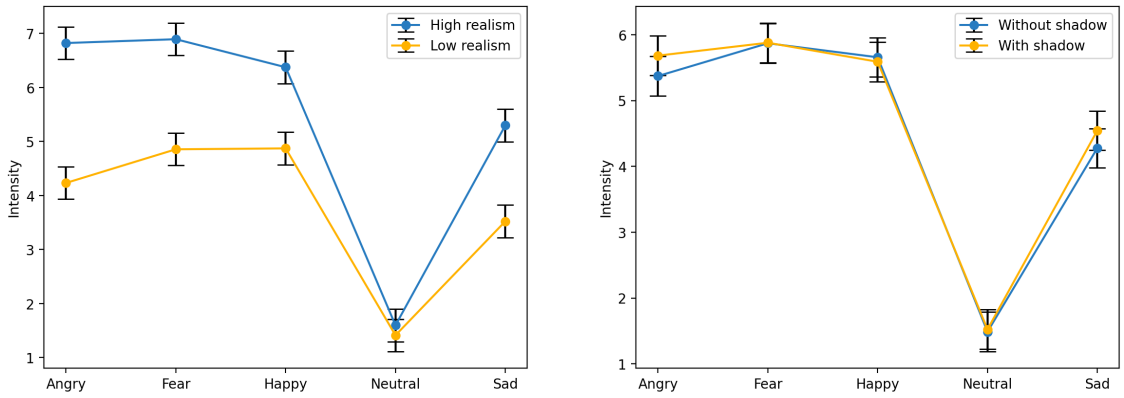
(b) Shadow

(c) Realism

Figure 5.3: The main effects of emotion intensity

I ran post hoc tests of these interactions of variances: emotion × realism and emotion × shadow. They have some effects on emotion intensity, as Figure 5.4 shows.

- For all the emotions except for neutral, high realism was rated more intense than low realism significantly.
- Anger and sadness were rated more intense with shadow significantly. Happiness was the only emotion that had a higher intensity when it was without shadow.



(a) Emotion × Realism

(b) Emotion × Shadow

Figure 5.4: The interactions between the variances of emotion intensity

Light Color	$\mathbf{F}(2,57) = 0.554$, $\mathbf{p} = 0.578$
Shadow*	$\mathbf{F}(1,57) = 7.692$, $\mathbf{p} = 0.007$
Emotion*	$\mathbf{F}(4,228) = 24.878$, $\mathbf{p} < 0.001$
Realism*	$\mathbf{F}(1,57) = 51.609$, $\mathbf{p} < 0.001$

Table 5.3: Main effects of genuineness: shadow, emotion and realism have effects on the emotion genuineness

