Empirical and modelling approaches to the psychology of musical awe

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STATEMENT OF ORIGINAL AUTHORSHIP

I declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where stated otherwise by reference or acknowledgment, the work presented is entirely my own.

DEDICATION

I would like to dedicate this thesis to Lucy for her unwavering support, reassurance, and abounding love. Thank you for listening to me endlessly talk through these ideas, caring for me when I was ill, and for giving me the strength to push through when I wanted to quit. From the bottom of my heart, thank you for everything.

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ABSTRACT

The experience of awe is one that we may all recognise, the feeling of being overwhelmed by a great force and often inspired from its presence. Research from various disciplines has recently taken an interest in understanding and explaining this phenomenon through psychological models guided by the extensive philosophical discourse on the sublime. This research project, through its seven studies, takes some of the first steps to validate and test these psychological models through participant-based experiences of awe evoked from music, known as 'musical awe'. Studies 1 and 2 examined first-hand accounts of musical awe, and found commonalities in experiences, associated judgements, and emotional sentiments through a mixed methods approach. Studies 3, 4, and 5 used the Musical Awe Corpus (MAC)—a collection of music excerpts from experiences of musical awe in Study 1—to examine shared musical associations and categorical groupings through online psychometric scale experiments. Study 6 investigated the relationship between judgements of size and associations of musical awe through a time-series, virtual object manipulation task. Lastly, Study 7 used music information retrieval techniques to extract and analyse musical features from the MAC to assess which features are prevalent and important to awe-associate music. Taken together, the findings of these studies advance a general characterisation of musical awe as an emotional phenomenon best understood as shared between two valenced-differentiated groups. The more common group is associated with positive valence and emotions of joy and wonder, whilst the other group is associated with threat and fear. However, both groups of musical awe show strong associations with size and power. Sonically, awe-related music, especially the negative valenced group, can be characterised by high levels of brightness, roughness, and extensive changes in spectral qualities. In conclusion, these studies largely support much of the theoretical grounding concerning the production and occurrence of awe, and from these

findings, a novel empirically driven model was created to expand and improve our understanding of musical awe.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS

AB	Aurora Borealis
ADF	Augmented Dickey-Fuller
ANOVA	Analysis of Variance
API	Application Programming Interface
ASMR	Autonomous Sensory Meridian Response
AWS	Amazon Web Services
BRECVEMA	Brain stem reflex, Rhythmic entrainment, Evaluative conditioning, emotional Contagion, Visual imagery, Episodic memory, Musical expectancy, and Aesthetic judgement
CAS	Composite Awe Score
CCM	Christian Contemporary Music
CTS	Composite Threat Score
DDMFCC	Double Delta Mel-Frequency Cepstral Coefficients
DMFCC	Delta Mel-Frequency Cepstral Coefficients
EC2	Amazon Elastic Compute Cloud
GAQ	Geneva Appraisal Questionnaire
HCDF	Harmonic Change Detection Function
HQ	Hannan Quinn
HTML5	Hypertext Markup Language (5th version)
HTTP	Hypertext Transfer Protocol
IMMA	Integrated Model of Musical Awe
ITPRA	Imagination, Tension, Prediction, Reaction, and Appraisal
JATOS	Just Another Tool for Online Studies

KPSS	Kwiatowski-Phillips-Schmidt-Shin
K-S	Kolmogorov-Smirnov test for normality
LED	Listener Experience Database
MAC	Musical Awe Corpus
MANOVA	Multivariate Analysis of Variance
MFCC	Med-Frequency Cepstral Coefficients
MIR	Music Information Retrieval
MTurk	Amazon Mechanical Turk
NAC	Negative Affect Composite
NHST	Null Hypothesis Significance Testing
NLP	Natural Language Processing
NRC	Canadian National Research Council (Conseil national de recherches Canada)
NLTK	Natural Language Toolkit
PAC	Positive Affect Composite
RMS	Root Mean Square
SCT	Supercell Thunderstorm
SEM	Strong Experiences with Music
SMA	Simple Moving Average
SMC	Sound and Music Computing
SPSS	Statistical Product and Service Solutions
VADER	The Valence Aware Dictionary for sEntiment Reasoning
ZCR	Zero-Crossing Rate

1 Introduction

One late summer’s evening in 2015 on the border of Wiltshire and Dorset in the South West of England, End of the Road Festival hosted the indie-folk musician Sufjan Stevens on its main stage. I found myself in the gathering crowd as the evening sun slowly set. In the still evening air, the performance started, and I found myself surrounded by the thousands of attendees standing shoulder to shoulder listening intently. Slowly the music began to fill the field with its delicate horn lines, rippling arpeggiated piano chords, and the sweet, sorrowful sound of a lap steel guitar. The amplified voices began to fill the forest clearing, hovering above the accompanying piano, which had now transitioned to playing block chords. The percussive swell of the cymbals rang out to create a sense of suspension in the musical timing—a free-floating sonic atmosphere that seemed to prime all in attendance for something magical, powerful, and transformative. On the backdrop of the stage, I could see several digital screens shaped like stained-glass cathedral windows, and spanning these panes were emotionally provocative images and videos showing tender, sepia-coloured depictions of the artist’s childhood photographs and family films. As the performance continued, the songs’ lyrics were sung in unison with the increasingly emotional crowd. The culmination of voices and the artificial church setting made it feel like we were a part of a religious service. Many in attendance openly wept. Nearing the end of the performance, I noticed something strange and compelling. After seventy minutes of music, an extended outro to the soft and melancholic song ‘Blue Bucket of Gold’ kept growing, adding layers upon layers of new musical textures, only to strip them all away suddenly. Emerging from this new silence, a large, mirrored ball appeared from behind the stage. It was slowly lifted to the ceiling rafters, and beams of lights were angularly thrown out from it to the surrounding grounds. As though complementing the imposing orb, the lap steel, together with the singers’ falsetto voices, sighed a phrase over a soft synth string patch. More instruments joined in and created a texture of digital sounds that swept across the audible spectrum. The atmosphere felt otherworldly, and for a moment it was as though the earth had stopped spinning. The combined power of the music and the stagecraft appeared to cause time to stand still, as the thousands of people in the audience, myself included, stood in awe with tears in their eyes.

The research project underpinning this thesis is concerned with understanding musical experiences, akin to which is described above (encompassing the emotions of wonder, surprise, elevation, and the sublime—further defined in the following chapter) that are characterized by the elicitation of a sense of awe, referred to throughout this project as ‘musical awe’. This area of research is important for several reasons. Powerful and transcendent experiences are often novel and meaningful events that point to feelings outside of normal or everyday experience and have personal significance to an individual. These types of experiences, originally described by Abraham Maslow as *peak experiences* (1964/1994), are ‘moments of highest happiness and fulfillment [*sic*]’ (1968, p. 73), and deserve to be examined through academic research to enhance our understanding of what characterises them and why they occur. Similar music-based experiences, known as strong experiences with music, may often be cherished by individuals as important memories which help shape beliefs, values, and identity (Gabrielsson, 2011). As a principal motivation for engaging with music is to interact with its emotional qualities (e.g. Juslin & Laukka, 2004; Schafer & Sedlmeier, 2009; Randall & Rickard, 2017), and as awe stands near the emotional apex of musical experience, its psychological and musicological understanding merits our attention and requires thorough examination. While there is now a renewed interest in the psychology of awe (e.g. Keltner & Haidt, 2003; Konečni, 2005; Piff et al., 2015; Shapshay, 2021), few investigations (Cotter et al., 2019; Pilgrim et al., 2017; Silvia et al., 2015) involving musical sources have been attempted. There is currently a gap in our knowledge of musical awe, one that this project intends to help fill by providing a detailed philosophical and empirical description of the phenomenon and investigating its causes.

This thesis expands our knowledge from the initial investigations into musical awe to help explain the role of music in these powerful experiences and how awe may arise in the music listener. Through critical engagement with Western philosophical discourse on the sublime—a closely related concept to awe—and psychological processes of emotion, the overarching aim of this project is to lay an empirical foundation for the study of musical awe and to provide the first extensive account of the phenomenon. Informed by Western philosophy and aesthetics, this research is primarily interested in assessing awe as an emotion experienced through a Western enculturation of music. In opening a new area of research, this project does not seek to examine every potential aspect of musical awe. Instead, through a series of empirical studies, the project is designed to probe several influential areas that together produce a robust overview of the psychology of musical awe. To produce this overview the research project is broken down into smaller, more focused and manageable components, all of which are addressed in the subsequent chapters through the use of empirical psychological methods. The main research question for this project—'What is musical awe and how and why does it occur?'—is supported by a series of subordinate questions, including: 'Who experiences musical awe?', 'Where do experiences of musical awe occur?', 'What types of music afford these experiences?', 'What are the emotional and conceptual associations related to the awe-associated music?', 'What is musical awe's relationship to the sublime and to awe in other domains?', 'To what extent do existing frameworks and models explaining awe apply to musical awe?', and 'How may musical awe best be presented through a general psychological model?'. Addressing these more specific questions affords a more informed and comprehensive answer to the main research question. As the topic of awe might easily spread across numerous disciplines and philosophical traditions, the scope of this project is limited in its investigations and focuses on a selection of emotion-related areas through a variety of methodologies—participant surveys and questionnaires, historical accounts, behavioural experiments, and computer-based musical feature extraction.

The structure of the thesis is designed to start from a broad vantage point and to sharpen its focus incrementally through investigating the narrower, more specific components that underpin experiences of musical awe. Seeking to produce as detailed an account of the phenomenon as possible, a mixed-methods approach was adopted to gather both qualitative and quantitative data relating to the high- and low-level psychological processes governing musical awe. Starting with a review of relevant literature in Chapter 2, the subsequent chapters detail a range of studies that investigate participant experiences of musical awe from a variety of perspectives. The first and second studies, found in Chapter 3, present an analysis of primary accounts of musical awe taken from participant surveys and historical accounts. Chapter 4 identifies commonalities in emotional perceptions of awe-associated music as measured across three rounds of studies. Chapter 5 investigates the relationship between perceptual "musical size" and awe through a computer-based, virtual object manipulation task. The final study in Chapter 6 centres on a feature-extraction analysis of awe-related music to identify relevant sonic and musical features that afford the experience of awe. Arising from the varied methodological approaches, the project concludes with a proposal for a novel model of musical awe in Chapter 7. This model provides a cohesive account of the phenomenon of musical awe that incorporates insights from the theoretical and empirical work developed throughout the thesis.

At the core of the thesis are some of the first empirical investigations into musical awe that have been conducted. In brief, the main findings of the project reveal that musical awe is experienced by a wide variety of people in diverse settings and for various reasons. Despite these differences, experiential commonalities are found through their shared associations between relevant emotions and the music's relation to vastness—that is, the perception of a piece of music as being somehow large or expansive. The kinds of music that afford experiences of awe were found to be of two opposing types, positive and negative, characterised by different emotional valence. These positive and negative experiences of awe are elicited in cases where listeners experience differing impressions and emotional outcomes of a piece of music despite making similar judgements about said piece's perceptual size. These versions of musical awe echo differences explored in other mediums and serve to expand our understanding of the diversity of music responsible for inducing awe in the listener. Music information retrieval analyses show that an array of features (e.g. low levels of rhythmic pulse clarity and high levels of timbral brightness and roughness) may be associated with awe-affording music, and significant factors that separate the two valenced forms of awe-associated music are the rate of timbral change and clarity of key. Furthermore, the model presented in Chapter 7, the Integrated Model for Musical Awe (IMMA), combines many of the previous theoretical ideas with the findings from the empirical data from this project's studies to propose a multi-stage psychological production model. This model describes the psychological process of musical awe in terms of a listener's encounter with a musical source, foregrounding how associations of perceived size, aesthetic judgement, and self-reflection may lead to the experience of awe. This project found musical awe to be a salient experience for many music listeners, and the findings presented throughout each of the studies contribute to our knowledge of musical awe and the psychological processes that underpin it. Nonetheless, the thesis concludes with suggestions for future research that would further expand this knowledge base.

Throughout the history of art and writing concerning awe and related emotional states, one iconic example from nature has commonly been cited: climbing a mountain to look down from the summit over the grandeur and vastness below. Edmund Burke described this 'greatness of dimension' as the impetus for feelings of awe from looking down from a mountaintop (1757/2015, p. 59), and Caspar David Friedrich famously painted a solitary male figure gazing out from a rocky precipice in *Wanderer above the Sea of Fog* (c. 1818). Samuel Taylor Coleridge also wrote in his notebooks of the exhilaration he felt from hiking Striding Edge in the Lake District while marvelling at the terrifying and wondrous mountain ridge:

> Travelling along the ridge, I came to the other side of those precipices, and down below me to my left no, no! no words can convey any idea of this prodigious wildness that precipice, its ridge sharp as a jagged knife, level so long and then ascending so boldly, what a frightful bulgy precipice I stand on, and to my right hand, the crag which corresponds to the other! how it plunges down like a waterfall, reaches a level steepness and again plunges! (Coleridge, 1957, p. 799)

Discovering what musical awe entails might be seen as a similar type of journey: a mountainside largely unexplored with great rewards of insight waiting for those who reach its peak. This research project begins by gathering a diverse selection of tools to plot a course to scale the mountain’s face, and through its empirical grounding transforms theoretical knowledge into testable methods that enable us to take the first steps up the mountain. The project concludes by looking down from the mountain upon the vista below, to, in a new light, reassess the experience of musical awe and its processes of conception in the mind of the music listener.

2 The sublime, the psychology of awe, and musical emotions

2.1 An introduction to awe

Awe is a powerful, pleasurable, and fearsome emotion experienced through an encounter with something overwhelming. Awe has been described as an emotion that exists 'in the upper regions of pleasure and on the boundaries of fear' (Keltner & Haidt, 2003, p. 297). While rare and short-lived, it can occur from a variety of experiences, especially from nature and art. Awe is an influential and meaningful emotion that motivates a sense of wonder and is often associated with religious, spiritual, and life-changing events. Awe-inspiring experiences with music are by no means common (Gordon et al., 2017; Keltner & Haidt, 2003; Shiota, Keltner, & Mossman, 2007), but such encounters may often induce powerful emotions in the listener. There is currently a lack of research on the experience of musically induced awe in the field of music psychology, with only a handful of studies investigating its salient features and occurrence. While it is clear that music can provoke an experience of awe in a listener (e.g. Cotter, Silvia, & Fayn, 2018; Pilgrim et al., 2017; Shiota, Keltner, & Mossman, 2007; van Elk et al., 2016), little is known of how it does so, the people it affects, or the environments from which it arises. In the past two decades, psychologists have proposed frameworks for understanding the experience of awe (Keltner & Haidt, 2003; Konečni, 2005; Shapshay, 2021), and aesthetics-based models for emotion production in music have categorised multiple ways in which one may experience awe (Juslin, 2013; Scherer, 1985, 2004). However, empirical evidence detailing how and why people experience musical awe is currently limited, and by gathering this type of evidence, the proposed theoretical frameworks (Keltner & Haidt, 2003; Konečni, 2005; Shapshay, 2021) can be tested for their applicability, accuracy, and suitability in expounding musical awe.

To establish what is known about the experience of musical awe and to summarise the important studies and findings in this area of research, this literature review is divided into three sections exploring the diverse but essential components of musical awe through different academic domains. The first section (Section 2.2) relates awe to the sublime by providing a historical overview of the rich philosophical discourse surrounding this concept. The second section (Section 2.3) details several psychological perspectives from contemporary research focused on examining awe as an emotion, who it affects, and how it is related to other emotions. The third section (Section 2.4) summarises the processes by which music can elicit emotional responses and how these processes may form a practical basis to be used in exploring experiences of musical awe. The literature review concludes with a synthesis of knowledge across these domains, highlighting unexplored areas and implications for the further study of musical awe that lead into the studies undertaken in subsequent chapters.

2.2 Philosophical foundations from the sublime

Studying awe has its difficulties, as the term has yet to be clearly defined in academic literature and is often colloquially used in ways that may lack rigour or specificity. Often understood as an emotional dyad comprised of fear and surprise (Plutchik, 2001, p. 349), experiences of awe are more striking than that of a simple combination of two emotions. In account of his own emotional reaction to his new-born son, Paul Pearsall identifies many of the characteristics of awe. He states that awe is 'the most intense, wonderful, upsetting, and transcendently terrible of all human emotions' (2007, p. xiii). This description of awe as an 'overwhelming and bewildering sense of connection with a startling universe that is usually far beyond the narrow band of our consciousness' (Pearsall, 2007, p. 9) speaks to the power and multivalent emotional characteristics present in these experiences as well as their meaningfulness to the individual. Because of these relationships, states of awe are unavoidably associated with the sublime, and this connection provides helpful insight from a vast array of philosophical literature on the topic. Through an encounter with a sublime object, one is forced to reinterpret one's relationship with the world, and the resulting emotion may be experienced as awe. This section of the literature review examines the discourse around the sublime as it pertains to objects in the world, and the emotional experience derived from them. For purposes of clarity, this review adopts a distinction in which 'the sublime' refers to objects or concepts that hold particular qualities, while the feeling that may be derived from those sublime objects or concepts (also frequently discussed as 'sublimity') is understood here as a type of awe. Many philosophers have directly incorporated their ideas of the sublime into their writings on aesthetics, a cross-section of which are reviewed here in depth.

The concept of the sublime has a rich tradition in Western philosophy, and this section chronologically outlines some of the influential works that have added to the discourse on the sublime. Starting with the Greek philosopher and rhetorician Longinus, writing in the first century CE, the sublime was an idea associated with an elevated writing style. Five sources were listed to itemise the principles of sublimity (Longinus, 2014, VIII, pp. 11-12). The first and most fundamental source of the sublime according to Longinus is grandeur of thought and speech. The other sources of sublimity are strong emotions, certain figures of speech, noble diction, and dignified word arrangement. The use of these five sources to elevate writing was thought to diminish rationality, enhance the creative process, and produce powerful emotions of pleasure and exaltation in the reader. For Longinus, the sublime was associated with beauty that moves us outside of our usual rational way of thinking. It helps us embrace wonder and act as a moral guide. The only significant mention of music by Longinus in *Peri Hypsous* (*On the Sublime*) is when musical harmony is used as a metaphor for proper paraphrasis, or rewording of text (Longinus, 2014, XXVIII, p. 25). These modifications in the text were applied to enhance the beauty and tone of a speech. Through further interpretation and expansion of ideas of grandeur, notably in Dante's *The Divine Comedy* (Alighieri, 1320/1977), the sublime became 'the paradoxical experience of being at once overwhelmed and elevated' (Shaw, 2017, p. 31). There is no definitive definition of the sublime as described by Longinus, but its two most influential characteristics pertaining to language and rhetoric were the power of grand conceptions and the inspiration of passionate emotions (Brady, 2018).

Interest in the discourse on the sublime was revived in the early eighteenth century by philosophers, artists, and critics, many of whom lived in Britain and Ireland. These scholars took the notions of grandeur and beauty originally identified with the sublime and linked them with concepts of creativity and timelessness to expand the discourse to a diverse set of aesthetic interests. Writing at the turn of the eighteenth century, John Dennis embraced the ideas found in Longinus' *Peri Hypsous* and expanded them to incorporate ideas of the infinite, the power of the gods, and reverential fear (Wheeler, 1986). In 1704, Dennis described gods, demons, hell, thunder, earthquakes, monsters, war, and famines (among many other examples) as entities that may raise our 'enthusiastic passions' (Dennis, 1704/1996, p. 38). These passions were described as a combination of fear and admiration, and though Dennis was writing on poetic intention and style, his contribution to the philosophy of the sublime is important for several reasons. He was the first to articulate a kind of duality found in responses to the sublime—both admiration and terror are related to these types of experience—to form a multivalent assessment of sublimity. Dennis was also the first to associate the sublime with objects, in doing so providing a grounding for the empirical reality of the sublime (Shaw, 2018, p. 14).

This object-based orientation was also seen in Joseph Addison's *On the Pleasure of the Imagination* (1712), where attention to the sublime moved from merely describing styles of writing to detailing characteristics that belonged to material things in the world. In this way, Addison sought to move the philosophical account of the sublime from a mere literary descriptor to a more generalisable, real-world phenomenon. Addison also emphasised the importance of visual aesthetics, beauty, greatness, and novelty in sublime objects. In the mid-eighteenth century, John Baillie's *An Essay on the Sublime* (1747) described the sublime as relating to the vastness of nature and specified that the sublime of nature is of superior quality to that which is associated with art. He went as far as to state that only through representations of nature can the sublime be found in artistic endeavours. Immense natural objects—e.g. vast extended views, mountains, heavens, and oceans—can 'fill the soul and raise it to sublime sensations' (Baillie, 1747, Section I). Furthermore, Baillie was the first to directly apply his concept of the sublime to music (Chrissochoidis, 2013). Baillie also introduced the idea of the sublime as acting in relation to the self, where the material qualities of sublime objects are only seen as grand or vast in comparison to the viewer. The height of a mountain and the depth of the ocean are immensely larger than the height of a person, and it is this type of reflective comparison to which Baillie drew specific attention. Alexander Gerard expressed a similar idea in *An Essay on Taste* (1759), in which he explained that the feeling of pleasure from the sublime comes from its ability to expand our imagination while we simultaneously wrestle with conceiving the immensity of the object in our minds, and in this act we experience 'a noble pride, and entertain[] a lofty conception of its own capacity' (Gerard, 1759, p. 26).

Edmund Burke's *A Philosophical Enquiry into the Origin of our Ideas of the Sublime and the Beautiful* (1757) is one of the most commonly cited texts on the topic of the sublime. Burke defined the sublime as the thing by which one is excited due to the delight felt by the idea of pain and danger without being in the actual circumstances producing the danger (1757/2015, p. 43). This was a significant shift in the discourse, as Burke focused on the negative and threatening side of sublime experiences and used a more phenomenological approach in his description, rather than solely investigating material or natural components. Here the sublime is starkly separated from the beautiful, and is best represented through terror, obscurity, power, privation, vastness, infinity, succession and uniformity, difficulty, magnificence, loudness, suddenness, and through feeling pain (Burke, 1757/2015, Section 2, pp. 42–71). These are all listed explicitly as possible sources for the feeling of the sublime. Burke emphasised power as a principal cause of this feeling, and he related it to vastness and infinity within the wider concept of grandeur. This relationship with size was fundamental to Burke's conception of the sublime.

> Greatness of dimension, is a powerful cause of the sublime … as the great extreme of dimension is sublime, so that last extreme of littleness is in some measure sublime likewise; when we attend to the infinite divisibility of matter, when we pursue animal life into these excessively small, and yet organized beings, that escape the nicest inquisition of the sense, when we push our discoveries yet downward, and consider those creatures so many degrees yet smaller, and the still diminishing scale of existence, in tracing which the imagination is lost as well as the sense, we become amazed and confounded at the wonders of minuteness; nor can we distinguish in its effect this extreme of littleness from the vast itself. (Burke, 1757/2015, p. 59)

In Burke's treatise, the concept of the sublime was constructed from fear, pain, and other negative elicitors, in direct contrast to that of beauty. While the sublime comes from pain and danger, beauty is defined as that which acts on our mind 'which excite[s] in us the passion or some correspondence of affection' (Burke, 1757/2015, p. 90). This division between beauty and the fearfully sublime is also echoed in modern thought concerning 'wonder' as an aesthetic experience of delight, and sublimity as the aesthetic experience of fear (Fisher, 2003). Burke's ideas emphasised our own physical and sensory awareness of the sublime and abstracted previous theories of the sublime to be more generalisable and applicable to a wider variety of situations. Burke did not write about the sublime in composed music. Instead, the only auditory references made refer to loud and harsh sounds (e.g. artillery, thunder, and storms), and these are referenced as examples of power and fear in his conception of the sublime. The Burkean sublime is a peculiar account of the experience, which is focused on pain and danger rather than the positive and wondrous affects previous championed. However, this work established that the discourse on the sublime would be primarily focused on objects and experiences rather than artistic or literary criticism (as in Longinus' *Peri Hypsous*), and it has since been a foundational text for empirical research in the twenty-first century (e.g. Keltner & Haidt, 2003; Pilgrim, Norris, & Hackathorn, 2017; Stellar et al., 2018; Chirco et al., 2018; Graziosi & Yaden, 2019).

Following Burke, Henry Home (known as Lord Kames) in *Elements of Criticism* (1761) made a distinction between the great, the sublime, and the beautiful. This taxonomic classification placed grandeur and beauty as the principal concepts, from which the great, the sublime, and the beautiful sprang forth. Both grandeur and beauty were related and seen as components of 'agreeableness', and the sublime was seen as a type of grandeur. This splitting of grandeur and beauty was akin to Burke's delineation of the sublime and the beautiful, and both Burke and Kames still held an important role for vastness of size in their theoretical models of the sublime. Significantly, Kames also described the 'emotion of sublimity' as the 'perfection of order, regularity, and proportion' (Kames, 1761/2005, p. 154), which connects the sublime to conceptions of beauty through a kind of technical assessment of enormity. Kames also identified the 'emotion of grandeur' as a serious, solemn, and pleasant feeling. These ideas still root the sublime, and its associated conceptions, firmly in the realm of positive evaluations, less terrible and terrifying than those proposed by the Burkean sublime.

Archibald Alison's *Essays on the Nature and Principles of Taste* (1790) again followed Burke in separating the beautiful from the sublime but explicated the role of imagination. 'If [s]ounds are [s]ublime in themselves, independently of all [a]ssociation, it seems difficult to account for contrary sound producing the same effect, and for the same sounds producing different effects, according to the [a]ssociations with which they are connected' (Alison, 1790, p. 146). Upon examining sounds that may produce feelings of sublimity, such as a lion's roar or an eagle's scream, Alison states 'that the [s]ublimity of such sounds should arise from the qualities of which they are expressive; and which are of a nature fitted to excite[] very powerful

[e]motions in our mind' (p. 157). Not only is imagination held as the responsible feature relating the sublime object to its associations, but objects themselves are not sublime outside of the perceiver's interpretation and imagination. This gives rise to the idea of the pluralistic or subjective sublime, in that instances of sublimity are largely situational and culturally dependent.

A contemporary of many of the above writers in Great Britain and Ireland, Immanuel Kant published *Observations on the Feeling of the Beautiful and the Sublime* in 1764. In this text, Kant named three types of the sublime: the terrifying, the noble, and the magnificent. These concepts were not fully expanded in his writing, but they are related respectively to feelings of dread and melancholy, quiet admiration, and 'beauty spread over a sublime prospect' (Frierson & Guyer, 2011, p. 16). The other notable idea expressed in the text was the relation of the sublime to an 'unforeseeable future' (Frierson & Guyer, 2011, p. 18), and the associated terror of the temporal sublime, a sublime expressed by the extent of eternity. In 1790, the same year as Archibald Alison's *Essays*, Kant's *Critique of the Power of Judgement* was published. Here, the ideas of the sublime build again on the philosophy of Burke and those before him with a specific focus on one of the primary factors of the sublime: our relations to the size of sublime objects and environments. In this text, two substantial contributions to the philosophy of the sublime are detailed: the mathematically and dynamically sublime (1790/1987, pp. 103–123). These two variants of the sublime emphasise negative emotional responses from encounters with objects of massive size, e.g. incomprehensibility, and fear. The mathematically sublime may occur when one encounters something infinite, its presence and size become unfathomable and 'beyond all comparison' (Kant, 1790/1987, p. 133).

> [What happens is that] our imagination strives to progress toward infinity, while our reason demands absolute totality as a real idea, and so (the imagination,) our power of estimating the magnitude of things in the world of sense, is inadequate to that idea. Yet this inadequacy itself is the arousal in us of the feeling that we have within us a supersensible power; and what is absolutely large is not an object of sense, but is the use that judgement makes naturally of

> certain objects so as to [arouse] this (feeling), and in contrast with that use any other use is small. (Kant, 1790/1987, p. 106)

In contrast, the dynamically sublime is defined by power, not size. This type of the sublime offers a kind of existential security in the rationalisation of the immense power of an object—aspects of nature can be perceived as fearful while one knows oneself to be in a position of safety. This contrast between safety and danger is at the core of the dynamically sublime experience. Though Kant offers two distinct forms of the sublime, they both are based in the sense of being overwhelmed by an object—the size and/or power dictates the type of sublimity—and in turn the individual feels small in response to the sublime object. The self-reflective nature of these experiences is key to the Kantian sublime and again places the relationship to the individual as a key component for the experience of the sublime.

Kant's examples of the sublime are exclusively experiences of nature and not of art (Guyer, 2006, p. 312). However, a contemporary of Kant, Johann David Michaelis, theorised how the sublime could be represented in music. Through a type of '"[u]niformity which is so great that it excludes variety"—by for instance the constant repetition of a rhythm, note or chord—or by creating such a "diversity" of ideas that the mind is overwhelmed by "thundering torrents of sound"' (le Huray & Day, 1987, p. 6) may the listener encounter sublime music. Through this type of experience of the dynamically sublime, affordances are granted to the individual to exceed the capacity of their own imagination, and, in Kant's view, this reveals, in part, the human condition. Friedrich Schiller, following in the philosophical tradition of Kant in his *On the Sublime* (1793) and *Concerning the Sublime* (1801), summarised the sublime as the ability to morally overcome and produce ideas when confronted with something physically larger than oneself (Schiller, 1967). Kant once again returns to the sublime in *Anthropology from a Pragmatic Point of View* (1798), where he describes the experience of the sublime as arousing surprise and inspiring awe.

Arthur Schopenhauer, in *World as Will and Representation* (1818) developed his philosophy of the sublime in the wake of Kant's accounts of the mathematically and dynamically sublime. He claimed that aesthetic pleasure could be extracted from terrifying sublimity through a process of consciously turning away from the perceived threat. Here the dynamically sublime was reinterpreted as a threat to human flourishing, and the mathematically sublime as a feeling of nothingness derived from the self-reflection of the infinite. Schopenhauer argued that these forms of the sublime act through two processes, interpreted as subjective and objective:

> First, the subjective side, the state of tranquil and will-less contemplation, and second, the objective side, the perception of the Platonic Ideas. These are jointly necessary and sufficient components of all aesthetic experience, with one key exception: the experience of music, which differs only in its objective side insofar as the listener does not perceive Ideas but rather the will itself, albeit through the condition of time. (Shapshay, 2012, p. 16)

Schopenhauer did not fully segregate beauty from the sublime and positioned the two on a spectrum, where feelings of beauty can become feelings of the sublime with the addition of threat and the transcendence of individuality. Schopenhauer had a more empirical approach to his philosophy of art than Kant and showed both nature and art to be equally capable of producing sublime feelings. He believed music to be the highest form of artistic expression because it was a direct copy of Will (Schopenhauer, 1818/2004), with music and philosophy attempting the same task from different perspectives. Notably, these lofty properties were only granted to 'absolute music'—that is, high-art, non-representational music (Horowitz, 2005, pp. 4–5).

Discourse on the sublime by philosophers and artists throughout the Romantic era continued to expand on ideas relating it to vastness. North American authors (e.g. Ralph Waldo Emerson, John Muir, and Henry David Thoreau) focused on the wildness and 'unexplored' landscapes of the American frontier as bastions for the sublime (Brady, 2018, pp. 108–113). William Wordsworth, writing about England's Lake District in *Guide to the Lakes* (1835), described the sublime and beautiful qualities of the light and shadow cast on the mountainous region (1835/1906, p. 26). Wordsworth later combined Kant’s two types of sublime experience into a transcendent and interconnected whole, a type of elevation and revelation where the sense of self is expanded beyond the individual. Several decades later, Friedrich Nietzsche’s contrasting concepts of the ‘Apollonian’ and ‘Dionysian’ in *The Birth of Tragedy Out of the Spirit of Music* (1872) also integrated the concept of the sublime, especially sublime art, into his philosophy. In brief, the Apollonian is the representation of logic and rationality, while the Dionysian is its opposite, representing emotion and irrationality. Nietzsche firmly placed the sublime within the Dionysian category and emphasised that it expressed ideas of transcendence. Similar to Kant’s dynamically sublime, the Nietzschean sublime ‘“takes in” and “tames” the terrible and absurd nature of existence’ (Costelloe, 2012, p. 115).

To summarise the philosophical work on the sublime through the eighteenth and nineteenth centuries, several significant ideas were established to explain the nature of sublime experiences. There was a reorientation from artistic critique to objects, environments, and self-reflection to better explain the nature and causes of sublimity. Through an emphasis on landscapes and nature, sublimity was situated as the channel between the self and the natural world. Furthermore, this position was understood through the reflexive nature of the sublime, as it forces one to compare oneself with the vastness of conceptual ideas and perceptual objects: ‘the sublime reconfigures the self in relation to nature, where the self experiences itself as limited human nature, yet as also having various capacities different from nature’ (Brady, 2018, p. 114). No longer did the sublime only encompass positive attributes of elevated language and rhetoric, but the ideas were reshaped to explain the particular feelings of pain and pleasure provoked by the sublime through imagination and a complex mixture of emotions.

