

Generation of Sublime Experience in Virtual Reality: Rhythm, Space and the Virtual Sublime

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ABSTRACT

Existing studies on users' experiences of the sublime in virtual environments have primarily concentrated on theoretical discussions of the sublime. By comparison, there is relatively little experimental research that examines how such experiences are actually evoked within virtual environments. In addition, some empirical studies tend to emphasise outcome-based data, while paying less attention to how sublime experiences are generated in the first place. This leaves a clear gap in understanding the underlying mechanisms of the virtual sublime. Building on the media characteristics of virtual spaces in VR and video games, as well as Henri Lefebvre's theory of rhythmanalysis, this study argues that the experience of the sublime in virtual environments unfolds over time rather than occurring instantaneously. In other words, it should be understood as a process shaped by spatial rhythm. More specifically, the sublime is likely to emerge when spatial rhythms are either coordinated or brought into tension. Situations such as spatial transitions, the sudden appearance of large-scale objects, supernatural events, or reversals of scale can be arranged in sequence to create moments of disruption and contrast, which in turn intensify users' experience of the sublime.

Based on this, the central research question of this study is: *Does spatial rhythm constitute and influence users' experience of the sublime in virtual reality environments?* To address this question, the study adopts a practice-based mixed-methods approach. Two comparative experimental scenarios will be developed by combining elements of traditional sublime theory with rhythm-oriented design. Data will be collected through physiological measurements, questionnaire-based scales, behavioural observation, and semi-structured interviews, allowing both objective and subjective aspects of user experience to be examined. The aim of this study is to extend the theoretical framework of the virtual sublime and to provide a clearer account of how such experiences are generated and facilitated within virtual environments.

Keywords: Virtual Sublime; Rhythmanalysis; Spatial Rhythm; Generative Mechanisms; User Experience Experiment

1.Introduction

In recent years, the rapid development of virtual reality has expanded the ways in which digital environments can be experienced, allowing users to engage with complex and multidimensional spaces in increasingly immersive ways. As VR technologies have been adopted across areas such as art and design, education, entertainment, and cultural communication, user experience has become an important focus of research. However,

most existing studies still concentrate on aspects such as presence, immersion, emotional response, and interaction efficiency. In comparison, less attention has been given to more complex forms of experience, particularly those related to aesthetic, philosophical, or transcendent dimensions, including the sublime.

The concept of the sublime, as developed within aesthetics and philosophy, provides a useful starting point for approaching such experiences. From the rhetorical perspective of Longinus, to the emphasis on affect in Edmund Burke, and later the rational account proposed by Immanuel Kant, the sublime has been understood as a response to magnitude, fear, and the limits of human perception and cognition. It is often described as going beyond ordinary aesthetic pleasure, involving not only emotions such as awe or fear, but also a sense of confrontation with something overwhelming or difficult to comprehend. In this sense, the sublime can be seen as both affective and cognitive, and often linked to embodied experience. With the development of digital media, these ideas have gradually been extended to virtual environments. Yet, much of this work remains at a conceptual level. There is still limited empirical research that examines how sublime experiences are actually produced in virtual space, particularly in relation to spatial design, temporal change, and embodied user experience.

Building on the characteristics of virtual environments and Henri Lefebvre's theory of rhythmanalysis, this study approaches the sublime not as something that occurs instantly, but as something that unfolds over time. In other words, it is treated here as a process shaped by spatial rhythm. This includes not only the presence of traditional sublime elements, such as large scale, threatening atmospheres, or the suggestion of the unknown, but also the way these elements are organised and experienced. For example, sudden spatial expansion, shifts in scale, the appearance of large structures, or changes in environmental pacing may introduce moments of disruption or tension. These moments can create a kind of cognitive and perceptual contrast, which may intensify the experience of the sublime. From this perspective, spatial rhythm is considered as one possible mechanism through which the sublime is generated, while user interaction plays a role in triggering and shaping this process.

Based on this line of thinking, the central research question is: *To what extent does spatial rhythm contribute to and influence users' experience of the sublime in virtual reality environments?* To explore this question, the study adopts a practice-based mixed-methods approach, combining design practice with both qualitative and quantitative methods. Two experimental scenarios will be developed, with different configurations of spatial rhythm embedded within each. User studies will then be conducted, using questionnaires, physiological measures, behavioural observation, and semi-structured interviews to capture different aspects of user experience.

Overall, this study seeks to move beyond purely conceptual discussions of the virtual sublime by examining how such experiences may be generated in practice. By bringing together design experimentation and theoretical analysis, it aims to offer a more grounded

account of the relationship between spatial design and higher-level aesthetic experience in VR, and to provide a basis for further research in this area.

