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Article

Ecological Approach to Cinematographic Lighting of the Human Face – A Pilot Study

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ABSTRACT

One key aspect of cinematographic lighting – and lighting in general – is its direction and how the lighting illuminates people and other objects of attention. In a natural setting, the light reaching the target usually has at least some level of directionality instead of being just ambient overall light. In cinematography directionality is used, among other things, to enhance the lit object's three-dimensionality in an otherwise two-dimensional medium by bringing out its shape and texture and separating it from the background. While lighting has typically been studied based on its physical qualities that render for quantitative measures, such as intensity or color spectrum, less is known about how cinematographic lighting gives rise to the spectator's emotive-cognitive experiences. Overall, film lighting has been studied surprisingly little, although both practical and academic literature emphasize its important role in cinematic expression. This paper presents a pilot study that examines viewers' emotional reactions to photographs of an expressionless human face under lighting from different directions. The initial results indicate that lighting that obscures, hides, or distorts facial features creates stronger emotional reactions in the viewer than lighting that reveals them, contributing to the scientific understanding of the audience's reactions and the filmmaker's creative decisions.

INTRODUCTION

The art of cinematography can be viewed as an intriguing interplay of numerous cognitive and affective perceptual variables that enable the viewer's meaningful engagement. One of these variables is light and the way the cinematographer chooses to light objects and spaces. The lighting of a film set or location must participate in cinematic storytelling by establishing time and place, creating mood, and guiding the audience's attention to relevant story elements. Together with all the other visual and auditory elements of the film, lighting creates an orchestrated cinematic experience by relying greatly on the viewer's unconscious or subliminal affective-cognitive meaning-making processes.

One central idea in this article is that the way light has illuminated objects and the environment during our evolution has affected – and still affects – the way we observe the world. This argument follows the view of ecological psychology that our environment has provided the things we must have for survival, and, during evolu-

tion, we have developed capacities to use this relevant environmental information to guide our actions (see, e.g., Anderson 2007).

Lighting effectively guides our emotional and biological reactions to phenomena around us, be this in our everyday life or when we are engaged with immersive cinematographic storyworlds. As a part of the audiovisual expression of film, cinematographic lighting taps into this ancient modus operandi to add layers of meaning to the story by establishing mood and tone (Brown 2016, 104–128) and by helping to evoke subliminal emotions and conscious feelings in the audience (e.g., Brewer, Lichtenstein 1982; Oatley 1995; Tan 1995; Zillmann 1995; Tan 1996; Tikka 2008).

LIGHTING FOR SHADOWS IN CINEMATOGRAPHY

During the first decades of the 20th century, film lighting evolved to serve numerous filmmaking functions (e.g., Keating 2009), and many lighting practices that became cinematographic conventions then, such as the so-called three-point lighting (see, e.g., Lowell 1992: 41–50), are still in use today (e.g., Alton [1949] 1995; Bordwell, Thompson 2008; Keating 2009, 2014; Brown 2018). Most of these conventions are rules of thumb for lighting human subjects since in narrative films our attention is usually focused on the characters of the story. Many conventions also deal especially with the direction of light, since direction substantially affects the visual appearance of any lit subject or object (e.g., Brown 2018: 70). Relevant conventions from the point of view of this study are the ones that leave the face partially or wholly in the dark or otherwise obscure or distort facial features from what we are used to seeing in daylight. These conventions are shortly presented below.

Low-key and Chiaroscuro Lighting

High contrast and deep shadows became common in horror films of the 1930s and films noir of the 1940s and '50s (e.g., Place, Peterson 1974: 65–76) and this "low-key lighting" has since then been used as one possible dramatic lighting style of somber or mysterious films and film scenes (Bordwell, Thompson 2008: 130).