The discourse on the sublime did not end with the nineteenth century, and through the philosophical conceptions of the sublime detailed above there has been a clear development of ideas that incorporate size, threat, and beauty into the modern philosophy of the sublime. Essentially, and for its application in this thesis, modern conceptions of the sublime often apply the discourse to and mould it around its application to art. Much of art has been disregarded from the historical discourse on the sublime due to its lack of vast perceptual scale, with the notable exception of architecture. Paul Crowther in *The Kantian Sublime* (1991) offers a reconstruction of Kant's sublime to incorporate a broader range of ways in which art may be sublime. The size and scale of the work of art could be vast due to its perceptual scale, personal significance, or the 'overwhelming character of some general truths embodied in the work' (Crowther, 1991, p. 164). This opening up of the concept of the sublime has been influential in the twentieth and twenty-first centuries for its applicability to all types of artistic endeavours. Barnett Newman, the American abstract expressionist painter, sought in *The Sublime is Now* (1948) to break away from European conceptions of beauty and embody freedom as a self-evident expression of the sublime.

> We are reasserting man's natural desire for the exalted, for a concern with our relationship to the absolute emotions. We do not need the obsolete props of an outmoded and antiquated legend. We are creating images whose reality is self-evident and which are devoid of the props and crutches that evoke associations with outmoded images, both sublime and beautiful. We are freeing ourselves of the impediments of memory, association, nostalgia, legend, myth, or what have you, that have been the devices of Western European painting. Instead of making *cathedrals* out of Christ, man, or 'life', we are making it out of ourselves, out of our own feelings. The image we produce is the self-evident one of revelation, real and concrete, that can be understood by anyone who will look at it without the nostalgic glasses of history. (Newman, 1948, p. 173, emphasis in original)

Modernist abstract art had a close relationship with the sublime, as the emphasis on formlessness and representation bear a resemblance to the mathematically sublime of Kant, the representation of the unrepresentable. Jean-François Lyotard held the avant-garde of modern art and their formless representations to be the best way to understand the sublime. In *Lessons on the Analytic of the Sublime* (1991/1994), Lyotard insisted that the sublime must remain irresolvable and irreducible (1991/1994, p. 127). The sublime pushes our conceptual powers to their limits and is revelatory of the instability of the world. The sublime is the tool of the avant-garde that reflexively interrogates the meaning and boundaries of art (Lyotard, 1992). Similarly, Gilles Deleuze described the sublime as a type of ‘fundamental irresolvability’ (1981/2003, p. 126). This emphasis on representation of the unrepresentable and the tension that this creates was a central focus for the twentieth century philosophy of the sublime.

Although the philosophical discourse on the sublime has somewhat fallen out of favour in recent years, several philosophers (e.g. Ronald W. Hepburn, Julia Kristeva , Ruby Meager, and Slavoj Žižek) have applied the concepts of the sublime to expand and interpret ideas in various domains, including aesthetics, environmentalism, psychoanalysis, and politics. It has also been used to examine accounts of wonder, sacred music, and the sublime’s role in religious practice (Saliers & Saliers, 2017; Srinivas, 2018). The terms ‘technological sublime’ and ‘digital sublime’ have been used to express the ‘astonishment, awe, terror, and psychic distance’ of the new technologies that have transformed our modern world (Mosco, 2005, p. 23). There are several additional Western philosophical writings on the sublime not detailed here, and for extended historical reviews see Brady (2018), Costelloe (2012), Doran (2017), Scott (2014), and Shaw (2017).

Lastly, it is important to mention that outside of Western philosophy there are analogous concepts of the sublime and experiences of awe. Though these are not detailed in this review, some have similar relationships to beauty and transcendence (e.g. Japanese ‘kami’ (神); Elçi & Yurt, 2020). Overall, many influential ideas from the long history of philosophical discourse on the sublime have shaped our understanding of the objects, components, and possible psychological processes associated with sublime experiences: the imposing size of objects from their physical presence and related abstracted characteristics; elements of surprise, unexpectedness, and self-reflection that bring us into comparisons with the sublime object; and feelings of transcendence that spring forth from beauty and fear.

2.3 The psychology of awe

The philosophy of the sublime has often described powerful experiences resulting from nature and art, and these are also transferable to experiences of awe—specifically, musical awe. As previously mentioned, the emotion of awe is in this project understood to be equivalent to sublimity: that is, the emotional experience of the sublime. There is currently no agreement how precisely to characterise the relationship between the sublime and awe. Recently, Arcangeli et al. (2020) described seven views of how awe and the sublime might be related, with the first being that 'awe and experiences of the sublime are the same type of experience' (p. 2). For this research project, this view is endorsed, and by examining the largely aesthetic experience of musical awe, many of the complications confounding the relationship between the sublime and awe are resolved. In this section of the literature review, an exploration of the research on awe explores those psychological studies that have been undertaken to understand the nature of awe and the sublime. Few of these studies examined music as the primary stimulus for experiences of awe, but over the last two decades, several studies have started to build a foundation for the study of awe through psychological inquiry. The psychology of awe builds from the insights found in the philosophical writings on the sublime and seeks to test the ideas developed over the course of the past centuries. It seeks to develop frameworks and models to better describe the experience of awe through observation and experimentation. Through the philosophical concepts detailed in the previous section (e.g. size, beauty, fear, and transcendence), the following section examines the components and processes germane to the psychology of awe and seeks to establish awe research within the field of affective science.

To investigate the feeling of awe as an emotion, researchers have endeavoured to construct psychological frameworks that seek to understand the constituent components of the emotion and deduce how these pieces may interact to produce a higher-level emotion such as awe. This method of deconstruction and reconstruction should prove useful for empirical research on awe since the component claims may be tested more accurately to provide evidence for their influence in the aggregate emotional experience. The first psychological interpretation of awe was provided by William McDougall, describing awe as a composite emotion made up of admiration—defined as the binary compound of power and wonder—and fear (1913, p. 131). This trinitarian complex of power, wonder, and fear can account for the variability in the pleasantness of experiences of awe, since the amount of fear may vary significantly from one experience to another.

The uncertainty and variability in the valence (general perception of pleasantness) of experiences of awe accounts for its convoluted and difficult relationship within emotional research. Without clear biological and/or social functions, awe has been difficult to define accurately (Lazarus, 1991a). However, the variability in awe's valence is infrequently mentioned in more contemporary research, where it is most commonly portrayed as a discrete positively valenced emotion (e.g. Campos et al., 2013; Rudd, Vohs, & Aaker, 2012; Shiota, Keltner, & John, 2006; Shiota, Keltner, & Mossman, 2007; Smith, Tong, & Ellsworth, 2014; Valdesolo & Graham, 2014; Van Cappellen & Sarpglou, 2012). Expanding the study of awe away from a componential analysis of terms, Frijda (1986) described awe as a heightened receptive mode for the unexpected. Similarly, Izard (1977) depicted awe as a feeling that motivates our curiosity. This cognitive approach provides the basis for some modern understandings of awe in psychology. In a recent panel discussion on the psychology of awe, the panellists described awe as a type of 'epistemic emotion' (from Pekrun & Stephens, 2012), a group of emotions centred around the acquisition of knowledge and the violation of expectations, which is closely related to wonder, surprise, and curiosity (Paulson, Sideris, & Valdesolo, 2020). This discussion concluded that awe can be viewed as a distinct emotion that is similar to wonder, but with an important focus on self-transcendence (Paulson, Sideris, & Valdesolo, 2020, pp. 31–32).

In 2003, Dacher Keltner and Jonathan Haidt developed a psychological framework for awe in their seminal paper 'Approaching awe, a moral, spiritual, and aesthetic emotion'. The aim of the research was to provide a foundation for understanding awe by assessing its constituent cognitive components (Smith & Ellsworth, 1985). It is important to note that the framework proposed here is modular: it describes specific features but accounts for variable experiences within the emotion by the subtraction or addition of ancillary features (also known as 'secondary features' in Ortony & Turner, 1991). Evaluating and synthesising putative cases of awe in multiple domains (religion, sociology, philosophy, and psychology), the researchers identified several important features of awe and proposed a model for awe. This model consisted of two tiers of cognitive appraisal: central appraisals (vastness and accommodation) and peripheral or ancillary[1] appraisals (threat, beauty, ability, virtue, and supernatural causation). These form the conglomeration of emotions understood as awe. This model has since become a foundational and the theoretical standard for investigating psychological components of awe, and is widely used in contemporary emotion research (e.g. Elk et al., 2016; Gordon et al., 2017; Pilgrim, Norris, & Hackathorn, 2017; Shiota, Keltner, & Mossman, 2007). Due to its influence in the field, a further examination of its features is required.

The central appraisals are the necessary features of all experiences of awe. These two central appraisals are vastness and a need for accommodation. The perception of vastness in this context is defined as 'anything that is experienced as being much larger than the self, or the self's ordinary level of experience or frame of reference' (Keltner & Haidt, 2003, p. 303). An encounter with a vast stimulus is not limited to physical frames of reference: a metaphorical sense of vastness may also be elicited by social standing, prestige, or authority (e.g. Durkheim, 1887/1972; Weber, 1978). Symbolic markers of physical size (e.g. loud and low-pitched sounds) and conceptual or abstract ideas are also capable of being experienced as vast.

[1] Also referred to as 'hedonic appraisals' (Keltner & Haidt, 2003).

Accommodation is the second necessary feature for experiences of awe. This refers to the process by which existing mental schemata—generalised patterns of behaviour and thought—must be adapted or changed to assimilate new experiences (Piaget & Inhelder, 1950/2000). When one is confronted with a stimulus more vast than previously experienced or imagined, there is often the need for an accommodation process. This is due to the stimulus challenging previously held schemata for concepts of size. Through this mental process, the information is either successfully assimilated into a new mental schema or fails to become assimilated altogether. This dualistic outcome of assimilation is the likely explanation for the hedonic variability found in awe. With more successful assimilation, a positive emotional response occurs and resembles our modern concept of awe, without fear or dread (Keltner et al., 2001). This positive association is also related to states of reverence and elevation (Haidt, 2002). When we fail to assimilate the vast stimulus, the fear and power of awe become dominant, and in response we submit to the vastness. '[W]e have the impulse to shrink together … that is to say, the instinct of submission' (McDougall, 1913, p. 130).

In Keltner and Haidt's framework, the ancillary appraisals of threat, beauty, exceptional ability, virtue, and the supernatural can vary within the experience of awe. One experience of awe may be beautiful and non-threatening, while another might be terrible and baleful. Although these two experiences differ widely from each other, if the central appraisals (i.e. vastness and need for accommodation) are met, any combination of these secondary features may be present. Threat is an important appraisal factor for its ability to negatively influence awe. A negatively valenced version of awe may be more commonly associated with non-Western cultures (Bagozzi, Wong, & Yi, 1999; Shiota et al., 2017). This negative version is also commonly associated with fear in religious traditions (Pargament & Mahoney, 2005; Sundararajan, 2002). Using previous research on awe-eliciting stimuli (Piff et al., 2015; Valdesolo & Graham, 2014), the duality of awe has been recently researched by Gordon et al.

(2017), who found that 12–24% of experiences of awe were threat-based variants. Similarities in the duality of awe can be seen in Kant's two-fold characterization of the sublime (Kant & Pluhar, 1790/1987), where the mathematically sublime and dynamically sublime may result in similar outcomes as the failure to assimilate and success of assimilation, respectively.

The other four peripheral appraisals of awe—beauty, exceptional ability, virtue, and supernatural causality—have been investigated in psychology and categorised into specific elements. The evaluation of beauty through balance and proportion (Arnheim, 1974; Birkhoff, 1933; Gombrich, 1984), symmetry (Humphrey, 1997), complexity (Berlyne, 1971), clarity (Solso, 1997), its relation to people (e.g. Merleau-Ponty, 1964), and the processing experience of the perceiver (Reber, Schwarz, & Winkielman, 2004) may all be influential factors in awe. Exceptional ability also colours perceptions of awe, theoretically demanding a greater need for accommodation. The witnessing of a high level of skill, far outside of one's ability, may seem unbelievable or impossible, triggering a reassessment in thought. Virtue is related to awe through concepts of reverence, elevation, and inspiration. These are important in perceivers' belief in 'what is possible, focusing attention not only outside the self but also on that which is greater than the self and beyond its perceived boundaries' (Shiota et al., 2017, p. 373). Lastly, supernatural causality is the perception of an influence from something otherworldly. These uncanny feelings can be horrifying (Angyal, 1941) if understood as coming from a malevolent source, or magnificent if from a benevolent source (a common occurrence in religious histories—e.g. Paul on the road to Damascus, Muhammad's revelation at Hira, and Arjuna and the vision of the Vishvarupa). Through these investigations and deconstructions of the peripheral or ancillary appraisals into specific elements, individual varieties of awe experiences can be explored with a sharpened focus.

With variability in peripheral appraisal factors, experiences of awe may manifest in different forms, but as previously stated, awe is a family of emotions that comprises a variety of experiences that are centred on the appraisals of vastness and accommodation. Vladimir Konečni (2005), in an attempt to synthesise concepts of the sublime with awe, took issue with Keltner and Haidt's (2003) framework and argued that the prototypical experience of awe relies predominantly on a characterisation of fear, but both fear and joy are important in his synthesis. In this view, the psychology of awe requires both joy and fear, since the sublime contains a necessary aspect of joy and 'aesthetic awe is the response to the sublime' (Konečni, 2005, p. 30). In an attempt to clarify the distinction between awe and aesthetic awe, Konečni states that aesthetic awe is the 'ultimate humanistic moment' (2005, p. 27) and is formed from a combination of fear and joy, and is a more primordial version of awe. The philosophically derived concepts of grandeur and existential security are mentioned by Konečni as important factors in the reaction to the sublime, and bear a striking resemblance to the central appraisals of vastness and accommodation discussed above. Aesthetic awe is theorised to be part of the 'Aesthetic Trinity', which is comprised of feelings of being moved and physiological chills—measurable by skin conductivity (Blood & Zatore, 2001; Panksepp, 1998), about which there is a significant body of research in music (e.g. Sloboda, 1991; Waterman, 1996).

These two models (Kelter and Haidt's framework and Konečni's Aesthetic Trinity) are not necessarily incompatible with each other. The ideas in the Aesthetic Trinity can be seen as a development and specific honing of Keltner and Haidt's framework. Using these proposed psychological foundations for awe, investigations into musical awe may now be based on a rather more informed starting point. The Keltner and Haidt framework provides a much-needed foundation for recent psychological research, and many studies have used it as their primary source for understanding experiences of awe.

The translation of the philosophical sublime to the domain of psychological research on the emotion of awe has been also interpreted through a two-tiered theory by Sandra Shapshay (2021). Here, Shapshay distinguished between a 'thin sublime'—an aesthetic response composed of a perception of vastness and the need for accommodation—and a 'thick sublime', which is the same aesthetic response with the addition of contemplation of the awe experience and an attempt to fulfil the need for accommodation. This two-tiered explanation of the sublime 'brings greater phenomenological precision [and] illuminates why there seems to be a basic, perennial core to these aesthetic responses … as well as historical contingency' (Shapsay, 2021, p. 133). Continuing from these frameworks, recent empirical research has investigated which situations invoke experiences of awe in participants. An innovative experiment conducted by Chirico et al. (2018) developed several virtual reality environments to produce feelings of awe in participants. These virtual settings were designed to emphasise width, height, complexity, and surprise as the virtual reality cues corresponding to the perceptual and conceptual components of awe (Chirico et al., 2018, p. 3). These ideas of size, surprise, and complexity were translated into corresponding virtual environments. The three settings positioned the viewer (i.e. the participant placed in these settings) in one of three environments: a snowy mountain top, on a forest floor surrounded by large trees, and a view of earth from outer space. Participants were placed into these virtual environments and were able to interact with the scenes by moving around, looking in all directions, and hearing the environmental sounds for each scene to build a sense of 'presence', or the 'feeling of being in another physical or imaginary place' (Chirico et al., 2018, p. 2). Through the experience and interactions with these awe-related virtual environments, participants reported that feelings of awe, presence, and positive affect were raised when compared to neutral, non-awe-related environments.

The growing body of psychological research on aesthetic chills has also been linked to experiences of awe (Grewe, Kopiez, & Altenmüller, 2009; Maruskin, Thrash, & Elliot, 2012; Panksepp, 1995; Rudd, Vohs, & Aaker, 2012; Schoeller & Perlovsky, 2016; Schurtz et al., 2012; Silvia et al., 2015; Sumpf, Jentschke, & Koelsch, 2015). As discussed by Vladimir

Konečni (2005), there is a connection between the occurrence of physiological shivers or chills with the experience of awe. These shivers are often described together along with gooseflesh/goosebumps (Schurtz et al., 2012). In a survey study (Bannister, 2018), participants were asked to detail the expression and quality of chills-eliciting music. Along with beauty and sublimity, participants reported awe as an emotion to describe the music that produced chills. It was found that crescendi, the presence of the human voice, and expressions of unity were recurring musical features reported by these participants. Similarly to awe-associated chills, this type of physiological response may also be akin to the chills reported from autonomous sensory meridian response (ASMR) reactions, which may have a positive impact on mental and physical well-being (Poerio et al., 2018; Shukla, 2021).

Feelings of awe have also been linked to changes in perception, with research suggesting occurrences of temporal dilation, where one's sense of time slows (Joye & Dewitt, 2016) and expands (Rudd, Vohs, & Aaker, 2012). Research into awe has also focused on the social domain of the emotion and its relationship with personality types. Graziosi and Yaden (2019) explored 'interpersonal awe', or the elicitation and induction of awe from other people. Participants wrote about awe elicited from a loved one, then independent coders rated the writings for various sentiments. Through two studies, the researchers found that feelings of awe are produced from the context of other people, especially from those who are socially close (e.g. friends, family, and loved ones). Additionally, the findings showed that these instances of awe hold general similar assessments of vastness, need for accommodation, and self-diminishment (Graziosi and Yaden, 2019, p. 269). The assessments of vastness and accommodation were 'relative and figurative' (p. 268), being experienced in terms of their relationship to the other person. However, interpersonal awe differs from the awe experienced through nature due to a lack of a feeling of connection with the natural world and without distortions of temporal perception. In further research into the social domain of awe experiences, Steller et al. (2018) showed a link between feelings of awe and the promotion of humility. This study found that people who were more prone to feelings of awe exhibited higher levels of humility. Participants watched videos of awe-eliciting scenes and the self-report findings suggested that the induction of feelings of awe led to more humble feelings in the participants. Furthermore, connecting these findings with Keltner and Haidt's (2003) framework for experiences of awe, experiences of vastness and a need for accommodation were shown to elicit feelings of humility in the participants.

The feelings of openness afforded by experiences of awe stem from the sense of connectedness, smallness, and transcendence (Bonner & Friedman, 2011; Nusbaum & Silvia, 2014). The feeling of being overwhelmed by an awe-eliciting stimulus necessitates that the experiencer is diminished in some way (Bai et al., 2017), humbled by a great presence (Campos et al., 2013), and made to feel small. However, not everyone is equally inclined to these feelings of awe. Silvia et al. (2015) investigated the personality trait of 'openness to experience'—a cross-culturally significant personality trait (McCrae & Sutin, 2009) and one of the factors in the widely used Five Factor Personality Model (McCrae & John, 1992)—as it related to awe-associated experiences. This study evoked feelings of awe in participants through images and music. In the first experimental phase of this study, images of the sky and space were shown to participants, and in the second phase the song 'Hoppípolla' by the Icelandic post-rock band Sigur Rós was played. This song was chosen as an awe-inducing stimulus because of its large sonic envelope, numerous crescendi, and dramatic shifts in volume[2] (Silvia et al., 2015, p. 379); these features mirror many of the conceptual ideas relating awe to size. The results of the study showed that the personality trait of openness to experience significantly predicted feelings of awe in the participants. Interestingly, the images were found to be more effective predictors of

[2] The terms 'volume' and 'loudness' are used throughout this project to refer to the objective intensity or power of a sound and the perception of that intensity or power, respectively. Note in other chapters, 'volume (loudness)' is often used to describe the general intensity of an audio signal in the abstract.

awe than the music, but this discrepancy was interpreted as being the result of differing musical preferences of the participants.

A recent psychological study involving awe-eliciting music by Ji et al. (2019) investigated the links between awe-associated music, motivation, and well-being. Participants listened to three minutes of ‘Victory’, composed by Thomas J. Bergersen and Nick Phoenix, and ‘The Dragon Warrior’ by Hans Zimmer, as their awe-eliciting music excerpts. These pieces of music shared many of the overall features of ‘Hoppípolla’, including dramatic changes in volume and large sonic envelopes, and these pieces fit firmly within the category of film music. The results showed that awe-eliciting music was positively linked with many motivational associations (e.g. altruism, seeking meaning, self-actualisation) due to its positive affect (Ji et al., 2019, p. 323), but there were no direct connections to well-being.

The renewed interest in the psychology of awe has largely been used to explore awe as it relates to its impact on social functions (Piff et al., 2015). Not only is awe a powerful emotion with phenomenological importance, but through the experience of awe, it is proposed that one can improve social relationship quality (Peters, Rowatt, & Johnson, 2011), reduce narcissism (Ashton & Lee, 2005), and more easily integrate into social hierarchies (Durkheim, 1887/1972). Furthermore, induced experiences of awe from videos of nature have been shown to facilitate social bonding (Van Cappellen & Saroglou, 2012). Another important social use for awe is in its relationship with religion and spiritual practice (Shariff & Norenzayan, 2007; Wilson, 2010). Here, the experiences of awe may afford instances of togetherness and universality, features that are particularly significant for religious practices (e.g. Krause & Hayward, 2013).

In summary, the above review of psychological research has shown several main findings for the study of awe. Importantly, feelings of awe can be generated from a variety of stimuli in laboratory conditions, and a variety of studies demonstrate feelings of awe affecting positive changes in motivational associations and social functions. These positive changes come about through a smaller sense of self brought on from an encounter with vastness and the resultant accommodative processes. Feelings of being moved and physiological chills are often co-occurrent reported states that are closely linked to awe, although their role and importance remain open questions. The psychological models have translated the main philosophical considerations of the sublime—power, wonder, and fear—and applied them in a general psychological framework to describe a wide variety of awe-related experiences.

While there are many directions for psychological investigations into awe and its multiple associations (e.g. investigations into personality, cultural and communal associations, ties to religion and spiritual practices, etc.), few psychological studies (Gordon et al., 2017; Ji et al., 2019; van Elk et al., 2016) have used music as an awe-eliciting stimulus. Moreover, when music is used, it is implemented primarily to examine external factors of interest (personality, well-being, etc.). Rarely do these studies examine the music itself in any meaningful capacity for how and why it is associated with feelings of awe. The following section outlines, in brief, how music evokes emotions in the listener and how these processes can be applied to our understanding of awe-related music.

2.4 Music and emotions

Contemporary research into music and emotions has moved away from the characterisation of music as a 'language of emotion' (Cooke, 1959), whilst there are ample connections between music and emotion (Hjort & Laver, 1997), the comparison to language does not accurately capture the relationship between the two. Music can be used to alter the way we feel (Juslin & Laukka, 2004; Lonsdale & North, 2011) and is capable of creating both simple and complex emotions in listeners (Corrigall & Schellenberg, 2013; Juslin & Västfjäll, 2008). The methods by which music achieves emotional influence are wide-ranging:

musical/acoustic cues, physiological responses, and cognitive appraisals are all important mechanisms that are often interlinked in the production of emotions from musical stimuli. These methods work together through social enculturation to create and construct emotional concepts that are widely recognise inside of one's culture. There is a large body of work concerning music and emotions, and this section summarises many of the main ideas of the field relevant to this review without aspiring to be wholly comprehensive.

Many acoustic features in music are analogous to those found in speech, while other cues are exclusive to music. First proposed in the component-process theory of emotion (Scherer, 1985), induced emotions affect the production of speech through the manipulation of vocal organs, causing variations in frequency, intensity, and rate of speech. Happiness, sadness, fear, anger, and disgust all alter prosodic aspects of speech and are associated with certain acoustic cues. A meta-analysis by Juslin and Laukka (2003) established commonalities between vocal and musical cues. Tempo and speech rate were both associated with physiological arousal. Faster musical tempi and speech rates were associated with high-arousal emotions (e.g. anger), and slower tempi and speech rates were associated with low-arousal emotions (e.g. sadness). Other researchers have further established tempo as an important musical feature for emotion (e.g. Gagnon & Peretz, 2003; Hevner, 1935, 1936, 1937; Juslin, 1997b; Juslin & Lindström, 2010). Juslin and Laukka's (2003) meta-analysis also found that higher-pitched voices and higher-timbre music were associated with high-arousal emotions. Low pitches in music and voice were associated with lower valence and higher arousal, suggesting that low pitches are perceived as threatening (Jacquet, Danuser, & Gomez, 2012). Loudness of voice and music was associated with arousal, with louder sounds associated with higher arousal. Additionally, the regularity of amplitude, frequency, and duration for voice and music was associated with positive psychological valence. The more regular the variation in each of these acoustic cues, the more they were associated with positive emotions.

Articulations in music are associated with arousal; staccato and legato musical cues are associated with high- and low-arousal emotions, respectively.

However, not all musical cues associated with emotion have direct parallels in speech. Unlike speech, musical modes—the relationship between pitches in a key—may convey a large amount of emotionally salient information. These emotional associations have been carefully investigated, demonstrating that positively valenced emotions are associated with major modes, and negatively valenced emotions with minor modes (Gabrielsson & Juslin, 2003; Juslin & Laukka, 2004). Beyond these modal associations, there are many more specific musical cues with emotional associations, and listeners' strong emotional responses to music often coincide with specific musical cues (Sloboda, 1991). Together these cues produce a complex network of interactions between musical cues and the weights of influence associated with cues. The resulting networks are unique to each listener (Juslin & Lindström, 2010). Furthermore, the cues are not deterministic in inducing emotions in the listener, but are only probabilistic (Juslin, 1997a; Juslin & Laukka, 2003). An implication of the probabilistic nature of emotion production from music is that individual experiences may vary from expected trends based on their unique cognitive weighting of cues.

Emotional associations with mode and other culturally influenced musical cues are made, at least in part (Bowling, 2013), through explicit or implicit cultural learning (Lundin, 1967; Juslin & Laukka, 2003; Trainor & Corrigall, 2010). Leonard Meyer (1956) posited that this system of expectancy in music was the basis for emotion and meaning in music. 'The norms and deviants of a style upon which expectation and consequently meaning are based are to be found in the habit responses of listeners who have learned to understand these relationships' (Meyer, 1956, p. 61). David Huron (2006) further developed the ideas of musical expectation and emotion through the ITPRA (Imagination, Tension, Prediction, Reaction, and Appraisal) theory of expectation. This theory presented discrete neurophysiological systems for each component of the theory and showed how emotion can arise from the fulfilment and/or violation of musical predictions.

All these predictions are built upon a listener's musical experience and informed by cultural attitudes and further influenced by socially derived understanding and use of emotions (Higgins, 2012). Though there is a more general debate about the universality of emotions and their psychological processes, this thesis promotes a social constructionist understanding of musical emotions, whereby perceptual categorisation of musical stimuli is necessarily informed by one's culture. This type of constructionist view of musical emotion production heavily relies on the listener's experiences, and goal direction to inform the types of emotional experiences that may be afforded to the listener (Barrett, 2017, p. 92). This framing helpfully moves away from a prescriptivist understanding of emotion—one based on simple stimuli inputs and emotional outputs—and allows the listener to build emotions using basic parameters of affect and valence along with myriad of their own culturally-informed emotional ideas (Cespedes-Guevara & Eerola, 2018).

To consolidate the varied theories of emotion and music, Patrik Juslin and Daniel Västfjäll (2008) developed the BRECVEM framework to explain how music can produce emotion in the listener. This framework is comprised of six mechanisms for emotion production. (B) Brain stem reflex is the process by which urgent sounds (e.g. suddenly loud or dissonant music) are attended to and 'increase *arousal* and evoke feelings of *surprise* in the listener' (Juslin, Harmat, & Eerola, 2013, p. 605, emphasis in original). (R) Rhythmic entrainment occurs when the body 'locks' into the rhythm of the music and the musical rhythm is internalised through heartbeat or other bodily functions. (E) Evaluative conditioning is the induction of emotion through the pairing of music with positive or negative stimulus. Through this repeated pairing, the emotional connections between the music and its valence are strengthened. Eventually, this causes the emotion to be felt by the listener even without the presence of the paired stimulus. Emotional (C) contagion describes the induction of emotion in a listener from the perception of emotional content in the musical materials themselves—heard as if they had 'person-like' characteristics. When music is perceived to be expressive of an emotion the listener may mimic this expression internally. (V) Visual imagery is the creation of visual mental representations from music. Music can be effective in producing visual imagery in listeners (Osborne, 1981), and may induce emotions through the metaphorical affordances of those images (Kövecses, 2007). (E) Episodic memory is the process by which music evokes a personal memory or event (Baumgartner, 1992), causing the emotion associated with that memory to be experienced. (M) Musical expectancy (described above) is the induction of emotion from the violation or confirmation of musical predictions in the continuation of the music (Huron, 2006). These mechanisms work together and are capable of producing states of arousal, or of simple, complex, and mixed emotions.

Certain responses to music may also require an aesthetic judgement to produce distinctive aesthetic emotions[3] (a kind of intuitive appreciation, e.g. awe, interest, and admiration). To account for these emotional responses to music, an additional component to the BRECVEM framework was added: aesthetic judgement (BRECVEMA; Juslin, 2013). Aesthetic judgement refers to the process of determining whether certain perceptual properties associated with aesthetic criteria (Levinson, 2003) are present in the music and to what degree. It involves higher cognitive processes than the other six BRECVEM mechanisms and is highly individualistic, flexible over time, and culturally dependent. The listener creates their own aesthetic criteria that function as filters for perceptual, cognitive, and emotional inputs. Perceptual inputs are low-level sensory impressions that are biologically based, mandatory for aesthetic processing (Jacobsen, 2006, p. 158), and relatively unchanging (e.g. symmetry, order,

[3] The term 'aesthetic emotion' is difficult to precisely define but differs from everyday emotions by the appreciation of aesthetic appeals, i.e. evaluations of preference. (Perlovsky, 2014).

and proportion). Cognitive inputs comprise knowledge-based higher-level concepts. Even information received at the moment of reception can strongly influence aesthetic judgements (Crozier & Chapman, 1981). Information about factors such as the musical style, composer, and history are organised as schemata and influence aesthetic judgements. As these are highly individualistic and malleable, education in the arts allows for more advanced interpretations (Sheridan & Gardner, 2012) and can alter these types of cognitive filters. Finally, emotional inputs resulting from BRECVEM mechanisms can inform and alter aesthetic judgements. However, there is no guarantee that an aesthetic judgement will be made in the first place. 'It is not that some listeners fail to detect perceptual features, it is simply that the features are "discounted" in the aesthetic judgement' (Juslin, 2013, p. 251). Even though the weights and criteria of aesthetic judgements are subjective, it is suggested that the aesthetic criteria for music broadly include the following concepts: beauty, expression, novelty, emotion, skill, message, style, and the sublime. Some of these concepts may be more important for aesthetic judgements than others. Istók et al. (2009) found beauty to be the most important criterion (others were skill, emotion arousal, novelty, and wittiness), but Juslin (2013) found that expression was the highest rated aesthetic criterion.

The BRECVEMA framework provides a unified model for investigation into aesthetic emotions, such as those of musical awe. Through this framework, awe can be better assessed through multiple mechanisms, providing a broader understanding of the phenomenon, with aesthetic judgement as the most interesting and applicable criterion for the experience of musical awe. The criteria for these aesthetic emotions deserve to be investigated so as to provide a better characterisation of these special emotions, even if at an individualised level.

2.5 A research path for musical awe

This chapter has outlined the relevant areas of interest that are significant for investigations into the experience and induction of musical awe. The long history of the philosophical sublime has led to psychological theories about how and why we experience musical awe. Even though awe-inducing music has been used as a tool to explore components and relationships of awe, the music that was chosen in these studies was often based on characteristics simply assumed to be important for awe. This speaks to a significant need for more focused research: the nature and occurrence of musical awe has yet to be established through empirical methods. This warrants further investigation into the music that actually induces awe and music’s relationship with those concepts important for the sublime and awe: vastness of size, threat, and beauty (among others). Musical ideas that express threat and beauty may vary depending on musical culture, but they plausibly exist in many cultures that express these fundamental ideas. Many of the components of awe and the sublime have conceptual and perceptual analogues in music and have yet to be explored.

Since the subject of awe has only recently been studied with scientific rigour, investigations into musical awe have been rare and insufficient to properly explain how and why the listener may experience awe from music. Recent explorations into the psychology of musical awe have made the first empirical strides (e.g. Gordon et al., 2017; Pilgrim, Norris, & Hackathorn, 2017; Silvia et al., 2015), but there remains much work still to be done in the field. The question of commonalities in experiences of musical awe remains open, and the first empirical evidence is presented in the following chapter. With the large amount of subjectivity in experiences of musical awe, as suggested by the appraisal models and frameworks for musical emotions (Keltner & Haidt, 2003; Juslin, 2013) and through Schopenhauer’s spectrum of sublimity, focusing on the central appraisal of size should prove valuable for musical awe research. To evaluate vastness as perceived musical size, research should utilise ideas of loudness, spectral qualities, imagery, setting, and production techniques.

It must be noted that the peripheral or ancillary appraisals listed in the Keltner and Haidt (2003) framework share appraisals often associated with sacred music. Religious organisations have an interest in invoking feelings of awe in their congregants, so investigating features, environments, and experiences of sacred music may prove valuable for understanding musical awe and its contexts. Although this project does not directly focus on this relationship, some examples in the following studies share the affordances of sacred music, similar to the example used at the beginning of the introductory chapter. Vladimir Konečni mentioned this religious connection when he stated that the prototypical example of awe can be found in mediaeval European churches (2008, p. 37). Sacred music is also strongly associated with transcendence and submission (McDougall, 1913), and the spectrum between beauty and sublimity theorised by Schopenhauer is influenced by personal transcendence (Shapshay, 2012).

