Blinded by the light: Does portrait lighting design affect perception of realistic virtual humans?

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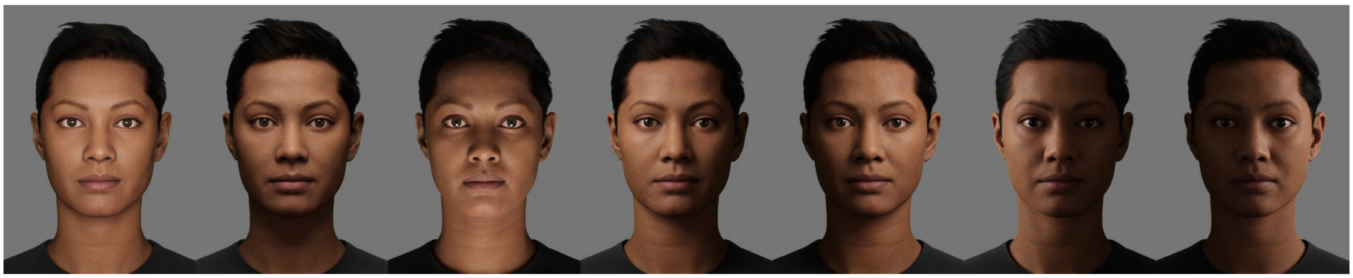

Figure 1: Female characters with neutral expression and smooth dark skin, illuminated by seven distinct portrait lighting designs: *Frontal, Paramount, Under, Rembrandt-Left, Rembrandt-Right, Split-Left,* and *Split-Right.*

ABSTRACT

Lighting has long been recognized as a crucial element in enhancing the appeal and emotional depth of characters across different media formats. This study investigates the impact of well-established portrait lighting designs on the perception of realistic digital human characters. We provide insight into how real-world lighting styles can be used to enhance the perceived appeal, trustworthiness, and emotional authenticity of digital human characters while minimizing the sense of eeriness. The findings of this study are expected to contribute to the understanding of how lighting influences the perception of digital characters and inform the development of more engaging virtual experiences in various domains.

CCS CONCEPTS

• **Computing methodologies** → **Perception**; **Rendering**; • **Applied computing** → **Media arts**.

KEYWORDS

perception, digital humans, portrait, lighting

1 INTRODUCTION

Lighting techniques have long been integral to shaping viewer perception and emotional response across various artistic domains [Hall 1992; McIver 2017]. While some conventional lighting practices in film-making have been empirically validated, confirming their psychological effects, the empirical support for many contemporary techniques remains sparse [Grodal 2005; Poland 2015; Wisessing et al. 2016, 2020]. This highlights the need for further research to bridge the gap between artistic intuition and scientific understanding.

One area where the impact of lighting is particularly significant is portrait lighting. The nuanced effects of light direction on facial perception have been acknowledged [Chen et al. 2014; Thompson et al. 2016], but the specific ways in which different portrait lighting techniques influence the perception of facial expressions in terms of appeal, trustworthiness, and eeriness remain under-explored. This research aims to address this gap by empirically investigating the impact of various portrait lighting designs on viewers' perceptions of digital characters.

The stimuli for this experiment consist of images portraying four digital humans with diverse skin tones, genders, and age-related features such as wrinkles. Each character is illuminated with seven distinct real-world lighting designs: *Frontal*, *Paramount*, *Under*, *Rembrandt* (left and right), and *Split* (left and right). The experiment is divided into two blocks. In Block A, participants rate the appeal, trustworthiness and eeriness of the characters with neutral facial expressions. Block B presents the characters displaying positive and negative emotional expressions, and participants evaluate the genuineness and intensity of the portrayed emotions. By systematically analyzing participant responses, this study aims to empirically assess the influence of lighting design on the perception of digital characters' emotional expression and overall appeal.

Our findings suggest that lighting design has a significant impact on perceived appeal, trust and eeriness ratings, with *Frontal*, *Paramount*, and *Rembrandt* styles being rated more favourably than *Under* or *Split*. Surprisingly, lighting design had very little effect on emotional intensity ratings, where emotions were rated similarly regardless of the illumination of the face. This goes against general practice for using lighting design to increase intensity. Genuineness of emotion was affected by lighting design, where positive emotion was perceived as less genuine under *Under* and *Split*, which are designed for horror and to heighten intensity. The findings of this research are expected to contribute to the development of evidence-based lighting design guidelines for more engaging and effective virtual experiences.

2 BACKGROUND

To explain portrait photography systematically, Chen et al. [2014] introduced a method for analyzing portrait lighting, confirming that established lighting designs like *Paramount*, *Rembrandt* and *Split* create images with distinct contrast features on the face. These effects facilitate our brain's ability to perceive underlying forms through a process known as shape from shading. However, although lighting significantly aids our perception of three-dimensional forms, the precise mechanisms by which the brain interprets these shading cues to assess the internal state of the subject remain poorly understood [Thompson et al. 2016]. Some lighting styles, such as *Rembrandt*, derive their names from traditional painting techniques. Sakuta et al. [2014] analyzed 40 portrait paintings to explore how lighting conditions affect face perception. Their study found that the angle of light influences the perceptions of person impressions and facial expressions in these artworks.

The challenge of lighting studies is the large number of parameters and the ability to create controlled stimuli consistently. Hence, each study is limited to exploring broad categories of light properties, such as light coming from left or right positions [Sakuta et al. 2014] or light coming from above or below [Wisessing et al. 2016]. There is a lack of research specifically investigating the real-world practice of portrait lighting designs that are widely used such as *Paramount* and *Rembrandt*. Other notable lighting styles—*Frontal*, *Under*, and *Split*—are also considered in this study.