In low-key lighting, the contrast ratio, or the ratio between the brightest and darkest areas of the scene or, in figure lighting, the brighter and darker side of the face/person, is high. When the light is also coming only (or mainly) from one light source, it is often called "chiaroscuro lighting" (literally "bright–dark" in Italian), which was probably first used in cinema in D. W. Griffith's short film *The Thread of Destiny* (1910) shot by G. W. Bitzer (Brown 2018: 19). The precursors of this lighting style in art were the Renaissance painters (e.g., Leitch 2003: 116–128), and many cinematographers of the first decades of cinema mention them as major influencers for their work and the visual style of their films. These early masters of "cinematic lighting" before the invention of film include such painters as Caravaggio, Rembrandt, de la Tour, Velasquez, Vermeer, da Vinci, and others (ibid.).

Underlighting

One highly expressive lighting technique applied especially in Hollywood melodramas of the 1930s and '40s was light from below, also dubbed "uplight" or "underlighting." This lighting style was already established in the silent era in Jack Conway's film *Alias Jimmy Valentine* (1928) as motivated lighting coming from a flashlight (Alton [1949] 1995: 54–55), but it had its cultural background also in theater, crime novel illustrations, and, to some extent, in German expressionism (Keating 2009: 77).

Because light does not usually come from below in nature and it, therefore, presents the face unnaturally, it was – and still is – often used to call the audience's attention to criminal characters in crime drama and evil antagonists in horror. According to Malkiewicz (2012: 170), Hollywood has lit good people "from heaven" and bad people "from hell" for decades and this practice continues, although the effect is not as salient with the more natural and often softer lighting of today. Also, the practical

FIGURE 1. Low-key chiaroscuro lighting in Caravaggio's *The Calling of Saint Matthew* (1599–1600)

know-how of filmmaking stipulates that underlighting can be unnatural and frightening (see, e.g., Lowell 1992: 34; Zettl 2016: 35), and it can make a character look "weird, dangerous, or at best untrustworthy" (Zettl 2016: 32), "lugubrious" (Monaco 2009: 219), "harsh" (Keating 2009: 148), or "menacing" (ibid., 246).

The likely reason for the use and presumed effects of underlighting is that our visual system assumes that light comes from a high angle and only from one direction (Ramachandran 1988). As Grodal (2007: 133) points out, humans probably had permanent access to other sources of lighting (i.e., firelight) only after our present visual system was fully developed and, therefore, for us, underlighting is an antinaturalistic effect. Because of this, a face illuminated from below can appear odd and unnatural to us or we, at the very least, link it with negative feelings (ibid., 153–154).

Light from Above and "Godfather Lighting"

Apart from underlighting, light coming straight from above – often called "overhead lighting," "top lighting," or "downlight" – can also alter facial features from what we are used to seeing in daylight – especially if the light is very directional and contrasty.

One famous version of this lighting method is the soft overhead lighting dubbed "Godfather lighting" because of its first known use in the film *The Godfather* in 1972 by cinematographer Gordon Willis. Depending on the softness and size of the overhead light source and the amount of fill lighting, this lighting technique can also obscure or hide actors' eyes.

Although Willis' work in the Godfather films is acclaimed today, his often underexposed low-key overhead lighting style of interior scenes was considered highly unorthodox according to the Hollywood standards of the time, which emphasized correct exposure and showing the actor's eyes. Willis has later explained in an interview that his lighting method came out of necessity to hide Marlon Brando's heavy makeup (Glassman et al. 1992), but he has also stressed that it felt more appropriate to hide the eyes of the mafia gangsters because of what was going on in their heads at certain moments in the film (Schaefer, Salvato 2013: 365). Without any evidence from academic studies, it can be speculated that Willis' overhead lighting may indeed increase the viewer's mistrust toward the characters due to missing or obscured eye contact.