The BRECVEMA (Juslin, 2013) and the Keltner and Haidt (2003) frameworks for awe share interesting commonalities that deserve further investigation. The potential criteria for aesthetic judgement in music bear a striking resemblance to peripheral appraisals: beauty, expression, novelty, emotion, skill, message, style, and the sublime on the one hand; and threat, beauty, exceptional ability, virtue and the supernatural on the other. Beauty and skill/ability are listed in both sets. This may suggest that the models target the same appraisals and might best be understood as part of one another. The aesthetic judgement section of the BRECVEMA model could be expanded to a point at which the 'awe branch' of aesthetic emotions contains additional appraisals. Both frameworks provide theoretical guiding criteria to understand potential cognitive processes and evaluations relating to musical awe, but empirical evidence is needed to assess their appropriateness and applicability.

Through philosophical investigation of the sublime, awe has been examined in terms of vastness, fear, and beauty. Psychology has extended these ideas and formed them into a practical framework to explain their relationship to each other, and from this foundation further questions arise regarding the production of awe from music. Are the existing psychological frameworks appropriate for studying musical awe? Is musical awe a common or rare experience? How similar are experiences of musical awe to each other? Are certain musical features and environments important to the production of awe? How and why does awe impart meaning to our musical experiences? These and many other questions are possible, as the investigation of awe is largely untrodden territory in musicology. The following chapters address many of these questions through empirical methods, and their findings test the theoretical frameworks proposed from philosophical and psychological research. Together, these findings will help to elucidate the opaque and enigmatic experiences of musical awe.

Through these studies, this project improves the characterisation and understanding of musical awe, starting with first-hand participant-based accounts. This begins in the following chapter, which details the first empirical investigations into participant experiences of awe from music. From these data, musical features, contexts, and emotional experiences associated with musical awe are assessed with regard to previously established theoretical and psychological frameworks and the commonalities in experiences and sentiments are evaluated. Through self-report and free response questions, participants' experiences speak to the aesthetic criteria detailed above and expand these ideas through personal experiences of musical awe. In the subsequent chapters (4–6), quantitative investigations focus on perceptual and conceptual aspects related to musical awe. Through these studies, the relationship between aesthetic qualities of music and virtual size, threat, and musical features is examined to produce a comprehensive model of musical awe in Chapter 7.

3 Studies 1 and 2: Exploring experiences of musical awe

3.1 Introduction

This chapter presents the findings of two exploratory empirical investigations into occurrences of musical awe. The first study focused on participant experiences through an online questionnaire and survey probing aspects of musical awe cognition, detailing the importance of awe-related properties such as environment, setting, and musical materials. Following participant responses in Study 1, Study 2 searched a music experience database for historical descriptions of awe-related experiences, analysing general trends in the descriptive language used by authors. Together, these studies establish certain ground truths about experiences of musical awe and lay the foundation for experimental investigations in the following chapters.

Seventy participants took part in an online questionnaire that gathered data on past experiences of musical awe. Quantitative psychometric scales found commonalities between participants, and qualitative data were gathered to help contextualise these experiences. In brief, while not something experienced regularly by listeners, musical awe was nonetheless found to be a widespread phenomenon throughout the population of the study. Participants perceived awe-inspiring music as large, virtuosic, and beautiful. Furthermore, an overwhelming majority reported their experience to be highly pleasurable, leading to heightened engagement with music. Settings in which musical awe commonly occurs appear to take two forms: large communal, group experiences and small or unaccompanied, contemplative isolation. Furthermore, Study 2 showed similarities in accounts of musical awe to those produced by participants in Study 1. Positive emotional appraisals dominated the findings, which mirrored those expressed in Study 1. These findings suggest that musical awe is often reported similarly and may be best understood through analysing commonalities in listeners' judgements. Using previously developed models of cognitive appraisal, these studies demonstrate that musical awe is not a simple phenomenon, and that it may emerge from a variety of situations. These investigations provide a basis for further study into emotional judgements, cognitive appraisals, and musical features that are associated with awe. From the findings of these empirical studies, individual interpretations and generalisations about the emotional phenomenon can now be grounded in real-world experiences.

These exploratory studies were chosen as the first investigations in this research project as part of a holistic approach to unpacking and understanding the psychology of musical awe. Starting from the vantage point of participants' experiences as expressed in their own words moves the study of musical awe into the realm of experience-grounded empiricism. This mode of investigation is important for understanding musical awe because it is a new area of research, and given this novelty, the theoretical claims regarding musical awe should be tested for their appropriateness and accuracy through participant-based research. Throughout this chapter, foundational theories of awe will be applied to individuals' reported experience of musical awe to determine commonalities in such experiences and to provide a high-level overview of how individuals perceive and understand them.

3.2 Supporting research

The concept of awe has been explored through natural and artistic elicitations of wonder, power, and the sublime (see Chapter 2 for an overview of these ideas). Though we use the term 'awe' to describe these experiences in common parlance, there remains no single, strict definition of its characteristics. Awe is often described in relation to other comparable emotions. This broader 'family' of emotions (Sanders & Scherer, 2009, p. 5) includes feelings of being moved, wonder, surprise, and fear. By assessing the shared characteristics of these related feelings, we can move closer to defining and describing experiences of awe in their own terms.

Recent studies in psychology have investigated awe in terms of cognitive appraisal schemes, namely the active and passive judgements made about a stimulus that help to form our emotions (Scherer, Schorr, & Johnstone, 2001). Influenced by emotional appraisal processes, a seminal paper by Dacher Keltner and Jonathan Haidt (2003) proposed a model of awe centred around two specific appraisal criteria: vastness and a need for accommodation (as described in the previous chapter). Within this proposed model, experiences of awe emerge due to the presence of a vast stimulus—that is, a stimulus that is both objectively large and larger than oneself—and is in some sense difficult to comprehend. However, this assessment is not limited to physical size. As an example, '[s]igns of vastness such as loud sounds or shaking ground, and symbolic markers of vast size such as a lavish office can also trigger the sense that one is in the presence of something vast' (Keltner & Haidt, 2003, p. 303). This abstraction of vastness could be applied to sonic stimuli: when the amplitude and pitch of sounds change over time, listeners can perceive a sense of the size of an object (Grassi, Pastore, & Lemaitre, 2013; Hauck & Hetch, 2019), and changes in spectral content, echo and reverberation help orientate the listener in auditory space (Clarke, 2013, pp. 92–93). Music may also be perceived as vast in ways that go beyond its audible sonic characteristics, such as through subjective associations driven by particular lyrical content.[4] The second central appraisal, the need for accommodation, describes the process by which existing mental schemas are altered to adapt to new information (Piaget & Inhelder, 1950/2000). Accommodation brings together concepts of confusion and obscurity found in novel information and prompts the creation of new schemas for their categorisation. Upon successful accommodation, impressions of wonder and enlightenment may be produced, and

[4] The term 'lyrical content' is used here simply to describe the presence of words in music.

contrastingly, fear and terror may result from unsuccessful accommodation.

This duality of awe has been illuminated in investigations of ‘threat-based awe’. For example, in one study, it was found that up to a quarter of experiences of awe are perceived as fearful and threatening (Gordon et al., 2017). However, most instances of awe are thought to be positively valenced (Shiota, Keltner, & Mossman, 2007). The relationship between fear and awe is complicated, as instances of awe are described as eliciting varying levels of fearfulness. This relationship between fear and awe may be explained by a process of fear suppression, where cognitive prediction failures trigger physiological symptoms of fear. However, if these responses are reconceptualised as profound emotions when fear is suppressed, this may yield an experience of awe or other similar reactions (Huron, 2017). Threat was not considered a central appraisal for awe in the Keltner and Haidt model, but rather understood as an ancillary or peripheral appraisal (along with beauty, exceptional ability, virtue, and supernatural causality). Interestingly, threat was also not considered a possible appraisal attributed to music. However, fear-inducing music has been a source of academic inquiry since the 18th century (Mattheson & Harriss, 1739/1981) and contemporary research continues this tradition, with neuroimaging studies exploring the brain pathways and cognitive processes by which music evokes fear (Koelsch et al., 2013). Fear is also a necessary component of awe as described in Vladimir Konečni’s Aesthetic Trinity (2005). This influential framework for awe described the emotion as the primordial aesthetic response to the sublime,[5] composed inherently of both fear and joy (p. 30).

Mixed emotional responses to musical cues may be fundamental in producing awe (Schubert, 2013), and Pilgrim, Norris, and Hackathorn (2017) suggested that a more nuanced

[5] A sublime stimulus is here is defined as a specific, rare, beautiful, and grand object. Notably, the term ‘sublime’ is also used by Huron (2017) to describe the family of similar reactions resulting from fear suppression.

approach to studying musical awe is required. This approach may be found in Alf Gabrielsson's (2011) in-depth interviews on strong experiences with music (SEM). Taken from participant recollections of SEM, commonly reported feelings were:

> Feelings of amazement, astonishment, the person feels taken by surprise, what is around them disappears, one is absorbed by the work of art, there is a change in the experience, it intensifies and becomes stronger than usual, the state is sufficient in itself, moments of total presence. When the experience goes over into a sort of finishing phase, the person is filled with happiness, joy, calm, gratitude, new opportunities open up, new insights take shape. (Gabrielsson, 2011, p. 454)

Although awe is not mentioned directly, 'astonishment' and 'surprise' are expressed explicitly, and these affects are closely related to awe through an expression of novelty. SEM also commonly exhibit multifaceted emotional responses, and musical awe may best be viewed as a specific type of strong experience with music.

Although there is only a small body of psychological research on awe, a systematic investigation into musical awe has not yet been undertaken. Furthermore, components of musical awe have been broadly hypothesised, but specific musical features and characteristics have yet to be explored. These appraisal models are theoretically applicable to all forms of awe, but musical awe has rarely been examined using rigorous methods or empirical evidence. This investigation not only seeks to better understand musical awe as a general phenomenon, but will also assess the appropriateness of these models for its examination. Motivated by the lack of empirical data supporting the proposed models and concepts of awe, this chapter seeks to provide a basis for better understanding musical awe through examining reported experiences of the phenomenon.

3.3 Aims

This chapter begins with the first two empirical investigations of this research project into musical awe. The primary aim of Studies 1 and 2 was to describe accounts of musical awe.

These reports were of musical experiences from recruited participants in Study 1 and of related experiences archived in databases in Study 2. Together, these accounts were analysed to better provide an expansive description of what is shared between, and therefore important, in these reported experiences. To understand these musical experiences, information regarding demographics, settings, musical features, and emotional and cognitive associations were analysed to provide general descriptions of emotional phenomena. Study 1 aimed to probe recollected experiences of musical awe from participants to find generalisable characteristics relating to emotional and cognitive perceptions, settings, and potentially important musical features responsible for an occurrence of awe. Study 2 investigated a collection of writings on musical experiences, and through textual analyses examined commonalities relating to experiences of awe. Together, the two studies aim to provide a high-level description and provide a broad understanding of the phenomenon to serve as a starting point to establish ground truths for the experience of musical awe. With a foundation for future research rooted in human experience, an important transfer from theoretical ideas and into testable and falsifiable empirical explanations can commence. Arising from these studies is a solid foundation for future explorations and investigations into musical awe.

3.4 Study 1: Participant experiences of musical awe

3.4.1 Methods

The following sub-sections outline the procedures and methodology for Study 1.

3.4.1.1 Ethics statement

The study was conducted in full accordance with the University of Oxford’s standards regarding participant-based research. All participants were provided with an information sheet

(Appendix Document 3-1), answered the questionnaire anonymously, and no identifying information was gathered from participants unless volunteered by their answers. Ethical approval was granted to the study prior to participant recruitment, and each participant completed a consent form prior to starting the questionnaire (Ethics Approval Reference: R49154/RE001, Appendix Document 3-2). The collected data were securely handled only by the researcher. Participants were able to elect not to answer any questions with which they felt uncomfortable, and they were free to withdraw their responses at any time during or after the collection of their data.

3.4.1.2 Participants

Seventy adults (36 men, 33 women, and 1 person identifying as non-binary; M_{age} = 36.4, *SD* = 15.5; age range: 18–78) were recruited to participate in the online survey and questionnaire. Anyone over the age of 18 was eligible to participate. Recruitment for participation was expedited through social media communication and university newsletters. Sixty-one participants were native English speakers and eight were non-native speakers. Represented nationalities were predominantly American and British (30 and 28, respectively). Additionally, participants reported a high degree of musical familiarity with a mean value of 14.1 years of musical education and 18.4 hours of music listening per week. One participant was excluded entirely from the analysis as their answers were not properly submitted to the survey site.

3.4.1.3 Materials and procedure

To gather data on participant experiences of musical awe, the study used a modified version of the Geneva Appraisals Questionnaire (GAQ, http://www.affective-sciences.org/researchmaterial). The questionnaire was designed and distributed using the

Bristol Online Survey (now Online Surveys, http://www.onlinsurveys.ac.uk). The modifications to the GAQ added further sections to gather data on complementary appraisal factors and posed free response questions for more general data collection. The first section gathered participants' background data including their age, gender, nationality, country of residence, native language, religion, level of education, years of musical education and/or practice, music listening frequency, and average live music attendance rate.

The second section provided an example of the experience of awe as found in nature using the following language:

> A classical example of awe might be found in nature: the kind of experience you might have after hiking up a mountain and you suddenly arrive at a cliff where you look down from a great height over a beautiful valley.

This prompt was constructed to reflect a common scene used in Western philosophical texts to describe a sublime experience (e.g. Coleridge, 1957). After participants were asked to recall a past musical experience that closely resembled the example provided, questions regarding the occurrence of their experience of musical awe were asked. These included providing a detailed description of the event (the name of the music present, details of the participants' setting, and description of the personal experience), the duration of the experience, time passed since the event, quality of recall, and its general pleasantness.

The third section asked participants to rate components of their experience based on contrastive terms—these terms were constructed from the peripheral appraisals of awe listed by Keltner and Haidt (2003)—using seven-point Likert scales.[6] These components were beauty, threat, supernatural influence, size, virtue, and virtuosity. Participants were also asked in what ways, if any, their experience of musically-induce awe 'changed the way [they] understood the music'. This question was answered through a free response.

[6] Likert scales are multi-point rating scales widely used in survey research to gauge participants' intensity of feeling for a given item.

The fourth and fifth sections asked for ratings of the characteristics of participants' experiences. These included questions on the abruptness with which the emotional experience occurred, predictability, familiarity with the experience, and its meaningfulness. Additionally, participants were asked about any changes in their perception of time, and familiarity or personal connections with the music, occurrence of chills, and lyrical content present in the music at the time.

The sixth section was a free response question that asked about the causation of the event. Participants were asked to describe the musical features that they believed contributed to their experience of awe, any visual imagery present at the time, the behaviour of themselves and others, as well as general factors relating to the causes of musical awe.

Participants were then asked in section seven to rate to what degree their experience of awe affected their engagement with the music and their listening pleasure. This was assessed through seven-point Likert scales. Section eight focused on the intensity and duration of participants' emotional experiences and their reactions to this intensity. The questionnaire concluded with section nine asking participants to rate standard emotional terms on Likert scales to designate each term's suitability in describing their experience of musical awe.

3.4.1.4 Data collection

Seven-point Likert-type psychometric scales were presented for various questions throughout the questionnaire. The endpoints of the scale were explicitly defined each time they were used. As an example, in section three participants were asked to '[e]valuate [their] previously described experience on a scale of 1-7 according to the given criteria' where the opposing terms 'ugly' and 'beautiful' were labelled for '1' and '7', respectively. In many cases the scales were used to assess the level of agreement with a particular statement, such as 'during the event your perception of time slowed down'. Here the end nodes of the scale were labelled ‘not at all’ and ‘extremely’ for ‘1’ and ‘7’, respectively. Such scales are widely used in behavioural research, as they offer participants an appropriate degree of choice and have the advantage of a neutral middle value (4.0). Questions requiring written answers allowed participants to write without a word limit to capture as much information as they were willing to provide. Participants were encouraged to write enough to accurately capture their ideas. Free response data were systematically analysed by way of thematic analysis (Guest, MacQueen, & Namey, 2012) and grounded theory (Glaser & Strauss, 1967) using NVivo 11 software.

3.4.2 Results for Study 1

Analyses focused only on participants who claimed they had experienced awe in response to music. Though 69 participants fully completed the questionnaire, three participants’ answers contained responses claiming never to have experienced musically-induced awe. These responses were therefore not included in the subsequent results. There was a variable number of responses to each question due to participants failing or preferring not to answer certain questions. Gathered data were reclassified into three broad analysis categories to examine elements expressed throughout the questionnaire: experiences of musical awe, appraisals of musical awe, and particular features in the music and setting. The results described below are analyses from psychometric scales and thematic analyses from free response questions.

3.4.2.1 Experiences of musical awe

Statistical and thematic analyses were conducted to ascertain commonalities between participants’ descriptions of musical awe. Multiple questions targeted varying aspects of musical awe and are summarised here to provide general accounts of occurrence, setting, and recollection. Free response questions asking for general descriptions of events, setting, and time were analysed together to provide a comprehensive view of participant responses.

Participants clearly identified the emotional response provided by the prompt and easily recalled experiences to match. Sixty-five participants (96%) claimed to have experienced awe in response to music. Only three participants (4%) reported that they had not experienced musical awe at all. Recollections were mostly from the relatively distant past, with 38 participants (60%) citing an experience from more than a year prior to their report. Only 25 participants (40%) reported an instance of musical awe from the last 12 months. Despite the length of time between the event and its recall, when asked how well the event was remembered, most participants reported vivid memories of the event. When asked of the clarity with which they were able to recall (1 = 'very unclear' and 7 = 'very clear'), the results showed a clear recollection of these memories ($M = 6.03$, $SD = 1.23$).

The settings in which participants experienced musical awe varied greatly, and four encompassing categories were found to be representative of the participants surveyed: concert hall (or similar setting), home, transportation, and other. The largest category contained 34 participants (53%) in which individuals reported being in a concert hall or a similar large acoustically designed performance space. Fourteen participants (22%) cited being at home, commonly reported as isolated alone in their room. Ten participants (16%) reported being in transport, and seven participants (11%) cited various other settings. Notably, the 'other' settings often mentioned being outdoors. Twenty-three (36%) participants surveyed were in a large group of people. An almost equal number of participants, 22 (34%), were in small groups, and 19 participants (30%) reported being alone.

Thirty-four participants (53%) reported a change in their perception of time passing during their experience of musical awe, while only six (9%) did not. Using a 1–7 psychometric scale where 1 = 'not at all' and 7 = 'very much so', participants generally reported more time elongation (M = 4.68, SD = 1.91) than contraction (M = 2.41, SD = 1.76). However, 24 participants (38%) were not certain if they experienced any changed time perception at all. Physiological chills/thrills from the music were reported by 55 participants (85%). When asked of the valence, or pleasantness, of the experiences, participants found these experiences overwhelmingly pleasant, and rated on a 1–7 scale where 1 = 'not at all pleasant' and 7 = 'extremely pleasant' significantly greater than the neutral level of 4.0 (M = 6.42, SD = .96), $t(61) = 19.69$, $p < .001$. When asked about its unpleasantness, participants did not find the experience negatively valenced (M = 1.49, SD = .82) $t(62) = 20.75$, $p < .001$. The speed of the onset of musical awe was not experienced as either gradual (1) or abrupt (7), sitting near the middle of the scale (M = 3.67, SD = 1.99), $t(63) = 1.33$, $p = .19$.

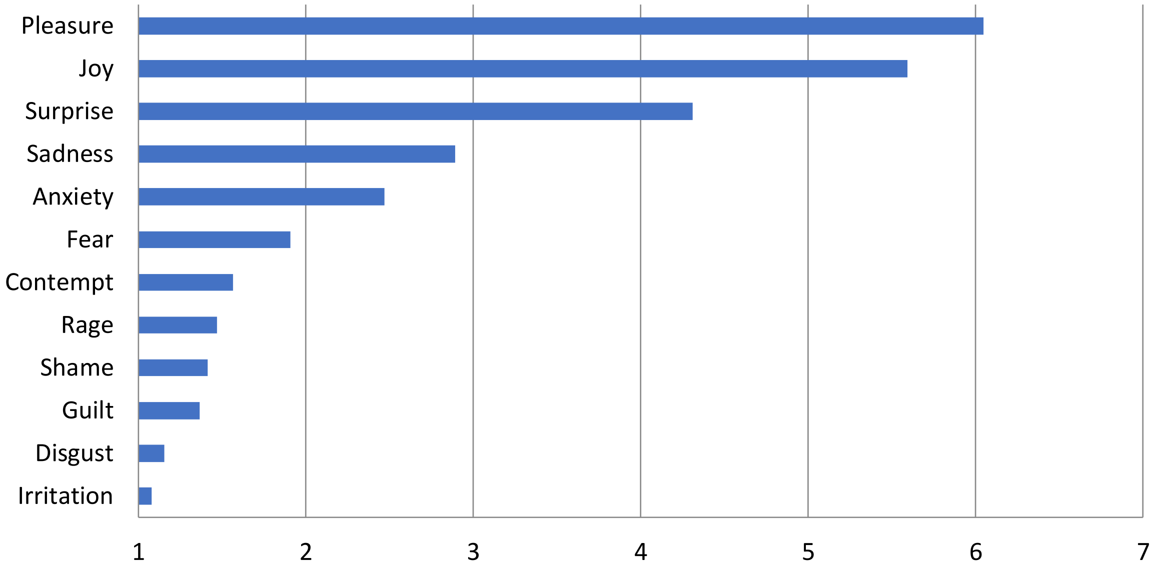
3.4.2.2 Cognitive appraisals of musical awe

The hypothesised central features of vastness and accommodation for musical awe were tested for their association among the participants' experiences, focusing specifically on the process of accommodation in relation to the musical material. Data collected from a seven-point scale were used to investigate the concept of 'vastness' (1 = 'small or tiny' and 7 = 'vast or grand'). A one-sample t-test indicated that perceptions of the musical size were rated as significantly more 'vast or grand' than the neutral level of 4.0 (M = 6.06, SD = 1.57), $t(63) = 10.49$, $p < .001$, $d = 2.64$. To investigate the concept of 'need for accommodation' specifically in relation to music, participants' free response answers were collected and thematically analysed into three categories based on their responses: (1) the event changed the way they experienced and/or understood the music; (2) the event did not change the way they experienced and/or understood the music; (3) unsure if the event changed the way they experienced and/or understood the music. A majority of participants, 43 (75%), reported a change in their experience and/or understanding of the music, while only 12 (21%) reported no substantial alteration in their experience or understanding of the music. Two participants (4%) reported that they were unsure.

To measure the proposed ancillary appraisals that shape experiences of musical awe, seven-point scales were analysed using independent *t*-tests to compare participant responses to neutral ratings of 4.0. For each participant in relation to their chosen awe-inducing music, the test coupled antithetical pairs of terms on opposite ends of the scale. The test compared ‘ugly’ (1) to ‘beautiful’ (7) and found that music was rated as significantly more beautiful than the neutral score ($M = 6.41$, $SD = 1.19$), $t(62) = 16.14$, $p < .001$. Rating music between ‘mundane’ (1) and ‘supernatural’ (7), results showed an inclination to associate with the supernatural greater than the neutral level of 4.0 ($M = 5.59$, $SD = 1.27$), $t(63) = 10.05$, $p < .001$. Music was perceived to be ‘virtuosic’ (7) rather than ‘ordinary’ (1) ($M = 5.95$, $SD = 1.40$), $t(62) = 11.10$, $p < .001$. The test comparing ‘wickedness’ (1) to ‘virtuousness’ (7) found that music was rated as significantly more virtuous than the neutral level of 4.0 ($M = 5.30$, $SD = 1.42$), $t(63) = 7.30$, $p < .001$, $d = 1.84$. Participant ratings for ‘threatening’ (1) and ‘safe’ (7) were significantly weighted towards safe greater than the neutral value of 4.0 ($M = 4.71$, $SD = 1.95$), $t(62) = 2.90$, $p = .005$, $d = 0.74$. However, ratings for safety were not strongly polarized, with a mean rating (4.71) only marginally higher than the neutral level, and effect size suggesting only a medium strength of the phenomenon.

Figure 3-1

Mean participant ratings of emotional terms



Note. Participants associated each term with their experience of musical awe; 1 represented no association and 7 a high association. Emotional terms organised by their mean value. Pleasure, joy, and surprise were all rated higher than the neutral value (4.0).

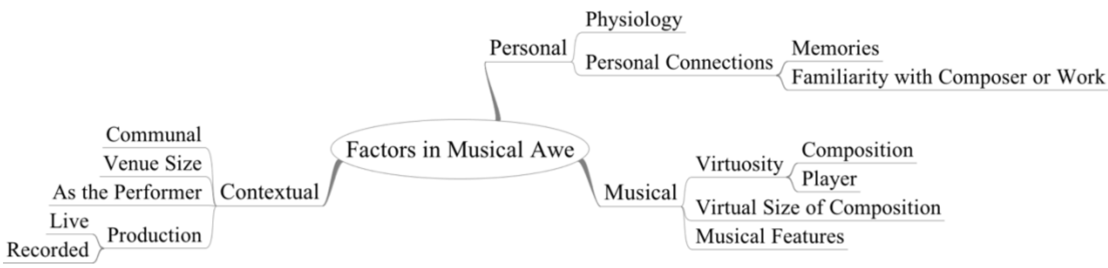
Emotional terms taken from the GAQ (Scherer, 2001) were rated by participants on a 1–7 scale (1 = 'not at all' and 7 = 'extreme') to deduce the general associations to common emotions as shown in Figure 3-1. The words were rated based on how well participants understood them to describe their emotional experience of musical awe. 'Pleasure' was rated as the highest (M = 6.05, SD = 1.44), followed by Joy (M = 5.59, SD = 1.72) and 'surprise' (M = 4.31, SD = 2.10). 'Sadness' was rated higher than other negatively-valenced emotions possibly due to its links with pleasure (Mori & Iwanaga, 2013; Vuoskoski & Eerola, 2017).

3.4.2.3 Factors of musical awe

Using participants' descriptions of awe-inducing musical events, personal connections associated with the music, and what participants thought caused them to experience awe, a systematic thematic analysis yielded three factorial domains that helped to describe and categorise contributing elements of musical awe. An inductive grounded theory methodology as described by Glaser and Strauss (1967) was used to form these factors through coding of participant terms and phrases. Data emerged through categorising and connecting similarly coded content from participants' responses. This analysis, shown in Figure 3-2, presents these as separate factors for analytical purposes, but this is not to imply that these factors act independently; many of the following factors may be dependent on others from different domains but are presented here in their categorical associations.

Figure 3-2

Triadic factors of musical awe



Note. Branch model detailing three factors involved in musical awe: musical, contextual, and personal.

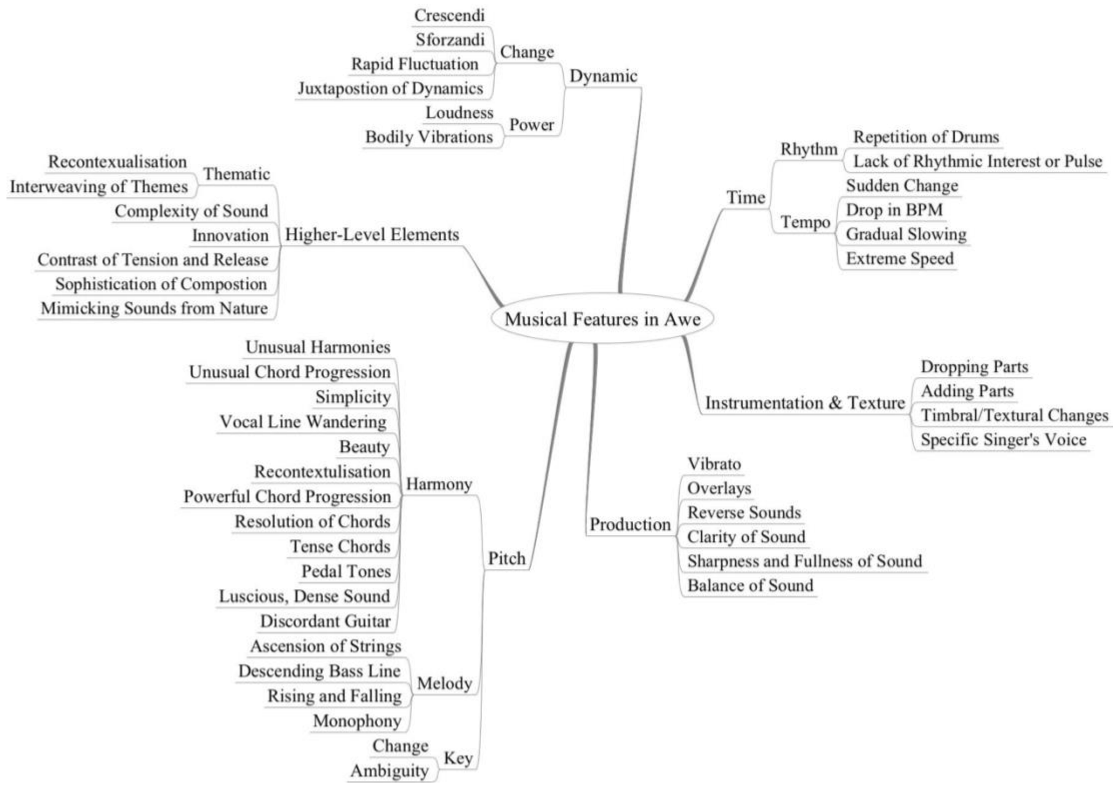
Musical factors describe the factorial domain encompassing the elements involved with the perception and cognition of the music itself. Contextual factors describe the influencing elements found in the setting and environment in which the music was presented. Communal experiences, descriptions of the venue, and acting as the performer can be found in the contextual factor domain. Personal factors describe the domain found within the individual experiencing awe, and may include physiological reactions, personal memories, and familiarity with music. Familiarity with the composer and/or work was a personal factor that was also measured quantitatively. Data collected with a seven-point scale were used to investigate participants' familiarity with the music (1 = 'not familiar' and 7 = 'very familiar'). A one-sample *t*-test indicated that musical familiarity was not rated as significantly different from chance (M = 4.36, SD = 2.36), $t(63) = 1.22$, $p < .228$, $d = 0.31$.

3.4.2.4 Musical features

Participants were asked to describe what they perceived to be the cause of their musical awe experience, and a thematic analysis was conducted to interpret the results. Figure 3-3 depicts a branching visualisation of the constituent elements of reported musical features. These factors were categorisable into six domains: pitch, time, dynamic, instrumentation and texture, production, and higher-level elements. Figure 3-3 illustrates the broad range of possible associations of musical features present in producing a sense of awe. Some of the elements within a category may be in opposition to others, but in the interest of investigating the subject in the broadest possible way, all reported features from participants were listed.

Figure 3-3

Musical features of awe as reported by participants



Note. Branching model of musical features of awe as reported by participants. Features were apportioned into six subcategories: dynamic, time, instrumentation and texture, production, pitch, and higher-level elements.

The subcategory of pitch had the largest number of reported factors and was commonly reported by the participants. Though participants frequently listed factors from multiple subcategories, the number of factors in each subcategory is not representative of the influence of that category in the experience of awe. Figure 3-3 is not weighted for the frequency of responses and simply reported features named by participants. The presence of lyrics, found in the Higher-Level Elements subcategory, was explicitly asked about in the questionnaire. Forty participants (63%) reported the presence of lyrics during their experience of musical awe. Sixteen participants (25%) reported that the content of the lyrics played an important role for musical awe. Many of these lyrics were affective due to the personal connections and memories from individuals.

> I had sang [*sic*] the lyrics while playing the piano for so many years, to hear them live was surreal. **(**Participant 68)

> [The lyrics] were about choosing to die and be released from pain or staying alive. It is how I felt my uncle was feeling as he was dying. (Participant 39)

Not all participants found lyrical content to be an important feature in eliciting musical awe. Fifteen participants (23%) reported that lyrical content had no importance in causing the experience of awe. The reported musical features involved in the experience of awe often differed greatly between participants. Participant 63 cited fast tempo and discordant guitars with unusual chord progressions, in contrast Participant 12 who cited the presence of heavy vibrato, alternation of falsetto, dynamic changes, and vocal approach as features of musical significance.

3.4.3 Summary of findings for Study 1

The participants in Study 1 vividly recalled experiences of musical awe from several years ago in their past. Nearly all of these participants had an experience with music that closely fit the prompt of the study, suggesting that these experiences may be rare but also widely shared, at least within the population studied here. The experience of musical awe described by the participants largely fits with a positively valenced and emotionally moving state. This positive bias reported in the participants' recollections may be due to the positively valenced leanings of the prompt itself. Though individual experiences did differ in their specifics, the experience of pleasantness and chills was widely reported. The results for the GAQ showed ratings for 'pleasure', 'joy', and 'surprise' were the strongest reported associated emotions.

The ratings of several cognitive appraisal questions showed support for many of the theoretical ideas of awe from the work of Keltner and Haidt (2003). Participants reported musical awe as an emotional experience understood as vast—the music involved in these experiences and the emotional experience itself were both conceptualised as vast. The experience of musical awe changed the way participants understood and interacted with the music, suggesting the need for accommodation in their experience of the music. Participants rated the ancillary hedonic criteria largely consistently, describing the music as beautiful, supernatural, virtuosic, and virtuous. The ratings for threat and safety did not show agreement between participants, suggesting that there may be something more complicated in these assessments for musical awe.