Recent advancements in digital human creation have made it possible to recreate the effects of different portrait lighting styles in well-controlled virtual environments. However, researchers must accept the risk of the uncanny valley, where highly realistic digital characters evoke feelings of eeriness, underscoring the delicate balance required in lighting design to enhance realism without triggering negative responses [Kätsyri et al. 2015; McDonnell et al. 2012; Mori et al. 2012; Zell et al. 2019]. While the perceptual process of material discrimination remains complex and not fully understood, humans demonstrate proficiency in perceiving different materials [Fleming 2014; Maloney and Brainard 2010]. Our vision system is adept at detecting small imperfections in modeling or shading that can evoke negative reactions [Seyama and Nagayama 2007]. Hence, wrinkled and smooth skin textures were considered in our study, as variations in face materials could also lead to undesired psychological effects [Zell et al. 2015].

In this study, appeal, eerieness, and emotional intensity were included so our results could be compared to those from previous work [Sakuta et al. 2014; Wisessing et al. 2016, 2020; Zell et al. 2015]. Furthermore, the study examines trustworthiness and emotional genuineness, motivated by the popularity of specific lighting styles such as *Frontal* and *Paramount* among content creators and news outlets, whose trust and genuineness are essential. Research has shown that facial age, emotional expression, and attractiveness all play a role in shaping perceptions of trustworthiness [Li et al. 2021]. The temporal dynamics of trustworthiness perception have also been explored, with studies indicating that trustworthiness can be rapidly and spontaneously attributed to faces based on emotional and structural cues [Dzhelyova et al. 2012]. Furthermore, the time course of facial attractiveness has been found to precede that of trustworthiness, suggesting that attractiveness may serve as a quick and accessible cue for making trustworthiness inferences [Gutiérrez-García et al. 2019].

3 EXPERIMENT

38 participants (19 females, 19 males) were recruited through Prolific, a reliable online platform for sourcing high-quality research participants. The participants were from around the world, aged 18 to 75 years (median age: 30). To ensure that the participants understood the context of the questions, the recruitment criteria required professional working proficiency in English or higher. All participants were screened for normal or corrected-to-normal vision and required to use a computer to take part in the study.

3.1 Stimuli

The stimuli for this study were created using *MetaHuman Creator*[1], *Unreal Engine 5.2*[2], and *Nuke 15*[3]. The process involved designing diverse realistic digital human characters and applying various portrait lighting techniques to them. All stimuli can be found in Appx. C and at https://www.pisut.net/#Research.

Characters. *MetaHuman Creator* was used to create 4 photorealistic characters, 2 females and 2 males, from *Tori, Rosemary, Lucian, and Keiji* base characters, representing a wide spectrum of ethnicity and skin tones. Each character had 2 variations in skin textures, wrinkled and smooth. Hair and facial hair were kept short to avoid obscuring the face. The top garment was a dark gray t-shirt (almost black). The participants were not made aware of the digital nature of these entities, which were simply referred to as "characters."

LIGHT	YAW(°), PITCH(°)
RIM	0, 90
FILL(L)	-45, 0
FILL(R)	45, 0
KEY	
- Frontal	0, 0
- Paramount	0, 45
- Under	0,-45
- Rembrandt(L)	-45, 30
- Rembrandt(R)	45, 30
- Split(L)	-85, 15
- Split(R)	85, 15

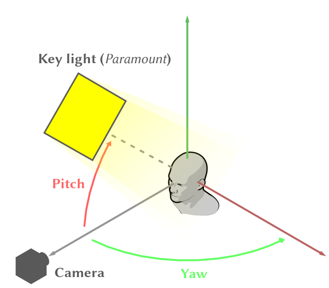

Figure 2: The yaw and pitch angles of the lights are measured from the line of sight with the character's head as the center. The angles of the fill and rim lights are the same for all designs, but the angle of the key light differs for each design (left). For example, the pitch and yaw angles of the key light in the *Paramount* design are 45°and 0°(right).

Lighting. The models were imported into *Unreal Engine 5.2* for lighting and rendering. Four square area lights (60cm × 60cm) were used as key, fill-left, fill-right, and rim lights. The key light intensity was 3 candela, fill lights were 0.1875 candela, and the rim light was 0.375 candela. The yaw and pitch angles of the lights are measured from the line of sight with the character's head as the center, shown in Fig. 2 (right). All lights are one meter from the character's face.

[1]https://metahuman.unrealengine.com/
[2]https://www.unrealengine.com/en-US/unreal-engine-5
[3]https://www.foundry.com/products/nuke-family/nuke

Fill and rim lights were fixed for all renders, while the key light angle was changed to create seven portrait lighting patterns [Grey 2004; Hunter et al. 2007; Hurter 2007; Präkel 2007], chosen for this study (Please see Fig. 2 (left) for the precise measurements):

- *Frontal:* This lighting method is popular among online content creators such as vloggers due to its simplicity and affordability. A single ring light is placed directly in front of the model, producing an evenly-lit look with minimal shadows. In this study, a square light was used to replicate the effect of a ring light.
- *Paramount:* Originating from *Paramount Pictures*, this technique places the key light directly in front of and above the subject, creating a symmetric, Butterfly-shaped shadow under the nose, hence also called *Butterfly* lighting. It's commonly used in glamour photography.
- *Under:* This setup, also known as *Monster*, is often used in horror or thriller genres to create an unsettling atmosphere. The key light is pointed upward from below the subject's face, creating deep shadows emphasizing any wrinkles or imperfections in the skin. This lighting pattern is the opposite of the *Paramount* setup.
- *Rembrandt (Left and Right):* Named after the Dutch painter *Rembrandt*, who often used this lighting pattern in his portraits, this setup places the key light at a 45-degree angle to the side of the face and slightly above eye level. This creates a small, triangular highlight on the less illuminated side of the face, known as the "Rembrandt triangle." Inspired by [Sakuta et al. 2014], this study used both left and right *Rembrandt* lighting setups.
- *Split (Left and Right):* Also called side lighting, this technique positions the key light directly to the side of the subject, creating a dramatic effect that divides the face into two equal halves: one fully illuminated and the other in shadow. This lighting pattern emphasizes the texture and contours of the face, making it a popular choice for artistic portraits. Both left and right *Split* lighting setups were used in this study.