Silhouette Lighting and the Underexposed Face

Silhouette lighting is any type of lighting that lights the background of the subject but leaves the subject in the dark. In this type of lighting, the viewer is aware of the presence of a person (because of the familiar human contour), but unable to see the facial features and expressions that are critical for our understanding of the other person's intentions and emotions (e.g., Eisenbarth, Alpers 2011; Schyns et al. 2007; Smith et al. 2007). Just like underlighting and overhead lighting, this type of lighting, too, can affect the audience by increasing the intimidating mood of a scene. Also, any type of lighting that underexposes the subject's face to a level where we can no longer clearly see the facial features may have the same psychological effect.

TOWARD A THEORY OF EMBODIED FILM LIGHTING

Filmmakers have developed several lighting methods to enhance a movie's plot, characters, theme, style, and overall mood (Grodal 2007), and the emphasis on film lighting and its importance for the medium is widely present in theoretical and practical books about film and filmmaking.

Cinematographer Blain Brown, for example, points out that lighting and controlling color are some of the most essential tools in the toolkit of a cinematographer. With them, the filmmaker can reach the audience on "a gut, emotional level" and "add additional layers of meaning to the content of the story" (Brown 2016: 8). Similarly, cinematographer and lighting designer David Landau (2014: 6) emphasizes how

FIGURE 2. Motivated lighting from below in *The Shining* (1980) (Cinematographer: John Alcott)
FIGURE 3. Soft overhead lighting in *The Godfather* (1972) (Cinematographer: Gordon Willis)
FIGURE 4. Silhouette lighting in *The Man Who Wasn't There* (2001) (Cinematographer: Roger Deakins)

lighting "gives a perception of emotion and invokes a response in the viewer's subconsciousness" and "allows the viewer to feel the emotional thrust of the image."

Apart from filmmaking textbooks and guides, many academic sources also emphasize the importance of lighting in cinematic expression (see, e.g., Bettetini 1973: 77; Pramaggiore, Wallis 2008: 107; Grodal 2007: 153; Bordwell, Thompson 2008: 124; Keating 2009: 1, 132), and, therefore, one would think that film lighting would have been studied extensively. Nevertheless, this does not seem to be the case and, as Grodal (2007: 152) points out, unlike for narration, no theory has been created for film lighting. Also, Geuens (2000: 152) has emphasized that, when it comes to lighting, filmmakers are unable to explain their work, and are at best vague when trying to do so. Geuens goes as far as to argue that "the function of light in motion pictures has never been clearly articulated" (ibid.). More recently, Nevill has noted that writing about lighting in moving image production has been unsystematic, under-theorized, and anecdotal and that the academic study of cinematography and film lighting has taken only phenomenological, historical, and ethnographic perspectives (Nevill 2018: 10–21; see also Nevill 2021: 9–32).

Despite the aforementioned shortcomings, some academic research on the technical and artistic history (e.g., Bordwell et al. 1985; Keating 2006, 2009, 2014) and semiotics (e.g., Roth 1978; Russell 1981; Leeuwen, Boeriis 2016; Sadowski 2016, 2017; Mohammed Ezzat Ibrahim Ammer 2020) of film lighting has been published over the years, and a lot of research on lighting and its effects has been conducted in fields other than cinema (e.g., Knez 1995; Knez, Niedenthal 2008; Hutchinson et al. 2011; Sleegers et al. 2013; Zhu et al. 2019). Also, the role of lighting in face recognition and identification (e.g., Johnston et al. 1992; Knez 1995; Hill, Bruce 1996; Adini et al. 1997; Enns, Shore 1997; Liu et al. 1999; McMullen et al. 2000; Favelle et al. 2007, 2011, 2017) and in judgments of emotion and gaze direction (e.g., Fotios et al. 2015) has been addressed. Recently, some studies taking a more empirical perspective on film lighting have been reported in master's theses and conference presentations (e.g., Shafiee, Bidin 2016; Poland 2015), while Nevill (2018) has examined lighting techniques used by cinematographers and other practitioners working with moving imagery in his practice-led doctoral research. Taking the spectator's perspective, Lotman (2016) and Voodla et al. (2020) have reported studies that measured how the sense of depth, created with lighting and other cinematographic tools, relates to the audience's empathy toward the film characters.

