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Effects of Stereoscopic Representations in Sublime Experiences Induced by Immersive VR

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Abstract

Sublimity has long been a theme in aesthetics, as one of the human emotions experienced when perceiving vastness, terror, or ambiguity. This study investigated the visual conditions that evoke sublimity using virtual reality (VR). Participants observed sublime content, developed based on previous research, under two factors conditions of (1) wide or narrow fields of view (FOV), and (2) 2D or 3D video presentations. We collected psycho-physiological evaluations from the participants. The results demonstrated that a wider FOV enhanced the perception of sublimity and pleasantness. In particular, gaze fixation time tended to increase under conditions of wider FOV and 3D presentation, supporting the effect of sublimity in VR. This suggests the potential of VR as a valuable tool for amplifying the experience of sublimity.

Introduction

The sublime is a traditional aesthetic category associated with human emotions experienced when encountering vast, terrifying, or ambiguous objects [1]. The sublime arises from a range of emotions (terror, awe, harmony, tranquility, pain, pleasure) and stimuli such as art (e.g., poems, music), nature (e.g., mountains), and intellectual pursuits (e.g., mathematical analysis) [2]. The triggers for the sublime have been subject to various discussions, often framed by contrasting axes: perception versus conception, art versus nature, beauty versus ugliness, and relationship with others versus self. A unified perspective has yet to be established.

However, how sublimity is perceived in visual arts and natural phenomena has been extensively studied in aesthetics and psychology. Ishizu et al. (2014) presented natural photographs to participants and classified them as sublime or non-sublime. They then conducted an fMRI experiment to analyze brain activity while participants viewed sublime photographs, revealing brain regions activated during the experience of sublimity [3]. Hur et al. (2020) studied the relationship between sublimity and fear in photographs. They proposed that beauty was correlated with low fear, high happiness, and low arousal, whereas sublimity was correlated with high fear, low happiness, and high arousal [4]. In another study, Hur et al. (2024) investigated the influence of presentation methods on sublimity and beauty in photographs. They reported that increasing presentation size increased sublimity more than beauty, and increasing presentation height affected both sublimity and beauty positively and in similar degrees [5].

Chirico et al. (2021) examined whether there was a difference in the degree of sublimity experienced between two primary elicitors of sublime emotions: nature and art. By having participants observe 360° video footage of works depicting nature and art, they revealed that works depicting nature elicited stronger emotional responses [6].

Previous research has primarily focused on 2D images and videos, while studies using immersive technologies like VR remain scarce. The advancement of modern VR technology offers enhanced immersion in visual experiences and provides new perspectives for the study of sublimity.

The purpose of this study is to investigate the visual conditions under which observing sublime content in VR evokes stronger feelings of sublimity. Specifically, we aim to clarify the influence of FOV and 2D/3D presentation on sublimity. We also aim to explore physiological indicators of sublimity based on participants' gaze data and subjective evaluations under these conditions.

Method

Stimuli

The experimental stimuli were created using Unity with HDRP. The stimuli consisted of silent 360° videos, lasting 65 seconds in total, including a 10-second crosshair image for gaze calibration followed by a 55-second experimental stimulus. To create content intended to evoke sublimity, we incorporated elements considered sublime from the literature. These elements are described below.

Definition: The “sublime” refers to an emotion evoked by overwhelming power or grandeur, inspiring awe and reverence. Unlike beauty, it is often characterized by a certain degree of fear or unease that transcends intellect.

1. *Mountains:* Mountains evoke sublimity through their immensity, ruggedness, and irresistible power.
- Fear and Reverence: "A 'sublime' in the style of Salvator Rosa, giving the viewer a sense of fear through elements such as diagonally extending tree trunks and branches, voluminous rocky mountains, distant rugged mountains, and violently flowing clouds" [7] indicates that the menacing aspects of mountains contribute to the sublime.
- Awe of Irresistible Force: "The fear and anxiety brought about by irresistible forces such as volcanic eruptions and harsh winter mountains most effectively deprive humans of their reasoning abilities, and therefore, it is a sublimity rooted in reverence for human greatness, such as tragic self-sacrifice and heroic actions" [8] indicates that the ferocity of nature and human helplessness towards it lead to reverence and, consequently, sublimity.
- Recognition of One's Own Smallness: "It is also the awe experienced when humans become aware of the smallness of their own existence when confronted with the towering Alps or Gothic cathedrals" [9] indicates that human humility and the recognition of one's smallness before vast mountains lead to the feeling of sublimity.