Facial Expressions. In addition to the default neutral expressions, mild positive (*Joy-02-Amusement*) and negative (*Sadness-02-Melancholy*) expressions from the *MetaHuman* pose library were applied.

Rendering and Image Finalizing. The characters were rendered with all lighting conditions and facial expressions using global illumination for realistic appearance. Automatic exposure adjustment in the render engine was utilized, and the histogram was monitored to maintain proper exposure of the renders despite the lower intensity levels relative to physical lights. A virtual 50mm lens and close-up composition were used to capture the characters, resulting in 4,096×2,160 pixel images. The images were imported into *Nuke* for fine-tuning. To assess brightness, a 300×300 pixel patch (Fig. 3 (left)) underneath an eye and one side of the nose (the key side for *Rembrandt* and *Split*) was sampled to calculate average luminance. Brightness was gamma-corrected to be within ± one standard deviation of the mean across the same characters (smooth and wrinkled skin) to minimize the effect of lightness variations. The characters were presented in front of a neutral grey backgrounds and cropped to 960×720 pixels (Fig. 3 (right)).

3.2 Procedure

The study employed a repeated measures, within-subjects design using an online questionnaire consisting of two blocks (Block A and Block B) presented in a randomized order. In each block, participants were shown one stimulus at a time, presented randomly. The stimuli were 960×720 pixel images, with the actual size varying based on participants' screen sizes. For each stimulus displayed, participants had to answer 3 questions in Block A and 2 questions in Block B. The median completion time was 23 minutes, with a short break recommended between blocks.

Figure 3: A sample of the original 3840×2160 pixel render from *Unreal* of the wrinkled fair-skinned female with a neutral expression illuminated by *Under* lighting, with a red 300×300 pixel square indicating where the image was sampled for lightness adjustment (left). The image was then post-processed and cropped to 960×720 pixels for the study (right).

Block A. aimed to investigate the effect of lighting on the perception of character appeal, trustworthiness, and eeriness. It consisted of 56 stimuli: 4 characters × 2 skin conditions (wrinkled, smooth) × 7 lighting conditions, all with neutral expressions. Participants rated each character on 7-point Likert scales for the following questions [Wisessing et al. 2020; Zell et al. 2015]:

- *How appealing is the character in the picture?*
  (1 = Extremely unappealing, 7 = Extremely appealing)
- *How trustworthy is the character in the picture?*
  (1 = Extremely untrustworthy, 7 = Extremely trustworthy)
- *How re-assuring is the character in the picture?*
  (1 = Extremely eerie, 7 = Extremely re-assuring)

Block B. aimed to investigate the effect of lighting on the perception of emotional genuineness and intensity. It consisted of 56 stimuli: 4 characters × 2 facial expressions (positive, negative) × 7 lighting conditions, all with smooth skin. Participants rated the genuineness and intensity of each character's emotional expression on a 9-point scales adapted from [Dawel et al. 2017] for the following questions:

- *This emotional expression looks genuine to me.*
  (-4 = Completely fake, 0 = Don't know, +4 = Completely genuine)
- *This emotional expression looks intense to me.*
  (1 = Weak, 9 = Strong)

Please refer to Appx. A for verbatim explanations of the questions in Block A and Block B.

4 RESULTS

We conducted 3-way repeated measures ANOVAs with factors *Skin texture* (2), *Character* (4), *Lighting* (7) for each of the Blocks A1–A3. For Blocks B1–B2, we conducted 3-way repeated measures ANOVAs with factors *Valence* (2), *Character* (4), *Lighting* (7). Sphericity violations were checked using Mauchly's test and where significant, we corrected using Greenhouse-Geisser. Only significant main effects and interactions are discussed in the text, with the F-values and effect sizes reported in Table 1, Appx. B to increase readability. Bonferroni post-hoc tests are reported in the text.

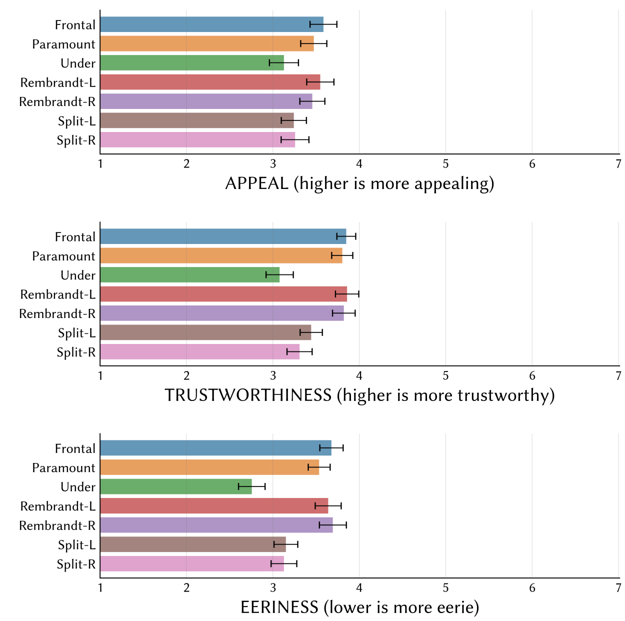

Figure 4: Main effect of *Lighting* for APPEAL, TRUST and EERINESS, with error bars indicating standard errors.

A1: Appeal. A main effect of *Lighting* was found for appeal ratings where faces under Frontal and *Rembrandt-L* lighting were significantly more appealing than *Under* ($p < 0.04$ in both cases) and *Split-L* ($p < 0.03$ in both cases) (Fig. 4 (top)). No significant difference in appeal between the left and right sides for *Rembrandt* or *Split*. Additionally, a main effect of *Skin Texture* was found where characters with wrinkled skin were rated as less appealing than those with smooth. A main effect of *Character* was also found where the fair-skinned female character was rated less appealing than all others ($p < 0.01$ in all cases). An interaction was found between *Skin Texture* and Character, however; posthoc showed that all characters with wrinkled skin were rated less appealing than those with smooth ($p < 0.001$ in all cases). Additionally, an interaction between *Skin Texture* and *Lighting* was found ($p^* < 0.001$). For wrinkled skin, most lighting styles were rated the same for appeal, except for *Under* which was rated lower than *Rembrandt-L* ($p < 0.03$). For smooth skin, there were more differences, more consistent with the main effect of lighting with *Under*, *Split-L* and *Split-L* being rated lower on appeal than the others (Fig. 5, Appx. B). No other interactions were found.