2.Critical Literature Review

In the eighteenth century, Edmund Burke was among the first to systematically shift the concept of the sublime away from classical rhetoric toward an emphasis on aesthetic psychology and emotional experience. In his account, the sublime is understood primarily as a form of human emotional and psychological response (Burke, 1757). Building on this, Immanuel Kant further reworked the concept by framing the sublime as a philosophical experience grounded in reason, cognition, and the capacities of the subject. Through his distinction between the mathematical sublime and the dynamical sublime, Kant repositioned the sublime beyond fear-based affect, describing it instead as a moment in which the limitations of imagination give way to an awareness of the subject's own rational and transcendental capacity (Kant, 1790). Together, these perspectives continue to inform contemporary discussions of the sublime, including those situated in digital contexts.

Within the context of digital media, this study focuses in particular on two related strands: the Digital Sublime and the Virtual Sublime. In exploring how sublime experience may emerge in virtual space, Thomas Betts draws on Kantian theory and combines code-based systems with artistic practice through the development of three experimental games. Based on this work, Betts proposes the concept of the digital sublime, which he describes as a state in which video games generate experiences that appear boundless, autonomous, complex, and ultimately beyond the player's full comprehension (Betts, 2014). His analysis identifies several key conditions of this experience, including complexity, permutation, dynamicity, and topology. These concepts overlap to some extent with the notion of spatial rhythm discussed in this study. For example, permutation refers to the continuous recombination and rearrangement of digital elements, while complexity describes the dense interaction of systems and structures. Dynamicity highlights the ongoing change and feedback within digital environments, and topology concerns the structural organisation of space and pathways. All of these can be seen as contributing to forms of spatial transformation, reconfiguration, and tension. However, Betts' work remains largely focused on system-level design mechanisms, and gives comparatively limited attention to how such structures are experienced by users. As a result, its explanatory power is somewhat constrained when considered from a user experience perspective.

In a different direction, Matthew Spokes seeks to examine whether the concept of the sublime is sufficient to explain contemporary player experience, or whether it requires reconfiguration for digital contexts. Drawing on Longinus, Burke, Kant, and more recent theoretical developments, Spokes introduces the notion of the virtual sublime and explores how video games function as a medium for such experience. He identifies four key components—rhetoric, awe, fear, and death—and argues that sublime experience in games emerges through the interplay of narrative structure, emotional intensity, and game mechanics, rather than relying solely on visual scale or spectacle. While this work expands

and adapts sublime theory to the specific conditions of digital media, it remains primarily theoretical and case-based. It does not engage with empirical user studies, nor does it extend its analysis to VR environments. Importantly, Spokes himself notes that the rapid development of digital technologies—including VR, live streaming, and eSports—requires ongoing revision of the theory. In particular, he suggests that VR may significantly reshape the experience of the sublime by enhancing embodiment, affect, and incorporation (Spokes, 2020).

A more design-oriented perspective can be found in the work of Barberis (2022), who proposes a framework for sublime experience grounded in visual design principles. In contrast to traditional accounts that emphasise emotional intensity or conflict, Barberis argues that the sublime may arise from a state of focused calm, characterised by reduced cognitive and emotional activity, somewhat analogous to meditative states. The framework is structured around two dimensions: Focus (including presence, contrast, and movement) and Calm (including empty space, unity in complexity, harmony, balance, and proportion), with additional factors such as brightness and novelty acting as enhancers. While these principles can, to some extent, be related to spatial rhythm, particularly in terms of organisation and pacing, the study does not include empirical validation. As such, its claims remain largely speculative and would benefit from further experimental investigation.

In addition to these theoretical contributions, several studies offer relevant insights without taking the sublime as their primary focus. For instance, Russ Hamer analyses the video game *Journey* through a philosophical and aesthetic lens, drawing on Burke, Kant, and Albert Camus. He shows how large-scale environments, spatial progression, environmental transformation, and emotional pacing can contribute to a form of experience that combines aesthetic intensity, interpersonal connection, and existential meaning (Hamer, 2020). This work provides a useful case-based perspective on how spatial design and experiential sequencing may contribute to the emergence of the sublime in digital environments.