2. *Light:* Light contributes to the sublime by blurring shapes and expressing infinity and invisibility. The video included a scene around 30 seconds where the sun rises from behind the mountains, creating a halo effect.

- Ambiguity and Infinity: "The actual forms are dissolved in the interplay of light. All that remains is light and color that erase and dissolve everything they touch. Here, 'obscurity,' which Burke cited as an important element of the sublime, and 'boundlessness,' which was a characteristic of Kant's sublime, are developed by light and color in the visual world" [10] indicates that light expresses sublimity by blurring shapes and creating boundlessness and obscurity.
- Omnipresence and Invisibility: “The sun is omnipresent and simultaneously invisible, unfathomable, intangible and unreachable. These terms could be seen as typical for the romantic zeitgeist. Especially Turner and the artists that followed in his footsteps ‘put the sublime on a canvas from the inside out’.” [11, 12] suggests that the sun's omnipresence, invisibility, and elusive nature are characteristic of Romanticism and contribute to the expression of the sublime.

3. *Clouds/Fog:* Clouds and fog obscure vision and blur objects, emphasizing infinity and mystery, thus evoking sublimity.

- Obscuration and Infinity: "The same with its Summit hidden by Clouds, & seemingly blended with the Sky" [13] indicates that the mountain peak hidden by clouds, appearing to merge with the sky, expresses infinity.
- Expression as a Medium: "Especially in the works of late Turner, not natural objects themselves, but the medium through which they are seen, namely light and shadow, fog and glare, spray, are expressed, and the shapes of objects are swallowed up by these media and disappear, becoming a depiction of nothingness, or something infinitely close to nothingness" [10] indicates that fog and other elements cover and obscure objects, depicting a state close to nothingness, thereby expressing the sublime.

4. *Sea/Lake:* The sea and lake express the duality of the sublime through contrasting states of roughness and tranquility.

- Contrast of Stillness and Motion: "Schiller cites 'a calm sea' as an example of theoretical sublime and 'a stormy sea' as an example of practical sublime" [14] indicates that a calm sea is cited as an example of theoretical sublime, and a stormy sea as an example of practical sublime, showing that the contrast between stillness and motion contributes to the expression of the sublime. A calm sea evokes awe from its infinite expanse and silence, while a stormy sea evokes fear from the ferocity and destructive power of nature, both leading to the feeling of sublimity.

By combining these elements, we created a sublime video that evokes awe, reverence, and a recognition of one's own smallness in viewers. We ensured that the trees, leaves, and grass moved naturally in the wind to maintain realism.

Figure 1. *Equirectangular panoramic image*

Measurements

Subjective indicies were collected using a five-point Likert scale questionnaire and structured interviews conducted after the experiment. The questionnaire included items for beauty, pleasantness, sense of scale, and sublimity, based on previous research. The post-experiment interviews asked whether participants noticed differences in stereoscopic viewing, which video they liked best and least, the perceived differences due to stereoscopy and FOV, and any other observations and feelings.

Objective indicies, including gaze position, head movement, cerebral blood flow, and heart rate, were acquired. Gaze position was converted to angles corresponding to the equirectangular projection. Gaze fixation was defined as gaze remaining within a 2-degree visual angle for at least 150 ms. Head movement was analyzed by calculating horizontal angular velocity. Changes in cerebral blood flow (oxyhemoglobin concentration change) and heart rate were calculated as changes from the baseline established during the 10-second gaze calibration, after standardization.

Layout / Conditions

Videos were presented using a head-mounted display (Vive Pro Eye: HTC). This HMD allows for gaze data acquisition at a sampling rate of 120 Hz. fNIRS (HOT-2000: NeU) was used to acquire cerebral blood flow and heart rate data at a sampling rate of 10 Hz. Participants sat on a chair with a rotation mechanism during stimulus observation. The experimental conditions were set by manipulating FOV and stereoscopic presentation. FOV was set to wide (110 degrees) and narrow (30 degrees), and stereoscopic presentation was set to 3D and 2D, resulting in a total of four conditions.