A2: Trustworthiness. A main effect of *Lighting* was found on trustworthiness ratings where *Under*, *Split-L* and *Split-L* were less trustworthy than *Frontal*, *Paramount*, *Rembrandt-L* and *Rembrandt-R* ($p < 0.04$ in all cases) (Fig. 4 (middle)). A main effect of *Skin Texture* was also found where characters with wrinkled skin being rated less trustworthy than smooth. A main effect of *Character* was found where the fair-skinned female character was rated less trustworthy than all others ($p < 0.04$ in all cases). The dark-skinned male character was also rated more trustworthy than the dark-skinned female ($p < 0.05$). An interaction between *Skin Texture* and *Character* was found where characters with wrinkled skin were rated less trustworthy than smooth for all characters ($p < 0.02$ in all cases) except for the fair-skinned female, where there was no difference in ratings between wrinkled and younger skin. Also, an interaction between *Skin Texture* and *Lighting* was found but post-hoc showed that all characters with wrinkled skin were rated less trustworthy under each light condition ($p < 0.001$ in all cases) (Fig. 6, Appx. B). Finally, an interaction between *Skin Texture*, *Character*, and *Lighting* was found, showing some individual differences in trustworthiness across lighting for different characters.

A3: Eeriness. A main effect of *Lighting* was found for eeriness ratings. *Frontal*, *Paramount*, *Rembrandt-L* and *Rembrandt-R* were the least eerie and significantly less eerie than *Under*, *Split-L* and *Split-L* (Fig. 4 (bottom)). A main effect of *Skin Texture* was also found where the wrinkled skin texture was rated significantly more eerie then the smooth. A main effect of *Character* was found showed that the fair-skinned female character was rated significantly more eerie than all others ($p < 0.02$ in all cases). We found an interaction between *Skin Texture* and *Character*, however post-hoc showed that all characters with wrinkled skin were rated more eerie than those with smooth ($p < 0.05$ in all cases). No interaction was found between *Skin Texture* and *Lighting* or between *Character* and *Lighting*, indicating that the eeriness ratings on lighting followed the same pattern across material variations in the skin and appearance of characters. However, a three way interaction between *Skin Texture*, *Character*, and *Lighting* showed some individual differences between character, lighting and texture.

B1: Genuineness. No main effect of *Lighting* or *Valence* was found on ratings of genuineness. However, a main effect of *Character* was found where the fair-skinned female character was rated significantly less genuine than all others ($p < 0.001$ in all cases). The fair-skinned male character was also rated less genuine than the dark-skinned male character ($p < 0.027$). We also found an interaction between *Valence* and *Character* where there were no differences in genuineness ratings for positive or negative expressions of any character except the fair-skinned male character, who appeared more genuine when expressing a negative emotion ($p < 0.0141$) (Fig. 9, Appx. B). We found an interaction between *Valence* and *Lighting* where genuineness ratings were the same for positive and negative for most lighting types, except *Under* ($p < 0.007$) and *Split-L* ($p < 0.421$), where negative ones were rated more genuine in those cases than positive. No other interactions were observed.

B2: Intensity. A main effect of *Lighting* was found on emotion intensity ratings, but no effects in post-hoc (except a trend towards characters viewed under *Under* lighting being rated more intense than *Split-L*. A main effect of *Valence* was found ($p < 0.002$) where positive expression was rated as more intense than negative. No main effect of *Character*, all were rated equally intense. An interaction was found between *Valence* and *Character* where the dark-skinned male character was rated more intense than the fair-skinned characters for positive valence expressions, while the fair-skinned female was rated more intense than all other characters for negative valence expression ($p < 0.021$ in all cases) (Fig. 8, Appx. B). Additionally, we found an interaction between *Valence* and *Lighting* where for *Frontal*, *Paramount*, *Rembrandt-L* and *Rembrandt-R* the positive valence was rated more intense than negative, whereas for *Under*, *Split-L* and *Split-L* there was no difference in intensity between positive and negative emotions ($p < 0.031$ in all cases) (Fig. 7, Appx. B). An interaction occurred between *Character* and *Lighting*, showing some differences of lighting intensity depending on the character. No more interactions were found.

5 DISCUSSION

Our results provide novel insights into the effect of portrait lighting design on the perception of virtual humans that will be valuable for developers. Expressions viewed under *Frontal*,*Paramount* and *Rembrandt* lighting were generally rated most positively, while expressions viewed under *Under* and*Split*lighting styles were rated more negatively on appeal, eeriness, and trustworthiness.

In general, lighting design did not enhance the perception of emotional intensity of a virtual humans expression, which is surprising from the point of view of general practice in cinematography, where lighting is often used to enhance character intensity. Prior work that investigated emotional intensity under different brightness levels of light [Wisessing et al. 2020] also found little effect on emotional intensity, however the authors concluded that the intensity of the expressions used in their study could have been too high to allow lighting to have an effect. Our study used more moderate expressions, but still found no effect of lighting design. In future studies, a full range of emotional intensities should be investigated to determine if there is a threshold where lighting begins to affect intensity ratings. Motion should also be considered in future work as our stimuli were all static.