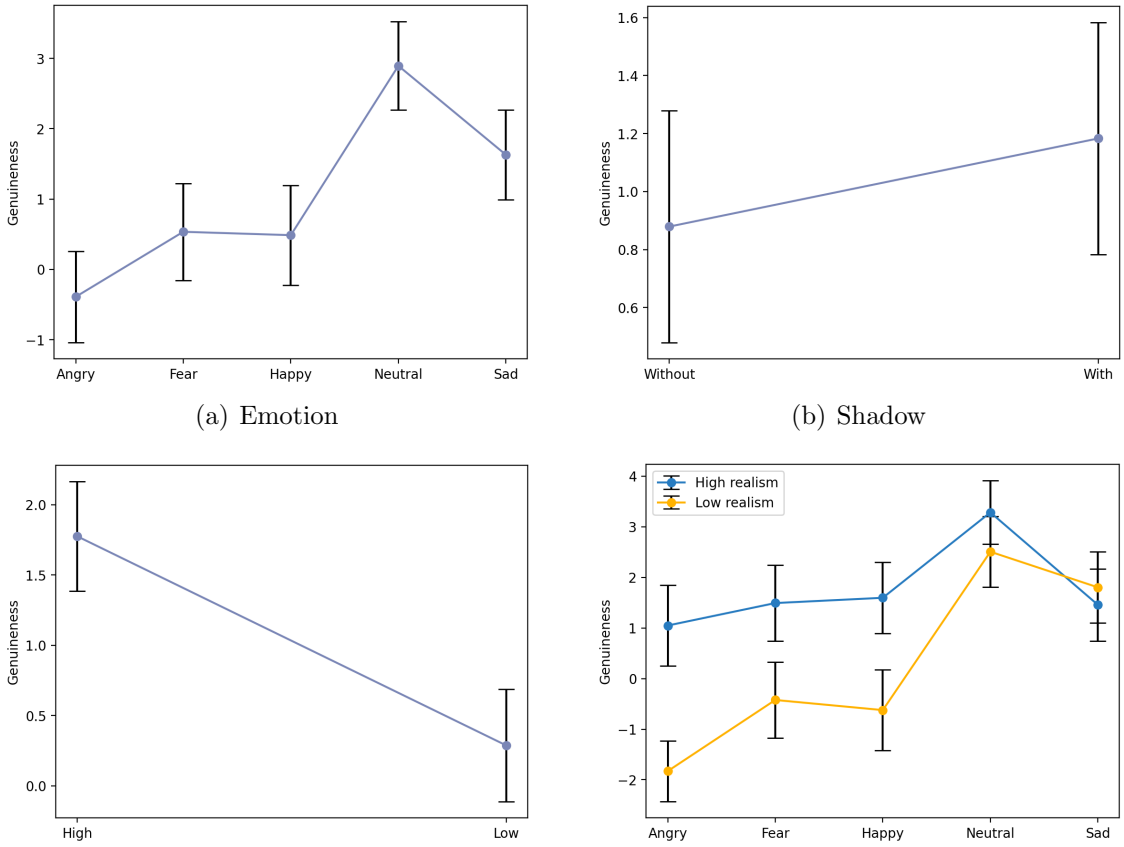
Genuineness

According to Table 5.3, shadow intensity, emotion and realism have effects on emotion genuineness. Figure 5.5 (a) - (c) show how these variances affect genuineness.

- **Emotion**: Neutral (average: 2.895) was the most genuine in all the 5 emotions. Anger (average: -0.391) was rated as the fakest one, which even had an average score of less than 0.
- **Shadow intensity**: Emotions with shadow (average: 1.183) were more genuine to the participants than those without shadow (average: 0.879).
- **Realism**: Characters in high realism (average: 1.775) expressed their emotions more genuinely than those in low realism (average: 0.287).

There was an interaction between emotion and realism, as Figure 5.5 (d) shows.

- Only sadness didn't have a significant difference between high and low realism. For the other emotions, stimuli of high realism were rated more genuine. The average scores of anger, fear and happiness in low realism were less than 0, which implied they overall looked fake.



(a) Emotion

(b) Shadow

(c) Realism

(d) Emotion × Realism

Figure 5.5: (a) - (c): The main effects of emotion genuineness; (d): The interaction between emotion and realism

5.3 Other Effects

One participant gave feedback that it was easier for him to recognize emotions from a character of the same race as himself. To investigate this, I averaged the results of every 2 characters of the same race, and see *race* (2) as a within-subjects factor. In the experiment of normal (white) light, 10 participants are white people and 10 participants are black people. In this case, the race of the participants can be seen as a between-subjects factor. I applied ANOVAs analysis to the data of normal light. The results of recognition and genuineness showed some interactions between the race of the characters and the race of the participants.

- Recognition: For the participants whose ethnicity is black, the accuracy of recognition on the black characters (average: 85.5%) is less than on the white characters (average: 89.5%). For the participants whose ethnicity is white, there was no significant difference.

- Genuineness: For the participants whose ethnicity is white, they rated the genuineness of the white characters (average: 0.095) less than the black characters (average: 0.875). For the participants whose ethnicity is black, there was no significant difference.

For the post hoc test results, see Table 6.12 and 6.13 in Appendix.

Chapter 6

Conclusions & Future Work

6.1 Discussion

Recognition

The participants had the highest accuracy in recognizing happiness and the neutral expression. The recognition was less accurate for all the negative emotions including anger, fear and sadness. The participants confused between these negative emotions. Research of Schwartz and Weinberger (1980) showed that there are some relations among specific emotions like depression elicited more complex emotion than sadness, including significantly more anger, fear, and anxiety. It implied that the connection between these 3 emotions can affect the recognition.

High realism increased the accuracy of emotion recognition. Anger had low accuracy when the characters were in low realism. Shadow doesn't have an effect on all the emotions, but the participants recognized neutral faces without shadow better than those with shadow.

Intensity

Of the emotions of happiness, sadness, fear and anger, sadness was the least intense one. In the laboratory experiment of Wisessing et al. (2020), anger was the most intense emotion, but in this experiment fear was the most. Overall, happiness, fear and anger were more intense than sadness.

Characters in high realism had more intensity of happiness, anger, sadness and fear than those in low realism. For the neutral expression, realism didn't have a significant difference.

Angry and sad emotions with shadow were more intense than those without shadow.

Happiness was the only emotion that had a higher intensity without shadow than without, which proved that darker shadow decreased the intensity of happiness (from Wisessing et al. (2020)).

Genuineness

Neutral was the most genuine of all the 5 emotions. Anger was rated as the least genuine one, which is different from the experiment of Tinwell et al. (2011) showing anger is less uncanny than other emotions.