Procedure

Twenty undergraduate students in their twenties participated in the experiment. First, informed consent was obtained, followed by an explanation of the definition of sublimity and the experiment. To ensure that participants did not miss the scene intended to evoke sublimity, we explained about the mountain and the sunlight. After the explanation, participants were fitted with the experimental equipment and performed gaze calibration. After calibration, the experiment began with participants facing forward in the VR space. After observing the stimulus, participants removed the HMD and answered the questionnaire. Gaze calibration, stimulus viewing, and questionnaire completion were repeated. The experimental stimuli were presented in randomized order. After completing all conditions, post-experiment structured interviews were conducted.

Results

Subjective Index

A two-way ANOVA was conducted on the five-point rating scale questionnaire, with FOV and stereoscopic presentation as factors. The results showed significant main effects of FOV and stereoscopic presentation on beauty (FOV: $p < .001$, Stereoscopic: $p = .012$, Interaction: $p = .733$). For pleasantness, a significant main effect of FOV was found (FOV: $p < .001$, Stereoscopic: $p = .437$, Interaction: $p = .560$). For sense of scale, a significant main effect of FOV was found (FOV: $p < .001$, Stereoscopic: $p = .900$, Interaction: $p = .058$). For sublimity, a significant main effect of FOV was found (FOV: $p < .001$, Stereoscopic: $p = .235$, Interaction: $p = .716$).