The music was not the only factor expressed as important to these experiences of musical awe. Personal factors, including individuals' histories and memories played an important role for many, and environmental factors including the presence of an audience and the effect of the space on the acoustic qualities of the music were also reported. The musical features reported to be influential showed a wide-ranging diversity, both in low-level sonic features of volume (loudness) and timbre and high-level musical features in the sophistication and/or simplicity of the composition. Summarising the influential musical features is not easily expressed, as these experiences were reported from different genres of music, and each may have its own set of important criteria. However, dynamics were commonly mentioned, often reported as significant changes in the intensity of the sounds and their associated power. This association of power and intensity mirrors the same fundamental ideas from the models of awe in both psychology (Keltner and Haidt, 2003; Konečni, 2005; Shapshay, 2021) and philosophy (Burke, 1757/2015; Kant, 1790/1987).

3.5 Study 2: Database explorations of musical awe

3.5.1 Materials and procedure

The findings of Study 1 suggest that experiences of awe may be generally categorisable in a variety of ways. One of those categories is through its association with positive valence and experiencing the music as 'vast', as reported by several of the participants. But do these findings hold for similar experiences in the past and from those not captured through the questionnaire and survey of Study 1? Through an examination of a wider range of musical experiences, a more thorough understanding of musical awe was devised. Study 2 investigated listeners' musical experiences relating to awe and the sublime from a wider range of times and people. It sought to substantiate the findings of Study 1 through an investigation of written texts on experiences of musical awe found in the Listening Experience Database (LED, http://www.open.ac.uk/Arts/LED; Brown et al., 2015). The LED contains a collection of primary written accounts of music listening from all types of music and from any historical period and culture. The database was developed in the United Kingdom by the Open University, Royal College of Music, and the University of Glasgow and went live in 2013. Though the database collected music listening experiences from around the world, British and American listeners constituted the majority of geographically annotated accounts with 3285 and 1103 accounts, respectively. The LED was chosen as the source for investigation because it is an English language-based open-source database with over 11,000 written instances of individuals' experiences of listening to music. A search function queried all instances of the words 'awe' and 'sublime' and from the database 84 texts were selected (29 texts contained the term 'awe' and 55 contained the term 'sublime'). These texts were used as the data for Study 2. Unlike Study 1, Study 2 did not have direct access to the participants and could therefore only examine the language used in these musical listening accounts. To explore these texts, several natural language processing (NLP) techniques were used to detail the language in the texts and to examine the sentiments expressed by the authors.

This NLP investigation into the texts used the Natural Language Toolkit (NLTK; Bird, Klein, & Loper, 2009) to calculate word frequencies and parts of speech. NLTK is a Python-based toolkit commonly used in academic research relating to computational linguistics for exploring text-based data (Hardeniya et al., 2016). The Valence Aware Dictionary for sEntiment [*sic*] Reasoning (VADER; Hutto & Gilbert, 2014) is an R programming package commonly used in sentiment analysis and was applied here to determine the associated valences of the texts. A standard list of stop words (e.g. ‘a’, ‘an’, ‘and’, and ‘the’) were isolated from NLP calculation to exclude commonly used words from the frequency calculations, and the results of these procedures are reported in the following section.

3.5.2 Results for Study 2

The source texts varied in length with an average word length of 186.79 words (*SD* = 140.35) for awe-related texts and 247.05 words (*SD* = 274.12) for sublime-related texts. To explore these texts for commonalities in language, word frequencies were calculated for the two queried groups (awe and sublime) using the NLTK. The toolkit counted each instance of all words in the texts, and additionally made a second list of only adjectives found in the text. These results derived the most common words throughout the texts, and these words were then compared between the awe-associated and sublime-associated texts. The results showed that for awe-associated texts, the highest frequencies of other words were ‘music’, ‘Beethoven’, ‘great’, ‘played’, ‘time’, ‘hall’, ‘piano’, and ‘orchestra’. For sublime-associate texts, the most common words were ‘music’, ‘great’, ‘heard’, ‘sung’, ‘time’, ‘church’, ‘effect’, choir’, and ‘orchestra’. The adjective frequencies were used to distil some of the general attitudes of the authors and examine the valence expressed in the texts. These revealed a large proportion of positive sentiments expressed from both the awe-associated and sublime-associated texts. Finally, to examine the similarities between the awe- and sublime-associated texts, the NLTK calculated the frequencies for the intersection of terms. This procedure compared the language between the two text categories and reported which words were used most across the two. ‘Music’, ‘great’, ‘Beethoven’, ‘time’, and ‘orchestra’ were the terms with the highest intersectional frequency. Using the same procedure, the intersection of adjectives showed a high incidence for positively valenced terms—‘great’, ‘good’, ‘grand’, and ‘orchestral’. The results of these six explorations can be seen in Table 3-1.

Table 3-1

Word frequencies and intersections of terms

Awe word frequencies		Sublime word frequencies		Awe adjectives		Sublime adjectives		Intersection of all terms		Intersection of adjectives	
awe	29	music	62	great	14	sublime	43	music	18	great	14
music	18	sublime	58	awe	11	great	35	great	14	good	9
Beethoven	14	great	35	young	9	good	21	Beethoven	14	grand	9
great	14	heard	30	good	9	musical	21	time	13	orchestral	7
played	13	sung	28	grand	9	orchestra	18	orchestra	12	present	6
time	13	time	26	orchestra	7	fine	18	heard	10	musical	6
hall	13	church	26	present	6	full	17	man	9	full	4
piano	13	effect	26	musical	6	grand	15	concert	9	light	4
orchestra	12	choir	24	deep	6	beautiful	11	good	9	young	3
festival	12	orchestra	23	solemn	4	perfect	11	grand	9	large	3
concert	11	voice	22	full	4			playing	8	Italian	3
playing	11	good	22	fourth	4			played	8	hear	3
man	11							moment	7	wonderful	3
heard	10							audience	7		
Liszt	10							solemn	6		
grand	9							room	6		
remember	9							performance	6		
good	9							present	6		
								musical	6		
								present	6		
								musical	6		
								hear	6		

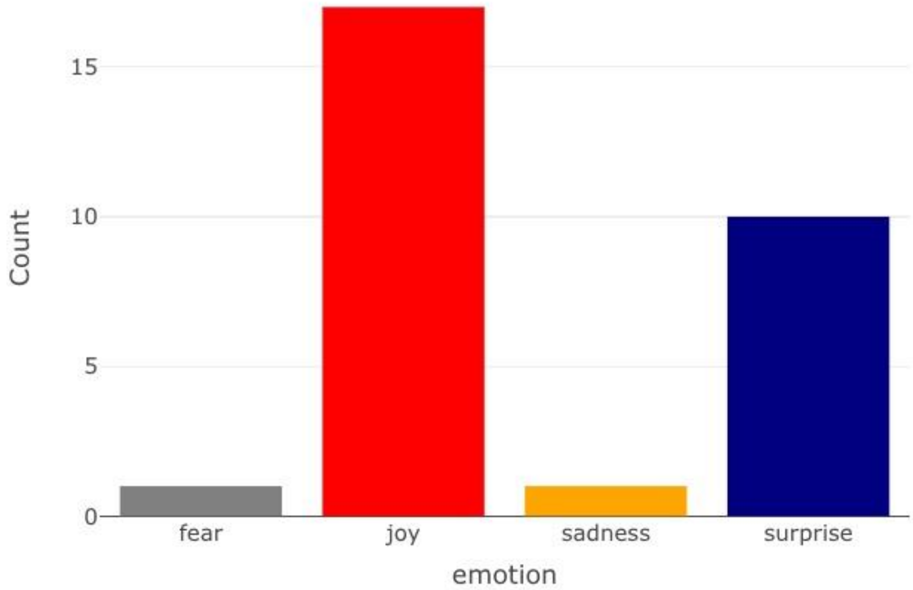
The results of the word frequency exploration suggest that there were many positive sentiments regularly expressed throughout the selected texts. In turn, it would be reasonable to conclude that the musical listening experiences related to awe were generally understood as positive events by the authors. However, only examining word frequencies in a collection of texts may lead to an incorrect generalisation of the sentiments expressed therein. For example, the negation of words through expressions like ‘not great’ would still register as containing the word ‘great’ and be added to the total count of positively valenced terms. To counter these potential biases in text exploration, the use of sentiment analysis techniques can incorporate a more sophisticated set of language-based rules to determine more accurately which sentiments are being expressed through the texts (Feldman, 2013).

3.5.2.1 LED sentiment analyses

To explore the language of the texts further and to examine the initial valence findings of Study 2, a sentiment analysis was performed on the texts using the VADER R package and the Canadian National Research Council (NRC) Emotion Lexicon (Mohammad & Turney, 2010; Mohammad & Turney, 2013). This statistical package is designed to determine the quantity and frequency of emotionally relevant sentiments in the extracted texts by finding emotionally related words to a gold-standard participant-based lexicon of established sentiments. By examining each text and generating its expressed emotion, an understanding of the emotion-relevant idea for awe and the sublime was explored. Examining the awe-associated texts first, the sentiment analysis showed that most of the texts (58%) expressed predominantly joy-related sentiments, and a significant number of the texts (34%) expressed surprise as their main emotion. Figure 3-4 illustrates these findings.

Figure 3-4

Emotional categorisation of awe-associated LED texts

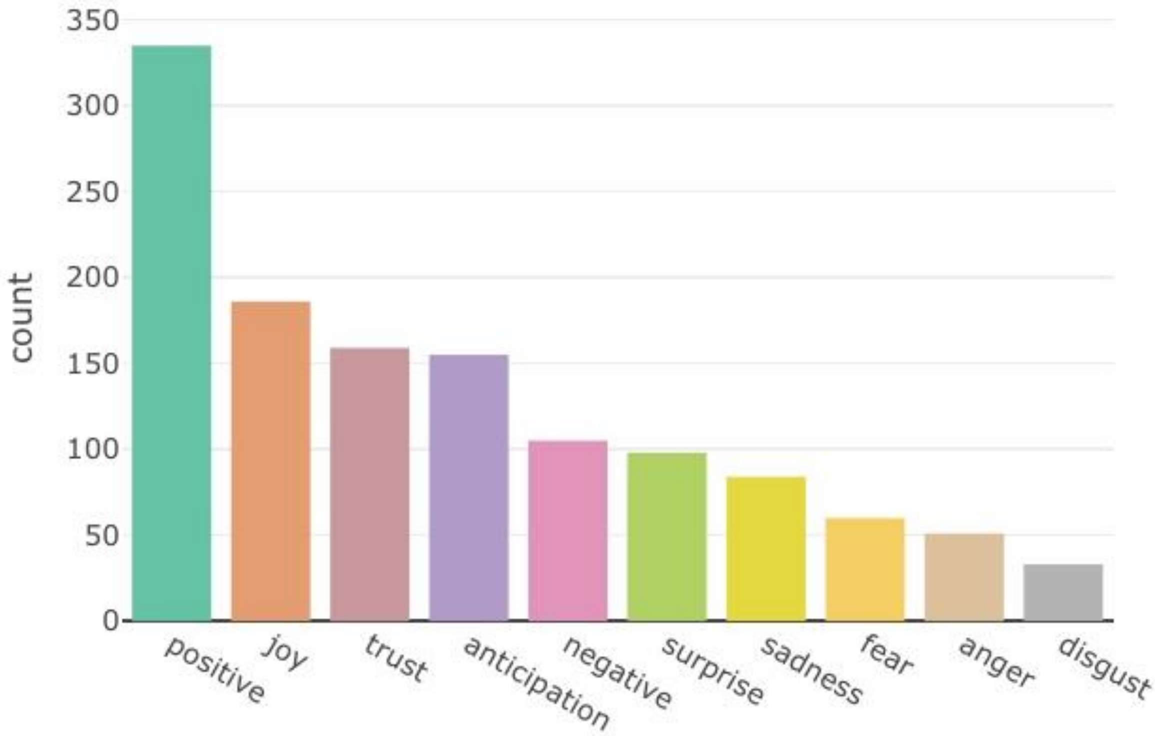


Note. A histogram for the sentiment analysis calculations showing that most of the awe-associated texts contain primarily positive valenced emotions of joy (58%) or surprise (34%). Only two texts expressed negatively valenced emotions of fear (3%) and sadness (3%).

A more descriptive sentiment analysis was performed that examined the total number of emotionally salient expressions found throughout the awe-associated texts. This resulted in a total of 1266 instances, labelled as sentiments (positive and negative) and emotions (joy, trust, anticipation, surprise, sadness, fear, anger, and disgust). The results showed that positive sentiments (335) were the most common finding and that emotions of ‘joy’, ‘trust’, and ‘anticipation’ were also found in large numbers, with totals of 186, 159, and 155, respectively. Figure 3-5 illustrates these results.

Figure 3-5

Distribution of emotional sentiments in awe-associated LED texts

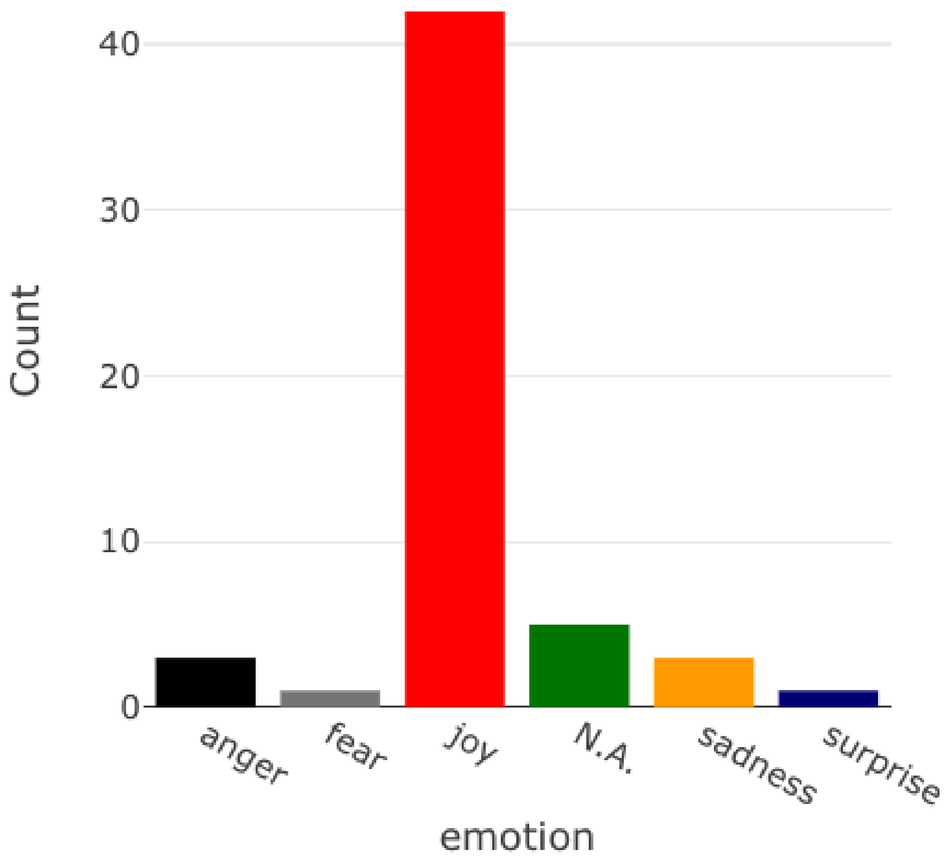


Note. The NRC designated emotions categories based on the basic emotion theory (Ekman, 1992; Ekman & Friesen, 1975, 1978;) and Plutchik's *Wheel of Emotions* (1980). The distribution for emotions expressed throughout the texts is largely positively valenced, with positive sentiments occurring three times as frequently as negative occurrences.

The same procedure detailed above was performed on the sublime-associated texts. The data showed similar results, with joy (42, 76%) being the dominant emotion expressed by the majority of the sublime-associated texts. Noticeably, in the sublime texts, surprise was much less frequent, with only one text (2%) having it as its main sentiment. The distribution of all sentiments and emotions found in the sublime-associated texts also showed a trend similar to that of the awe-associated texts, with the frequency of positive sentiments (845) towering above those of negative sentiments (269). Frequencies for the emotions of 'trust' (416), and ‘anticipation’ (334) followed that of ‘joy’ (429) in approximately the same proportion as they were found in the awe-associated texts. Figures 3-6 and 3-7 illustrate these findings.

Figure 3-6

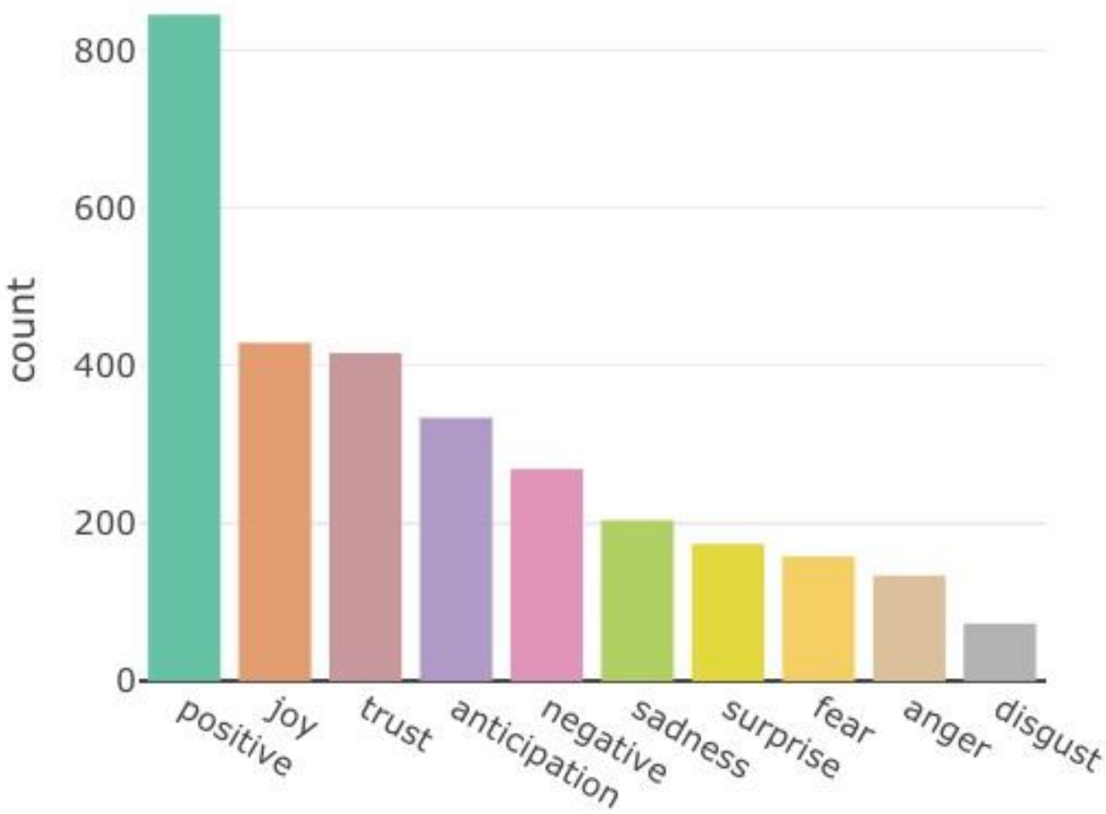
Emotional categorisation of sublime-associated LED texts



Note. Joy was the most frequent sentiment expressed by the sublime-associated texts in the LED with 42 of the 55 texts (76%) identified as primarily expressing the emotion. All other emotions (apart from the five listed were found so infrequently that the non-applicable (N.A.) categorisation was the second highest category summarising five texts (9%). Only three texts primarily expressed sadness and anger, and fear and surprise were expressed as the main emotions from single texts.

Figure 3-7

Distribution of emotional sentiments in sublime-associated LED texts



Note. The distribution of emotions expressed in the sublime-associated texts of the LED. One notable difference between the two LED groups is that sublime-associated texts show a reduced frequency of surprise-related sentiments.

The battery of sentiment analyses showed that there are chiefly positive sentiments and emotions expressed by listeners who experience feelings of awe and the sublime. Both awe- and sublime-associated texts in the LED were found to have similar patterns of sentiments and emotions but differed in their occurrence of surprise. Positive sentiments dramatically outweighed those of negative sentiments and joy was the most common emotion expressed in the LED texts. These results are consistent with the findings of Study 1.

3.5.2.2 LED qualitative example

Examining word frequencies and implementing sophisticated statistical packages to deduce overarching trends for a large volume of text provides a broad, high-level analysis, but through qualitative examination of the awe-associated texts of the LED, a complementary and more intimate understanding of musical awe experiences may be obtained. This subsection examined one particularly insightful text found in the LED to uncover some of the relevant and more nuanced ideas applicable to an understanding of musical awe. It is important to mention that not all of the LED texts contained a high level of detail in their expressions of awe. The following excerpt is found in *A Genius in the Family* where Hilary du Pré recounts hearing her mother on the radio.

> My earliest memories of music are of listening to Mum's broadcasts. The wireless was on the sideboard and I remember Gran's obvious excitement as she hoisted me in her arms and gently settled me next to it. 'Come on Hilary, we're going to listen to Mummy playing the piano.' Gran hushed me when the announcer said: 'Today's recital will be given by a young English pianist, Iris Greep, in a programme including Bach, Schumann and Brahms.' Listening to Mum on the wireless was a constant source of wonder to me: I knew it was important, and I knew it was Mum playing as I had heard her practising those pieces many times before. Sometimes I could hear her breathing, some breaths deeper and noisier than others. Everything in house came to a standstill and I was aware of a sense of almost holy awe. Gran sat completely still in the chair. I wondered how on earth Mum and the piano could fit inside such a small box, a thought that puzzled me for years. She seemed so close to me that I expected to see her climb out of the wireless when she had finished. (du Pré & du Pré, 1997, p. 9)

In this extract, several important ideas are expressed by the author that provide experiential evidence to the environmental influences and cognitive appraisals important in the experience of musical awe. The term 'wonder' is used twice, both connected with the technological marvel of the radio. Somehow, almost if by magic, the sounds of her mother and her piano playing are being broadcast through a small box, and this made no sense to a young child. Finally, the size of the radio added to the wondrous sentiments—how could an object so small house her mother and a piano? This speaks to a sense of mystery of the unknown, the reverence for which is not fully understood, and a need for accommodation. The second important idea expressed was the sense of importance of the event. The act of listening to the radio was set aside from normal activities of the day and explicitly understood as something that was *special*. The third idea was the role of family and human connection being a significant feature, as this event would not have carried the same weight without knowing that it was her mother on the radio. The fourth idea was that of 'stillness', mentioned twice in the excerpt—that the house came to a standstill and that her grandmother 'sat completely still'. This listening experience seemed to have culminated in a quasi-religious experience where all the child's attention was being paid to the sounds on the radio, and the world around her was frozen, ushering in a sense of 'holy awe'.

These attributes seem to have played an important role in the emotional experience, but are they consistent with the appraisal criteria hypothesised in theoretical frameworks for awe? It is not immediately apparent how Keltner and Haidt's (2003) principal appraisals of vastness and accommodation can be used to interpret this account, but there are nonetheless some interesting parallels. Importantly, the text does not detail the author's thoughts on the music itself but focuses on the environmental features of the event. Through these details, parallels to cognitive appraisals can be drawn. Vastness can be understood as the child's sense of importance of the event, and the fact of her mother being on the radio was a prominent event in the household, this could be interpreted as a kind of socially-informed vastness (Keltner & Haidt, 2003, p. 303). More clearly, the need for accommodation is more openly demonstrated. The familiar sounds of her mother's piano playing are juxtaposed with her incomprehension of how they were coming through the radio, and this confusion can be understood as part of a process of accommodation.

Similar ideas can be found in the sublime-associated texts, especially those of positive experiences, religious associations, and a relation to perfection. But importantly, the expressions of wonder and astonishment are absent in the sublime-associated texts, suggesting this may be a meaningful way in which these two descriptions of musical experiences differ.

3.5.3 Summary of findings for Study 2

The results from Study 2 showed that accounts of musical awe share commonalities with those of sublime musical experiences. The terminology used in the LED point toward positive experiences of joy being the dominant emotional expressions for awe- and sublime-associated texts. These findings mirror those found in Study 1, with 'joy' and 'pleasure' being the highest rated emotional terms for associating with past experiences of musical awe. An important differentiation was found in the expression of surprise and wonder: awe-associated texts had higher ratings for expressions of surprise than sublime-associated texts, and this can be interpreted as an increased need for accommodation (as detailed in the previous section). With these expressions of surprise, musical awe may be understood as a reaction to the sublime and fit into Vladimir Konečni's description of aesthetic awe as 'the primordial and prototypic human responses to the sublime (2005, p. 28).

3.6 Discussion

The retrospective nature of the questionnaire presented some problems and limitations for Study 1. Even with the claim of high levels of clarity for the recollection of the reported events and of the experiences of musical awe, certain responses were limited by participants' memories. In enquiring about past experiences, it may not be appropriate to expect that the details of events and experiences can be comprehensively and meticulously reported. Similar limitations apply to Study 2, as the LED texts are primarily accounts of listening experiences based on memories of events and feelings—often from years ago—and it is to be expected that many details are absent. Furthermore, the antithetical terms for ancillary appraisals developed by the researcher (e.g. ‘small or tiny’ and ‘vast or grand’) may not be perfectly precise in detailing the expression of the ideas, but the conventions and common language used function as a substantive method to capture concepts accurate enough to investigate the hypothesised general appraisals. Nonetheless these data provide a starting point for further investigations. Though reported experiences may require a more individualistic approach (e.g. interview methods) to capture the full richness of the phenomenon, the spirit of their content has been revealed through Studies 1 and 2 and provides several key findings of the emotional and psychological processes involved in musical awe.

3.6.1 Characterisation of musical awe

One fundamental starting point for this research into musical awe was to detail its incidence in a sampled population. Is musical awe only experienced by few people in particular circumstances, or is it better understood as a more pervasive or universal phenomenon? Though the data are mostly representative of American and British avid music listeners, in these communities it seems that musical awe is an experience that is at least pervasive enough to be considered a near-ubiquitous phenomenon for those who participated in Study 1. If one were to examine the database in Study 2, musical awe, i.e. explicit mentions of the term, were rarely reported, as only 29 texts in the 11,000 item database contained that specific term. It has been thought that the emotion of awe is a universal phenomenon, and this study suggests that musical awe may indeed be a very widespread experience from those who purposefully engage with music. However, this does not suggest that musical awe is a frequently occurring emotional phenomenon whilst listening to music. Recollected experiences of awe were reported over a year from their occurrence, and the rarity of the experiences parallel those found within the research on strong experiences with music (Gabrielsson, 2011). Though the sample sizes used in Studies 1 and 2 were too small to draw comprehensive conclusions, these findings do suggest that musical awe is a rarely occurring phenomenon which is nonetheless experienced by many avid music listeners.

The settings in which musical awe occurred were varied, but the majority cited concert hall-like venues while also in the presence of other people. Konečni (2005) claimed that music that produces awe must be ‘colossal’, and that this is only achieved by experiencing music in ‘vast architectural spaces that have not only excellent acoustic qualities but are also of extraordinary beauty’ (p. 37). The data do not fully support this claim; instead, a more representative model describing these settings would incorporate large acoustic performance spaces as a contributing element that aids in musical awe but is not a necessary condition. It should also be noted that many musical features present during experiences of awe are well suited for large concert halls, while certain other features may be better realised in more intimate settings. Isolation and solitary listening were also reported as settings in which participants experienced musical awe. These instances may be best understood as examples of ‘deep listening’, when one is powerfully engaged by strongly emotion-producing music (Becker, 2004).

In Study 1 there was no evidence of subjective time alteration during experiences of musical awe. This is likely due to the difficulty in recalling this element in retrospect, and in future may be better explored in an experimental (live listening) setting. Another difficulty in participant reporting can also be seen in the ratings for the onset of awe. Again, retrospective self-reports may not have produced clear results due to the difficulty of recalling such specific, time-bound properties after a significant passage of time. Chills were recalled by most participants suggesting a strong relationship between physiological features and the experience of awe. Again, it was hypothesised in Konečni’s (2005) Aesthetic Trinity that chills were compulsory for the experience of aesthetic awe, as chills are viewed as a prevalent physiological component of the closely related experience of ‘being moved’ (Scherer &

Zentner, 2001, p. 363). Study 1's general ratings for pleasantness suggest that musical awe is an overwhelmingly positive experience. This positive bias was also found in Study 2 and suggests that musical awe may be understood as a largely positive experience, or that reports of positively valenced musical awe are simply more commonly expressed than those of negative valence. This finding may seem surprising due to awe's relationship with fear and power, but the association with fear may only be present in the threat-based variant of awe (Gordon et al., 2017), and associations with power are not inherently negative. Additionally, it might be expected that retrospective reports detailing experiences of music are biased to be positively valenced due to negative emotions being socially undesirable (Berinsky, 2004; McDermott, 2007). The prompt given to participants in Study 1 used the term 'beautiful' to describe the valley one might look upon after ascending a mountain. This specific framing may have biased participants to report positively valenced musical awe experiences more regularly than negative experiences than if the prompt had used more neutral language. In subsequent studies in this project, the word 'beautiful' was omitted from participant prompts to achieve a more neutral use of language.

The results from Study 2 help to provide data in establishing awe as a reaction to sublime experiences. With recent research comparing experiences of awe and the sublime (Aracangeli et al., 2020), several possible relationships between the two states were hypothesised. As the data from Study 2 revealed similar sentiments and emotions expressed, the relationship between the two may be best understood as functionally of the same kind, with awe and sublime experiences seemingly only differing in their expression of surprise.

3.6.2 Appraisals and components of musical awe

Vastness appeared to be the most common element reported in general descriptions of events and the quantitative data. The concept of vastness in music was expressed in several ways and could aid in the explanation of several musical factors and features listed in the Figures 3-2 and 3-3. Contextual factors relate to the experience of musical awe by virtue of the size and space of the venue, among other considerations. Here vastness can be seen in large concert halls, outdoor festivals, and the size of the audience present during a performance.

> About halfway through the song, all instrumentation drops out except for drums and a unison yell that rushes into a raucous riff. That moment was pure ecstasy. Not just for me, I think most of the crowd experienced it as well. Which is what made the moment so powerful. (Participant 9)

Each of these factors in a given setting may affect one’s perception of size and cause one to feel small in comparison. Looking specifically at the virtual size of a composition and its musical features, ideas of vastness are again present. Musical features that incorporate ideas of vastness are found in each subcategory listed in Figure 3-3, and are especially evident in the dynamic features (e.g. crescendi and loudness leading to bodily resonance and vibration), with their association between amplitude and size (Grassi, Pastor, & Lemaitre, 2013). The description of pitch features including ‘powerful [sounding] chord progressions’ and ‘luscious, dense sound’ refer to a perceived fullness of sound. This fullness of sound is related to its virtual size through the presence of multiple sources. For example, an orchestral crescendo with many parts being played simultaneously that create complex chords might understandably be perceived as vast, even to the point, as Participant 29 reported, of being ‘engulfed in the music’.

Vastness was seen to have strong and clearly demonstrated connections with the experience of musical awe, the other central appraisal, a need for accommodation, required further interpretation to assess its experiential prominence. In the questionnaire, accommodation was recontextualised as a ‘change[] in the way [participants] understood the music’. This rephrasing of accommodation poses difficulties for a direct assessment of accommodation due to language used, as the questionnaire only captured one way in which accommodation may have been involved. Nevertheless, by reframing accommodation in this way, results from Study 1 suggested that a form of accommodation was present in the majority of experiences of musical awe. Participants also expressed feelings of inspiration from the new way that the music was experienced. Accommodation may be viewed through a wider lens, one that views changing existing schemas inside and outside the musical materials, as detailed in Section 3.5.2.2's qualitative assessment of 'wonder'. The feeling of awe itself may be what requires accommodation, that it is the affective component of the emotion that may present a cognitive dissonance between the internal stirrings of the body and the incomprehension of the music. Accommodation processes may also be seen in cases where the listener merges with the music itself as a transcendent act (see Gabrielsson & Bradbury, 2011).

In the Keltner and Haidt (2003) theoretical model of awe, the only peripheral or ancillary appraisals specific to musical awe were thought to be beauty and ability/virtuosity. However, Study 1 found that appraisals for supernatural causation and virtuousness were also important due to their strong reported associations. Their addition to an appraisal framework is not without precedent, as music's relation to the supernatural has been explored across cultures and through time (e.g. McClelland, 2013; O'Keefe, 1996). Assessing all the ancillary appraisals in this study, musical awe was reported as beautiful, skilful, virtuosic, supernatural, and virtuous. And the ratings of general emotional terms unsurprisingly echoed similar positively-valenced terms: pleasure, joy, and surprise were the terms rated with mean values over the neutral midpoint. These expressions were also seen in the sentiment analyses from Study 2. These results are consistent with the idea of successful accommodation of musical information producing pleasant feelings in the listener.