Empirical research on the sublime in VR remains limited, and where it does exist, it is often centred on the concept of awe. While awe can be considered a key component of sublime experience, it does not fully capture its complexity. The sublime involves a broader range of emotional and cognitive responses, and reducing it to awe alone risks oversimplification. Nevertheless, studies on awe provide useful methodological references. For example, Quesnel and Riecke (2018) employ a mixed-methods approach to examine whether interactive VR can elicit awe, combining physiological measures, questionnaires, and open-ended interviews. Their findings suggest that VR can indeed induce high levels of awe. Similarly, Chirico et al. (2018) design four VR environments and demonstrate that awe-related responses are significantly higher in specific conditions, particularly in large-scale natural settings. More recently, He et al. (2024) translate traditional sublime theory into a set of VR design principles, identifying three key dimensions—terror, obscurity, and distance or modification—and testing them through comparative experimental scenarios. Their results indicate that while sublime-oriented design significantly enhances awe, increased embodiment primarily affects immersion rather than awe itself.

Overall, existing VR studies that focus on awe demonstrate a clear connection to the broader concept of the sublime. As an emotional response centred on feelings of wonder and reverence, awe reflects how individuals react when confronted with vastness, uncertainty, or transcendence. For this reason, it is often treated as a key component of sublime experience.

However, awe cannot be considered equivalent to the sublime as a whole. The sublime encompasses a wider range of affective and cognitive responses, including fear, a sense of pressure, feelings of smallness, and forms of transcendental awareness. Relying solely on awe as a measure therefore risks simplifying, or even overlooking, the more complex emotional and cognitive structure of the sublime. Despite this limitation, such studies remain valuable. They offer a practical starting point for decomposing and operationalising an experience that is otherwise difficult to quantify, and they provide a foundation for developing more multidimensional measurement frameworks in future research.

In this sense, although awe-based experimental studies do not fully capture the complexity of the sublime at a conceptual level, they make an important methodological contribution. In particular, they offer useful insights into how multiple sources of data can be integrated, how subjective experience can be balanced with objective measurement, and how more systematic frameworks for analysing complex experiences may be constructed. These contributions provide a valuable basis for further developing a more comprehensive understanding of sublime experience.

3. Research Gap

Based on a review and synthesis of previous studies, this research finds that the overall volume of literature in this field remains relatively limited, with several notable gaps in key areas. For example, there is still a lack of systematic analysis and empirical validation regarding the mechanisms through which sublime experience is generated in virtual environments. At the same time, it remains unclear whether, and to what extent, sublime experience in VR is influenced by core experiential factors such as presence and immersion, as existing findings have yet to reach consistent conclusions. This suggests that, although current research has begun to engage with complex emotional experiences in virtual environments, it largely remains at an exploratory stage, with both the depth and scope of investigation still requiring further development.

From the perspective of research structure, existing studies tend to follow a predominantly vertical pattern of development. That is, individual studies often focus on exploring a specific problem or theoretical perspective in depth, while the connections between different studies remain relatively limited. As a result, there is a lack of strong horizontal integration across the field. This mode of development means that research findings often remain relatively isolated, making it difficult to form a continuous and systematic line of inquiry, and leading to a certain degree of fragmentation at the overall level.

Furthermore, due to the absence of stable horizontal linkages, there are relatively few studies that engage in sustained dialogue or mutual reinforcement across different lines of research. Consequently, some potentially valuable research directions, although identified in individual studies, have not been further developed or extended in subsequent work. In other words, certain arguments, once proposed, have not been consistently followed up or empirically examined, limiting their potential to contribute to a more cumulative body of knowledge.

Some research has focused on constructing theoretical accounts of the sublime, often through case analysis and conceptual synthesis. While these studies offer valuable insights, they are rarely supported by empirical validation. For instance, certain perspectives suggest that the sublime may emerge from states of focused calm rather than from the interaction of multiple intense emotions. However, without experimental evidence, the reliability of such claims remains open to question. On the other hand, empirical studies in VR have tended to focus on the measurement of awe. Although awe constitutes an important component of sublime experience, it cannot be treated as equivalent to the sublime as a whole. Reducing the sublime to awe risks oversimplifying a more complex experiential structure. Therefore, a more comprehensive approach would require a clearer decomposition of the contributing factors of the sublime, combined with both qualitative and quantitative methods, in order to capture its multiple dimensions more effectively.

In addition, with regard to the media-specific characteristics of virtual space and the notion of spatial rhythm, relatively few studies have provided systematic and in-depth analysis. Although some research has begun to examine user experience in VR from the perspectives of immersion and interactivity, there remains a lack of focused discussion on virtual space as a distinct medium. In particular, limited attention has been given to how its internal spatial structure, modes of temporal unfolding, and patterns of user engagement collectively shape the experiential process. This is especially evident in relation to spatial rhythm, where existing work tends to remain at the level of indirect reference or partial analysis, rather than treating it as a central analytical framework.