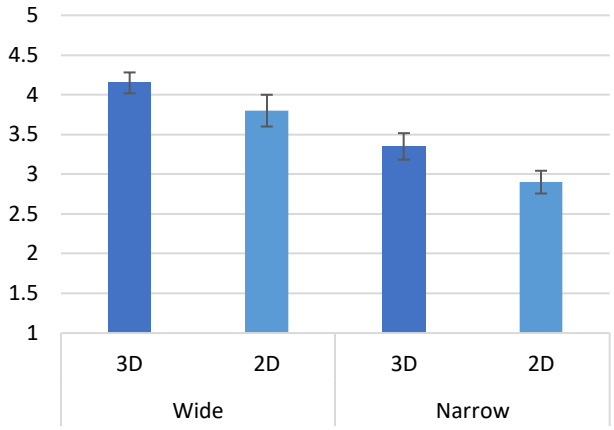

Figure 2. *Result of Beauty*

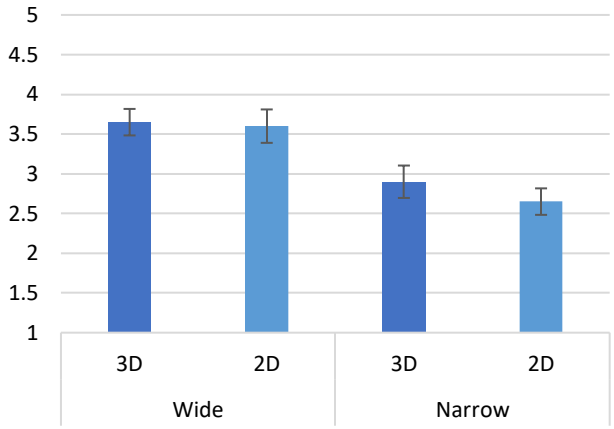

Figure 3. *Result of Pleasantness*

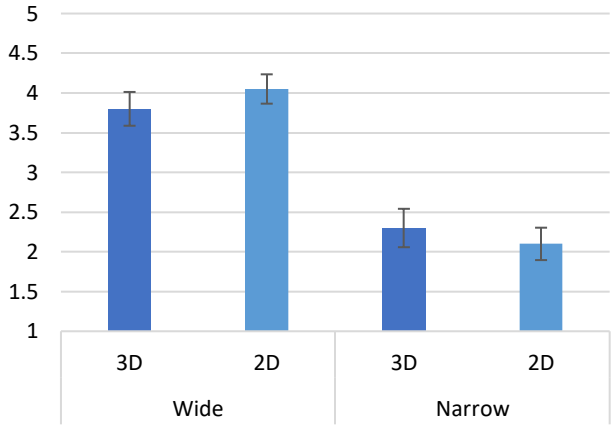

Figure 4. *Result of Scale*

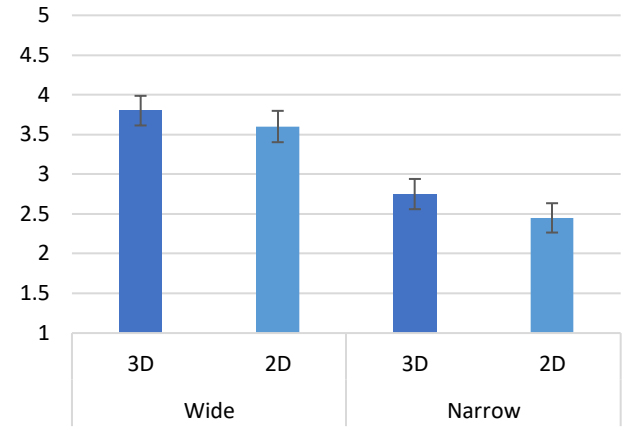

Figure 5. *Result of Sublimity*

Objective Index

The mean and standard error of the number of gaze fixations are shown in Figure 6. A two-way ANOVA with FOV and stereoscopic presentation as factors revealed significant main effects of FOV and stereoscopic presentation (FOV: $p = .005$, Stereoscopic: $p < .001$, Interaction: $p = .749$).

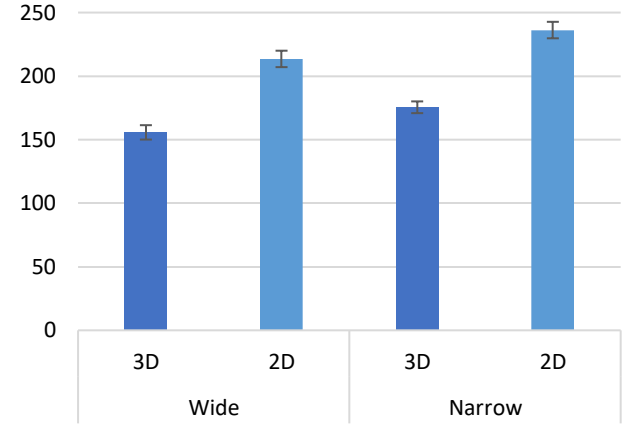

Figure 6. *Result of Fixation count*

The mean and standard error of gaze fixation duration are shown in Figure 7. A two-way ANOVA with FOV and stereoscopic presentation as factors revealed significant main effects of FOV, stereoscopic presentation, and a significant interaction (FOV: $p = .033$, Stereoscopic: $p < .001$, Interaction: $p = .008$). Simple main effects tests revealed main effects of FOV in 3D ($p = .007$), stereoscopic presentation in the wide FOV condition ($p < .001$), and stereoscopic presentation in the narrow FOV condition ($p = .004$).

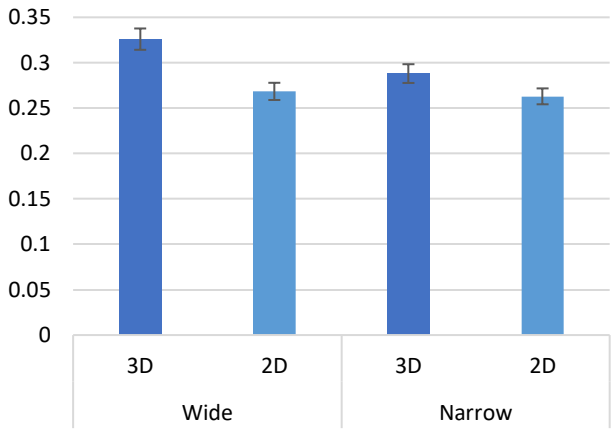

Figure 7. *Result of Fixation duration*

The mean and standard error of horizontal head angular velocity are shown in Figure 8. A two-way ANOVA with FOV and stereoscopic presentation as factors revealed significant main effects of stereoscopic presentation and a significant interaction (FOV: p = .217, Stereoscopic: p = .026, Interaction: p = .022). Simple main effects tests revealed significant differences for FOV in the 3D condition (p = .009) and for stereoscopic presentation in the wide FOV condition (p = .003).

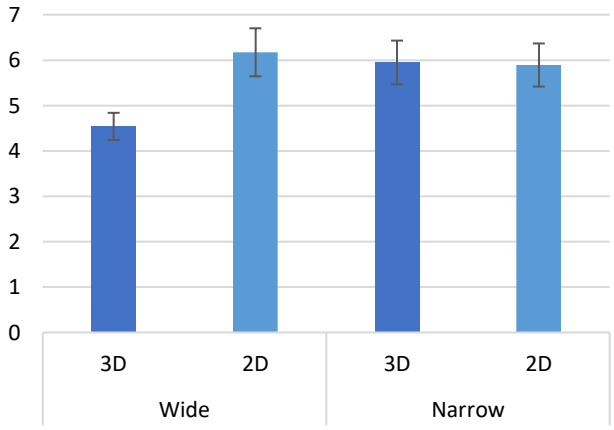

Figure 8. *Result of Head yaw velocity*

The results of changes in cerebral blood flow from baseline are shown in Figure 9. A two-way ANOVA with FOV and stereoscopic presentation as factors revealed a marginally significant main effect of FOV (FOV: p = .086, Stereoscopic: p = .671, Interaction: p = .448).