The diverse features of musical awe reported by participants indicate that awe may arise in a variety of musical styles through different means. Some of these features can be attributed to aspects of unexpectedness found in the composition (e.g. sforzandi, juxtaposition of dynamics and themes, etc.). Other features reflect the conceptual beauty of the music, as was often reported by the participants (e.g. clarity and balance of sound, beautiful harmonies). The musical features listed in Figure 3-3 are best viewed as potential ingredients for the experience of musical awe. Contradictory features may appear in the same subcategory (e.g. gradual slowing of tempo and extreme speed), and certain combinations of features may be more represented in a population. The mixture of ‘discordant guitars’ and ‘extreme speed’ were reported musical features that may have implied a threat-variant of awe, but the presence of threat and other negatively-valenced emotions were also seen in the power dynamics between the performer and the audience.

> Awareness of [the] immense space of the venue, as the strings expanded to fill it—as if it was the only sound there…the sustained but crescendoing strings... It was incredible, I suppose, because I was so used to hearing the music in the inner spaces of my head (via headphones) and not in this huge environment. Suddenly it was something so much bigger than me, something I shared in communion with so many other people. As if worshipping at some kind of ritualistic altar, all stood in the dark watching this small lit-up figure amidst a sea of sound. (Participant 58)

The quote from Participant 58 demonstrates that the musical features likely work in tandem with contextual factors and personal factors to produce the complex emotion of awe.

There is also a more culturally contingent point for this chapter’s discussion in that the idea of musical awe being probed in these studies is based on a Western conception of philosophy and aesthetics, and therefore the prompt that was used in Study 1 provides an example of awe that only accounts for one specific kind of musical awe. The prompt provided described climbing a mountain and looking down over a valley. This was derived from the type of potentially sublime-inducing situation that is typically used in Western philosophical writings. Using this prompt to examine recollective memory does not easily allow for experiences of musical awe that do not fit well within a Western understanding of awe and the sublime. Outside of the Western conception of musical awe, there may be further types of experiences of musical awe that are not accounted for (nor actively pursued) in the first Study. Since the research undertaken in this thesis makes no attempt to adopt a cross-cultural approach, the results should be seen in context of the narrower cultural boundaries implemented by a Western, Eurocentric understanding of musical awe experiences.

3.6.3 Conclusion

The conclusions drawn from the questionnaire in Study 1 and the general analyses in Study 2 should be viewed as a springboard for the rest of the research project, as they provide the basis for further, more focused research. The data gathered in the study provide an empirical basis from which to design more specific perceptual experiments. It is apparent that musical awe is a topic suitable for further empirical research as seen by the richness of data produced from an online questionnaire. From exploring participants' experiences in this study, musical awe can be understood as a particular type of strong experience with music (Gabrielsson, 2011) that shares many features with being moved (Menninghaus et al., 2015) and creates intense emotions in the listener through an encounter with an idea of vastness and power. This perception of vastness and its accommodation are the primary concepts that distinguish awe from other emotional responses to music. This extends to the differences between sublime- and awe-associated experiences in Study 2. The specific outcome of this accommodation may dictate or influence the hedonic tone of musical awe; however, musical awe tends to be reported as exceptionally pleasurable and joyful. By what mechanisms these outcomes are determined remains an open question, but the mediating effects of contextual and personal factors clearly play a significant role. With somewhat generous interpretations of vastness and accommodation, the Keltner and Haidt (2003) framework can be applied to individual characteristics of musical awe, and in general commonalities were found in participants' responses for the proposed peripheral appraisals and emotional term associations. This suggests that musical awe was generally experienced similarly between participants and is largely consistent with the components of the proposed framework.

With the general data gathered from the questionnaire and database exploration on various emotional and conceptual aspects of musical awe, this chapter has elaborated on the possible mechanisms and effects of musical awe for the listener. Commonalities of experience as detailed in this chapter provide a general understanding of reports of the phenomenon of awe. Nonetheless there is a broad diversity of music associated with musical awe, and how that music is perceived is the focus for the following chapters. From this initial study it appears that the perception of large musical size and positive valence are strongly associated with these experiences. But to what extent are the musical and sonic features responsible for these perceptions? Are the experiences of musical awe primarily due to the music and its intrinsic features, or are the environments and individuals predominately responsible for accounts of awe? As predicted in psychological frameworks and reported by participants themselves, the sonic qualities of the music itself have a significant role in awe and deserve to be explored further. The following studies in this project take the foundations established in the previous chapter and test several components for perceptual ideas to establish a music-centred exploration of musical awe. This includes using the music mentioned in Study 1 by participants and testing it for a variety of associations. This approach will examine which features are influential in the relationship between size and musical features, and are therefore important for musical awe. The combination of these studies ultimately seeks to construct a more comprehensive model of musical awe that explains these rare and powerful emotional experiences.

4 Studies 3, 4, and 5: Perceptual investigations into emotional and appraisal components of musical awe

4.1 Introduction

This chapter presents an investigation into listeners' emotional judgements of music excerpts that relate to experiences of awe. Designed in three studies, this chapter seeks to understand the relationship between a musical corpus comprising examples that have been established as relating to musical awe (see Chapter 3), images with associated valence components, a battery of emotional terms, and terms associated with cognitive appraisals. The chapter is influenced by recent research into the psychology of awe that has provided some of the first empirical investigations into threat-based variants of awe (e.g. Gordon et al., 2017). These studies found that experiences of awe are largely divisible into two categories based on valence: intrinsically positive or negative assessments of events. This chapter applies the findings of the existing research—namely, that experiences of awe are often diverse, yet categorisable based on valence—to the phenomenon of musical awe, examining whether the positive and negative associations of awe reported in relation to other modalities of experience apply to cases of musical awe.

All three studies in this chapter used an online within-subjects design in which each participant was required to answer all questions. The first study asked participants (N = 71) to rate two images for their appropriateness to music found in the Musical Awe Corpus (MAC), a collection of awe-related music excerpts identified in Study 1 (see Chapter 3, Section 3.4). The two images depicted awe-eliciting situations in nature, namely the aurora borealis and a supercell thunderstorm, and were drawn directly from an existing study (Gordon et al., 2017). These images were used as prompts for two opposing valence-based versions of awe: positive and negative. The second study in this chapter asked participants (*N* = 50) to rate a battery of twelve emotional terms for their appropriateness to the musical excerpts. The terms presented were 'amazement', 'anger', 'anxiety', 'awe', 'distress', 'fear', 'happiness', 'nervousness', 'joy', 'sadness', 'warmth/tenderness', and 'wonder'. As with the images in Study 3, this list of terms was drawn directly from a previous study (Gordon et al., 2017), which sought to assess recalled personal memories of awe-like experiences. By using these terms, the studies presented in this chapter represent a continuation of previous research in the study of awe, applied here to cases of musical awe. The final study reported in this chapter (Study 5) is similar in format to Study 4 in that it asked participants (*N* = 51) to rate specific appraisal-based terms on their appropriateness to music drawn from the MAC. The terms presented were based on Keltner and Haidt's (2003) central and peripheral cognitive appraisals listed in their theoretical framework for awe: 'beautiful', 'powerful', 'skilful', 'supernatural', 'threatening', 'vast', and 'virtuous'. Study 5 aimed to test these theoretical associations with awe to examine if those terms were appropriate and meaningful when applied to music associated with experiences of awe. Later in the chapter, the findings of the three studies are analysed and distilled into a cohesive account of the judgements and perceptions of awe-related music, leading to conclusions about emotional and perceptual ideas associated with awe-related music, and informing the studies reported in subsequent chapters by establishing valence-based categories for more targeted investigation.

4.2 Supporting research

4.2.1 Awe as a multi-valenced emotion

Previous chapters have explained in detail the complexity of musical awe and its relationship to valence—the 'goodness' or attractiveness of a situation or event (Frijda, 1986,

p. 207)—and are restated here for clarity. Colloquially, experiences of awe are understood to be overwhelming and powerful, but they also are understood to be positively valenced. This understanding of awe resembles a classical depiction of the emotion, one that embraces beauty and wonderment. These positive appraisals are also common in contemporary reporting of experiences of awe: the results from Study 1 showed that most experiences of musical awe were reported positively (see Chapter 3 for a full description). However, some of the seminal writings on awe and the sublime, notably from Edmund Burke (1757/2015), have suggested that the experience of awe may take two forms: one of beauty and serenity and the other of fear and terror. The philosopher Immanuel Kant (1764/2011) also described the sublime in multiple permutations: noble, splendid, and terrifying. With this foundation, most psychological investigations on the experience of awe have been focused on only the positive side of the emotion (Campos et al., 2013; Rudd, Vohs, & Aaker, 2012; Shiota, Keltner, & John, 2006; Shiota, Keltner, & Mossman, 2007; Valdesolo & Graham, 2014; Van Cappellen & Saroglou, 2012), and only recently has psychological research explored the negatively valenced variant of awe (Gordon et al., 2017; Piff et al., 2015; Vohs & Aaker, 2012). These recent examinations of awe investigated the emotion as a complex experience, where some of the instances had features in common with other negatively valenced emotional states, like fear and threat.

Though empirical research into the multi-valenced nature of awe is relatively new (e.g. Gordon et al., 2017), psychological frameworks have long suggested that awe may be multi-valenced and associated with fear and dread (Keltner & Haidt, 2003, p. 297; Lazarus, 1991b; Smith, Tong, & Ellsworth, 2014). Novel empirical studies have also supported the multi-valenced hypothesis and have shown that awe is not exclusively reported as a positively valenced experience, with a minority of self-reports focusing on negative emotions associated with awe. In a study by Gordon et al. (2017), approximately twenty per cent[7] of self-reported experiences of awe were understood as pertaining to the 'threat-based' variant, which the authors noted 'represents a mixed state, combining awe with feelings of fear' (p. 325). These frameworks often draw upon contemporary understandings of appraisal theory, a generalised theory of emotion positing that emotions are primarily elicited through the evaluations (appraisals) of events (Roseman & Smith, 2001; for a review, see Scherer, Schorr, & Johnstone, 2001). Through these appraisals, emotions with similar attributes may be grouped into 'families'.

Moreover, emotions need not be perfectly static, and they may exhibit variations, or *colourings*, of other emotional aspects (Ekman, 1992; Shaver et al., 1987;). Compare, for example, the joy of eating a delicious meal (temporally extended and dynamically changing) with the joy felt from seeing an old friend (likely more immediate and singular). Keltner and Haidt's (2003) framework for awe explores an array of valence possibilities in hypothesised experiences of awe through ancillary, peripheral, or *colouring* appraisals. In this model of awe, the five peripheral or ancillary appraisals (ability, beauty, supernatural causation, threat, and virtue) account for the valence differences in awe-related states, and awe is understood as *coloured* by means of these factors in different ways (Keltner & Haidt, 2003, p. 304). Through these appraisals, awe can take on many forms and produce a spectrum of associated valences. This framework explicitly lists music as having the potential to elicit awe, though it only cites 'beauty' and 'ability' as common and significant peripheral appraisals for musical awe. In the light of Study 1 (Chapter 3), this conclusion may be considered questionable, as music was shown to relate to *all* of the Keltner and Haidt (2003) appraisals cited for awe. As an example of these additional appraisals, supernatural associations in music are a common pairing with

[7] In the Gordon et al. (2017) study, 12–24% of reported awe experiences were assigned to a threat-based subset category.

unnerving visuals in horror film scores to signify and heighten supernatural and unnatural scenes. Consider this short musical analysis: 'After a freeze-frame of one of the zombies tearing the flesh off of a human bone with his teeth, an eerie theremin melody plays on the soundtrack [and] whole ghouls snarl and eat human limbs and entrails' (Heffernan, 1997, p. 20). The pairing of the theremin sound with horror, futuristic, and supernatural film and television scenes is a staple of these genres (Summers, 2013). Through its ubiquity, and process of evaluative conditioning (Juslin, 2013), the sound of a theremin has become a culturally salient shorthand for the supernatural and is commonly perceived with those associations. These kinds of culturally salient associations afford a large and diverse set of cognitive appraisals to be made onto musical materials, and their relationship to musical awe has yet to be explored.

4.2.2 Threat, negative valence, and music

The positive emotional associations of musical awe neither adequately describe nor accurately capture all variations of musical awe. The same may be said for many strong experiences with music. For example, of the nearly one-thousand participants interviewed by Gabrielsson, twenty-three per cent reported their Strong Experiences with Music (SEM) as negatively valenced (2011). These negative emotional experiences are valid expressions of what was felt when listening to music, and they should be included in any robust examination of musical awe. In Keltner and Haidt's (2003) framework, 'threat' is the appraisal with the most negative valence associations, yet it is not included as a prominent appraisal for music in their evaluation of awe eliciting stimuli. However, perceptions of musical threat have previously been investigated by examining fear and anxiety as responses to threatening stimuli (Lang, Davis, & Ohman, 2000). A wealth of research has explored the perceptual relationship between music and fear in many forms: child development (Cunningham & Sterling, 1988;

Terwogt & van Grinsven, 1988, 1991), musical preference (Konečni, 1979), film music (Gosselin et al., 2005), cross-cultural relationships (Balkwill & Thompson, 1999; Juslin & Laukka, 2003), and through music's sonic qualities (Huron 2008; Huron, Kinney, & Precoda, 2006). Cross-modal research has also shown that music can enhance the valence ratings of fearful images (Baumgartner, Essen, & Jäncke, 2006; Baumgartner et al., 2006). Therefore, through its connections to fear, threat may be considered one of many appropriate appraisals for experiences of musical awe.

4.2.3 An empirical approach for perceptions of musical awe

There is currently scant empirical evidence for the emotional perceptions and judgements related to musical awe. For example, while Silvia et al. (2015) found that 'openness to experience' is an important personality trait that mediates experiences of musical awe, no studies have investigated the relationship between awe and the music that elicits such an emotion. This chapter begins to fill this lacuna in the literature by investigating the relationship between awe-associated music and its general emotional perceptions. Through associative ratings of images, emotional descriptors, and appraisal terms, the studies in this chapter provide an emotional and conceptual basis for an understanding of musical awe based on experiential and perceptual commonalities. The investigations used musical excerpts reported by the participants in Study 1 to investigate the emotional and conceptual judgements related to these excerpts. This approach helps to bridge the gap between individuals' experiences and general associations and emotional appraisals. The studies presented in this chapter focus on *perceived* emotions from music, namely the listener's perception and understanding of the emotional expression of the music regardless of whether participants actually *feel* that emotion themselves (Hodges, 2010, p. 280). Using previous research as a foundation for these studies, this chapter investigates whether music associated with awe is differentiated in terms of valence in the same way as are non-musical experiences of awe (Gordon et al., 2017), and examines these potential variants of musical awe with regard to their emotional and cognitive associations.

4.3 Aims

The aims of Study 3 were to investigate whether MAC excerpts could be identified with visual representations of awe, and to assess whether any such generalisations could be categorised into multiple valence-based domains. The aims of Study 4 were to examine participant ratings of various emotional terms in relation to the MAC excerpts, and to assess possible emotional groupings to determine the relationship between emotional terms and valence conditions of the music. The aim of Study 5 was to examine participant ratings of MAC excerpts for various conceptual terms related to the central and peripheral appraisals proposed by Keltner and Haidt (2003). Taken together, the three studies aimed to provide an empirically driven perceptual and conceptual basis for music associated with the experience of awe. It is important to note that this participant-based foundation for perceptual categorisation of awe-related music forms an empirical basis for subsequent studies that take these findings as their starting point. As this project is rooted in the *experience* of musical awe, understanding how the music is *perceived* is fundamentally important to answering the questions set out in this project.

4.4 Methods

4.4.1 Construction of the Musical Awe Corpus

The musical stimuli in this study were informed by participant responses from Study 1. The questionnaire in Study 1 (see Chapter 3) asked participants about musical examples that had previously produced feelings of awe for them. These responses were organised into this project's Musical Awe Corpus (MAC, individually detailed in Appendix Table 4-1), a collection of pieces of music from a wide variety of genres associated with experiences of awe. Within the MAC, there are 70 pieces of music listed from the questionnaire. An additional 30 pieces of music were added to the MAC from various online forum posts which collected musical examples that were related to experiences of awe through the production of thrills/chills and piloerection (at the time of collection a relevant crowd-sourced Reddit post[8] was used to identify these pieces of music). These additions to the MAC were chosen because the language used to describe experiences from this music was similar to participant responses from Study 1. Moreover, there is an established theoretical relationship between being moved, thrills/chills, and awe (Konečni, 2005; Konečni, Brown, & Wanicet, 2008; Menninghaus et al., 2015) and these additions to the MAC act as an extension of the materials collected from the questionnaire in Study 1. All musical materials were gathered from YouTube, using content with the highest recording quality and largest view count to compile the MAC. This collection procedure for the experimental materials ensured that the sources for the musical excerpts were conventional recorded versions of the musical pieces. To systematically reduce the MAC to a selection of music that primarily captured musical qualities related to ideas in participant experiences of awe, all music with lyrical content was omitted. The elimination of vocal and lyrical content on the MAC yielded 42 musical pieces (39 from Study 1 and three from additional online sourcing) to be used in these studies. To assemble a more homogeneous body of music, examples that had only a single representative of their genre (in this instance, folk rock, free jazz, and lounge music) were omitted from the MAC for this study. Excerpts were then taken from the 39 pieces, each ranging from 22–32 seconds in duration (M = 28 s, SD = 2.40). Each excerpt of music was indicative of the musical piece from which they were

[8] See https://www.reddit.com/r/AskReddit/comments/4hhgrf/serious_whats_a_song_that_gives_you_goosebumps_or/

extracted, as decided by the researcher and informed by the participants' description of the music reported in Study 1. This selection process was carried out by the researcher and was adjusted to result in musically coherent segments for each of the excerpts.

For the logistics of experimental testing, the number of excerpts needed to be reduced. To achieve this, a distilled collection of music excerpts that were emblematic of positive and negative valence were selected from the list of 39 excerpts. This was accomplished through a pre-test that labelled the valences of the excerpts. Five expert listeners (a collection of music academics and professional musicians) listened to the 39 awe-related excerpts and 20 neutral excerpts and rated both positive and negative associations for each music excerpt on a 7-point Likert-type scale. All 59 music excerpts were randomised per participant, and from the valence pre-testing the 10 highest-rated excerpts for both the positive and negative ratings were labelled as 'positive' and 'negative' music excerpts respectively. Together, these excerpts comprise the MAC_1 (see Appendix Table 4-2), a subset of the MAC used for the perceptual testing in this chapter and further studies. The MAC_1 is not indicative of all instances of musical awe, but through its systematic and limited creation, its collection of excerpts is expressive of positive and negative valence associated with experiences of awe. The emotionally neutral music excerpts used in this testing were taken from Muzak pieces commonly used as background music for retail shops and online video content. These neutral excerpts were approximately 30 seconds in duration and were musically coherent extracts of each piece. The 10 Muzak excerpts rated lowest for both negative and positive associations were then compiled into the neutral excerpts. Adding the 10 neutral excerpts to the MAC_1 produced a total of 30 excerpts in three types of valence (positive, negative, and neutral) to be used as experimental materials for Studies 3, 4, and 5.

4.4.2 Participants

Ethics approval for these studies was obtained through the Central University Research Ethics Committee (CUREC) of the University of Oxford (Ethics Approval Reference: R59691/RE001). All participants were provided with an information sheet (Appendix Document 4-1, 4-2, and 4-3) and fully completed an informed consent form (Appendix Document 4-4) prior to their participation. In Studies 3 and 4, participants were recruited through various methods: university newsletters, music faculty announcements, social media, and word of mouth. A raffle-style prize draw of a £50 online gift card acted as an incentive for taking part in the study. The two limitations placed on recruitment were that participants must be at least 18 years of age and of normal, or corrected-to-normal, hearing. In Study 5, participants were recruited through Amazon Mechanical Turk (MTurk), an online crowdsourcing site. Workers in this study were paid $5.00 (USD) to complete the experiment. The recruitment through Amazon MTurk was used to ensure that the participants had not taken part in any of the previous studies in this research project.

Seventy-one (43 female, 26 male, 2 non-binary) participants of a mean age of 37.15 (range 18–83, *SD* = 17.27) took part in Study 3. The participants resided mainly in the United States and the United Kingdom, with counts of 38 and 24 respectively. The other nine participants reported their countries of residence as Austria, Brazil, Canada, Denmark, Egypt, Germany, Greece, Hong Kong, and Lithuania. Participants reported a high level of experience with music with an average of 17.35 hours (*SD* = 16.71) of music listening per week and 8.56 years (*SD* = 9.70) of musical training.

Fifty (19 female, 31 male) participants took part in Study 4 with a mean age of 29.02 (*SD* = 8.77). The participants primarily resided within the United States and the United Kingdom, with counts of 14 and 27 respectively. The other nine participants reported their countries of residence as Austria, Belgium, Germany (2), India, Ireland, Italy, the Philippines, and Sweden. Participants reported a high level of experience with music with an average of 13.63 hours (*SD* = 10.10) of music listening per week and 9.32 years (*SD* = 7.54) of musical training. Only eight participants (16%) reported to have also previously participated in Study 3; these carry-over participants are accounted for in Section 4.6.2. Fifty-one (26 male, 24 female, 1 non-binary) participants with a mean age of 37.50 (range 22–71, *SD* = 10.90) took part in Study 5. Due to the hosting of the experiment on servers located in the United States, the participants resided almost entirely in the United States, with only one participant residing in the United Kingdom. The participants reported a varied degree of music listening, with a mean of 12.45 hours (*SD* = 12.36) of music listening per week, and reported low levels of musical training with an average of 2.14 (*SD* = 3.97) years. Notably, 25 of the 51 participants (49%) in Study 5 reported zero years of musical training.

4.4.3 Materials

Studies 3, 4, and 5 used the same musical excerpts from MAC_1 as experimental stimuli, and each excerpt was normalised for volume in Audacity 2.2.1.0. The visual stimuli in Study 3 were extracted from a previous study on emotional associations of awe (Gordon et al., 2017). These visual stimuli were photographs of nature: one was a serene night landscape with the aurora borealis lighting up the sky, and the other was of a supercell thunderstorm with a large tornado-like cloud sweeping across farmland (as seen in Figure 4-1). The purpose of these images in previous studies conducted by Gordon et al. (2017) was to act as a non-verbal associative cue for awe in two forms distinguished by valence. The image of the aurora borealis is intended to represent wonder, openness, and a positive form of awe; the image of the supercell thunderstorm represents dread, fear, and carried negative associations. Study 4 did not use any additional materials other than the MAC_1 and a list of emotional terms, also taken from the Gordon et al. (2017) study, which participants rated for appropriateness to the music. Study 5 used the MAC_1 and a list of appraisal terms derived from Keltner and Haidt (2003).

Figure 4-1

Two awe-associated images used in Study 3

Note. Images of the aurora borealis (left) and a supercell thunderstorm (right) used in Study 3. Both images were chosen due to their use as priming stimuli in a previous study (Gordon et al., 2017) where they were used to guide participant recollections of awe. Each image is suggestive of different valence associations (positive and negative) whilst simultaneously conveying awe-related environments.

4.4.4 Experimental procedure

Studies 3, 4, and 5 were hosted online. Participants were able to access the experiment website on a variety of web browsers and complete the tasks in a location of their choosing. Participants could abort the studies at any time and were allowed to remove their data if they wished. Introductory instructions requested that participants wear headphones during the experiments to ensure that the music excerpts were able to be heard with appropriate clarity. All three studies used an online, repeated measures experimental design in which each participant listened to all music excerpts, one after another. The independent variable was the set of musical excerpts, which itself was grouped into three categories based on valence.

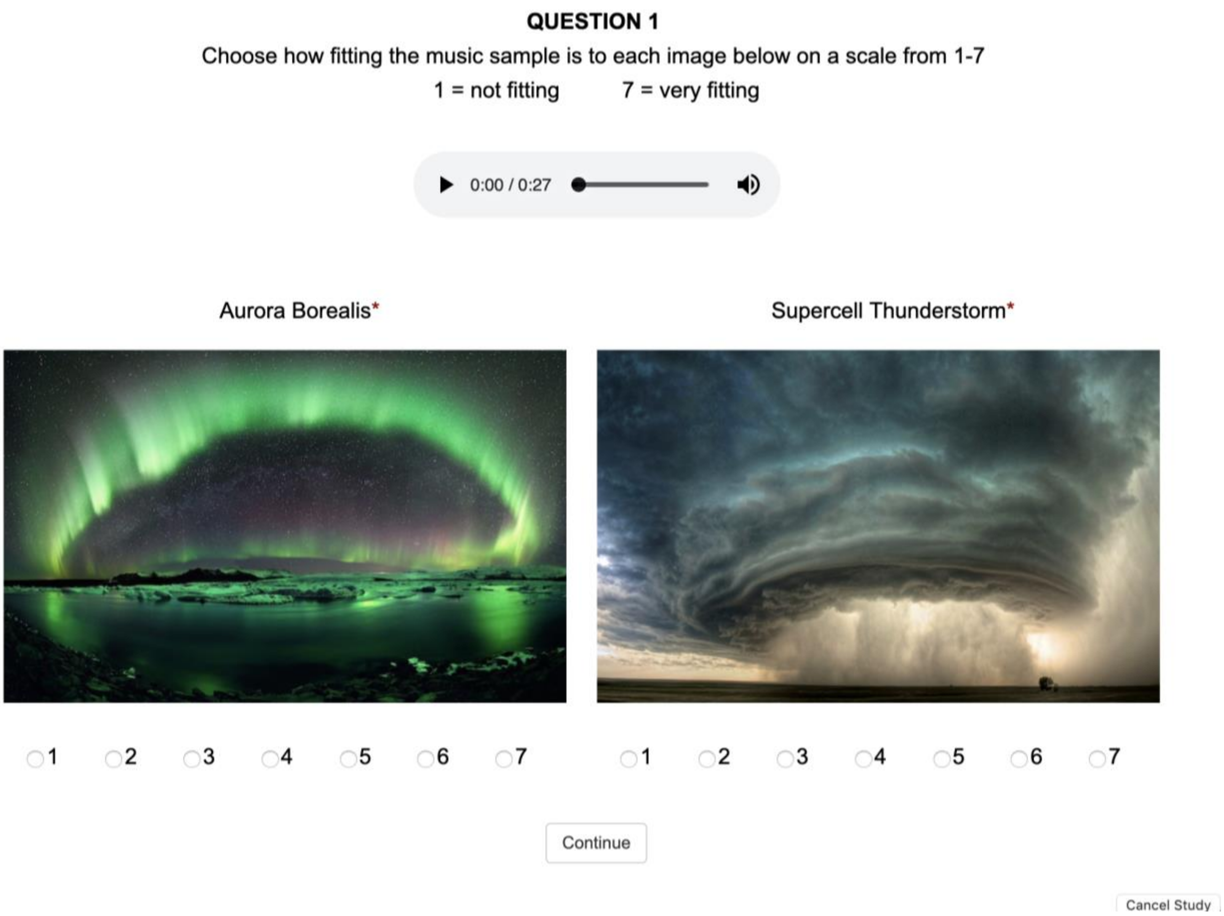
Participants listened to 30 excerpts (10 from each valence group: positive, negative, and neutral) in a per-participant randomised order and rated each excerpt for their recognised appropriateness to each image or term. The experiments were coded in JavaScript using plugins from the JSpsych 6.0.4 API (de Leeuw, 2018), a library for web-based behavioural experiments, and were hosted on Amazon Web Services (AWS) EC2 servers. JATOS (Just Another Tool for Online Studies) 3.3.2 (Lange, Kühn, & Filevich, 2015) was installed on the server and acted as the mediating framework within which participant data would be collected for Studies 3, 4, and 5. Through recruitment notifications, participants were able to access the website where each experiment was hosted. Once a participant started an experiment, an HTTP cookie was sent to the participant's web browser to ensure that no participant could access the experiment and enter data more than once.

After providing consent to take part in the study, participants completed an online information sheet detailing their age, gender, country of residence, musical listening habits, and years of musical training. Additionally, in Studies 4 and 5 participants were asked if they had previously participated in any studies related to this research project. Before taking part in the experiment, two test trials were presented to participants in order to familiarise them with the functionality of the experimental study and website. The test trials were identical to the experimental trials in their presentation but used different musical excerpts. During the test and experimental trials, participants were able to listen to the music excerpts as many times as they wished through an in-built HTML5 audio player. Each participant was asked to complete the 30 experimental trials. At the end of the experimental trials, participant data were saved to the AWS server for analysis. Both Studies 3 and 4 used similar methods, varying only in their dependent variables.

In Study 3, musical excerpts were paired with images, acting as the dependent variable. Participants were asked to rate each of the images for how well they seemed to fit with the music being presented. (A screenshot of the experimental trial can be seen in Figure 4-2.) Participants rated each image on a scale from 1 to 7 on its appropriateness to the music being played.

Figure 4-2

Study 3 experimental trial screenshot



Note. A screenshot of the first experimental trial showing the layout of the participant interface. The music excerpt played automatically, and participants were prompted to select a rating for each of the images based on the perceived appropriateness of the music to the images. Once both selections were made, clicking the ‘Continue’ button advanced the participant to the next trial.

In Study 4, the rating of the emotional terms of the musical excerpts constituted the dependent variable. Participants were asked to rate the following terms for their appropriateness on a scale of 1–7: ‘amazement’, ‘anger’, ‘anxiety’, ‘awe’, ‘distress’, ‘fear’, ‘happiness’, ‘nervousness’, ‘joy’, ‘sadness’, ‘warmth/tenderness’, and ‘wonder’, the terms being presented in alphabetical order. (A screenshot of the experimental trial can be seen in Figure 4-3.) Participants performed 12 ratings (one for each term) for each of the 30 experimental trials.

Figure 4-3

Study 4 experimental trial screenshot

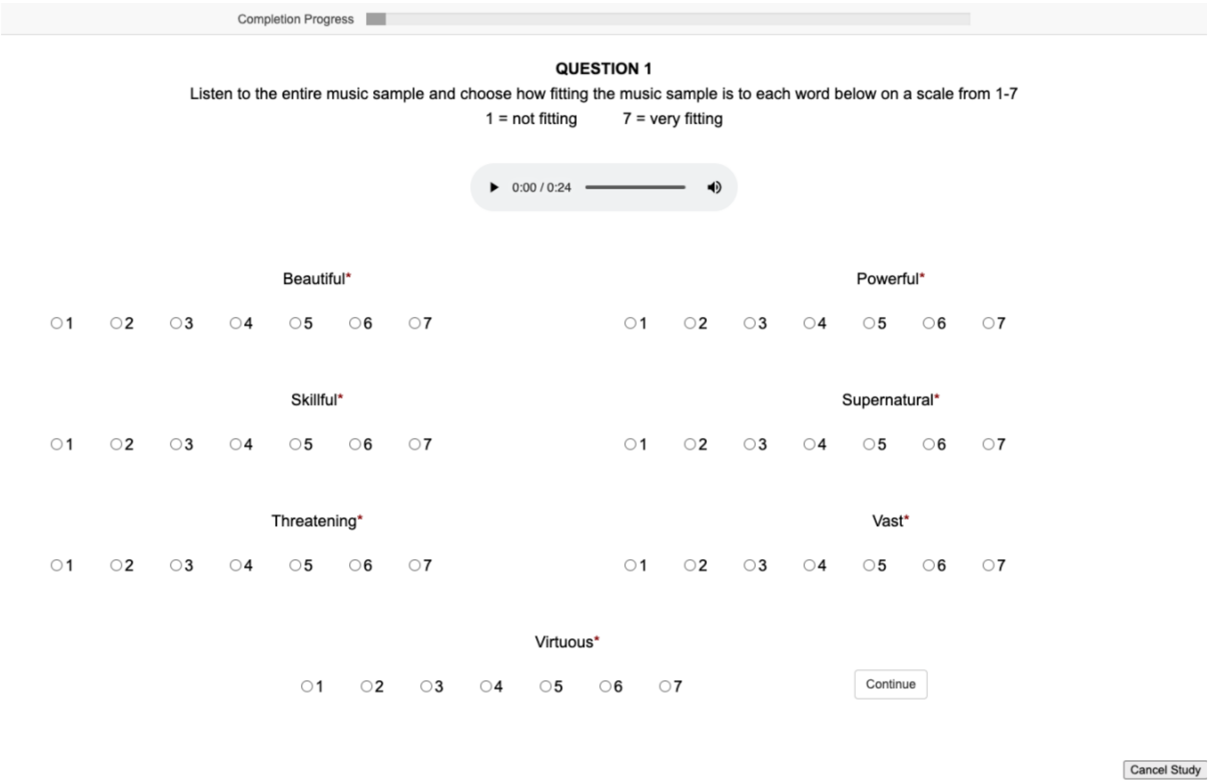
Note. A screenshot of the participant interface for Study 4. The music excerpt played automatically, and participants were prompted to select a rating for each of the terms based on the perceived appropriateness of the music to the images. Once all 12 selections were made, clicking the 'Continue' button advanced the participant to the next trial.

In Study 5, the rating of the appraisal terms of the musical excerpts constituted the dependent variable. Participants were asked to rate the following terms for their appropriateness on a scale of 1–7: 'beautiful', 'powerful', 'skillful' [*sic*], 'supernatural', 'vast', and 'virtuous'. As in Study 4, the terms were presented in alphabetical order. These terms for Study 5 were derived from the hypothesised peripheral appraisals listed in Keltner and Haidt's

(2003) study. While ‘beautiful’, ‘supernatural’, ‘threatening’, and ‘virtuous’ were taken verbatim from previous research, ‘skil(l)ful’ was an experimentally relevant adaption of Keltner and Haidt’s term ‘ability’. ‘Powerful’ and ‘vast’ were chosen to test their association of experiences of awe. (A screenshot of the experimental trial can be seen in Figure 4-4.) Participants performed seven ratings (one for each term) for each of the 30 experimental trials.