At the same time, studies that approach the sublime from the perspective of spatial rhythm are even more scarce. This suggests that, within the current body of research, sublime experience in virtual environments has not yet been fully understood in terms of its processual and rhythmic characteristics, and that its generative mechanisms still require further theoretical development. Approaching the problem through a combined focus on the media characteristics of virtual space and spatial rhythm therefore offers a way to address these gaps, while also providing a more dynamic and structured perspective on the analysis of sublime experience.

Based on this, the present study takes the intrinsic properties of virtual space as its starting point, with particular attention to its three-dimensionality, interactivity, and process-oriented nature of experience. On this basis, it introduces spatial rhythm as a key analytical

lens in order to examine and evaluate the mechanisms through which sublime experience is generated. Through this approach, the study seeks to extend existing research on complex emotional experience in virtual environments, while contributing additional theoretical and practical insights to the field.

From this perspective, virtual space can be understood as possessing distinct media characteristics. Most notably, it operates as a three-dimensional environment that requires users to access and engage with it through digital interfaces. Users do not encounter such spaces in a single moment; rather, they explore, observe, and interact with them over time. This process-oriented mode of engagement is central to how experience is formed. Users' emotional and perceptual responses emerge gradually through ongoing interaction, rather than instantaneously.

This idea is further supported by Marie-Laure Ryan's discussion of narrative immersion. In her work, she highlights how spatial immersion in virtual environments is constructed through movement, exploration, and shifts in perspective, rather than through the immediate apprehension of a complete spatial structure. At the same time, the temporal dimension of immersion emphasises that experience in VR unfolds through user progression and situational development. In this sense, user experience is inherently structured as a process within time. This implies that users come to understand virtual space incrementally, through navigation and shifting points of attention, which in turn shapes how experience is organised. Such processual characteristics provide an important basis for understanding how spatial rhythm may structure and influence the emergence of sublime experience in VR (Ryan, 2018).

In parallel, Henri Lefebvre's theory of rhythmanalysis offers a framework for examining how space, time, and the body interact in the structuring of human experience. Lefebvre argues that rhythm is not simply repetition, but is constituted through the interplay of repetition and difference, including variation, interruption, continuity, and changes in intensity. He identifies multiple forms of rhythm, such as cyclical rhythm, linear rhythm, polyrhythmia, eurhythmia, and arrhythmia (Lefebvre, 2004). When considered in relation to virtual environments, sublime experience may be closely associated with elements such as vastness, repetition, spatial expansion, disruption, and temporal transformation. Given that VR experiences unfold through embodied interaction over time, rather than as instantaneous perception, there is a strong correspondence between the characteristics of sublime experience in virtual space and Lefebvre's conception of rhythm.

From this point of view, examining sublime experience in VR through the combined lens of virtual space as a medium and spatial rhythm as a structuring principle opens up a new line of inquiry. By proposing a mechanism grounded in these perspectives, this study seeks to contribute to a more systematic understanding of how sublime experience is generated. At the same time, through practice-based research and a mixed-methods approach, it aims to strengthen the empirical foundation of this field and address existing gaps in current studies.

4. Research Questions

Building on the preceding literature review and identified research gaps, this study addresses the need to reconsider sublime experience in virtual environments from the perspectives of virtual space as a medium and spatial rhythm as a structuring principle. In doing so, it aims to propose a new account of how sublime experience may be generated within virtual space. Accordingly, the central research question is: *In virtual reality environments, does spatial rhythm constitute and influence users' experience of the sublime?*

The purpose of this question is to better understand how sublime experience in VR emerges through the interaction between space, time, and user engagement. To explore this, the study examines the characteristics of virtual space alongside relevant theoretical frameworks, incorporating Henri Lefebvre's theory of rhythm analysis into the analysis of sublime experience. Two comparative experimental scenarios will be developed, each designed with different configurations of spatial rhythm—one characterised by relatively low levels of rhythmic variation, and the other by more pronounced and dynamic rhythmic change. Through user experience experiments, data will be collected on user behaviour, questionnaire responses, and physiological indicators. These data will then be analysed to examine how spatial rhythm may function as a core mechanism in the generation of sublime experience in virtual environments.

In addition to the main research question, the study proposes three sub-questions to support and structure the overall investigation:

1. What types of spatial rhythm exist within virtual environments?
2. What spatial design factors contribute to the construction of spatial rhythm within virtual reality environments?
3. How does spatial rhythm shape users' sublime experience through behavioural, emotional, and cognitive responses?