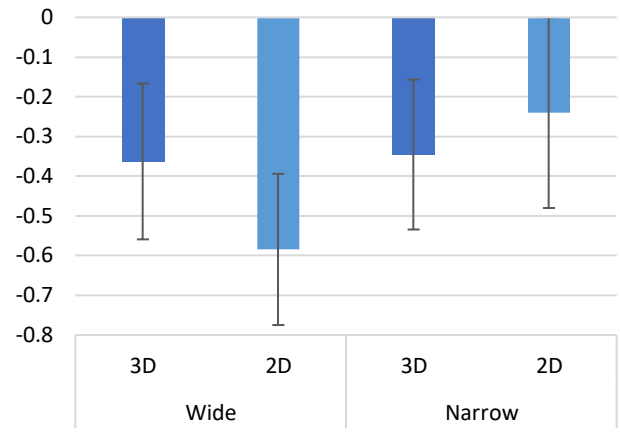

Figure 9. *Result of NIRS*

The mean and standard error of changes in heart rate from baseline are shown in Figure 10. A two-way ANOVA with FOV and stereoscopic presentation as factors revealed no significant differences (FOV: p = .732, Stereoscopic: p = .924, Interaction: p = .897).

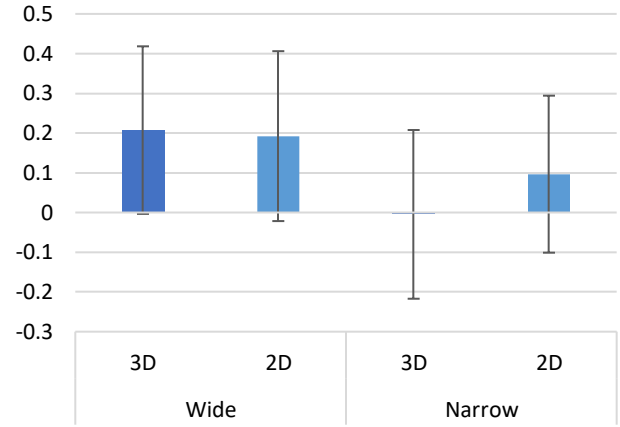

Figure 10. *Result of Heart rate*

Discussion

Subjective evaluations showed that beauty, pleasantness, sense of scale, and sublimity were rated higher with a wider FOV. Furthermore, beauty was rated higher with stereoscopic presentation. This suggests that a wider FOV is crucial for the elements constituting the sublime experience. The higher evaluation of beauty with 3D suggests that stereoscopy has a positive effect on sublimity experienced through landscapes.

Previous research [5] has suggested that increasing size enhances sublimity more than beauty. The effect sizes of FOV were η^2 = 0.250 for beauty and η^2 = 0.302 for sublimity, supporting previous research. Furthermore, the effect sizes were η^2 = 0.210 for pleasantness and η^2 = 0.463 for sense of scale, suggesting that FOV has the greatest impact on the sense of scale.

Objective evaluations showed that the number of fixations was lower in 3D and in the wide FOV condition. Additionally, the duration of each fixation was longer in 3D and in the wide FOV

condition. Furthermore, the fixation duration was even longer in the 3D × wide FOV condition. The head movement results showed that angular velocity was lower in the 3D × wide FOV condition. This implies that 3D and wide FOV result in smoother eye movements, allowing for calmer observation of the video stimuli. This could have a positive impact as an emotional experience on the sublime experience, which is a complex emotional experience involving multiple emotions. These results correspond with the subjective evaluations, suggesting that 3D × wide FOV effectively contributed to the sublime experience.