The interesting first effort to find some preliminary basis for an overall theory of film lighting is Torben Grodal's article "Film Lighting and Mood" (2007). In his article, Grodal hypothesizes that lighting creates feelings in us if the objects' transient features are not in accordance with the "tacit knowledge" – a term coined by philosopher Michael Polanyi (1967) – we have about those objects. As an example, Grodal uses Carl Dreyer's film *Vampyr* (1932) where "the moonlit landscapes impede full object recognition, and the special viewing conditions are represented by a mood that marks the depressed visual orientation along with the diminished capabilities for action and control" (ibid., 157).

It must be stressed here that to Grodal, as to other film theorists adopting the approach of ecological psychology (see, e.g., Anderson et al. 2007), a film scene is a setting much in the same way as any other setting we observe in a natural environment. As Grodal (1997: 6) points out, films are viewed in a conscious state and are mostly about other human beings "perceiving, feeling, and acting in, or in relation to, a visible and audible world."

What Grodal is building on is the theory of affordances by ecological psychologist James J. Gibson (1979). Gibson's affordances are environmental properties that are related to our ability to use them, and for us to perceive an affordance, we need to detect an environmental property that provides an opportunity for action (Gibson,

FIGURE 5. Example frames from *Vampyr* (1932) (Cinematographers: Rudolph Maté & Louis Née)

Pick 2000: 15–16). Some examples could be the flatness and solidity of the floor to indicate affordance for walking; the shape, size, and height of a chair for sitting; different kinds of handles for grabbing; and, from the perspective of the present study, a human face for interpersonal communication.

In his theory of film mood, Grodal uses affordance to explain how film lighting can evoke emotions and feelings and help set the mood for a scene. According to Grodal, in this process, our feelings express the general affordances of the scene under its specific lighting conditions that can, for example, facilitate or impede interaction (2007: 157). In other words, lighting that prevents us from getting enough information to make inferences and construct narrative coherence also diminishes the feeling that the situation is in our control which, in turn, may instill emotions and feelings in us.

THE ECOLOGICAL VALUE OF THE FACE AND THE EYES

The human face is an important tool of social communication (e.g., Zebrowitz 1997; Jack, Schyns 2015), and we infer a lot from both the static and the dynamic features of the other person's face (e.g., Fridlund, Russell 2006). This nonverbal facial information is important for our ability to understand and mirror others' thoughts and feelings (e.g., Frith 2009), and we constantly try to observe whether what a person says is in line with their nonverbal communication (e.g., Ekman et al. 1988; Ekman 2003). On the subliminal level, amygdalae, the part of the brain responsible for activating the responses of our autonomic nervous system together with the hypothalamus, are known to respond not only to threatening or otherwise relevant visual targets such as snakes, spiders, predators, heights, etc. (e.g., Hoehl et al. 2017) but also to human faces and emotional states displayed on them (e.g., Dimberg, Öhman 1996; Dimberg et al. 2000; Vuilleumier et al. 2001, 2002; Sander et al. 2003; Pourtois, Vuilleumier 2006; Juruena et al. 2010; Hoehl et al. 2017).

In the process of extracting emotional information from the face, the area around the eyes is especially relevant to us. Our subliminal "scan" of a face usually starts from the eyes and then moves to other parts of the face to quickly discriminate fear from other emotions (Eisenbarth, Alpers 2011; Schyns et al. 2007; Smith et al. 2007). We also automatically orient ourselves in the direction of the other people's gaze to find information about threats and other targets crucial for our survival (e.g., Driver et al. 1999) and, as social beings, detect very quickly if the other person's gaze is directed at us (Perrett et al. 1985) and even expect it to be directed at us (Mareschal et al. 2013).