We did however find some emotion-specific effects of lighting design on emotion intensity ratings where the more appealing light types (*Frontal*, *Paramount*, *Rembrandt*) were rated more intense for positive emotion, while the less appealing styles (*Under*, *Split*) were rated equally for positive and negative. This result is similar to Wisessing et al. [Wisessing et al. 2020] where they found an emotion-specific effect on perceived intensity. In their case, they tested brightness and found that brighter conditions intensified the perceived intensity of happiness. Our result differs from Sakuta [Sakuta et al. 2014] who found that high-contrast lighting (like our*Split*condition) enhanced the perception of negative emotion. However, in their study they used actual artworks and did not control for the character or expression across lighting which may have been a confound.

We found very little effect of lighting direction (right or left) on any of the ratings for *Rembrandt* and *Split* lighting styles, which supports the finding by Sakuta [Sakuta et al. 2014] who found no effect of impressions between the original portrait artworks with high contrast on one side of the face and the mirror-reversed images. However, they did find differences between the impressions of original artworks with different light angles, perhaps due to the artists intentions.

Genuineness of expression was not affected by lighting very much apparent from where negative emotions were rated as more genuine than positive under *Under* and *Split*. This is consistent with these styles being more common in horror movies, which may have reduced the genuineness of positive emotions under these lights.

Our work adds new findings for the Uncanny Valley as lighting design can effect eeriness ratings of virtual humans. Characters appeared more eerie under *Under*, and *Split* lighting than the others. An interesting future direction would be to compare against real human photos. Developers can be confident that *Frontal*, *Paramount* and *Rembrandt* lighting were all equally capable of ensuring low levels of eeriness for virtual humans.

Some individual differences were seen across characters. In particular, characters with wrinkled skin were rated more eerie and less appealing across the board than those with smooth skin. This is in-line with prior work showing the appealing effects of smooth skin [Fink et al. 2006; Zell et al. 2015]. Characters with wrinkled skin were surprisingly rated less trustworthy as well [Johansson-Stenman 2008], perhaps due to generally young age of the participant population (median age of 30), as prior work has found that older adults tend to trust avatars of a similar age [Lee et al. 2018].

Trust is a topic of great interest in the virtual agent community and our results suggest that trust ratings can change depending on the lighting, with the more negative lighting styles (*Under*, *Split*) eliciting lower trust ratings. However, further work will be needed to determine if this result would translate to real conversational interactions with virtual humans.

Additionally, we found some differences in trust ratings between the characters which could be due to differences in facial features [Ferstl et al. 2017; Ferstl and McDonnell 2018; Ferstl et al. 2021; Wang et al. 2013]. Alternatively, it is possible that appeal and trust ratings influenced each other, as prior work [Gutiérrez-García et al. 2019] found that earlier attractiveness impressions could bias trustworthiness inferences. Future work should separate these questions into different blocks, or test trust more implicitly [McDonnell et al. 2012; Pan and Steed 2016; Torre et al. 2019].

While our results provide novel insights into the effect of portrait lighting style on the perception of virtual humans that will be valuable for developers, there are some limitations to our work. We tested only photorealistic virtual humans and the effect on lower quality or cartoon style is unknown. Additionally, we only tested static images, and the effect of dynamic stimuli should be investigated in the future.

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A QUESTIONNAIRE QUESTIONS AND EXPLANATIONS

The following questions and explanations were provided verbatim to the participants during the study:

A1: How appealing is the character in the picture?

Extremely unappealing means the person is highly unlikable and unengaging. If this person were the main character in a movie, you would not be interested in their presence and would prefer to watch scenes without them.
Extremely appealing means the person is highly likable and engaging. If this person were the main character in a movie, you would be captivated by their presence and eager to watch more scenes featuring them.

A2: How trustworthy is the character in the picture?

Extremely untrustworthy means the person appears to be insincere, dishonest, and unreliable. You would not believe what this person says or trust their words, and you would feel uncomfortable sharing a secret with them.
Extremely trustworthy means the person appears to be sincere, honest, and reliable. You would believe what this person says and trust their words, or feel comfortable sharing a secret with them.

A3: How re-assuring is the character in the picture?

Extremely eerie means the person looks gloomy, unsettling, or disturbing, leaving you with a sense of fear or unease when observing them.
Extremely re-assuring means the person looks comforting, calming, or pleasant, leaving you with a sense of ease and security when observing them.

B1: This emotional expression looks genuine to me.

A genuine expression is one that reflects the person's true feelings, such as a sincere smile when they are happy or a look of fear when they are actually scared. On the other hand, a faked or posed expression is one that the person puts on deliberately, without actually feeling the emotion, like a polite smile for a photo or an exaggerated scared face while playing with a child. To answer this question, a rating of *-4 means you believe the expression is completely faked* or posed, and the person does not feel the displayed emotion at all. A rating of *+4 indicates that you think the expression is completely genuine*, and the person truly feels the emotion they are showing. Select *0 if you cannot tell* whether the expression is genuine or faked and are just guessing. Please focus on the authenticity of the emotion rather than the intensity of the expression. A subtle expression can be completely genuine, while a strong expression may be entirely faked.

B2: This emotional expression looks intense to me.

Please rate the intensity or strength of the emotional expression displayed in the image, regardless of whether it appears genuine or faked. Intensity refers to how strongly the emotion is being expressed, not how authentic it seems. Use the 9-point scale to indicate the intensity of the expression, where *1 means the expression is very weak* or subtle, and *9 means the expression is very strong* or intense. Choose the number that best represents your perception of the emotional intensity conveyed by the facial expression in the image.