The first sub-question aims to clarify how virtual space is structured through rhythm and how such rhythm is experienced by users. The second focuses on the design perspective, examining how spatial rhythm is constructed through specific design mechanisms within virtual environments. The third shifts attention to the user side, exploring how the designed spatial rhythms are reflected in both subjective and objective user data, and how they influence the experience of the sublime. In this sense, it is closely tied to the interpretation of experimental results and serves to ground the study's theoretical claims in empirical evidence.

5. Research Methodology

This study aims to investigate the generative mechanisms of sublime experience in virtual reality environments, with a particular focus on how spatial rhythmic transformations, through the combined influence of environmental design and user interaction, may evoke experiences such as awe, fear, a sense of smallness, and transcendence. Given the

complexity of sublime experience, which involves not only measurable emotional and physiological responses but also subjective meaning-making, experiential processes, and spatial perception, a single research method is unlikely to capture its full structure. For this reason, the study adopts a practice-based research approach as its overall framework, combined with a mixed-methods design integrating both quantitative and qualitative methods, in order to produce more comprehensive and explanatory findings.

5.1 Practice-Based Research

In order to conduct user experience experiments, it is necessary to construct corresponding virtual reality environments. As such, this study follows a practice-based research approach. Based on the research questions, the experimental VR environments will be differentiated according to the degree of sublime-related attributes embedded within them. Specifically, two environments will be developed: one characterised by a higher level of sublime attributes and the other by a lower level. These differences will be primarily achieved through variations in spatial rhythm.

The design of sublime attributes and spatial rhythm within these environments will be informed by existing theories of the sublime, rhythm analysis, and case studies of virtual spaces in video games, as discussed in the theoretical framework of this study. After constructing the experimental environments, a sufficient number of participants will be recruited to take part in offline VR user experience experiments. Data will then be collected and analysed systematically to examine the relationship between spatial rhythm and sublime experience.

5.2 Mixed-Methods Approach

This study adopts an explanatory sequential mixed-methods design. First, quantitative experiments will be conducted to collect both subjective and objective data from participants experiencing two comparative VR environments: one with low spatial rhythmic variation and one with high spatial rhythmic variation.

Following this, behavioural observations and semi-structured interviews will be used to further interpret and complement the quantitative findings. This approach allows for a systematic measurement of emotional responses associated with sublime experience, while also examining whether variations in spatial rhythm significantly influence the intensity of such experiences. At the same time, it enables the identification of behavioural patterns and response characteristics during the experience process, offering a deeper understanding of how participants perceive and interpret sublime experience in VR.

5.3 Quantitative and Qualitative Methods

This study prioritises quantitative methods, with qualitative methods serving a complementary role. The quantitative component is primarily used to test whether there are

significant differences in the various dimensions of sublime experience across different VR environments. The qualitative component, by contrast, focuses on analysing participants' behaviours, cognitive processes, and emotional interpretations during the experience, thereby providing explanatory support for the quantitative results and contributing to a more complete understanding of the generative mechanisms of the sublime.

To better measure sublime experience, it is necessary to decompose it into several measurable components. In this study, the sublime is understood as a composite emotional experience consisting of multiple dimensions, including awe, fear, surprise, a sense of smallness, perceived vastness, transcendence, and novelty.

For the quantitative measures, both questionnaires and physiological data will be used. In terms of questionnaires, the Awe Experience Scale (Yaden et al., 2019) will be employed to assess awe-related dimensions, including aspects such as surprise, vastness, and transcendence. Fear will be measured using the S-Anxiety subscale of the State-Trait Anxiety Inventory (STAI-State), which captures participants' immediate anxiety and tension levels (Delgado et al., 2016). The sense of smallness will be assessed using the Small Self Scale (Tyson, 2021). To reduce participant burden, some questionnaire items may be adapted or selectively constructed to better align with the needs of this study.

For physiological measurements, the study will record galvanic skin response (GSR), heart rate, respiration rate, and eye-tracking data. GSR will be used to assess emotional arousal, as experiences of awe, fear, tension, and overwhelm are often associated with changes in physiological activation. It has been widely used in VR user experience research and is considered a reliable indicator of emotional arousal (Toczek, 2016; Ishaque et al., 2020; Kim et al., 2024). Heart rate will be used to observe emotional activation in response to events such as sudden spatial expansion, the appearance of large-scale objects, or approaching threats (Skarbez et al., 2017). Respiration rate will be included because breathing patterns often change under conditions of tension, fear, or immersion. Eye-tracking data will be used to analyse where users look, how long they attend to specific elements, and whether their attention is drawn to large-scale spaces or key visual features, thereby providing insight into attention, spatial exploration, visual rhythm, and the perception of vastness.