Considering the lighting of a face, our face perception is based on shape and surface information that draws on implicit knowledge of upright faces and ecological lighting conditions, i.e., light usually coming from a high angle (Favelle et al. 2017; see also Adini et al. 1997). Any other lighting direction, such as light from below, weakens our ability to recognize a face (Favelle et al. 2017), and lighting that hides, obscures, or distorts facial features reduces our ability to extract emotional information from the face (e.g., Fotios et al. 2015), which may cause emotional distress.

A PILOT STUDY

A pilot study was conducted to investigate whether the direction of light on the observed face would affect test subjects' assessments of their own emotional response or how pleasant or unpleasant they rated the depicted face. Based on the practical experience of a professional cinematographer (SH; the author of the paper) and the theoretical matters discussed earlier, the initial hypothesis was that any type of lighting that hides, obscures, or distorts facial information would result in more negative emotions and a lower pleasantness rating.

In their research, Lang and colleagues (1993) have identified the central features of emotion to be arousal, valence, and dominance. Based on these dimensions, it was further hypothesized that the abovemen-

tioned lighting types would make test subjects rate their arousal higher, their feeling of dominance lower, and the valence more negative than they would do in lighting that reveals the whole face and comes from an ecologically familiar angle, that is, from above the eyeline, as is usually the case in a natural setting.

Stimulus Images

The experiment stimuli consisted of nine black-and-white photographs of an expressionless male face (Figure 6) lit from different angles using the same 40x40 cm LED (light-emitting diode) light source diffused with standard 1/2 white diffusion gel (Rosco) to make the light mimic natural daylight (a method used extensively in professional photography and cinematography). For lighting setups 1–5, only the angle of the key light was varied; for setups 6–7, the light was lowered to ground level and the diffusion gel was removed. The face in setups 6–7 was four stops underexposed, which significantly obscured the facial features. For the silhouette lighting in setups 8–9, the key light was switched off altogether. Backlit and silhouette photographs were also shot both without (setups 6 and 8) and with (setups 7 and 9) a catchlight in the eyes.

All photographs were taken in a photography studio in front of an evenly lit green chroma key background. The lightness level of the background was kept close to middle gray (18% gray), although some light from the key light was allowed to fall on the background to keep the look of the setting natural (i.e., light from a specific direction falling on both the subject and the background). In photographs 1–4, a small LED light was also placed above the subject to create a touch of light on the hair that would not interfere with the key light.

Although the photographs were originally shot in color, chroma information was lifted from the final stimulus images to keep the independent variables to their minimum. There is, for example, evidence that color may affect how we interpret facial expressions (Young et al. 2013).

Test Subjects

The test subjects consisted of 19 people (11 male, 8 female) aged 18–79 years (mean age = 43.47, SD = 14.204). Of the test subjects, 17 were right-handed and 2 left-handed (self-reported). All test subjects had normal or corrected-to-normal visual acuity (self-reported). Nine of the 19 test subjects had received college-level education in filmmaking.

Measurements

Subjects rated their emotional response to stimulus images on three nine-point self-assessment manikin (SAM) scales (Lang 1980; Bradley, Lang 1994) that measured perceived arousal (from calm to aroused), perceptions of dominance (not in control–in control), and the valence of the response (from negative to positive). Based on earlier studies using self-assessment ratings (e.g., Bradley, Lang 1994; Lang et al. 1997) and in accordance with the circumplex model of affect (Russell 1980; Russell, Barrett 1999; Posner et al. 2005), it was further assumed that the ratings would reflect the test subjects' emotional state after seeing a stimulus image.

After evaluating their own emotional responses, the subjects were also asked to evaluate the pleasantness of the seen face by using a nine-step Likert scale ranging from "very unpleasant" to "very pleasant." The scope of the term "pleasant" was not defined in any more detail, but the subjects were instructed to focus on the appearance of the depicted face instead of their own feelings.