B STATISTICS AND GRAPHS

Factor	F-statistics	p-value	η_p^2
A1. Appeal			
Skin Texture	$F^*(1, 37) = 93.191$	$< 0.001*$	0.716
Character	$F^*(2.401, 88.829) = 10.251$	$< 0.001*$	0.217
Lighting	$F^*(3.842, 142.161) = 7.244$	$< 0.001*$	0.164
Skin Texture × Character	$F^*(2.342, 86.652) = 45.119$	$< 0.001*$	0.549
Skin Texture × Lighting	$F^*(5.360, 198.322) = 5.517$	$< 0.001*$	0.130
A2. Trustworthiness			
Skin Texture	$F(1, 37) = 93.191$	< 0.001	0.716
Character	$F^*(2.401, 88.829) = 10.251$	$< 0.001*$	0.217
Lighting	$F^*(3.842, 142.161) = 7.244$	$< 0.001*$	0.164
Skin Texture × Character	$F^*(2.342, 86.652) = 45.119$	$< 0.001*$	0.549
Skin Texture × Lighting	$F^*(5.360, 198.322) = 5.517$	$< 0.001*$	0.130
A3. Eeriness			
Skin Texture	$F(1, 37) = 65.914$	< 0.001	0.640
Character	$F^*(2.321, 85.871) = 11.252$	$< 0.001*$	0.233
Lighting	$F^*(3.982, 147.33) = 17.627$	$< 0.001*$	0.323
Skin Texture × Character	$F^*(2.325, 86.013) = 26.628$	$< 0.001*$	0.418
B1. Genuineness			
Character	$F^*(2.094, 77.463) = 32.935$	$< 0.001*$	0.471
Character × Valence	$F^*(2.599, 96.160) = 4.324$	$< 0.010*$	0.105
Valence × Lighting	$F^*(4.721, 174.674) = 2.714$	$< 0.025*$	0.068
B2. Intensity			
Valence	$F(1, 37) = 12.406$	< 0.002	0.251
Character	$F(1.957, 72.405) = 2.019$	< 0.142	0.052
Lighting	$F^*(4.442, 164.366) = 2.813$	$< 0.024*$	0.071
Valence × Character	$F(2.763, 102.229) = 26.467$	< 0.001	0.417
Valence × Lighting	$F^*(5.331, 197.258) = 5.356$	$< 0.001*$	0.126
Character × Lighting	$F^*(11.756, 434.980) = 2.381$	$< 0.007*$	0.060

Table 1: Summary of ANOVA results, with asterisks indicating Greenhouse-Geisser adjustments due to sphericity test failures.

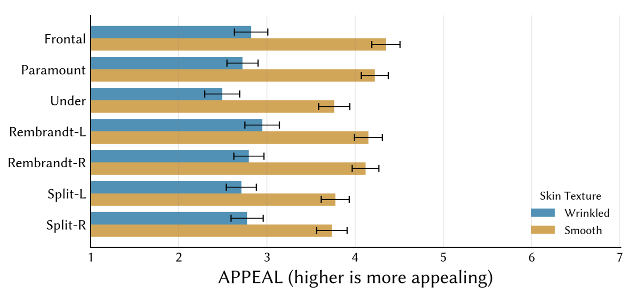

Figure 5: Interaction between *Skin Texture* and *Lighting* for APPEAL ratings. Error bars indicate standard error.

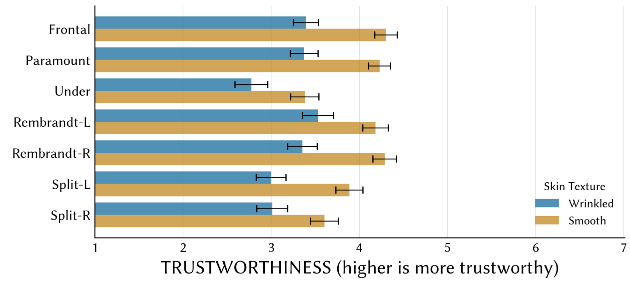

Figure 6: Interaction between *Skin Texture* and *Lighting* for TRUST ratings. Error bars indicate standard error.

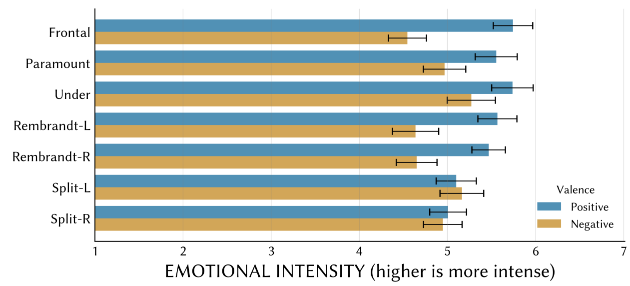

Figure 7: Interaction between *Valence* and *Lighting* for EMOTIONAL INTENSITY ratings. Error bars indicate standard error.

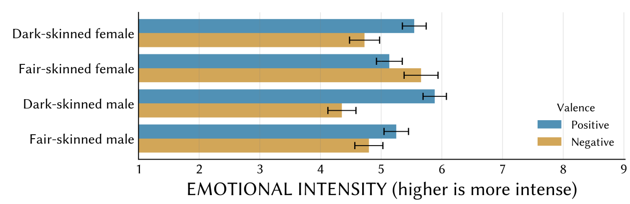

Figure 8: Interaction between *Valence* and *Character* for EMOTIONAL INTENSITY ratings. Error bars indicate standard error.

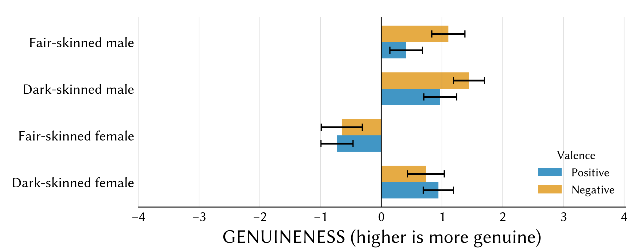

Figure 9: Interaction between *Valence* and *Character* for EMOTIONAL GENUINENESS ratings. Error bars indicate standard error.