Figure 4-4

Study 5 experimental trial screenshot



Note. A screenshot of the participant interface for Study 5. This experiment ran identically to that of Study 4 where ratings of appropriateness were chosen for each of the appraisal terms and then advanced to the next trial. ‘Skillful’ was spelled as seen for the benefit of the predominately US participant pool in the experiment.

4.5 Hypotheses

The analyses of Studies 3, 4, and 5 were designed in relation to one another, as they use the same music excerpts and the same experimental design. However, each of these studies sought to understand different perceptual and cognitive experiences related to music in the MAC. The individual hypotheses set out below should be seen as a combined effort to categorise the music excerpts of the MAC_1 and how they are understood by listeners. The formal hypotheses were designed to be tested through analyses using descriptive and inferential statistics, by way of null hypothesis significance testing (NHST). The following sections detail all hypotheses from the three studies in this chapter and denotes them with an abbreviation of $H_{X\text{-}Y}$, where X is the study number and Y the specific hypothesis found within the study.

4.5.1 Study 3 hypotheses

The hypotheses for Study 3 addressed broad ideas about generalisability and divisibility of the music excerpts found within the MAC.[9]

$H_{3\text{-}1}$: There will be an agreement of ratings between participants; participants will make similar appraisals for the same musical excerpts and music types.

$H_{3\text{-}2}$: Image ratings for positively and negatively valenced music excerpts will be significantly different; positive excerpts will have higher ratings for the aurora borealis, and negative excerpts will have higher ratings for the supercell thunderstorm image.

$H_{3\text{-}3}$: The neutral excerpts (the Muzak samples) will be rated lower for both the aurora borealis and supercell thunderstorm images compared to the positive and negative excerpts.

$H_{3\text{-}4}$: As both images depict awe-eliciting situations, some of the MAC_1 excerpts (from the positive and negative conditions) will show high ratings for both images. However, it is expected that this will only apply to a minority of the excerpts.

4.5.2 Study 4 hypotheses

The hypotheses for Study 4 were constructed based on the results of a previous study (Gordon et al., 2017). This study sought to replicate those findings using MAC_1 musical excerpts as the experimental stimuli. The division of the emotional terms into composite categories (composite awe score, composite threat score, positive affect composite, negative

[9] As NHST only tests a null hypothesis (H_0), the positive hypotheses presented in this chapter (and following chapters) are interpretations of the expected results that reject the H_0s.

affect composite) used the same divisions as Gordon et al. (2017). Study 4 explored the relationships between these categories and assessed their appropriateness to the musical excerpts.

$H_{4\text{-}1}$: The positive music excerpts will be rated higher for the term 'awe' than negative or neutral excerpts.

$H_{4\text{-}2}$: The composite awe score (consisting of 'awe', 'wonder', and 'amazement') will be rated higher for the positively valenced music excerpts.

$H_{4\text{-}3}$: The composite threat score (consisting of 'fear', 'anxiety', and 'nervousness') will be rated higher for negatively valenced music excerpts.

$H_{4\text{-}4}$: The ratings of the composite awe score and the composite threat score for excerpts will be dissimilar.

$H_{4\text{-}5}$: The positive affect composite (consisting of the terms 'happiness', 'joy', 'warmth/tenderness') will show higher ratings for positive music excerpts and correlate with the positive awe score.

$H_{4\text{-}6}$: The negative affect composite ('anger', 'sadness', and 'distress') will be rated higher for negatively valenced excerpts and correlate with the composite threat score.

4.5.3 Study 5 hypotheses

The hypotheses for Study 5 were based in part on Keltner and Haidt's (2003) theoretical exploration of experiences of awe. Here, the peripheral appraisals that were hypothesised to be associated with awe-related events were tested for their association with positive and negative variants of awe-inducing music.

$H_{5\text{-}1}$: The results will show a different pattern of appraisal terms associated with different types of awe-inducing music such that positive and negative music types will show different appraisals.

H_{5-2}: The positive music excerpts will be rated higher than the negative excerpts for the appraisal terms ‘beautiful’ and ‘virtuous’, due to both terms being associated with positive valence.

H_{5-3}: The negative music excerpts will be rated higher than the positive excerpts for the term ‘threatening’, due to threat being a fundamental appraisal associated with negative valence.

H_{5-4}: The appraisal of vastness was deduced from its relation to power (Burke, 1575/2015; Keltner & Haidt, 2003) therefore, it is hypothesised that ‘powerful’ and ‘vast’ will be highly correlated.

H_{5-5}: There will be more peripheral appraisal criteria relevant to musical awe than was proposed in theoretical research. For example, the feature of ‘threat’ was not hypothesised to be relevant to awe-inspiring music, but here it is hypothesised that many, if not all, of the proposed features are strongly perceived in the music that compromises the MAC_1.

4.6 Results

4.6.1 Study 3: Musical Awe Corpus and images

Firstly, identification of participant outliers was conducted in order to remove anomalous data. The variance of all participants’ ratings per music type was calculated, and through the maximal normalised residual test (Grubbs, 1950), it was found that all participants’ variances were within the expected distribution. The variance of Participant 67 was the furthest from the population, with a *z*-score of 2.28 but did not reach significance with an alpha set at 0.05.

To explore the data, the responses were reduced to six categories: two sets of image ratings for each of the three music types (positive, negative, and neutral). Table 4-1[10] details

[10] Table 4-1 can also be found in the Appendix under Appendix Table 4-6.

the descriptive statistics for the image ratings of each music type. These data are comprised of the mean values for each image rating, and this resulted in the average of ten musical excerpts being used for each participant's response to each music type. As an example, a participant listened to a music excerpt pre-classified as positive and scored two images—aurora borealis (AB) and supercell thunderstorm (SCT)—for their appropriateness to the music. Through the course of the experiment, the positive valence music type was encountered nine additional times resulting in a total of ten ratings for the same valence condition. The mean ratings for each of the images (AB and SCT) were averaged with all other participants to produce the Table 4-1 entries for $\text{Positive}_{\text{AB}}$ and $\text{Positive}_{\text{SCT}}$. Since the data extracted had no missing values, the weighting between conditions remained equal.

Table 4-1

Descriptive statistics and Cronbach's α for all categories of Study 3

	Music Type	***M***	***SD***	***N***	**Cronbach's α**
AB Ratings	$\text{Positive}_{\text{AB}}$	4.66	1.01	71	0.77
	$\text{Negative}_{\text{AB}}$	2.72	1.11	71	0.84
	$\text{Neutral}_{\text{AB}}$	2.34	1.50	71	0.96
SCT Ratings	$\text{Positive}_{\text{SCT}}$	2.52	0.87	71	0.75
	$\text{Negative}_{\text{SCT}}$	5.39	0.90	71	0.77
	$\text{Neutral}_{\text{SCT}}$	1.22	0.53	71	0.92

AB = aurora borealis

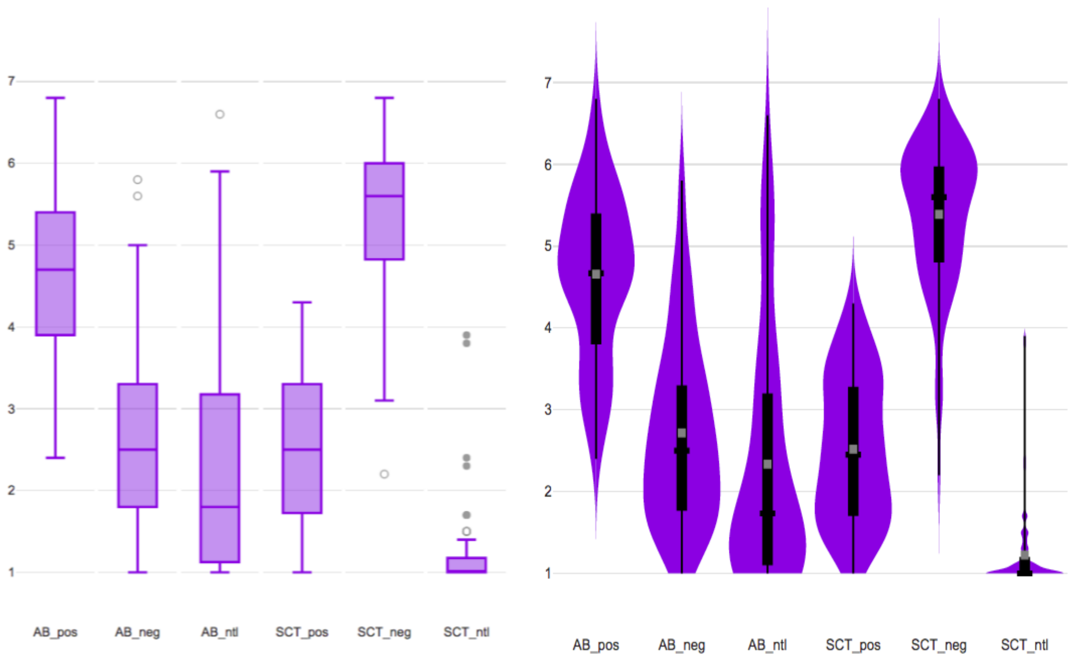
SCT = supercell thunderstorm

Table 4-1 shows the descriptive statistics associated with Study 3, and from these data a general understanding of the distribution can be obtained. To test H_{3-1} a Kolmogorov-Smirnov (K-S) test of normality was performed on each of the six conditions. The four conditions of interest, Positive_{AB}, Negative_{AB}, Positive_{SCT}, and Negative_{SCT}, all had low K-S test statistics values (D) and alpha values above 0.05. This suggests that data were all normally distributed. The neutral music type showed a high kurtosis value of 16.40 for the SCT ratings and were positively skewed suggesting a non-normal distribution. These results were expected insofar as the neutral samples would not be consistently rated highly for either of the images. This analysis supports H_{3-1} in that the ratings showed a high level of agreement between the participants. These results also support H_{3-1} in showing that a normal distribution in the experimental results was seen when grouping the excerpts under the same valence types.

Examining mean values for aurora borealis (AB) ratings, it is clear that Positive_{AB} associations were rated higher than both the Negative_{AB} and Neutral_{AB} music conditions. Examining the supercell thunderstorm (SCT) ratings, the Negative_{SCT} means are rated higher than the Positive_{SCT} and Neutral_{SCT} means, supporting H_{3-3}. The standard deviation was highest for Neutral_{AB} ratings (1.50), suggesting that ratings for association with the aurora borealis image were most variable or unstable within the neutral music type. Overall ratings for Negative_{SCT} were rated the highest with a value of 5.39, and Neutral_{SCT} values were rated the lowest with a value of 1.22.

Figure 4-5

Music type and image rating distribution

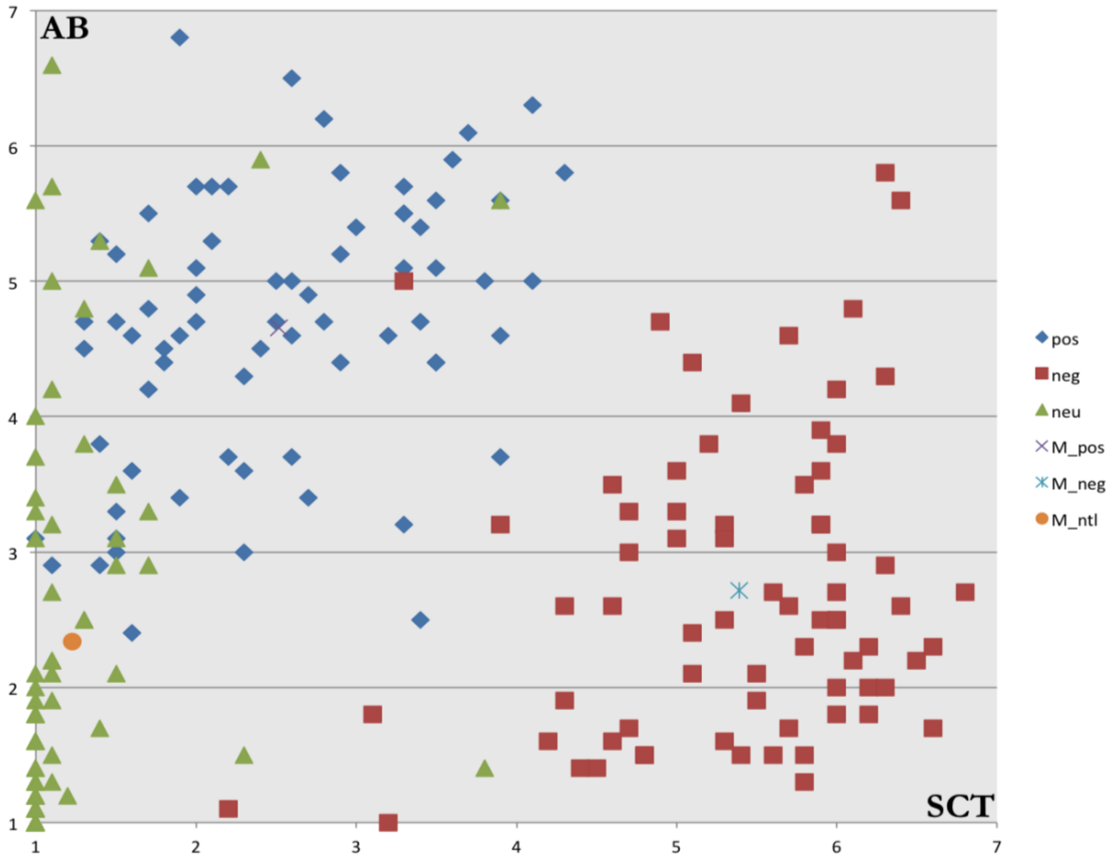


Note. Box and whisker plot (left) and violin plot (right) of the data from Table 4-1. Images are abbreviated as 'AB' for aroura borealis and 'SCT' for supercell thunderstorm. Music conditions are abbreviated as 'pos' for the positive music condition, 'neg' for the negative music condition, and 'ntl' for the neutral or non-awe music condition. Results from the combinations of images and music conditions are paired together (e.g. 'AB_pos' denotes the results of the aroura borealis paired with the positive music condition). The data categories illustrated here show differences in ratings between music type and the generalisability or agreement of ratings for each condition. $\text{Positive}_{\text{AB}}$ and $\text{Negative}_{\text{SCT}}$ are rated higher than other categories with mean values of 4.66 (SD = 1.01) and 5.39 (SD = 0.90), respectively.

The ratings shown in Figure 4-5 suggest that there may be statistically significant differences in the data between the two image categories based on their valence association. To further illustrate these differences, Figure 4-6 plots a two-dimensional scatterplot of both image ratings showing each participant's mean associative values.

Figure 4-6

Two-dimensional representation of image ratings by music type



Note. Scatterplot of 71 participants' mean ratings of all three music types: positive, negative, and neutral. Each value represents the average image ratings of ten stimuli. Two-dimensional group means are also shown for each condition (M_pos, M_neg, M_ntl). Positive music is labelled in blue and negative in red. Ratings for the supercell thunderstorm are on the x-axis and ratings for the aurora borealis are on the y-axis.

To test for the significance of the bifurcation seen between the positive and negative music types and to address $H_{3\text{-}2}$, a multivariate analysis of variance (MANOVA) was performed. This was done by aggregating the participant responses per musical excerpt into a single mean value for analysis. This produced 60 mean values divided between valence group association and image ratings. There was a highly significant effect of music type on image ratings; Pillai's Trace = 1.709, $F(4, 54) = 79.39$, $p < 0.001$. To examine this finding further, two one-way repeated measures analyses of variance (ANOVA) were performed on the mean value per musical excerpt (see Appendix Table 4-7). The first ANOVA examined the ratings for the aurora borealis image. Mauchly's test indicated that the assumption of sphericity had been violated; $\chi^2(2) = 17.16$, $p < 0.001$. The degrees of freedom were therefore corrected using Huynh-Feldt estimates of sphericity ($\varepsilon = 0.67$). The results showed that there was a highly significant effect of the music type on the ratings of the aurora borealis image; $F(1.64, 117.12) = 131.64$, $p < 0.001$. Parallel tests were conducted for the ratings of the supercell thunderstorm where Mauchly's test indicated that the degrees of freedom did not need to be corrected; $\chi^2(2) = 2.10$, $p < 0.350$. The results showed that music type had a highly significant effect on the ratings of the supercell thunderstorm image; $F(2, 140) = 714.54$, $p < 0.001$. Taken together, these results demonstrate that the type of music had a statistically significant effect on the ratings for both images. These results support H_{3-4} in the claim that the image ratings would be bifurcated along a valence divide.

The previous analyses examined the average values from the perceived valence of the musical materials without differentiating individual excerpts of the same categories. It is important to further examine the component parts of these general trends and explore data related to the individual musical excerpts that constitute the MAC_1. The results listed in Appendix Tables 4-3, 4-4, and 4-5 are of the individual music excerpts and present the variability found between the associated image ratings.

Appendix Tables 4-3, 4-4, and 4-5 report the mean values of both AB and SCT image ratings, differences between those ratings (also shown in Appendix Table 4-8), and *t*-test results examining those differences for all music stimuli. Appendix Table 4-3 shows that almost all the positive excerpts were rated higher for the image of the aurora borealis when compared to ratings for the supercell thunderstorm image. Pos_{08} was the only piece of music that did not reach significance when between the AB image ratings (*M* = 3.23, *SD* = 1.95) and SCT ratings (*M* = 3.76, *SD* = 2.67); $t(140) = 1.57$, $p = 0.118$. This excerpt provides evidence that certain awe-related music can be applicable to both image ratings, suggesting a simultaneous positive and negative valence perception. The excerpt Pos_{10} had both the highest rating for the aurora borealis image and largest difference between the AB image rating (*M* = 5.94, *SD* = 1.25) and the SCT image rating (*M* = 2.35, *SD* = 1.45); $t(140) = 15.82$, $p < 0.001$, with a difference value of 3.59. Even with the most polarised excerpt, these data showed that there is at least some association made from the music to the opposing image. Positive music excerpts showed a moderate negative correlation between the image ratings that approached significance: $r = -0.58$. $N = 10$, $p = .081$. As one would expect, this trend showed that a higher rating for the aurora borealis image would result in a lower rating for the supercell thunderstorm image.

Addressing the negative music excerpts (detailed in Appendix Table 4-4), all musical excerpts had higher SCT ratings than AB ratings, and all excerpts reached significance in comparisons of the two image rating values. Neg_{09} had the highest SCT rating (*M* = 6.15, *SD* =1.47) and the lowest AB rating (*M* = 2.11, *SD* = 1.63); $t(140) = 15.53$, $p < 0.001$. Negative music excerpts showed no correlation between mean values of image ratings; $r = 0.102$, $N = 10$, $p = 0.78$. For this collection of negative music excerpts, these results showed that there was a high level of variation between ratings: a high image rating for SCT or AB was not associated with a low rating for the other image. This finding speaks to $H_{3\text{-}4}$ in that excerpts can be rated high for both images yielding an overlap of image ratings (previously seen in Pos_{08}). It should be noted that no mean ratings of any of the negative excerpts exceeded a 4.0 (mid-point of the 1–7 scale) for AB ratings, and no mean ratings of any of the positive excerpts exceeded a 4.0 for SCT ratings. This finding supports $H_{3\text{-}6}$ in that there are very few excerpts in the positive or negative music types that have significant levels of crossover between image ratings. Additionally, the *t*-test results found in Appendix Table 4-1 and 4-2 added support to $H_{3\text{-}2}$ and

$H_{3\text{-}3}$, showing on a more granular level that individual musical excerpts are also largely polarised by image ratings based on valence of the music type.

Appendix Table 4-5 details ratings of AB and SCT images for the ten neutral music excerpts. These ratings were consistent in that low ratings were present for both images: mean AB ratings were all under 2.5, and SCT ratings were under 1.28. It is notable that ratings for the AB image were higher than the SCT image for all ten excerpts and reached significance in their respective *t*-tests. This finding was likely due to the choice of music used for neutral excerpts: the Muzak and 'café lounge' excerpts were composed (at least in part) to be used as background music (e.g. Milliman, 1986), and a strong negative valence would not be suitable for this use.

In summary, the results of Study 3 show that the three music types constituting the tested excerpts from the MAC_1 were perceived similarly by participants and were clearly grouped into categories based on valence. However, correlations between image ratings on the individual excerpt level are more nuanced and merit further discussion (see Section 4.7.1).

4.6.2 Summary of results: Study 3

The results of the Study 3 hypotheses are found below:

$H_{3\text{-}1}$: Participant ratings were systematic and non-random, showing agreement in ratings across music excerpts and music type. (supported)

$H_{3\text{-}2}$: Positive and negative music types were significantly different, with AB ratings higher for positive conditions and SCT ratings higher for negative conditions. (supported)

$H_{3\text{-}3}$: Neutral excerpts were rated lower for both images compared to the positive and negative excerpts. (supported)

$H_{3\text{-}4}$: No excerpts showed a high rating for both AB and SCT ratings; no excerpt reached over 4.0 for both image ratings. (rejected)

Examining the overall results for Study 3, the Musical Awe Corpus (MAC) excerpts largely worked in the way that was hypothesised. The pre-categorisation of materials made by the expert listeners that yielded the positive, negative, and neutral groupings of the music excerpts was rated similarly by the participants in the online experiment. These results serve as validation for the pre-test categorisation and suggest the MAC can be used for further perceptual testing. Additionally, there was a high level of agreement between participants' ratings of music types: positive excerpts were scored more highly for the aurora borealis (AB) image and lower for the supercell thunderstorm (SCT) image; and the converse was true for negatively valenced music types. This lends support to the idea of valence being an important and appropriate factor by which to separate and analyse experiences of musical awe. These ratings were assessed further to reveal that the valence category of the excerpt resulted in statistically different ratings for the two images. Only one excerpt (Pos_{08}) did not fit the expected trend, showing a nonsignificant difference between the values.[11] A naive hypothesis might be that the relationship between image ratings would show a strong negative correlation. For example, an excerpt that was rated extremely high for one image would be rated extremely low for the other. Pearson correlations performed between image ratings for each music type were difficult to assess due to the small number of excerpts (10 per condition). While music indicative of a positive valence showed the expected negative correlation at a moderate level, this relationship was not seen in relation to the negative music types. These results suggest that there is a more nuanced and complex relationship between awe-related music and the image ratings. This can also be seen in the ratings for the term 'awe' in the following study, Study 4, where both positive and negative music types had a statistically similar relationship with the term (see Section 4.7.2 for a more thorough analysis).

[11] Excerpt Pos_{08} was an excerpt from Iannis Xenakis' sound mass piece *Metastaseis*. The conflicting ratings between the two images may be explained by its atonality and nonmetrical attributes. These types of acoustic and musical characteristics are explored further in Chapter 6.

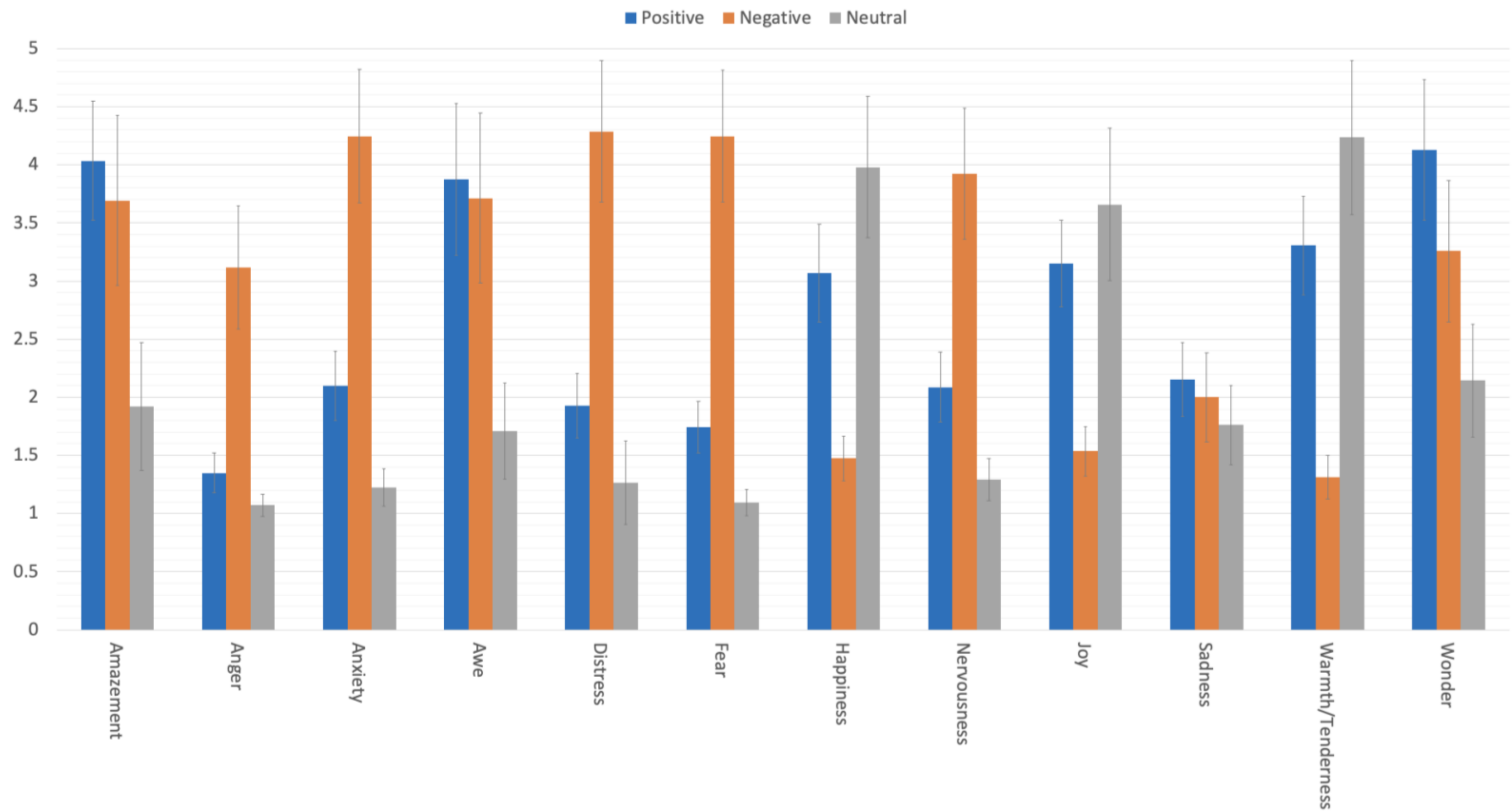
4.6.3 Study 4: Musical Awe Corpus and emotional terms

The results reported in this section are explorations of emotional rating data to investigate how participants associated emotional terms between valence categories of musical excerpts. To remove problematic data from the dataset, any block of experimental trials completed in less than 15 minutes was excluded. The JATOS experiment framework recorded the elapsed time for each section of the experiment. This allowed the researcher to examine the metadata associated with the study. If a participant completed the experimental section in under 15 minutes, they could not have listened to the excerpts as instructed (since the excerpts themselves took a total of approximately 15 minutes), and their data were removed from the dataset. Only the data from Participant 28 were removed from the dataset, due to their elapsed recorded time of 110s.

Appendix Table 4-9 provides the mean values, standard deviations, number of participants, and Cronbach's alpha for each emotional term. The rows are divided into valence categories (positive, negative, and neutral), where each reported mean is an aggregate value comprised of multiple ratings. For example, the first three rows describe participant ratings for the word 'amazement'. The ten excerpts labelled with positive valence were averaged, resulting in an aggregate mean value of 4.03 (found in row 1, column 1 of Appendix Table 4-9). Taken as a whole, the descriptive statistics show that the emotional terms used in this experiment vary greatly depending on the valence type of the music. Cronbach's alpha values show that the majority of the results are above the 0.70 value, suggesting that the data are appropriate for exploratory research (Lance, Butts, & Michels, 2006; Nunnally, 1978).

Figure 4-7

Emotional term ratings by valence category



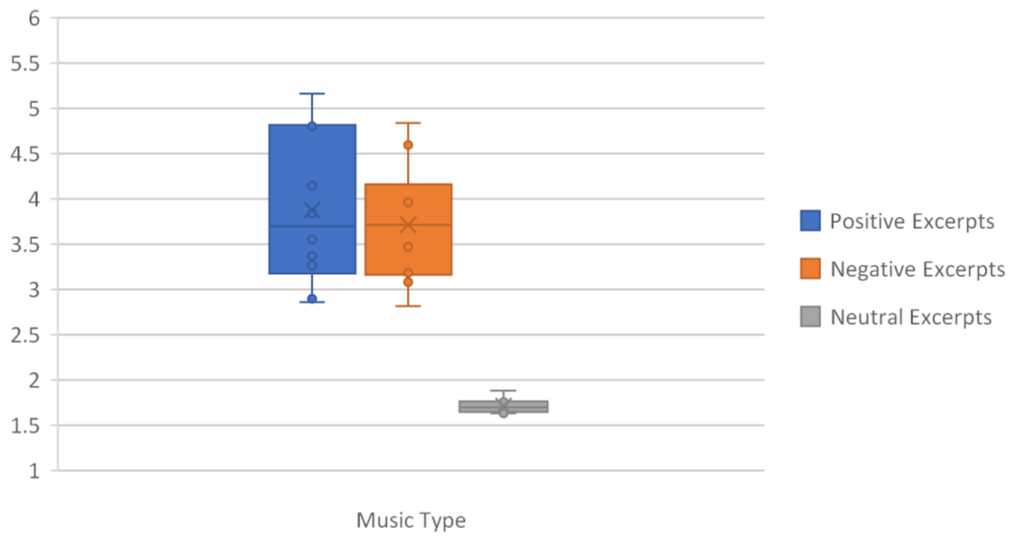
Note. Mean values and standard deviations for each rated emotional term. Each term shows ratings for the three music types: positive, negative, and neutral. Note that this figure is a visualisation of Appendix Table 4-9.

To investigate the relationships between the positive and negative types for the twelve emotional terms, the means and variances were compared through multiple *t*-tests, generating Appendix Table 4-10. The results of these comparisons show that ratings for the positive and negative music excerpts were significantly different for ten of the twelve tested terms. 'Sadness' and 'awe' did not reach significance. However, the ratings for those two terms were quite different: positive and negative ratings for 'sadness' (M = 2.15 and 2.00, respectively) were low, suggesting sadness was not a prominent emotional appraisal for the MAC. Positive and negative ratings for 'awe' (M = 3.87 and 3.71, respectively) were higher for both of the awe-related music types. An analysis of variance was performed showing that there was a significant effect of the musical type (positive, negative, and neutral) on the ratings for 'awe': $F(2, 47) = 81.01$, $p < 0.001$. Examining this result further, participants rated 'awe' for the positive musical excerpts (M = 3.87, SD = 1.30) and negative excerpts (M = 3.71, SD = 1.46) similarly. A paired samples *t*-test between the mean values for the positive and negative music types showed that there was not a significant difference between these ratings of 'awe': $t(48) = 13.38$, $p = 0.20$. This finding rejects $\text{Hypothesis}_{4\text{-}1}$ and suggests that the term 'awe' is not only, nor primarily, associated with positive affect. The mean ratings for awe on a per-song basis are shown in Figure 4-8. From the results, it is apparent that positive and negative ratings are similar and separate from the neutral music type. However, these results may be unreliable due to an increasing chance of a Type I error with each comparison. To remedy this problem, a one-way ANOVA was performed on the mean participant values of the dataset to analyse the difference between positive and negative music types. However, the homogeneity of variances (Leven statistic) was violated for the majority of comparisons, and a non-parametric Kruskal-Wallis *H* test was chosen in its place. The results showed that the terms 'amazement, 'awe', and 'sadness' did not reach significance between positive and negative musical excerpts. The results of the term comparisons are found in Appendix Table 4-11.

To account for the eight participants that completed both Studies 3 and 4, a parallel Kruskal-Wallis *H* test was performed to examine whether there were any significant differences in these comparisons. After extracting the eight participants and rerunning the test, the same terms 'amazement', 'awe', and 'sadness' were the only terms that did not show a significant difference between positive and negative music. Together with the similar mean ratings, this suggests that the complete dataset and the reduced set are comparable. Further explorations of the data will therefore continue to use the complete dataset.

Figure 4-8

Mean ratings for 'awe'



Note. Participant ratings of 'awe' for three music types in all 30 music samples. The difference between ratings scores for positive, negative, and neutral samples shows a clear association of the term 'awe' with those excerpts. Neutral music samples were consistently rated less for awe with a mean value of 1.71 (SD = 0.71) compared to the positive (M = 3.87, SD = 1.30) and negative (M = 3.71, SD = 1.46) music excerpts.

The analyses from Gordon et al. (2017) grouped specific emotional terms into several composite scores to evaluate broad emotional concepts, and this technique is used in the following section. The ratings for twelve emotional terms were clustered together into four groups: composite awe score (CAS), composite threat score (CTS), positive affect composite (PAC), and negative affect composite (NAC). These four aggregate scores (each described below) were used to evaluate the relationship between broad emotional perceptions and music type.