All images, questions, and scales appeared on a computer display placed in front of the participant. Each stimulus image was shown for 10 seconds after which a question about arousal, dominance, valence, or pleasantness was presented with a corresponding scale. After the participant had chosen their answer by moving a cursor on the scale with arrow keys on the keyboard, the scale disappeared, and the next image was presented. All answers were recorded for analysis using a nine-step numerical scale ranging from -4 to +4.

FIGURE 6. Experiment stimulus images. (Eyelight in setups 7 and 9 might not reproduce here.)

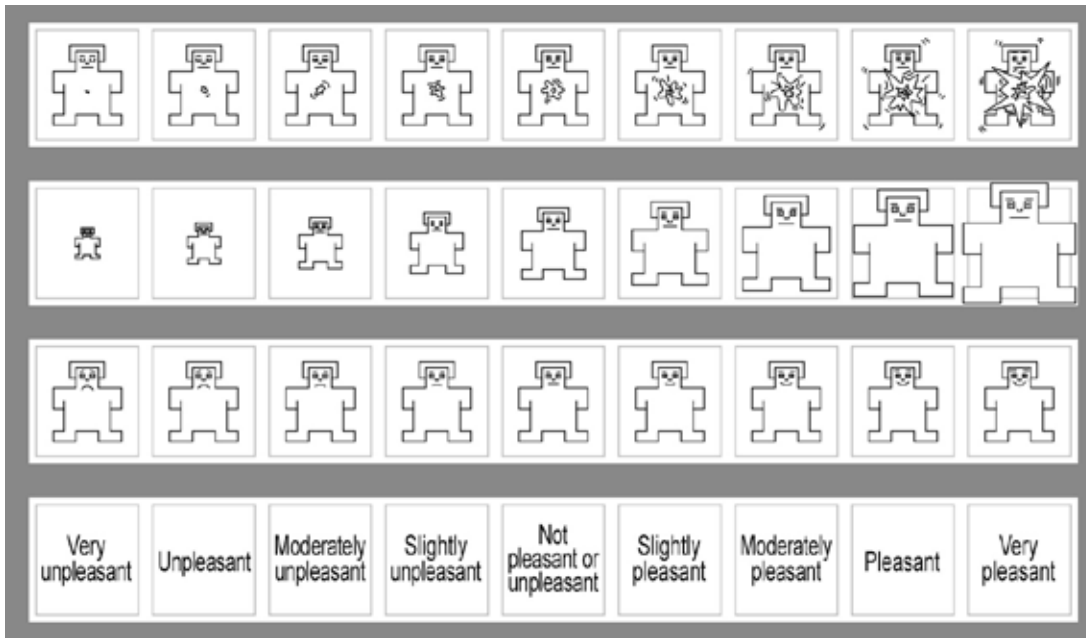

FIGURE 7. SAM scales to assess test subjects' experience of arousal, dominance, and valence (Lang 1980), and a Likert scale to assess the pleasantness of the depicted face

Analyses and Results

A one-way ANOVA was performed to compare the effect of lighting setups on the assessments of arousal, valence, dominance, and pleasantness, and it showed a statistically significant difference between all lighting setups in all measures (Arousal: $F(8, 162) = 9.191$, $p < .001$, $\eta^2 = .312$; Dominance: $F(8, 162) = 2.849$, $p = .005$, $\eta^2 = .123$; Valence: $F(8, 162) = 5.046$, $p < .001$, $\eta^2 = .199$; Pleasantness: $F(8, 162) = 16.938$, $p < .001$, $\eta^2 = .455$). The subjective ratings varied most on the dimension of dominance, which is in accordance with earlier studies using SAM scales (see, e.g., Bradley, Lang 1994).

Overall, the test subjects assessed setups 1–3 (frontal lighting, 45-degree lighting, and 90-degree side lighting) lowest in arousal and highest in valence, dominance, and pleasantness. Setups 4–9 were assessed as more arousing, more negatively valenced, less dominance-inducing, and less pleasant-looking than the first three.