The qualitative component serves to complement and interpret the quantitative findings. A more robust interpretation of objective data requires reference to participants' subjective experiences. Therefore, participants' subjective feedback will be analysed alongside questionnaire and physiological data.

Two qualitative methods will be used: behavioural observation and semi-structured interviews. Behavioural observation captures implicit responses, as participants' unconscious reactions are reflected in their actions. In this study, behavioural data will be recorded through both in-VR and external video recording. First-person VR recordings will capture what participants see, their gaze direction, navigation paths, and responses to specific environmental features. External recordings will capture facial expressions, body movements

(such as hesitation, withdrawal, or avoidance), and vocal responses, providing additional audiovisual data. Previous research has also used behavioural indicators, such as physiological reactions like goosebumps, as markers of awe during VR experiences (Quesnel & Riecke, 2018).

Semi-structured interviews, by contrast, capture conscious and reflective responses. A set of predefined questions will be used after the quantitative data collection, while participants will also be encouraged to elaborate freely based on their personal experiences. Although such responses may reflect what participants believe to be their genuine feelings, they can also be influenced by individual differences such as personality, prior experience, and cognitive interpretation. Therefore, interview data will be analysed in conjunction with behavioural and quantitative data to form a more comprehensive and systematic understanding.

6.Practice-Based Research Design

The practical design of this study focuses primarily on the construction of sublime attributes and the organisation of spatial rhythm within virtual environments. Drawing on theoretical analysis and case studies from video games and VR spaces, the study identifies key factors that contribute to the construction of the sublime. These factors are then integrated into the design of virtual environments through the lens of rhythm analysis, leading to the development of two comparative experimental scenarios.

Across these two scenarios, core sublime-related attributes—such as infinity, vastness, monumentality, and mystery—will be kept largely consistent. In addition, to ensure comparability at the level of overall experience, both environments will maintain the same standards in terms of visual quality, material resolution, and model detail. This approach is intended to provide participants with a consistent audiovisual baseline, minimising the influence of extraneous variables on user experience.

Unlike many existing studies that focus primarily on constructing sublime features within a single environment, this study does not employ a neutral control scene lacking sublime qualities. Instead, two virtual environments with the same theme and spatial layout will be designed. The key distinction lies in the transformations and interactions that occur within the environments, that is, differences in spatial rhythm.

In terms of thematic design, the study proposes a setting based on ancient high-tech ruins on an alien planet. This theme offers strong potential for expressing sublime qualities while allowing the exclusion of non-player characters. By removing social interaction elements, the design avoids potential confounding effects related to character presence and instead enables a more focused investigation of spatial rhythm. Technically, the environments will be developed using a contemporary game production pipeline, including high-polygon models, high-resolution PBR materials, and potentially 3D-scanned assets. The final environments will be implemented in Unreal Engine 5, with post-processing adjustments

applied to achieve a high level of visual realism and a stable interactive experience.

The primary distinction between the two experimental scenarios lies in their rhythmic structure. Drawing on Henri Lefebvre's theory of rhythmanalysis, the high-sublime condition will be designed to incorporate rhythmic tension, disruption, and repetition within the spatial experience. The study aims to examine how such rhythmic configurations may contribute to the emergence of sublime experience. From this perspective, sublime experience in virtual environments is understood as a process that unfolds through embodied interaction, as users explore, perceive, and interpret the environment over time. In this sense, the experience can be likened to engaging with a spatially structured narrative, in which environmental transformations and contrasts gradually evoke the sublime.

Accordingly, within the selected theme, the low spatial rhythm condition will involve minimal deliberate rhythmic variation. In contrast, the high spatial rhythm condition will include a series of designed rhythmic events, such as the gradual emergence of monumental structures, abrupt environmental or atmospheric changes, non-triggered interactive events, and periodic spatial reconfigurations. These design elements are expected to alter the spatial rhythm of the environment and, in turn, influence users' experience of the sublime. Before the formal experiment, pilot testing will be conducted with a small number of participants to identify potential issues, such as difficulties in navigation or misunderstandings of the designed interactions. Based on participant feedback, the environments will be refined and retested until no major issues are reported. Only then will the main user study be carried out.

During the formal experiment, participants will first be introduced to a simple VR training environment, designed to familiarise them with basic interactions such as movement, turning, and selection. After this, each participant will experience both experimental scenarios. The order of exposure will be randomised to avoid potential order effects.