The composite awe score (see Appendix Table 4-12) was comprised of the ratings for the following terms: 'awe', 'wonder', and 'amazement'. The Cronbach's alpha scores yielded excellent levels of agreement ($\alpha > 0.90$) between the three terms suggesting that they can be analysed together. A paired samples *t*-test showed significantly different values for positive ($M = 4.01$, $SD = 1.18$) and negative ($M = 3.56$, $SD = 1.39$) music excerpts; $t(126) = 5.56$, $p < 0.001$. These results support $H_{5\text{-}2}$, which predicted that the composite awe score would be rated higher for positive than for negative music excerpts.

Similar to the construction of the composite awe score, the composite threat score consisted of the terms 'fear', 'anxiety', and 'nervousness'. The Cronbach's alpha scores showed a satisfactory level of agreement between the three terms ($\alpha = 0.87$), suggesting that they can be analysed together. A paired samples *t*-test yielded significantly different ratings for positive ($M = 1.98$, $SD = 0.57$) and negative ($M = 4.14$, $SD = 1.14$) music excerpts; $t(126) = 23.32$, $p < 0.001$. The mean value for negative music excerpts was rated significantly higher than the positive excerpts, which supports $H_{4\text{-}3}$. $H_{4\text{-}4}$ stated that the composite awe scores and composite threat scores would be significantly different. Two paired samples *t*-test showed that the positive excerpts ($M = 2.04$, $SD = 1.21$) and negative excerpts ($M = -0.58$, $SD = 1.50$) were statistically different from each other in both CAS and CTS; $t(146) = 20.41$, $p < 0.001$; $t(146) = -4.70$, $p < 0.001$, respectively, and supporting $H_{4\text{-}4}$.

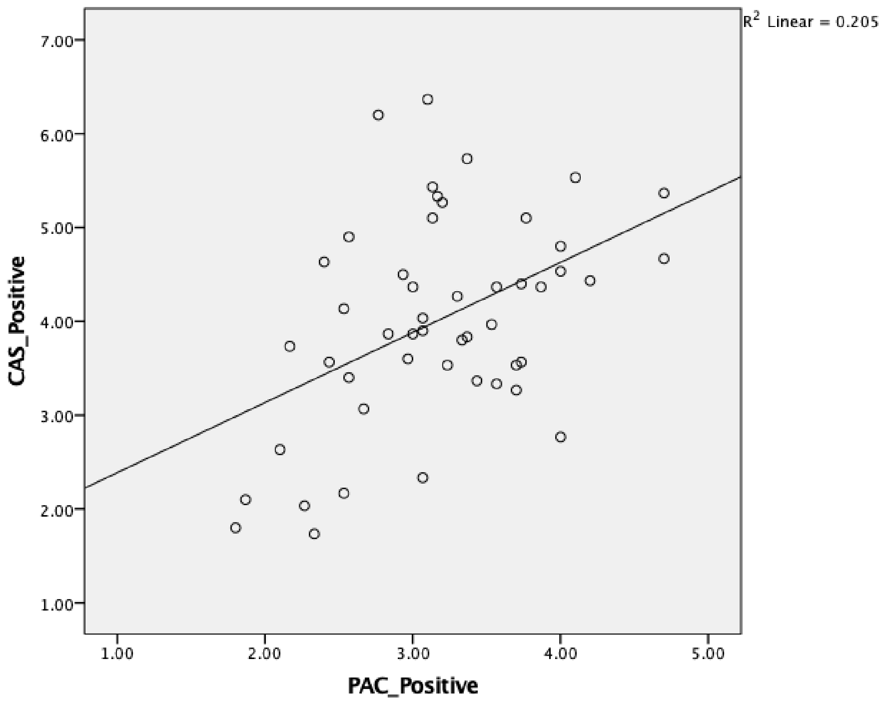
The positive affect composite score was comprised of the terms ‘happiness’, ‘joy’, and ‘warmth/tenderness’ and can be found in Appendix Table 4-14. The Cronbach’s alpha scores yielded acceptable levels of agreement between the three terms ($\alpha > 0.78$) suggesting they can be analysed together. A paired samples *t*-test yielded significantly different ratings for positive ($M = 1.98$, $SD = 0.57$) and negative ($M = 4.14$, $SD = 1.14$) music excerpts; $t(126) = 23.32$, $p < 0.001$. The mean value for negative music excerpts was rated significantly higher than the positive excerpts, which supports $H_{4\text{-}2}$.

The final grouping of terms produced the negative affect composite score was comprised of the terms ‘distress’, ‘anger’, and ‘sadness’ and can be found in Appendix Table 4-15. The Cronbach’s alpha score for the negative music type approached the 0.70 threshold ($\alpha > 0.69$), suggesting they can be analysed together. A paired samples *t*-test yielded significantly different ratings for positive ($M = 1.81$, $SD = 0.62$) and negative ($M = 3.14$, $SD = 1.39$) music excerpts; $t(126) = 11.07$, $p < 0.001$. As expected, the results showed that negative music types were rated significantly higher than positive music excerpts for negatively valenced emotional terms. The mean value for negative music excerpts was significantly higher than the positive excerpts, supporting $H_{4\text{-}6}$.

A Pearson correlation examined the relationship between the ratings of positive music excerpts between the composite awe scores and the positive affect composite. Seen in Figure 4-9, the relationship was positive, moderate, and statistically significant; $r = 0.453$, $n = 49$, $p < 0.001$. This supports $H_{4\text{-}5}$, which predicted that there would be a positive correlation between these two ratings.

Figure 4-9

Correlation between composite awe scores and positive affect composite scores

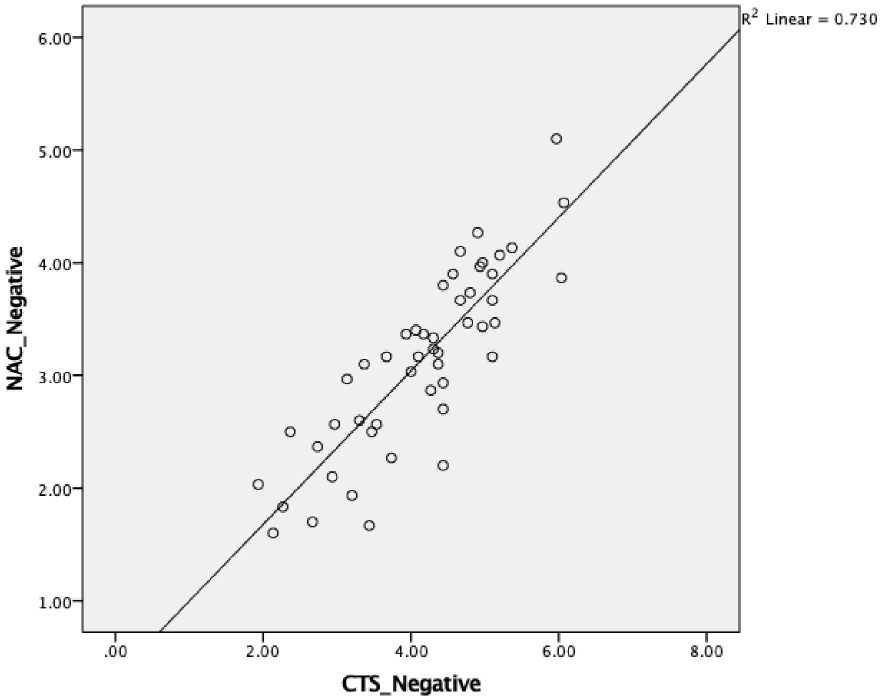


Note. The scatterplot shows a positive correlation between the composite awe scores and the positive affect composite; $r = 0.453$, $n = 49$, $p < 0.001$. The line of best fit can be described with the following expression: $y = 1.64 + 0.75x$.

A Pearson correlation examined the relationship between the ratings of the negative affect composite (NAC) and the composite threat score (CTS) of the negative excerpts. It was found that the relationship between these two ratings was strong and positive; $r = 0.855$, $n = 49$, $p < 0.001$ (illustrated in Figure 4-10). This supports $H_{4\text{-}6}$, showing that the perceptions of negative affect and threat were rated similarly.

Figure 4-10

Correlation between negative affect composite scores and composite threat scores



Note. The scatterplot shows a strong positive correlation between the composite threat scores (CTS_Negative) and the negative affect composite (NAC_Negative) of the negative music excerpts; $r = 0.855$, $n = 49$, $p < 0.001$. The line of best fit can be described with the following expression: $y = 0.32 + 0.68x$.

Exploring the Pearson correlation data further (see Appendix Tables 4-12, 4-13, 4-14, and 4-15), the following calculations compare the valence categories of each of the composite scores (CAS, CTS, NAC, and CTS). The relationship between the composite awe scores (CAS_Positive) and the composite threat scores (CTS_Positive) of the positive excerpts did not reach statistical significance; $r = 0.211$, $n = 49$, $p = 0.221$. This suggests no important relationship between these composite categories. Examining the same composite groups (CAS_Negative and CTS_Negative) from the negative music excerpts yielded a moderate, positive, and statistically significant relationship; $r = 0.399$, $n = 49$, $p = 0.005$. The correlation between the positive music excerpts for the composite awe scores (CAS_Positive) and negative affect composite (NAC_Positive) did not reach significance; $r = 0.163$, $n = 49$, $p = 0.264$. The negative music excerpts for the composite awe scores (CAS_Negative) and the negative affect composite (NAC_Negative) showed a moderate, positive, and statistically significant value; $r = 0.413$, $n = 49$, $p = 0.003$. Finally, the relationships between the positive affect composite (PAC) and the composite threat scores (CTS) were not significant ($r = 0.111$, $n = 49$, $p = 0.446$; and $r = –0.060$, $n = 49$, $p = 0.683$, for positive and negative music types respectively).

In sum, what this study has shown is that the emotional term ratings were largely dependent on the valence of the musical excerpts and that composite rating scores were helpful in illustrating the general emotional divisions seen in the perception of music types. Furthermore, the reported correlations between the four composite groups revealed a complex relationship between several emotional categories (further discussed in Section 4.7.2).

4.6.4 Summary of results: Study 4

The results of the Study 4 hypotheses are found below:

$H_{4\text{-}1}$: Ratings for the term ‘awe’ were not significantly different from the negative music type ratings but were higher from neutral music excerpts ratings. (rejected)

$H_{4\text{-}2}$: The composite awe score (consisting of ‘awe’, ‘wonder’, and ‘amazement’) was rated higher for positively valenced music excerpts. (supported)

$H_{4\text{-}3}$: The composite threat score (consisting of ‘fear’, ‘anxiety’, and ‘nervousness’) was rated higher for negatively valenced music excerpts. (supported)

$H_{4\text{-}4}$: The composite awe score and the composite threat score for excerpts were significantly dissimilar. (supported)

$H_{4\text{-}5}$: The positive affect composite (consisting of the terms ‘happiness’, ‘joy’, ‘warmth/tenderness’) was rated higher for positive music excerpts and positively correlated with the positive awe composite score. (supported)

$H_{4\text{-}6}$: The negative affect composite (‘anger’, ‘sadness’, and ‘distress’) was rated higher for negatively valenced excerpts and positively correlated with the composite threat score. (supported)

The Cronbach’s alpha scores suggest that most of the terms used in this experiment had a high level of agreement between participants. The only term that did not meet the 0.70 alpha level for positive or negative music types was ‘joy’. It was unclear why the perception of joy was difficult to rate for these excerpts, as the similar positive music type ratings for the term ‘happiness’ were rated above the 0.70 threshold for Cronbach’s alpha. The heterogeneity found in the ratings for ‘joy’ may suggest that the perceptions of negative music in the MAC may have higher variability for particular positive affects. However, it can be reported with confidence that this variation was limited within the lower boundary of the ratings: the mean value for ‘joy’ and ‘happiness’ were still under 2.00 (M = 1.53 and 1.48, respectively). *T*-tests between the means of positive and negative music types for each term showed that all but two terms yielded significantly different values. The terms ‘awe’ and ‘sadness’ did not reach significance, suggesting that there is no apparent perceptual difference between these excerpt types. This is a surprising finding, because ‘awe’ was expected to be rated higher for positive music excerpts, given that the term is generally associated with positive experiences (e.g. Campos et al., 2013). These results suggest that ‘awe’ is in fact an appropriate term for describing both positively and negatively valenced versions presented in this experiment. However, these results also suggest that ‘sadness’ may not have been an appropriate emotional evaluation for the awe-related music presented in the experiment, as the data did not show a significant differentiation between these two forms of musical awe. It is interesting that neither of the two basic emotions of ‘happiness’ and ‘sadness’ are differentiated between the valence versions of awe-related music, suggesting that these simpler emotions are not relevant to discussion of the positive and negative versions of awe. The differentiated of positive and negative music types for the composite awe score and the composite threat score suggests that a threat-based variant of awe has salient perceptual features. The statistically significant difference between positive affect composite and negative affect composite scores suggests that the same divide between awe and threat exists between positive and negative affect. The positive affect composite scores and composite awe scores showed a moderate correlation, and the negative affect composite scores and composite threat scores showed a strong correlation. This suggests that the emotional terms rated together may be perceived similarly. For example, if a piece of music is rated as threatening, there is a high probability that the music is also rated as angry and distressful. Interestingly there was a moderate correlation between the composite awe score and the negative affect composite, suggesting that perceptions of awe in music are not limited to positively valenced ideas but also involve negatively valenced assessments. This claim is supported by the null *t*-test result found when comparing mean values for the term ‘awe’. This is all evidence for a bifurcation of our understanding of experiences of musical awe. Similar to the conclusions of Gordon et al. (2017), it is seen here that the music related to experiences of awe can be categorised into two ways: a negative variant and a positive variant. Previous research has described these two types of experiences as the ‘threat-based variant’ and the ‘awe-based variant’ (Gordon et al., 2017), but the term ‘awe’ does not describe the emotional associations of the positive variant particularly well. Examining the highest ratings for each of the valence types (found in Appendix Table 4-9), it would be more reasonable to describe these two types of awe as ‘wonder-based awe’ and ‘distress-based awe’.

Comparing the composite score results of Study 4 to the recalled experiences study by Gordon et al. (2017), important differences were revealed. The composite awe scores (CAS) results of Gordon et al. (2017) were rated highly for both positive and negative recalled experiences (*M*s = 6.31, 5.93). However, in Study 4, the CAS mean values were significantly lower (*M* = 4.01 and 3.56 respectively). This trend was indicative of many of the scores reported across the experiments, which was likely due to perceptual ratings being weaker than the ratings of personally recalled experiences. However, this trend does not apply to the composite threat scores (CTS). Music excerpts were rated higher for negative music types (*M* = 4.14) and lower for positive types (*M* = 1.98) in Study 4 when compared to the mean values for recalled experiences from the Gordon et al. (2017) study (*M* = 3.61 and 2.05, respectively). This may be due to the perceptual clarity of anger and distress in music (Huron 2008; Huron, Kinney, & Precodaet, 2006), while recalled memories may be less vivid (and visceral) when reporting these emotional associations.

4.6.5 Study 5: Musical Awe Corpus and appraisal terms

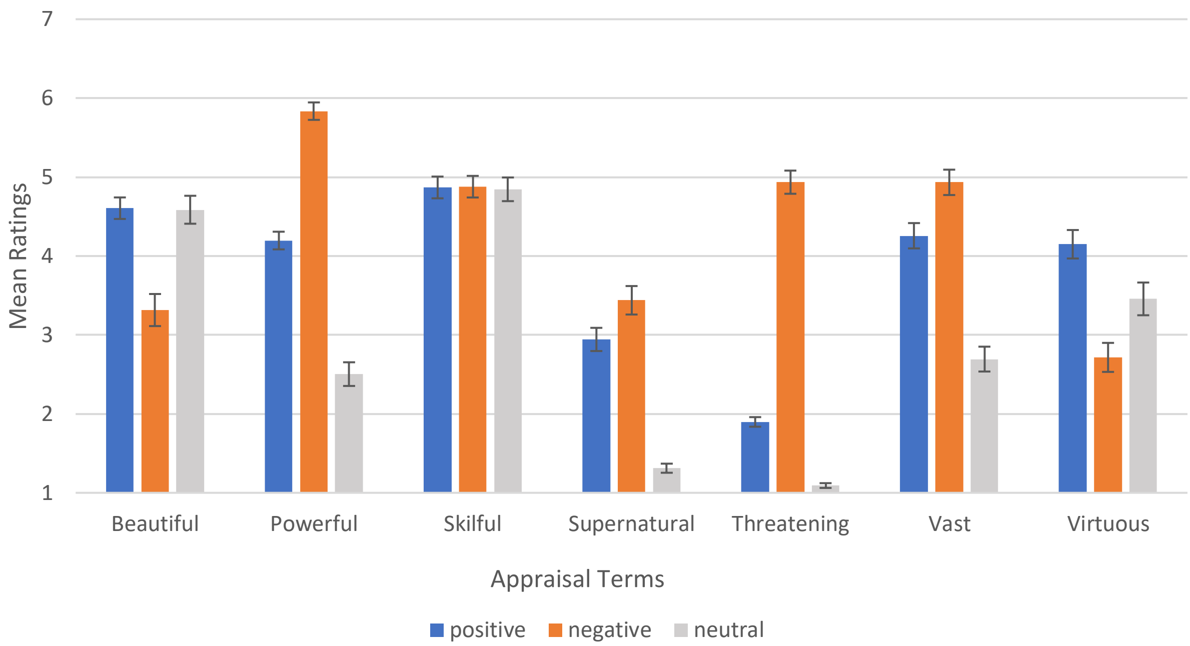
The results reported in this section detail explorations of the appraisal terms that have been hypothesised to relate to experiences of awe. Since the participants for this study were sourced through Amazon Mturk, the following precautions were put in place to minimise the collection of problematic data: unambiguous instructions were given to participants to listen to each music sample in their entirety before answering the associated questions. A global timer in JATOS ran synchronously to each participants' access to the experiment, and any participants who completed the experiment in less than 15 minutes had their data removed and not included in this analysis. This figure was chosen as the minimum amount of time to listen to each of the music samples in their entirety. Due to the experiment being open to a large number of possible participants and the nature of a paid online experiment, many participants did not fully complete the experiment, and others submitted answers within less than the minimum time allowed. This yielded a total of 51 participants for the analyses in this section.

Appendix Table 4-16 provides descriptive information on the ratings of each of the appraisal terms tested in this study, including means, standard deviations, and Cronbach's alpha values. The data presented are organised in the same manner as for Study 4.

Taken as a whole, the descriptive statistics (Figure 4–11 and Appendix Table 4-16) show that the ratings for appraisal terms show differences in conceptual associations between positive and negative music types. Cronbach's alpha calculations suggest that there was a consistency in the ratings for each music type in each appraisal term category, i.e. every calculation reached above the 0.70 threshold, except for one (marked in Appendix Table 4-16 with ***).

Figure 4-11

Mean values of appraisal terms



Note. Mean ratings and standard error for each appraisal term and the corresponding music type (from Appendix Table 4-13). All terms except 'skilful' showed differentiation between ratings of different music types. There was no significant difference in the ratings for 'skilful'; $F(1.576, 78.8) = 0.055$, $p = 0.911$ (see text). Overall, music excerpts in the negative music type showed higher mean scores in ratings of 'powerful', 'threatening', and 'vast', while positive music excerpts showed higher ratings for the terms 'beautiful' and 'virtuous'.

The mean values for the appraisal terms add convincing evidence to support hypotheses $H_{5\text{-}2}$ and $H_{5\text{-}3}$. 'Beautiful' was rated higher for positive music types ($M = 4.61$, $SD = 0.97$) and lower for negative music types ($M = 3.32$, $SD = 1.45$); $t(100) = 5.281$, $p < 0.001$. Negative music types were rated higher ($M = 4.94$, $SD = 1.05$) for the term 'threatening' than positive types ($M = 1.90$, $SD = 0.43$); $t(100) = 19.134$, $p < 0.001$. 'Supernatural' was the only term rated with mean scores lower than the midpoint (4.0), lending support to $H_{5\text{-}5}$.

To test for a significant difference between the three music types and terms and to address $H_{5\text{-}1}$, a repeated-measures MANOVA was performed. This analysis was performed with the aggregate ratings of the 51 participants and showed a highly significant effect of the music type on ratings of the appraisal terms; Pillai's Trace = 1.631, $F(14, 190) = 59.973$, $p < 0.001$. Following from this result, further ANOVAs were performed to examine each of the appraisal terms. For each of the seven appraisal terms, the Mauchly's test indicated that the assumption of sphericity had been violated (see Appendix Table 4-17), and the degrees of freedom were corrected using Huynh-Feldt estimates.

The results show that there was a significant effect of the music type on the ratings of all but one of the appraisal terms: 'beautiful'; $F(1.833, 91.6) = 49.749$, $p < 0.001$, 'powerful'; $F(1.351, 67.6) = 297.152$, $p < 0.001$, 'supernatural'; $F(1.827, 91.4) = 149.809$, $p < 0.001$, 'threatening'; $F(1.236, 61.8) = 655.342$, $p < 0.001$, 'vast'; $F(1.525, 76.3) = 121.971$, $p < 0.001$, and 'virtuous'; $F(1.775, 88.7) = 34.663$, $p < 0.001$. The only term that did not reach significance was 'skilful'; $F(1.576, 78.8) = 0.055$, $p = 0.911$. These results support $H_{5\text{-}1}$ in showing all but one of the appraisal terms had statistically different ratings for the music types.

To explore the relationship between the ratings for the appraisal terms, all seven of the examined term ratings were correlated, and several moderate-to-strong correlations were found between the terms. These calculations used 20 ratings from each participant ($N = 51$), consisting of 10 ratings for positive excerpts and 10 ratings for negative excerpts, resulting in 1,020 data points. The strongest five correlations are reported here in order of their strength. Pearson correlations showed a moderate positive correlation between the ratings of 'vast' and 'powerful'; $r(1018) = 0.59$, $p < 0.001$, supporting $H_{5\text{-}4}$. There was a moderate positive association between the terms 'beauty and 'virtue'; $r(1018) = 0.54$, $p < 0.001$. 'Beauty' and 'skilful' also showed a moderate positive correlation; $r(1018) = 0.49$, $p < 0.001$. A moderate negative correlation was found between the ratings of 'virtuous' and 'threatening'; $r(1018) =$

–0.43, $p < 0.001$. Finally, a moderate positive correlation was found between 'supernatural' and 'threatening'; $r(1018) = 0.43$, $p < 0.001$. The complete matrix of correlations can be found in Appendix Table 4-18.

4.6.6 Summary of results: Study 5

$H_{5\text{-}1}$: For six of the seven appraisal terms, the ratings for positive and negative music types were dissimilar. (largely supported)

$H_{5\text{-}2}$: Positive music excerpts were rated higher than negative excerpts for the terms 'beautiful' and 'virtuous'. (supported)

$H_{5\text{-}3}$: Negative music excerpts were rated higher than positive excerpts for the term 'threatening'. (supported)

$H_{5\text{-}4}$: There was a moderate positive correlation between the appraisal terms 'powerful' and 'vast'. (supported)

$H_{5\text{-}5}$: All the appraisal terms tested for their association with music in the MAC_1 were rated with consistency in their music groups, and only the term 'supernatural' failed to show a positive or negative rating above the midpoint (4.0). This suggests the terms used in Study 5 were relevant to perceptions of music that comprised the MAC_1. (supported)

The Cronbach's alpha scores showed a high level of internal consistency. This suggested several relevant points for the analysis. Firstly, it appears that the general perceptions and understandings related to the appraisal terms were widely understood, as the excerpts of MAC_1 were generally appraised similarly. The only term that failed to meet the 0.70 threshold was that of the positive excerpt ratings for the term 'threatening' (at 0.597). This may be due to the term 'threatening' being an obviously negatively valenced emotional term, and for one to rate positively valenced music as threatening may have been confusing for participants. Looking into the data further, this lack of agreement for the positive 'threatening' ratings may have originated from a particular music excerpt—specifically, excerpt 14 (Pos03) received significantly higher ratings for 'threatening' ($M = 5.51$, $SD = 1.49$), compared to the total mean ($M = 1.90$). Removing this excerpt brings the Cronbach's alpha value to 0.662, which then approaches the threshold for exploratory research.

As this study is focused on the relevance and applicability of hypothesised terms related to awe, each of the terms is discussed below. The mean values for ratings of 'beauty' for positive ($M = 4.61$, $SD = 0.97$) and neutral music ($M = 4.59$, $SD = 1.26$) were not significantly different; $t(100) = 0.09$, $p = 0.929$. However, there was a significant difference between positive ($M = 4.61$, $SD = 0.97$) and negative ($M = 3.32$, $SD = 1.45$) music groups; $t(100) = 5.29$, $p < 0.001$. These findings suggest that similar appraisal processes for beauty may be used in many types of music, not only positively valenced awe. Nevertheless, these results show a substantial difference between positive and negative music types, suggesting that judgements of beauty may be a helpful way to divide experiences of awe-related music.

However, it is unknown whether beauty may be a useful measure for understanding awe-related music when referring to a broader corpus of music. For example, 'powerful' was rated the highest of all the appraisal terms (positive: $M = 4.20$, $SD = 0.80$; negative: $M = 5.84$, $SD = 0.80$). This term was not one of the appraisal terms hypothesised by Keltner and Haidt (2003), but was chosen for this study for its philosophical underpinning to experiences of awe. Since awe can be understood as a reaction to a sublime experience (Arcangeli et al., 2020; Shapshay 2013a, 2013b), and 'power' has been theorised as a primary property of the sublime (Burke, 1575/2015), 'power' was rightfully tested for its awe-based associations in Study 5. The results showed higher ratings for the negatively valenced music excerpts than for the positive, but both were rated over the midpoint (4.0) in contrast to the neutral sample ($M = 2.50$, $SD = 1.07$). As 'powerful' was expected to be fundamental to experiences of awe, here the results show that it was also solidly reflected in the appraisals of awe-related music, for both positive and negative types.

'Skilful' was rated similarly among all music types, which suggests that appraisals of skill may not be the most beneficial way to distinguish variants of musical awe. As a result, an appraisal of skill (originally described as 'ability') was seemingly not a marker of awe-related music. These results may be explained by music's connection with skill in general. Due to music generally being considered a skilful practice, and by rating performances that were not specifically selected for their virtuosity, music in any form may be rated above average for 'skilful', regardless of its relationship to awe. Even though these results suggest that 'skilful' may not be a distinguishing appraisal for awe-related music, there may be instances of musical awe where ability and skilfulness represent important aspects—for example, a musically demanding passage that was superbly executed. However, these types of evaluations of skill were not represented in the stimuli tested in Study 5. Furthermore, the lower level of musical training seen in participants of this study may be suggestive of a failure to recognise or consider skilfulness and ability as it relates to music performance.

The mean ratings for 'supernatural' were all under the midpoint score of 4.0, with negative music excerpts being rated slightly higher (M = 3.44, SD = 1.29) than positive excerpts (M = 2.94, SD = 1.05). Examining the data for each of the excerpts, only one of the negative excerpts (excerpt 12 (Neg01); M = 4.43, SD = 1.85) had a mean rating over 4.0. For this specific music excerpt, there was broad disagreement regarding the ratings, as shown in its standard deviation and the range of scores (encompassing every possible rating from 1–7). However, there was generalised agreement that the neutral music excerpts were not associated with the term 'supernatural' (M = 1.31, SD = 0.41). This shows that there were only limited low-level appraisals being made when judging awe-related music, at least in part, as 'supernatural'.

The term 'threatening' exhibited more definitive results, with higher ratings for the negative music excerpts (M = 4.94, SD = 1.04) and lower ratings for positive music excerpts (M = 1.90, SD = 0.43), the difference being statistically significant; $t(100) = 19.12$, $p < 0.001$. This finding suggests that threat is often a clear indicator and association of negatively valenced awe-related music.

'Vast', like 'power', was not included in the original five appraisals theorised by Keltner and Haidt (2003) but was listed as a 'central feature'. The results show that music related to experiences of awe may be appraised as 'vast' for both positive and negative music types, and that these ratings correlate positively with each other; $r(1018) = 0.59$, $p < 0.001$. The term 'vast' was chosen as a central appraisal for awe due to its perceptual salience, as well as 'to capture the many aesthetic cases of awe in which power does not seem to be at work' (Keltner & Haidt, 2003, p. 303). From the results of Study 5, both 'vast' and 'powerful' produce high ratings with negative excerpts being rated higher than positive excerpts.

The final appraisal term 'virtuous' showed higher values for the positive excerpts (M = 4.15, SD = 1.29) than the negative ones (M = 2.72, SD = 1.31). Notably, the neutral music excerpts fell between these means (M = 3.46, SD = 1.48). These results suggest that appraisals for virtue do not simply mirror the valence of the music (see the results for 'happiness' and 'joy' in Figure 4-7) but perhaps are directed from a relatively neutral understanding of virtue and swayed by appraisals of beauty and threat (higher for more 'beautiful', and lower for more 'threatening'), as these terms have the highest correlations with 'virtuous'. This suggests an interconnectedness between these appraisals, forming a network in which certain appraisals are dependent on others. To test this post-hoc theory of interconnectedness, a multiple regression was run to predict the positive excerpt ratings of 'virtue' from 'beautiful', 'powerful', 'supernatural', 'threatening', and 'vast'. 'Skilful' was omitted from this analysis due to its non-significant relationship with music type. The variables predicted statistically significant ratings for ‘virtuous’; $F(5, 504) = 68.16$, $p < 0.001$, $R^2 = 0.403$, and the ‘beautiful’, ‘threatening’, and ‘vast’ variables added statistically significantly to the prediction; $p < .001$. To examine this result, a second regression was run on the participant mean values (i.e. each participant’s average ratings for each music condition, resulting in 51 ratings). The variables again statistically significantly predicted ratings for ‘virtuous’; $F(5, 45) = 14.5$, $p < 0.001$, $R^2 = 0.617$. Only the variables ‘beautiful’ and ‘vast’ added statistically significantly to the prediction; $p = 0.022$ and $p < 0.001$, respectively. To test the negative music type for ‘virtuous’, the same analyses were performed; $F(5, 504) = 42.86$, $p < 0.001$, $R^2 = 0.298$. The results showed that ‘beautiful’, ‘threat’, and ‘vast’ added statistical significance to the prediction; $p < 0.001$. The analysis of the participant means showed a better fit for the model; $F(5, 45) = 12.53$, $p < 0.001$, $R^2 = 0.582$l. With this analysis, only the term ‘vast’ added statistically significantly to the prediction; $p < .001$. This exploration of the data suggested that appraisals for ‘vast’ were a key predictor for ‘virtuous’, and ‘beautiful’ appears to be predicative of ‘virtuous’ in positive musical excerpts. These results suggest that ‘vast’ is a fundamental appraisal driving some of the other associations.

From the results of Study 5, it is clear that positive and negative music types were appraised differently and have often contrary associations for the terms tested in Study 5. Ignoring ‘powerful’ and ‘vast’, to examine the five ‘peripheral’ appraisals (i.e. threat, beauty, ability, virtue, and supernatural) hypothesised by Keltner and Haidt (2003), this study has provided the first empirical evidence for the applicability of these features to awe-related music. It was hypothesised that awe-inspiring music would usually have the features of ‘beauty’ and ‘ability’ (here tested as ‘skilful’), while the others were less appropriate for music. Overall, Study 5 suggests that each of these appraisal terms can be important to the perception and understanding of musical awe. The clearest example can be found in ratings for ‘threatening’, a prominent feature for negative music excerpts, and which should be included in our understanding of a negative variant of musical awe. ‘Virtuous’ and ‘supernatural’ also show differences from non-awe-related music. It is argued that all hypothesised peripheral appraisals are appropriate to music (even ‘skilful’ in specific contexts as described above). Finally, the ratings for ‘vast’ and ‘power’ convincingly support the idea that they are central components of awe-related music. Additionally, since these central features are not only present in the *experience* of awe but were carried over and recognisable in the *perceptions* of awe-related music, a primary experiential feature of musical awe has been proven to be testable in a less ecologically valid setting. This suggests that the musical features themselves may hold important acoustic information for the elicitation and recognition of awe.

4.7 Discussion

The results of the three studies presented in this chapter strongly suggest that perceptions of awe-related music are similar. These studies have provided ample evidence to establish that the awe-affording excerpts used in these studies are widely understood as being associated with similar emotional characteristics and ideas. While each musical excerpt in its valence-based category did not produce the same recognition of emotions and appraisal, the results strongly suggest that there was enough commonality in these judgements to assert that there are at least two perceptibly distinct forms of awe-related music. The results of Study 3 showed that that awe-related excerpts of music can be divided into two opposingly valenced groups. Further tests (MANOVAs and ANOVAs) were performed on positive and negative valence associations and showed a significant effect of music type (positive vs. negative valence associations) on ratings of the aurora borealis image and the supercell thunderstorm image. The results of Study 4 suggested that specific emotional terms have stronger relations with different variants of awe. This study ran independently of Study 3, and the results of Study 4 showed that negatively valenced variants of the MAC have strong associations with negatively valenced terms, and positively valenced MAC excerpts were associated with positive emotional terms. Notably, the term ‘awe’ was not rated significantly different between the positive and negative music types, suggesting that the use of the term ‘awe’ may be equally appropriate for both types of music. The results from Study 5 showed distinct appraisal profiles between negatively valenced and positively valenced MAC_1 stimuli. This study concluded by proposing two variants of awe based on the emotional terms with the highest ratings—namely, ‘wonder-based musical awe’ and ‘distress-based musical awe’, both of which are interpreted with the previously identified categories of ‘positive-’ and ‘threat-based’ awe.