Silhouette lighting (setup 8), silhouette lighting with eye light (setup 9), and bottom lighting (setup 4) received the highest mean arousal scores (+1.68, +1.47, +1.32, relatively) and the lowest mean pleasantness scores (-1.95 for all). For valence, setups 4–9 all received mean scores close to -1, and for dominance, the mean assessments were also slightly on the negative side of the scale. All mean assessment scores are presented in Figure 8 below.

A post hoc independent samples t-test was also conducted to see if the test subjects with a film education background ($N = 9$) had rated the stimulus images differently than the subjects without film education ($N = 10$). The test results showed no statistically significant relation between film education and ratings (Arousal: $t(169) = .791$, $p = .430$; Dominance: $t(169) = 1.302$, $p = .195$; Valence: $t(169) = -.884$, $p = .378$; Pleasantness: $t(169) = -1.194$, $p = .234$).

CONCLUSIONS

Based on the results, the examined lighting setups were divided into positive setups (1–3) and negative setups (4–9). The test subjects rated the positive setups more favorably, that is, lower on arousal and higher on valence, dominance, and pleasantness, than the negative setups. These results indicate that the better the facial features are revealed by lighting that comes from some angle typical of a natural setting, the more positive is the reaction of the viewer in all measured dimensions. The results are in accordance with the original hypothesis that lighting setups that obscure, hide, or distort facial features would be rated more negatively than others. With regards to lighting setup 3 (90-degree side lighting), where only one side of the observed face was clearly visible, the assessment means were more positive than was expected. The reason for this may be that the human face is rather symmetrical and seeing only one side of a face (a hemiface) may be enough to provide the observer with sufficient information about the other person's intentions and emotional state. Furthermore, as heightened arousal combined with negative valence has been associated with an emotional dimension that includes such feelings as distress, fear, and nervousness (e.g., Russell, Barrett 1999; Watson et al. 1999), it can be assumed that using negative setup lighting styles (setups 4–9) in cinematography may cause or increase these feelings in a film audience. This conclusion would also be in accordance with the empirical experience accumulated in professional practices of cinematography that assume that leaving faces in the dark or lighting them from unnatural angles can add to the film's or the film scene's intimidating mood and/or imply negative qualities in film characters (e.g., Lowell 1992: 34; Keating 2009: 148, 246; Malkiewicz 2012: 170; Zettl 2016: 31–32). Also, regarding underlighting, this conclusion would be consistent with Grodal's (2007: 153–154) assessment of the unnatural appearance of light coming from below and its link with viewers' negative feelings.

Regarding the relationship between the test subjects' film education and their assessments, this pilot study could not