C STIMULI

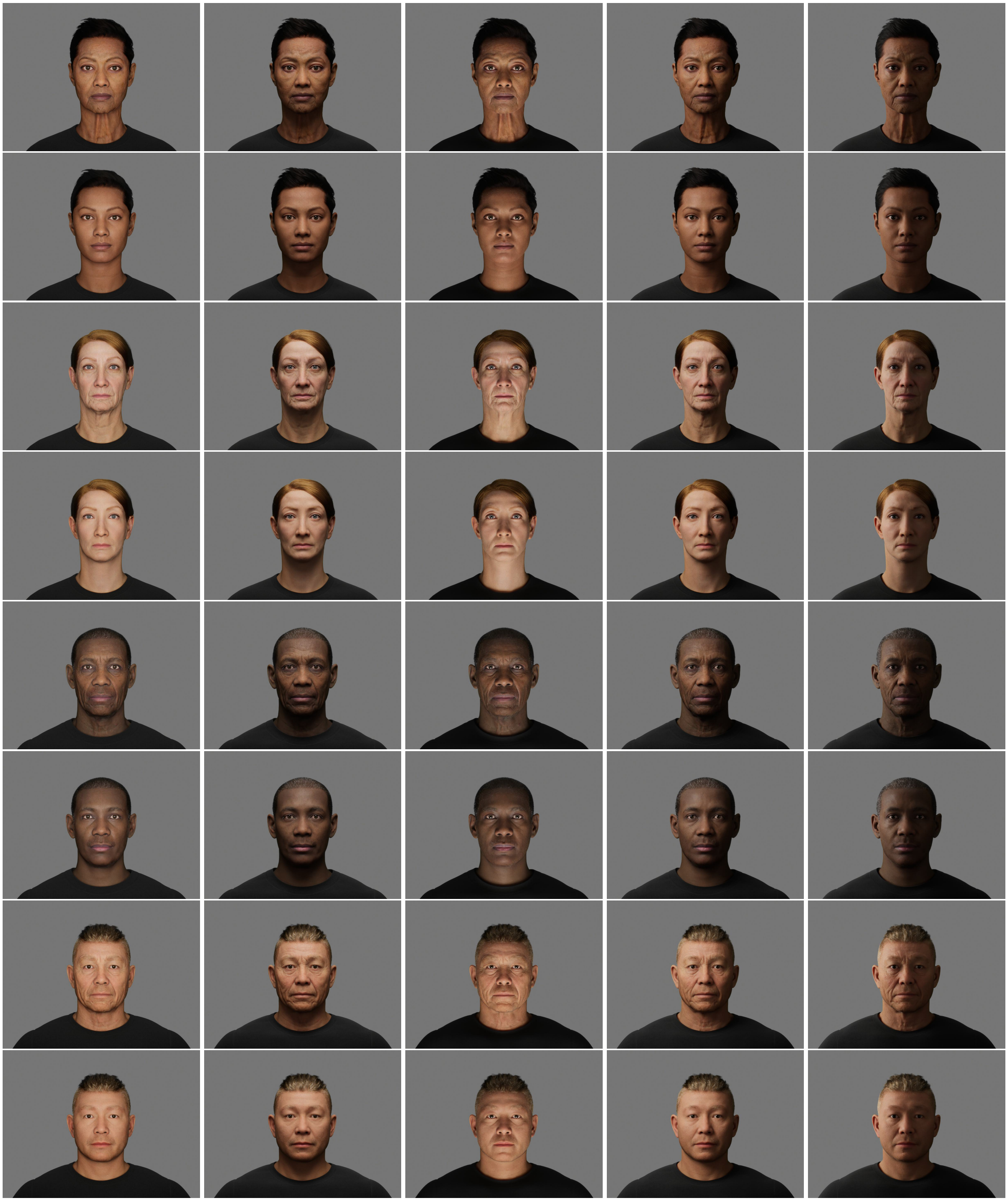

Figure 10: All four characters with neutral expression, wrinkled and smooth skin, illuminated by *Frontal*, *Paramount*, *Under*, *Rembrandt-Left*, and *Split-Left* lighting designs. The resolution of all stimuli is 960×720.