The cerebral blood flow results showed that viewing the video suppressed prefrontal cortex activity, and this suppression was further enhanced by the wide FOV. This suggests that viewing the video had a calming effect, which was further enhanced by the wide FOV. However, since no correlation with sublimity was found, further investigation remains a future task. Regarding heart rate, no differences were found, so the relationship with the sublime experience was unclear at the stimulus intensity used in this study.

Conclusion

This study conducted an experiment to clarify the influence of FOV and stereoscopic presentation on the sublime experience in VR. The results revealed the following:

- A wider FOV elicits stronger feelings of sublimity and other related emotions.
- 3D presentation results in higher ratings of beauty compared to 2D.
- The 3D × wide FOV condition results in smoother eye movements, corresponding with subjective evaluations.

This study quantitatively evaluated the sublime experience using VR, demonstrating the effectiveness of VR in presenting the sublime experience. However, regarding physiological indicators, the relationship with sublimity requires further investigation. Exploring physiological indicators related to sublimity is an important consideration for future VR content design.

References

[1] DAI NIPPON PRINTING Co., Ltd., “Sublime,” artscape, 2024/3/11, https://artscape.jp/artword/6151/, 2024/12/31.

[2] Pelowski, M., Hur, Y.-J., Cotter, K. N., Ishizu, T., Christensen, A. P., Leder, H., & McManus, I. C., “Quantifying the if, the when, and the what of the sublime: A survey and latent class analysis of incidence, emotions, and distinct varieties of personal sublime experiences,”, Psychology of Aesthetics, Creativity, and the Arts, 15(2), pp. 216-240, 2021.

[3] Ishizu, T. & Zeki, S., “A neurobiological enquiry into the origins of our experience of the sublime and beautiful,” Front. Hum. Neurosci. 8:891, 2014.

[4] Hur, Y.-J., Gerger, G., Leder, H., & McManus, I. C., “Facing the sublime: Physiological correlates of the relationship between fear and the sublime,” Psychology of Aesthetics, Creativity, and the Arts, 14(3), pp. 253–263, 2020.

[5] Hur, Y.-J., Hallam-Evans, C., Garfen, Y., Baiza, A., Backhouse Spriggs, T., Mircea, M.-T., Nagy, O., Pye, E., & McManus, I. C., “Differentiating the visual aesthetics of the sublime and the beautiful: Selective effects of stimulus size, height, and color on sublimity and beauty ratings in photographs,” Psychology of Aesthetics, Creativity, and the Arts, 18(6), pp. 904-920, 2024.

[6] Chirico A, Clewis RR, Yaden DB, Gaggioli A, “Nature versus art as elicitors of the sublime: A virtual reality study,” PLOS ONE, 16(3): e0233628, 2021.

[7] Taji, A., “Wuthering Heights and pastoral Englishness: Sublime landscapes and the memory of yeomen,” [“Arashi ga Oka” to Denentoshi-teki Englishness: Sukou na Fukei to Youman no Kioku], Studies in English literature. Regional branches combined issue, 12, pp. 7-16, 2019. (in Japanese)

[8] Yamada, T., “Architectural design based on an analysis of the “SUBLIME,” Master's thesis, Tokyo Metropolitan University, 2016. (in Japanese)

[9] Nakazawa, N., “Human Nature, Sympathy, and Manners: Burke’s Social Thought in his Enquiry into the Sublime and Beautiful,” Aichi Gakuin University Economic Review, 9(2), pp. 37-52, 2022.

[10] Katsuyama, H., “The sublime in English romantic poetry and painting: Coleridge and late Turner,” English Literary Society of Doshisha University, Shuryu, 63, pp. 31-45, 2002.

[11] Zwagerman, J., “De stilte van het licht: Schoonheid en onbehagen in de kunst,” [The silence of light: Beauty and unease in art], Singel Uitgeverijen, pp. 110-114, 2015.

[12] Turnhout, M. M. M. van, “Sublime Light. An artistic and philosophical comparison of sublimity in the art of JMW Turner and O. Eliasson,” Radboud University Educational Repository, 2017.

[13] Samuel Taylor Coleridge, “The Collected Works of Samuel Taylor Coleridge, Volume 2”, Princeton University Press, p. 1070, 1970.

[14] Matsuyama, Y., “On Schiller's theory of the sublime: In search of the beautiful soul and the sublime soul,” [Schiller no Sukou-ron wo Megutte: Utsukushi Tamashi to Sukou na Tamashi wo Motomete], Proteus, 10, pp. 9-37, 2008. (in Japanese)

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