Emotions with shadow were more genuine to the participants than those without shadow. This indicates that a proper amount of shadow can increase the emotion genuineness of virtual characters.

Only sadness didn't have a significant difference between high and low realism. For happiness, anger, fear and neutral, high realism increased genuineness. The average scores of anger, fear and happiness in low realism were less than 0, which implied they overall looked fake.

Other

From the feedback of the participant, I assumed that recognizing characters' emotions of the same race would be easier. But the data showed opposite results as I expected, where the black participants had lower accuracy on the black characters. And the white participants rated less genuineness for the white characters than the black characters.

6.2 Conclusion & Future Work

This research proved shadow intensity and realism have effects on the emotion perception of virtual characters. Artists and developers can increase the emotion intensity and genuineness by controlling the lighting conditions.

However, light color didn't have an effect on the perception of the emotions, which is different from our hypothesis. I only used blue and yellow as different variances for the light color. More light colors like red, purple and green light could be tested in a perception experiment.

Interesting results about race are found in the experiment, even though they're different as I expected. There were only 2 characters for each race. More characters should be used in the experiment to avoid the factor of character itself.

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Appendix

Please note that the variances **realism** and **shadow** have 2 factors, so the significance results of their pairwise comparisons are same as those in Chapter 5. Only post hoc results of emotions or interactions between variances are listed here.

Main Effects

Recognition

	Angry	Fear	Happy	Neutral	Sad
Angry		1.000	<.001	0.012	1.000
Fear	1.000		<.001	0.010	1.000
Happy	<.001	<.001		0.248	<.001
Neutral	0.012	0.010	0.248		0.024
Sad	1.000	1.000	<.001	0.024	

Table 6.1: Post hoc: significance levels of different emotions in pairwise comparisons

Emotion × Realism	$\mathbf{F}(4,228) = 52.744$, $\mathbf{p} < 0.001$
Emotion × Shadow	$\mathbf{F}(4,228) = 4.830$, $\mathbf{p} < 0.001$

Table 6.2: Interactions between the variances of recognition with a significance level less than 0.05

	Angry	Fear	Happy	Neutral	Sad
2 realism levels	<.001	.179	.485	1.000	.067

Table 6.3: Post hoc: significance levels of emotion × realism in pairwise comparisons

	Angry	Fear	Happy	Neutral	Sad
2 shadow levels	.069	.892	.784	<.001	.665

Table 6.4: Post hoc: significance levels of emotion × shadow in pairwise comparisons

Intensity

	Angry	Fear	Happy	Neutral	Sad
Angry		.012	1.000	<.001	<.001
Fear	0.012		1.000	<.001	<.001
Happy	1.000	1.000		<.001	<.001
Neutral	<.001	<.001	<.001		<.001
Sad	<.001	<.001	<.001	<.001	

Table 6.5: Post hoc: significance levels of different emotions in pairwise comparisons

Shadow × Light Color	$\mathbf{F}(2,57) = 3.329$, $\mathbf{p} = 0.043$
Emotion × Realism	$\mathbf{F}(4,228) = 52.744$, $\mathbf{p} < 0.001$
Emotion × Shadow	$\mathbf{F}(4,228) = 4.830$, $\mathbf{p} < 0.001$

Table 6.6: Interactions between the variances of intensity with a significance level less than 0.05

	Angry	Fear	Happy	Neutral	Sad
2 realism levels	<.001	<.001	<.001	.079	<.001

Table 6.7: Post hoc: significance levels of emotion × realism in pairwise comparisons

	Angry	Fear	Happy	Neutral	Sad
2 shadow levels	<.001	.921	.281	.741	<.001

Table 6.8: Post hoc: significance levels of emotion × shadow in pairwise comparisons

	Angry	Fear	Happy	Neutral	Sad
Angry		<.001	.233	<.001	<.001
Fear	<.001		1.000	<.001	.004
Happy	.233	1.000		<.001	.027
Neutral	<.001	<.001	<.001		.007
Sad	<.001	.004	.027	.007	

Table 6.9: Post hoc: significance levels of different emotions in pairwise comparisons

Emotion × Realism	$\mathbf{F}(4,228) = 17.505$, $\mathbf{p} < 0.001$

Table 6.10: Interactions between the variances of intensity with a significance level less than 0.05

	Angry	Fear	Happy	Neutral	Sad
2 realism levels	<.001	<.001	<.001	<.001	.398

Table 6.11: Post hoc: significance levels of emotion × realism in pairwise comparisons

Genuineness

Other Effects

	Black Participants	White Participants
2 race	.005	1.000

Table 6.12: Post hoc: significance levels of race in pairwise comparisons

	Black Participants	White Participants
2 race	.854	009

Table 6.13: Post hoc: significance levels of race in pairwise comparisons