Following each experience, participants will complete a set of questionnaires. After completing both conditions, they will take part in a semi-structured interview. Regarding the administration of questionnaires, the study initially proposes integrating them directly into the virtual environment, allowing participants to complete them immediately after each experience, with responses automatically recorded. However, the feasibility and reliability of this approach may require further validation. If necessary, conventional paper-based questionnaires will be used instead.

7.Ethical Considerations

This study aims to investigate the generative mechanisms of sublime experience in virtual reality environments through a practice-based and mixed-methods approach. It focuses on how spatial rhythmic transformations, shaped by environmental design and user interaction, may evoke experiences such as awe, fear, a sense of smallness, and transcendence. Given that the study involves the recruitment of human participants for in-person VR experiments,

as well as the collection of questionnaire data, physiological measurements, behavioural recordings, and semi-structured interviews, ethical considerations form a central component of the research design. To ensure compliance with academic ethical standards and to safeguard participants' physical safety, psychological well-being, privacy, and data security, the study follows principles of informed consent, risk management, confidentiality, data protection, and research transparency.

Prior to participation, all individuals will receive a detailed participant information sheet outlining the purpose of the study, experimental procedures, VR experience content, physiological data collection methods, behavioural recording and interview processes, potential risks, and the intended use of data. Participants will only be enrolled after they have fully understood this information and voluntarily signed an informed consent form. They will be clearly informed of their right to withdraw from the study at any stage without any negative consequences. This process is intended to ensure participants' autonomy, informed decision-making, and voluntary engagement, in line with standard ethical requirements for human-subject research.

As the study involves immersive VR experiences, potential physical risks must be carefully considered. VR exposure may induce symptoms such as motion sickness, visual fatigue, nausea, or balance disruption. To mitigate these risks, participants will be screened in advance to exclude individuals who are particularly sensitive to VR or prone to severe motion sickness. During the experiment, session duration will be controlled and appropriate breaks will be provided. In addition, an immediate withdrawal mechanism will be in place, allowing participants to stop the experiment at any time if discomfort occurs, with appropriate assistance provided where necessary.

Beyond physical effects, the study also engages with emotionally intense experiences, including fear, pressure, and a sense of smallness, which may generate psychological stress. In particular, high-sublime environments involving large-scale spaces, sudden spatial transformations, darkness, or threatening elements may induce short-term anxiety in some participants. To address this, extreme shock-based design elements will be avoided, and all affective stimuli will be kept within ethically acceptable limits. Participants will be continuously monitored during the experiment, and the session will be terminated if necessary. After the experiment, a debriefing session will be conducted to explain the purpose of the study, alleviate any residual psychological discomfort, and ensure that participants have returned to a stable emotional state.

The physiological data collected in this study include galvanic skin response (GSR), heart rate, respiration rate, and eye-tracking data. Although these are non-invasive measures, they still constitute personal physiological information and therefore require careful handling. All physiological data will be stored in anonymised form using coded identifiers, with no recording of unnecessary health-related information or clinical interpretation. The data will be used exclusively for research purposes and stored on encrypted devices, accessible only to authorised members of the research team. Participants will also have the

option to decline specific physiological measurements without affecting their eligibility to participate in the study.

Behavioural data will be collected through first-person VR recordings, external video recordings, and audio capture. As these recordings may include facial images, body movements, and voice data, privacy protection is particularly important. Participants will be fully informed about the use of recordings during the consent process, and additional consent will be obtained specifically for video and audio data. All recorded materials will be anonymised during analysis, and no identifiable images or recordings will be made public. In any dissemination of results, only anonymised and aggregated findings will be presented. Raw recordings will be securely stored and permanently deleted after the required retention period.

Semi-structured interviews will be conducted to capture participants' subjective interpretations of their experience. As these may involve personal emotional responses and self-reflection, care will be taken to avoid leading questions or additional psychological pressure. Participants will be free to skip any questions or terminate the interview at any time. All interview data will be anonymised to ensure confidentiality.

As the study is conducted within the United Kingdom, all data management procedures will comply with the General Data Protection Regulation. The research will adhere to principles of data minimisation, purpose limitation, secure storage, and restricted access. Personal identifying information will be stored separately from research data, and all questionnaire, physiological, and behavioural data will be managed using coded identifiers. Digital data will be protected through encrypted storage systems and secure cloud services where applicable.

Given the practice-based nature of the study, the researcher is directly involved in the design of the experimental environments, which introduces the potential for researcher bias. To address this, the study will explicitly acknowledge the researcher's positionality and employ triangulation across quantitative data, behavioural observation, and interview findings to enhance objectivity. Where possible, additional researchers may be invited to assist in data coding and analysis, further improving transparency and reliability.