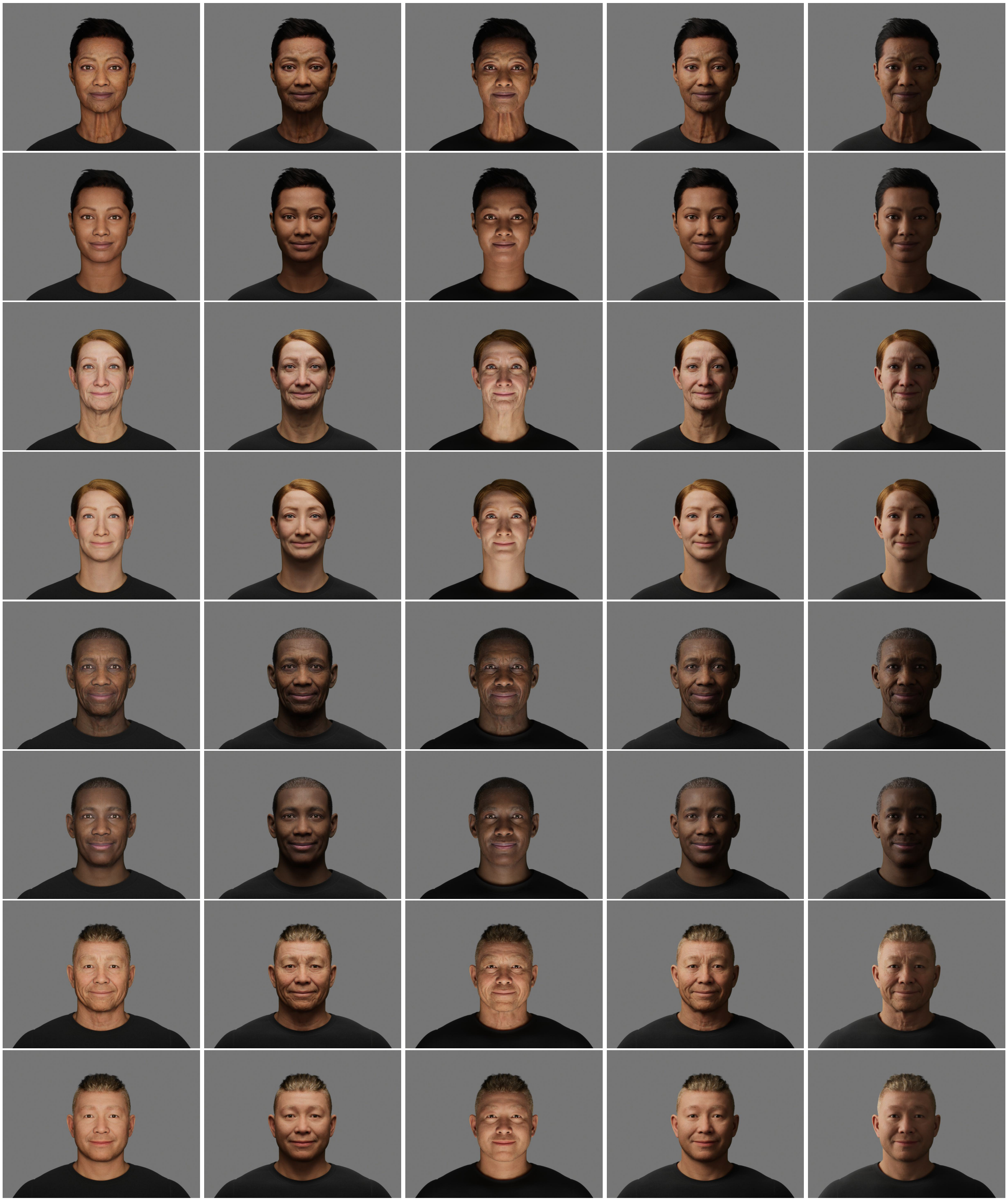

Figure 11: All four characters with positive expression, wrinkled and smooth skin, illuminated by *Frontal, Paramount, Under, Rembrandt-Left,* and *Split-Left* lighting designs. The resolution of all stimuli is 960×720.

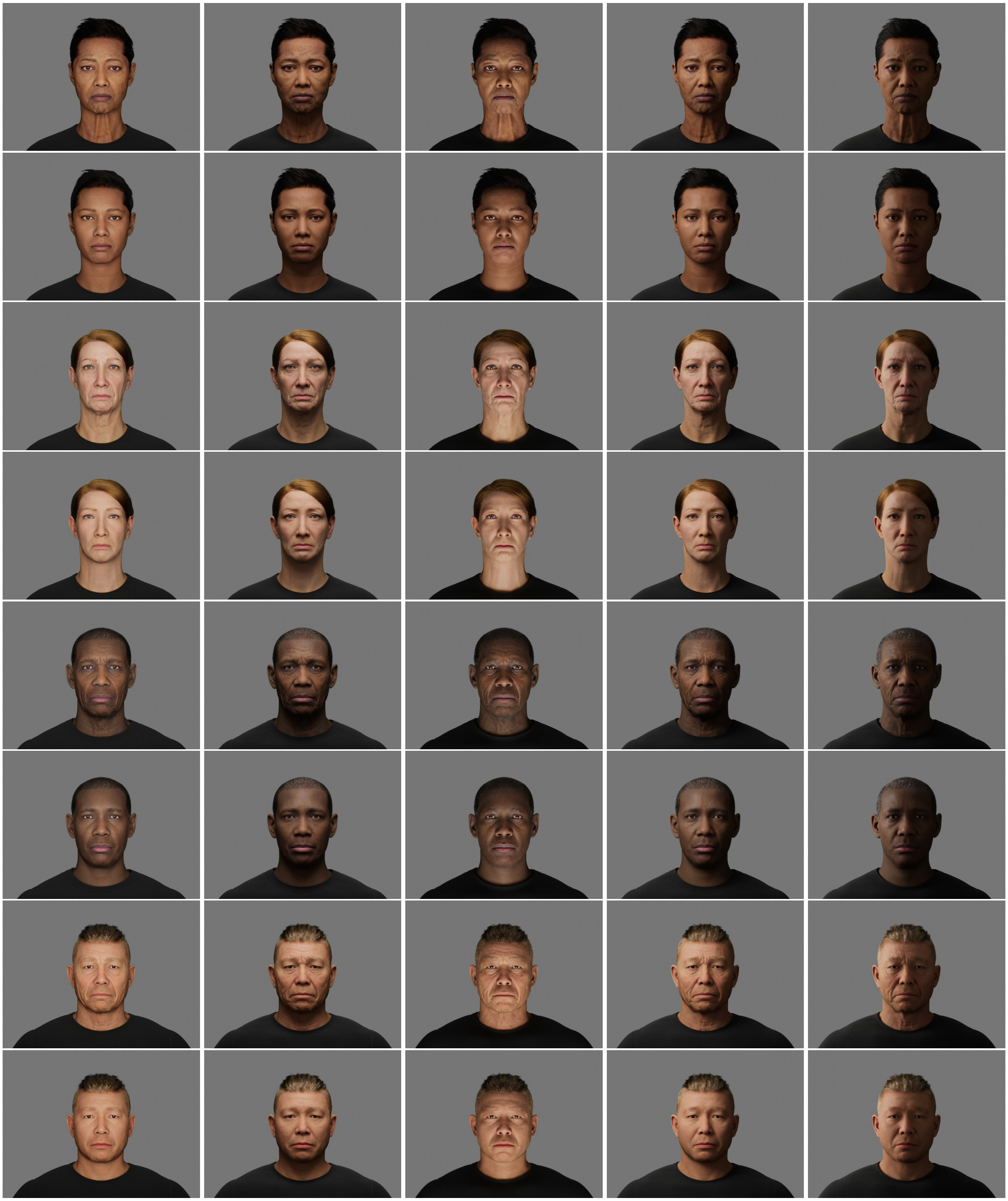

Figure 12: All four characters with negative expression, wrinkled and smooth skin, illuminated by *Frontal*, *Paramount*, *Under*, *Rembrandt-Left*, and *Split-Left* lighting designs. The resolution of all stimuli is 960×720.