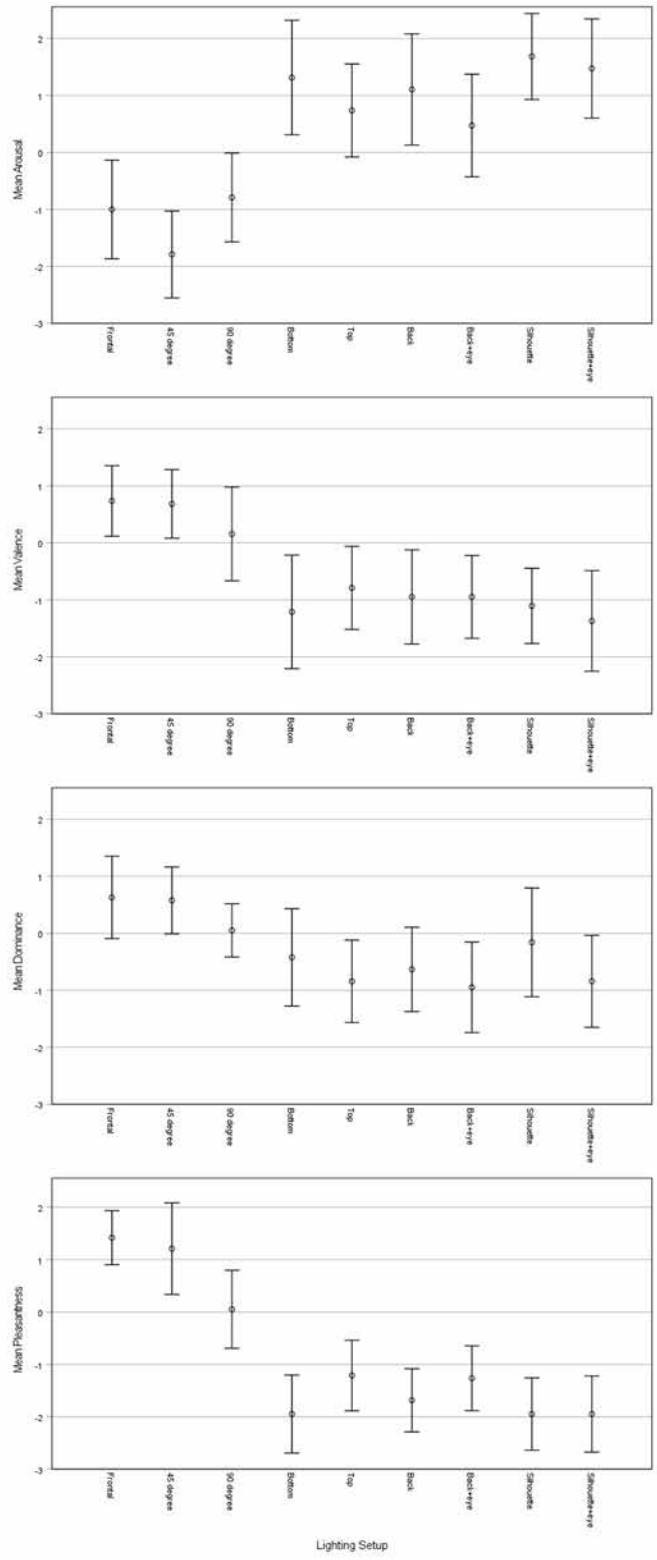

FIGURE 8. Assessment means of all lighting setups with 95% error bars

find any statistically significant correlation between them. Although further studies are needed, this result suggests the possibility that both film professionals and non-professionals first evaluate faces and lighting emotionally instead of evaluating them cognitively.

GENERAL DISCUSSION

The goal of this pilot study was to determine the extent to which the direction of light falling on an observed face would affect viewers' self-assessed emotional reactions measured in dimensions of arousal, valence, and dominance, as well as their assessment of the face's pleasantness.

In accordance with the hypotheses, the results indicate that lighting directions and conditions that obscure, hide, or distort the facial features of film characters may increase the negative feelings linked to these characters, and may also affect the overall experienced mood of the film scene due to impeded object recognition and diminished ability for action and control as proposed by Grodal (2007).

Nevertheless, since the experimental stimulus consisted only of photographs of a human face, this study lacked diegetic context, movement, sound, and preceding and succeeding images of a narrative film – aspects that all contribute to viewers' reactions in a real film-watching setting. Future studies may want to explore the effects of lighting by using film clips or even feature-length films as a means to better generalize the results to a genuine film-watching experience (e.g., Jääskeläinen et al. 2021). The possible differences between watching faces with a direct versus an averted gaze (see, e.g., Adams, Kleck 2005) under different lighting setups could also be studied since the latter is more common in narrative fiction films.

Also, apart from measuring viewers' conscious feelings using SAM or other self-assessment methods, future studies may want to assess viewers' subliminal emotional reactions to different types of lighting using event-related psychophysiological measures such as skin-conductance responses, pupillometry, or facial electromyography (fEMG), all of which have been applied in studies involving emotional visual stimuli (see, e.g., Cowley et al. 2016 for a review of these methods).

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