In terms of participant recruitment, the study will follow principles of fairness and voluntariness, avoiding any form of coercion or undue influence. Particular care will be taken in educational contexts to ensure that power dynamics, such as teacher–student relationships, do not affect participants' decisions to take part. All participants will be recruited voluntarily and provided with appropriate compensation.

Overall, while this study seeks to explore the mechanisms through which sublime experience is generated in VR environments, ethical considerations remain integral to its design. Through rigorous procedures for informed consent, risk management, privacy protection, regulatory compliance, bias mitigation, and post-experiment debriefing, the study aims to

ensure that participants' rights and well-being are fully protected. In research involving intense emotional responses, embodied interaction, and subjective experience, ethical practice is not only a requirement for legitimacy but also essential to the validity and integrity of the research outcomes.

8.Reflection & Conclusion

Overall, this study focuses on the generative mechanisms of sublime experience in virtual reality environments, approaching the topic from the relatively underexplored perspectives of virtual space as a medium and spatial rhythm. By drawing on and synthesising traditional theories of the sublime, as well as research on the digital and virtual sublime, and by considering the spatial and processual characteristics of VR, the study proposes that sublime experience in virtual environments does not emerge instantaneously. Rather, it is gradually constructed and intensified through rhythmic spatial unfolding as users interact with the environment. This perspective responds to existing limitations in explaining how the sublime is formed in virtual contexts and offers an alternative analytical pathway for understanding complex affective experiences in VR.

At the methodological level, the study adopts a practice-based approach combined with mixed methods, integrating both quantitative and qualitative strategies. Through the design of comparative virtual environments with different spatial rhythmic characteristics, and the use of questionnaires, physiological measurements, behavioural observation, and semi-structured interviews, the study examines user experience from multiple dimensions. This approach allows not only for the capture of emotional fluctuations and physiological responses associated with the sublime, but also for a deeper understanding of how such experiences are interpreted and constructed by users. In particular, by comparing environments with high and low levels of spatial rhythmic variation, the study attempts to test the role of spatial rhythm in shaping sublime experience, thereby making its theoretical assumptions empirically examinable.

From a reflective standpoint, several limitations remain. First, in terms of measurement, although the study decomposes sublime experience into dimensions such as awe, fear, a sense of smallness, and transcendence, these dimensions are not entirely independent and may overlap to some extent. How to maintain measurement validity while avoiding redundancy in scales remains an issue for further refinement. Second, while physiological data provide insight into emotional arousal, their interpretation still relies on subjective reports and behavioural observations. This raises the challenge of effectively integrating multi-source data in a coherent analytical framework. Third, although the experimental design controls for visual quality and spatial structure, individual differences among participants—such as prior gaming experience, spatial cognition, or emotional sensitivity—may still influence the results. Future studies could address this through larger sample sizes or more refined grouping strategies.

At the theoretical level, one of the key contributions of this study lies in bringing together

the processual nature of virtual space and Henri Lefebvre's theory of rhythm analysis, and in proposing spatial rhythm as an important mechanism in the generation of sublime experience. In contrast to perspectives that treat the sublime as something triggered directly by visual scale or emotional intensity, this study emphasises that sublime experience emerges progressively through continuous spatial and temporal variation. This perspective not only provides a more nuanced understanding of VR experience, but also offers a foundation for design-oriented research. At the same time, the study suggests that, as an experience-centred medium, VR does not rely solely on traditional narrative structures for its aesthetic impact, but rather on the dynamic relationship between spatial organisation, rhythmic variation, and user engagement.

In terms of practical implications, this study offers a set of design-oriented insights for virtual environment creation. By incorporating the concept of spatial rhythm, designers may more deliberately shape the user's experiential process—for example, through spatial expansion, guided movement, environmental transformation, and moments of rhythmic disruption—in order to enhance emotional intensity and cognitive tension. Such strategies may be relevant to fields including digital art, immersive exhibitions, game design, and virtual cultural communication.

In summary, this study proposes a rhythm-based explanatory framework for understanding sublime experience in virtual environments and provides an initial empirical exploration through practice-based and experimental methods. While certain limitations remain, the study contributes to theoretical integration, methodological development, and practical exploration in this area. Future research may extend this work by examining more complex virtual environments, multi-user interaction scenarios, and longer temporal experiences, in order to further investigate how spatial rhythm shapes the emergence of the sublime and to refine the theoretical framework of sublime experience in VR.

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