The findings across these three studies disagree with the findings of Yaden et al.’s (2019) study on experiences of awe. In this study, the researchers were interested in valence, themes, and triggers for experiences of awe. This was not limited to musical awe, and most experiences of awe investigated were of another domain, with music listed as a trigger for less than five per cent of the participants. However, they found an extremely positive association with experiences of awe and positive valence through participant ratings of a battery of emotional terms. Yaden et al. were also interested in the peripheral appraisals, renamed as ‘themes of awe’, in their study. Their results showed beauty and ability as the two substantial associations for participants. ‘Virtue’, ‘supernatural’, and ‘threat’ were all rated low in agreement of influence for participants. The discrepancies between Studies 3, 4, and 5 and Yaden et al.’s investigation can be explained through the differences in methods. Yaden et al. used retrospective approach (similar to that used in Study 1 of this project; see Chapter 3, Section 3.4), where participants recalled past experiences of awe and were asked to write about these experiences and answer related questions. Naturally, some of the same biases described in Chapter 3 were also applicable to this study, and the preponderance of positively valenced experiences may have been expected as a result.

4.7.1 Conclusion

The foundational claim tested by the studies presented in this chapter is that music associated with experiences of awe can be categorised in specific ways to better understand the experience of musical awe. This categorisation is important because it suggests that the experiences and perceptions of music associated with awe are not entirely idiosyncratic to individuals, and that the subjective experiences of musical awe are not impenetrable to objective investigation. Moving away from phenomenological accounts of musical awe into stimulus-based experimentation allows research to investigate the particular perceptual components found in the sonic and musical qualities of awe-affording music.

These studies have provided empirical evidence that music associated with awe is largely perceived as one of two valence-based categories: positive: 'wonder-based awe' or negative: 'distressed-' or 'threat-based awe'. This largely matches the awe- and threat-based sublime categories described by Gordon et al. (2017). The judgements of music associated with awe are different from those judgements from personal recollections of awe, but it is reasonable to conclude that there are many similarities between the two modalities. Both personal recollection and music-based experimentation assessments show that there are substantial differences between positive and negative valence variants of awe. This divide therefore provides empirical evidence in support of philosophical and psychological frameworks regarding the differentiation of experiences of awe. Burke (1757/2015), and Kant (1764/2011) described different forms of the sublime, and these variants can be interpretated to be expressed within the data presented in these studies (see Chapter 7, Section 7.2.3). The data also suggest that the framework presented by Keltner and Haidt (2003) should be expanded to incorporate threat-based appraisals as pertinent evaluations for the understanding of musical awe. The features of 'virtue' and 'the supernatural' may also have importance within awe-related music but may be dependent on which variant of musical awe is being experienced. With the validation and importance placed on the vastness as a central feature, the subsequent steps of this project will seek to understand the influence of perceptions of size and vastness to awe-related music and the musical and sonic factors responsible for these perceptions.

4.7.2 Limitations

The primary limitation of these studies can be found in the creation of the MAC. This collection of musical excerpts is based on 71 participant responses to the online questionnaire of Study 1. The prompt used in Study 1 unintentionally emphasised a positively valenced form of awe due to the used of the term 'beautiful', and in turn the MAC may reflect this positive valence bias. However, in the construction of the MAC_1, the experimental testing subset of the MAC used in Study 4, this bias was lessened due to expert listeners assessing MAC without previous knowledge of the positive valence language used in Study 1. However, the limitation remains; the corpus from which the MAC_1 was selected, suffers from a potential positive bias in its creation, and the music used in the Study 4 may have been influenced due to this oversight.

The sampled population had a high degree of music exposure and education and was ultimately limited by the outreach of the recruitment methods. This limitation was in part mitigated by the incorporation of broader perspectives and examples of musical awe from online sources. However, even with this addition, it is difficult to make any claims regarding universal experiences of musical awe. For example, no vocal music was included in the experimental version of the MAC, and this excludes a considerable portion of the reported music from Study 1. The results presented within this chapter should be understood as particular versions of musical awe and do not constitute a comprehensive view of the phenomenon. Secondly, there were limitations in the online self-report methodology. The demand characteristics of the experiments may have been deduced by the participants making ratings dependent on an understood classification of excerpts. Self-presentation bias is another limitation for self-reporting where participants ratings for undesirable traits may be affected by 'issues of self-esteem and social desirability' (Zentner & Eerola, 2010, p. 210).

A further limitation comes in the cultural specificity of the music, participants, and emotional affordances raised by the music. As the music of the MAC was developed from Western (primarily British and American) participants and tested on a similar participant population, these pieces of music are reflective of a Western enculturation of music and aesthetic attitudes. This limits the universal reach of this study but does advance a particular Western aesthetic categorisation of awe-related music.

These studies suggest how different types of emotional associations are relevant to the perception of musical awe. However, they do not comment on the nature of those relations to perceptions of size and the actual musical content present in the excerpts. With the establishment of common participant perceptions and appraisals, the following step in exploring these musical experiences is to investigate both perceptions of size and the musical features themselves. Chapter 5 presents a study that experimentally develops the relationship between perceptions of size and awe, and Chapter 6 presents several analyses that address this gap in knowledge by analysing acoustic features present in the MAC. The results from the present chapter are used to inform the categorisation of positive awe-related music and negative awe-related music to be tested in the following studies.

5 Study 6: Time series analyses of perceptions of musical size, recognition of awe, and causal interpretations

5.1 Introduction

The previous chapter explored the idea that musical awe may take two different forms—a positive version characterised by wonder and joy, and a negative version related to fear and threat. Though these forms could be understood as distinct forms of awe, both were shown to have a shared perceptual foundation in power and vastness. Recalling the images used in Study 3, the aurora borealis and a supercell thunderstorm, these images depicted massive objects and environments. The power of a thunderstorm and the vastness of the illuminated northern sky are archetypal environments for the elicitation of awe. But how can power and vastness be understood in music? The study presented in this chapter seeks to answer this question by investigating the connection between vastness and music through the analysis of participant ratings of the size of music in a virtual acoustic space and ratings of awe. Vastness is a conceptually dense cognitive assessment, and to estimate or measure the vastness of an object or environment can be problematic due to the complex perceptual qualities associated with the task. Which is more vast: the ocean or the sky? The approach adopted in this chapter is to transform and reduce vastness into the more tractable and quantifiable judgement of size—a central aspect of vastness. This chapter presents an investigation into the relationship between perceptions of musical size and judgements of musical awe. The study expands on the previous chapter's findings concerning the different types of musical awe by directly probing judgements of size to examine whether these judgements are altered by the valence of awe-related music. Using time series analysis, Study 6 also investigates continuous and temporally related data to establish possible causal links between assessments of musical size and musical awe.

5.2 Supporting research

5.2.1 Musical size, space, and auditory looming

Sound surrounds us. It passes through the air and other mediums travelling distances proportionate to its amplitude. Physically, sound is composed of density waves that propagate and disperse from their origin in all directions, slowly running out of energy until their kinetic momentum is fully absorbed by a medium. To describe the size or space that a sound occupies, a physical description of the length and span of excited particles does not perfectly capture how a listener may experience that sound. Our auditory system has evolved in a world filled with sounds, and the awareness and predictability of environmental sounds has provided myriad evolutionary advantages. Our interpretations of sounds depend on our distance from the origin, the energy and quality of the sound-producing event, and the medium though which it travels.

William Gaver, writing on ecological acoustics, described the importance of examining sounds as auditory events set inside their environment: ‘sounds are caused by and convey information about the interaction of materials at a location in an environment’ (1993, p. 1). The environmental interactions and manipulations of sounds grant the listener information about the location and nature of the sound. We are interested in sounds in our environment because they afford actionable information about the world. This ecological framework (emerging from the work of James Gibson) has been applied to how we listen to music and can provide a helpful framework for the interpretation of sounds ‘available to a perceiver’ (Clarke, 2013, p. 91).

Listening to music in a three-dimensional virtual space is comparable to the intuitive process of listening to a sound in one’s actual environment. As a vehicle drives past your window, and without looking outside you can deduce its directionality, speed, the presence of water on the road, etc. The pick-up of perceptual information used to place a vehicle in the world has its equivalent within music in the capacity to situate musical sounds in a space—real or virtual. This process of sound spatialisation also occurs when listening to recorded music. Though the listener is not physically situated in the space in which the musical sounds were produced (e.g. concert hall or recording booth), the listener can detect and formulate a 'virtual space' in the same manner as for real physical spaces. These virtual spaces are not governed by the same rules as physical spaces and through various recording techniques, virtual spaces can be manipulated and transformed to mimic and expand the sense of spatialisation (Doyle, 2005). Through effects including echo, reverb, and panning, the spatial characteristics of recorded music can be endlessly manipulated to influence how a listener places them in a virtual space. Trevor Wishart described the virtual acoustic space as a 'landscape' (1985, p. 140) where three complementary components define the space: (1) the nature of the perceived acoustic space, (2) the disposition of sound-objects within the space, and (3) the recognition of individual sound-objects. The nature of the space is specified by the acoustic cues involved in listening to the sound-object—with resonance and reverberation time being of particular importance (Hameed et al., 2004). The disposition of sound-objects within the space relates to the distancing of sounding objects from the listener. Finally, the recognition of sound-objects refers to the ability of the listener to identify the source of the sound. With these three axes of virtual space, musical objects can be conceptualised inside a virtual space in the same way that sounding objects are situated in reality.

The positioning of sounds in space can be further explained through research into auditory motion and auditory looming, both involving attending to sounds approaching the listener. Auditory motion in an environment is perceptually prioritised when compared to static sounds (e.g. Bach et al., 2009; Freiberg et al., 2001). 'Looming sounds initiate a series of protective physiological, cognitive, emotional, and behavioural responses that do not occur in response to sounding objects that move in any other direction' (Neuhoff, 2016, p. 1). Interestingly, approaching visual objects are accurately estimated to arrive in the correct time (McBeath et al., 19955; Reagan & Vincent, 1995), whilst in predicting approaching (i.e. looming) sounds, there is a systematic error that results in looming sounds being heard closer and faster than their equivalent receding sounds (McCarthy & Olsen, 2017; Neuhoff, 2016). This difference is hypothesised to be due to an adaptive perceptual bias (Neuhoff, 1998) evolutionarily developed to keep the listener safe by providing additional time to the listener for responding to potential threats more easily.

In our everyday experience of sounds, the environments in which they occur often provide us complementary visual cues for their occurrence and movement. In the vehicle example previously mentioned, looking out of the window on first hearing the sound of an approaching vehicle would usually be accompanied by the sight of a vehicle driving past the window, and the sounds produced are incorporated into an understanding of the event. These multi-modal associations strengthen our understanding of the world through the spatialisation of objects and how sounds operate in an environment. In a virtual acoustic space, a listener applies these same perceptual understandings of a physical environment to the virtual environment. These virtual environments allow for properties that mimic (or transform) the real-world characteristics of objects and actions, and through this virtual and ecological understanding of sound, judgements of size may be made. Examining music through virtual spaces and their ecological associations affords a method to investigate what this study is calling 'musical size': the size of a musical object situated in a virtual space.

5.2.2 Size, awe, and experimentation

Musical size provides a pathway to explain how judgements of vastness may be made in relation to music. A fundamental hypothesis is that the perception of a large and powerful object is a pre-condition for the feeling of awe (Keltner & Haidt, 2003). It is not required for the object to be physically large, but one's encounter with the object must be conceptualised as large through at least one modality. Largeness/Vastness interpreted as musical size could be reasonably understood as a sound-object within a virtual acoustic environment that occupies a large spatial volume. The intensity of a sound has a direct audio-visual interaction to how visual objects are understood, with the more intense (louder) the sound, the larger the object is perceived (Takeshima & Gyoba, 2012) and/or the closer the object is to the observer (Cochran, Throop, & Simpson, 1968). Therefore, it would be expected that intensity, perceived as loudness, would have a significant relationship to experiences of awe. To test for these connections, an experiment would need to investigate how perceptions of musical size relate to loudness in awe-related music.

5.3 Aims

The previous chapter discussed three studies relating to emotional associations of selections from the Musical Awe Corpus (MAC). These studies found that awe-related music can be divided into two perceptual categories that are largely dependent on the perceived valence of the music. This yielded one group of music related to negative emotions (e.g. fear and threat) and another that was associated with positive emotions (e.g. wonder and joy). Study 5 also showed that the music in the experimental version of the MAC (i.e. MAC_1) was rated highly for general associations with size. These data mirrored responses in Study 1 in which participants rated the music which induced their own experiences of musical awe as 'vast' in some way (see Chapter 3, Section 3.4.2.2). The positive and negative types of awe-related music are used in this chapter's study to examine how perceptions of musical size are related to perceptions of awe and to investigate if these relationships are influenced by the type of awe-related music.

The aims of Study 6 were to provide experimental support for a causal link between perceptions of musical size and perceptions of musical awe and examine how these ratings related to each other. By measuring real-time participant ratings of size and awe over the course of musical excerpts, this study investigated whether the manipulation of musical size would directly affect ratings of awe. Study 6 was interested in the perception of musical size through the experimental manipulation of amplitude, and explored how perceptions of both awe and size differ when dynamic variation in music is reduced through high levels of compression. Finally, this study explored the differences between ratings of size and awe in positively and negatively valenced music samples.

5.4 Methods

5.4.1 Selection and construction of stimuli

Study 6 used four pieces of awe-related music to use as experimental stimuli. The study was designed to use full musical examples to replicate a more musically realistic listening experience. Only four pieces of music were chosen to be used in this study capturing time-series ratings because each piece of music used was of relatively long duration (several minutes). The musical stimuli for this study were selected from the MAC (see Chapter 4, Section 4.4.1), using stimuli that had previously been rated for awe-related terms in Studies 4 and 5 (see Section 4.6.3 and Section 4.6.5, respectively). To capture a wider understanding of the relationship between perceptions of musical size and awe, musical stimuli were selected from both the positive and negative music groups of the MAC_1. From the MAC_1, specific data from Studies 5 and 6 (see Chapter 4, Sections 4.6.3 and 4.6.5) were used as selection criteria to determine which pieces of music should be used in Study 6. Pieces that were previously rated highly for ‘awe’, ‘fear’, ‘wonder’, ‘amazement’, and ‘power’ were selected as musical stimuli for Study 6. The justification for these selection criteria was to utilise musical materials that were highly associated with the general perception of awe and awe-related ideas (Gordon et al., 2017).

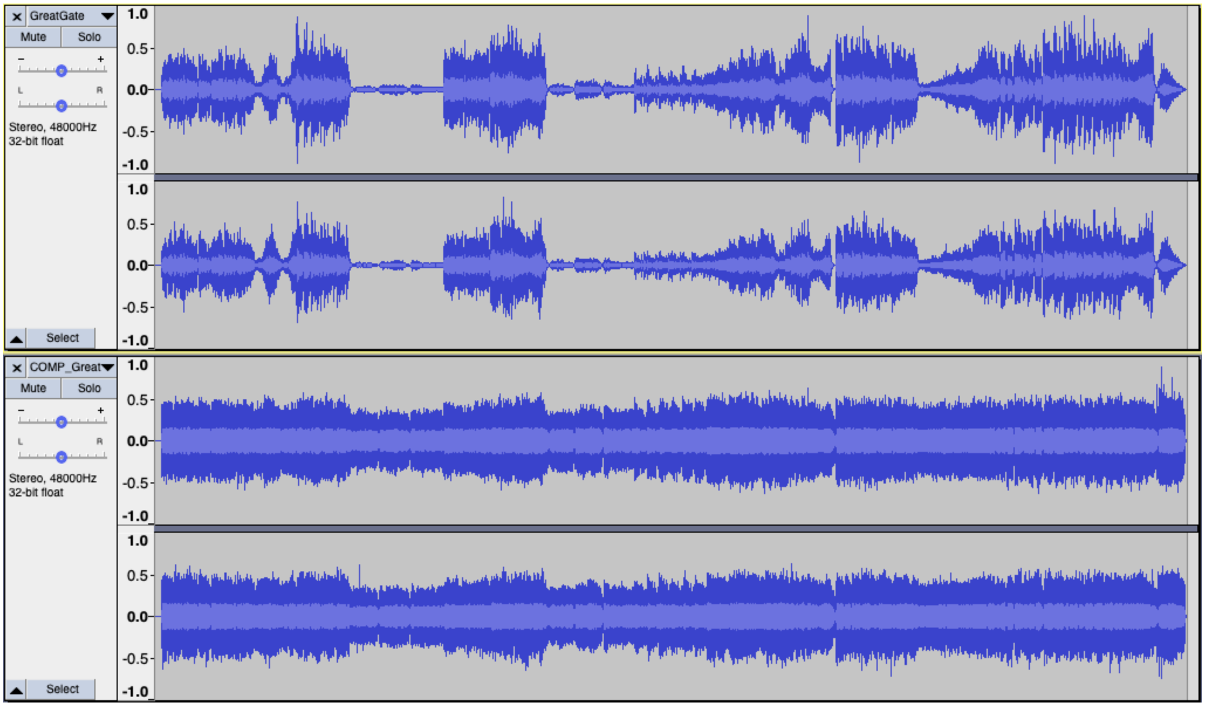
These pieces and their perceptual ratings for awe-related terms in Study 5 are as follows. The first selection from the positively valenced music group, which scored particularly high in several awe-related ratings, is 'The Great Gate of Kiev’ from Modest Mussorgsky’s suite ‘Pictures at an Exhibition’. It was rated the highest for ‘awe’, ‘power’, ‘amazement’, and ‘wonder’ compared to the other music in its valence category. Richard Wagner’s ‘Ride of the Valkyries’ was the music selected from the negative valence category. It similarly scored highly in ratings for ‘awe’, ‘wonder’, ‘amazement’, and ‘power’. A second negative music sample was ‘The Gnome’ from Mussorgsky’s ‘Pictures at an Exhibition’. To balance the number of stimuli between positive and negative valence conditions, a second positive stimulus was also selected: Sigur Rós’s ‘Hoppípolla’. This piece was selected due to its previous use in research on music and awe (van Elk et al., 2016) where it was selected specifically because of its ‘positive valence to awe’ (p. 4).

The experiment presented each musical selection in its entirety, and to ensure high fidelity of the music, 320 Kbps digital recordings were used throughout the experiment. To construct the experimental (compressed) music stimuli, each piece of music was copied and transformed through the compressor effect in Audacity 2.3.2 using the following criteria:
-30dB threshold, -80 dB noise floor, 10:1 compression ratio, 1.00s attack time, 1.00 release time. The resultant music was then compressed a second time using the same criteria. This compression procedure produced music samples that had only trivial amounts of amplitude

variation throughout their duration. Loud sections and quieter sections in the original music were now transformed in the compressed music samples, to produce a stimulus with near-constant amplitude, as depicted in the second track of Figure 5-1.

Figure 5-1

Visualisation of compression between conditions



Note. Stereo waveforms of Mussorgsky's 'The Great Gate of Kiev' seen as uncompressed (top) and highly compressed (bottom). The loud and quiet sections of the piece have been attenuated in variability through the compression technique. This yielded a high degree of amplitude constancy throughout the compressed versions of all the experimental stimuli in Study 6.

Finally, the eight pieces of music (four uncompressed and four compressed), were then normalised to -1.0dB. This procedure set the maximum volume of each track to the same amplitude, reducing any recording volume discrepancies between the pieces of music used in the experiment.

5.4.2 Participants

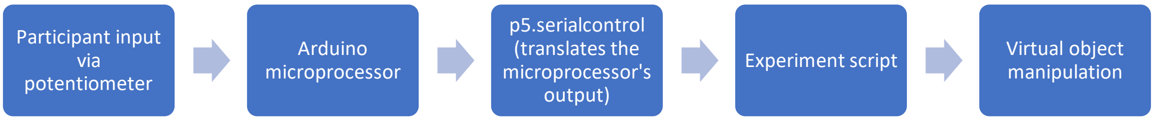
Ethics approval for Study 6 was obtained through the Central University Research Ethics Committee (CUREC) of the University of Oxford (Ethics Approval Reference: R59691/RE001). All participants provided fully informed consent prior to their participation. Only five individuals were selected to participate in the study. The limited number of participants was due to the COVID-19 (SARS-CoV-2) pandemic at the time of data collection, rendering a traditional call for participation unsafe and impractical. The participants were an opportunity sample, and varied widely in age and musical background. The five participants (three female, two male) had a mean age of 38.8 (range 24–59, *SD* = 18.02) and all shared the same country of origin and habitation: the United Kingdom. Participants reported an average of 14.4 hours of music listening per week, and an average of 16.4 years of musical training (*SD* = 14.47). One of the participants, Participant 4, was a professional musician with several decades (54 years) of musical training and experience. None of the participants had taken part in previous studies in this project.

5.4.3 Materials

Study 6 used the four musical pieces described above in 5.4.1. Each piece of music had an uncompressed and compressed version resulting in eight musical stimuli to be used in experimentation. With the musical materials acting as the independent variable, the dependent variables were the ratings for perceived size and awe. These ratings were recorded using a physical input device and a series of software systems working in tandem. A visualisation of the step processes of the experiment materials can be found in Figure 5-2.

Figure 5-2

Process map of experimental materials in Study 6



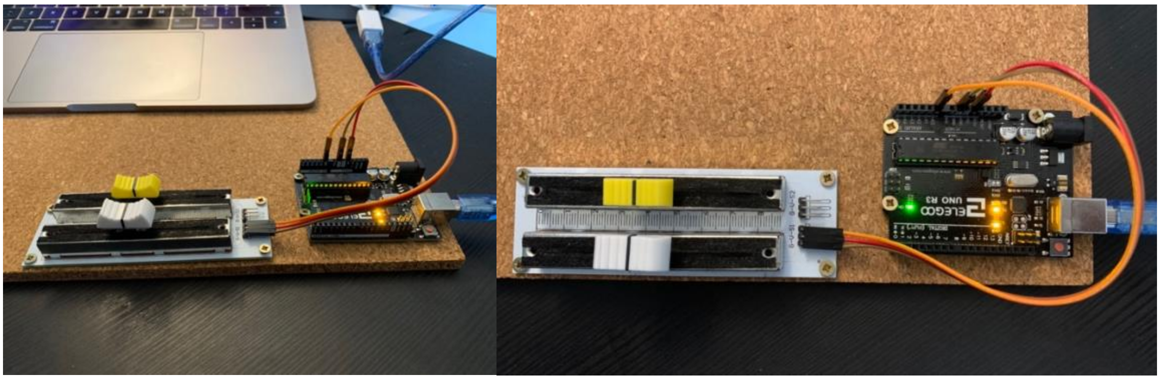
Note. The step processes for the dependent variable in Study 6 visualised from participant input to virtual object manipulation.

The ratings for both size and awe judgements were recorded through the manipulation of a linear potentiometer, a similar device to a slide fader on an audio mixing console (referred to as a 'slider'). The signal from the potentiometer was then sent to an outboard microprocessor, and then to the computer to communicate with the experiment script. The position of the slide potentiometer produced a signal that was read by the microprocessor through the Arduino 1.8.10 software. The Arduino microprocessor continuously ran a script that read the potentiometer at 9600 baud and mapped potentiometer values between 0–255 that were to be used by the experiment script. This range of values was chosen to afford a wide range of ratings from participants and to provide smooth movement of on-screen objects, as the values generated by the potentiometer are used to generate these objects. Before these values could be directly read by the script, the information from the participant input was first translated by the p5.serialcontrol software to render the data accessible to the experimental script. The experiment script was hosted through a web server for a Chrome browser-based app and ran in the Google Chrome browser, version 88.0.4324.192. The participant input data then interacted with the experiment script (written in JavaScript) to manipulate the size or movement of the on-screen objects, depending on the trial condition. Finally, these values were logged for collection and analysis. In summary, when the participant moved the slider to the right, values increased, and when the slider moved to the left, values decreased. The numbers generated by the positioning of the slider manipulated the on-screen object, and then the numbers responsible for object manipulation were stored for analysis.

Participants used the bottom horizontal slider with the white push-pull cap (seen in Figure 5-3) to manipulate the on-screen objects. The yellow slider cap above the white cap was used as a guide for centring the slider to the mid-point, with a value of 128. The wires attached to the slider were connected to the microcontroller, an ELEGOO UNO R3 (an identical circuit copy of the Arduino Uno Rev3). Signals from the microcontroller were then sent through USB to the computer running the experiment.

Figure 5-3

Experimental equipment

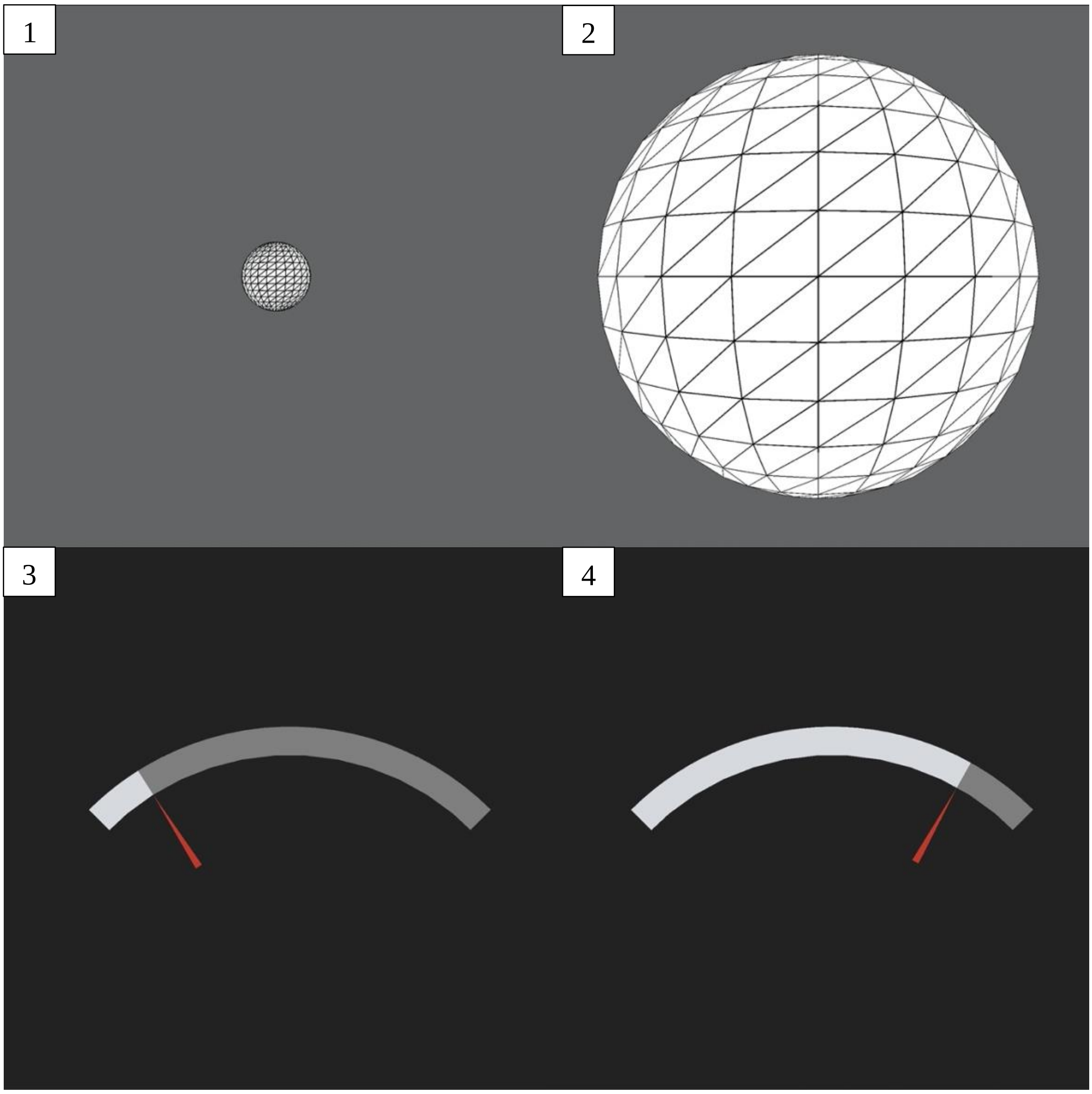


Note. The potentiometer and microprocessor setup as presented to the participants.

The on-screen materials shown in four images depicting the experiment in various forms are shown in Figure 5-4. The size of the wire-frame sphere grew and shrank based on participant input from the slider. In the size rating task, the farther to the right the slider was moved, the larger the sphere would appear. The farther the slider was moved to the left, the smaller the sphere would appear. In the awe rating task, the farther to the right the slider was moved, the needle on the gauge would move farther to the right. And similarly, inputs to the left would move the needle left.

Figure 5-4

Digital experimental materials



Note. Four image screen shots of the experimental trials. The size task (top) shows a small sphere that was generated from an input of 35 (image 1), and the large sphere was generated from an input of 210 (image 2). The awe task (bottom) shows a low-awe rating that was generated from an input of 35 (image 3), and a high awe rating that was generated from an input of 210 (image 4).

5.4.4 Experimental procedure

Participants were first asked to read the corresponding information sheet (Appendix Document 5-1) and complete the consent form (Appendix Document 5-2) for the study. The researcher then assured participants that they could remove their data in the future, and that they could stop the study at any point if they wished. Demographic information was gathered about participants' age, gender, country of residence, musical listening habits, and years of musical training. Study 6 used a within-subjects design, rating either the perceived size of the music or the perceived amount of awe being conveyed by the music. As there were two different tasks in this experiment, the dependent variable changed based on the trials, and the independent variable was the compression condition (uncompressed or compressed).

Before beginning the test trials to familiarise themselves with the hardware interactions, the following prompt about musical awe was read to each participant. 'A classical example of awe might be found in nature: the kind of experience you may have after hiking up a mountain and you suddenly arrive at a cliff where you look down from a great height over a valley'. This prompt was similar to the prompt originally used in Study 1 to first gather experiences of musical awe (see Chapter 3, Section 3.4.1.3) but omitted the word 'beautiful' to achieve a more aesthetically neutral presentation of awe. Each participant was allowed to ask questions about the procedure, and they were then asked to complete two test trials. Participants wore Sony WH-1000M3 noise cancelling headphones to mimic quiet laboratory listening conditions and to minimise any external noise. During these test trials the volume was adjusted so that the sound was comfortable for each participant, and the volume was not adjusted after this point. The first trial stated on the screen, 'Move the slider to make the sphere grow and shrink as you feel it relates to the size of the music'. The trial played 30 seconds of music while participants moved the slider right and left to familiarise themselves with how their physical inputs altered the on-screen wire-frame sphere (see the top examples of Figure 5-4). The second trial was similar to the first, but instead of a practice trial for perceptions of musical size with a sphere on screen, participants moved an onscreen gauge to reflect the level of perceived awe (see the bottom examples of Figure 5-4). The instructions read, 'Move the slider to move the gauge left and right. Indicate how awesome and/or how awe-inspiring you find the music to be, with all the way to the right being indicative of an extreme amount of awe and all the way to the left being not at all.' After each of the test trials, the participants were asked to rate their familiarity and liking for the piece of music they have just heard, both on a scale from 1-10. Participants practised with the two test trials and were then asked if they had any questions before continuing to the experimental trials.

The 16 trials (8 x 2 design, 8 musical stimuli consisting of 4 uncompressed and 4 compressed musical stimuli, each rated for 2 judgements, size and awe) were randomised per participant, and a short break was given after 8 trials were completed. As there were four different pieces of music being used in this experiment, the time per trial was variable, and was between 165s (2min and 45s) and 318s (5min and 18s) (M = 256s, 4min and 16s; SD = 68.13s). After the sixteen trials, participants were encouraged to describe in their own words how they went about rating the pieces of music and to provide any associations made during the experimental task. The entire experiment lasted approximately 75 minutes per participant.

5.5 Hypotheses

The hypotheses for Study 6 are based on the theorised relationship between size and awe—the higher the values for musical size, the higher the ratings for associations of awe. The rationale for this connection is based on an extrapolation and simplification of a central appraisal of awe as detailed in Keltner and Haidt's theoretical investigation (2003). According to this proposed framework, one of the principal requirements for experiences of awe is as an encounter with something *vast*. The study uses virtual object size as a measurable perceptual analogue for the more conceptual idea of vastness. Due to the ecological association of size with loudness, that is that large objects produce loud sounds (e.g. Hauck & Hecht, 2019), the hypotheses of this study seek to detail the relationship between perceptions of size and awe through manipulation of compression levels. With music devoid of volume (loudness) differences, changes in ratings for awe may signal other important sonic elements in the music. Additionally, to examine any differences in the size-awe relationship due to musical valence, both positive and negative awe-associated music were used as stimuli.

$H_{5\text{-}1}$: Ratings for size will be positively correlated with ratings for awe.

$H_{5\text{-}2}$: Ratings for size will decrease in variability for the compressed music samples.

$H_{5\text{-}3}$: Similar to $H_{5\text{-}2}$, ratings for awe will decrease in variability for the compressed music samples. This is hypothesised due to the causal relationship between ratings of size and awe.

$H_{5\text{-}4}$: Music type (positive and negative) will have no significant difference on the relationship between ratings of size and awe. This is hypothesised as all types of experiences of awe are thought to emerge from an encounter of vastness, here understood and tested as virtual object size.

$H_{5\text{-}5}$: Participant ratings for object size will be predictive of ratings for awe. This causal link between size and awe is hypothesised due to perceptions of size being a necessary component for the experience and recognition of awe. This tested causality is predicted to be unidirectional, where ratings of size predict ratings for awe and not vice versa.

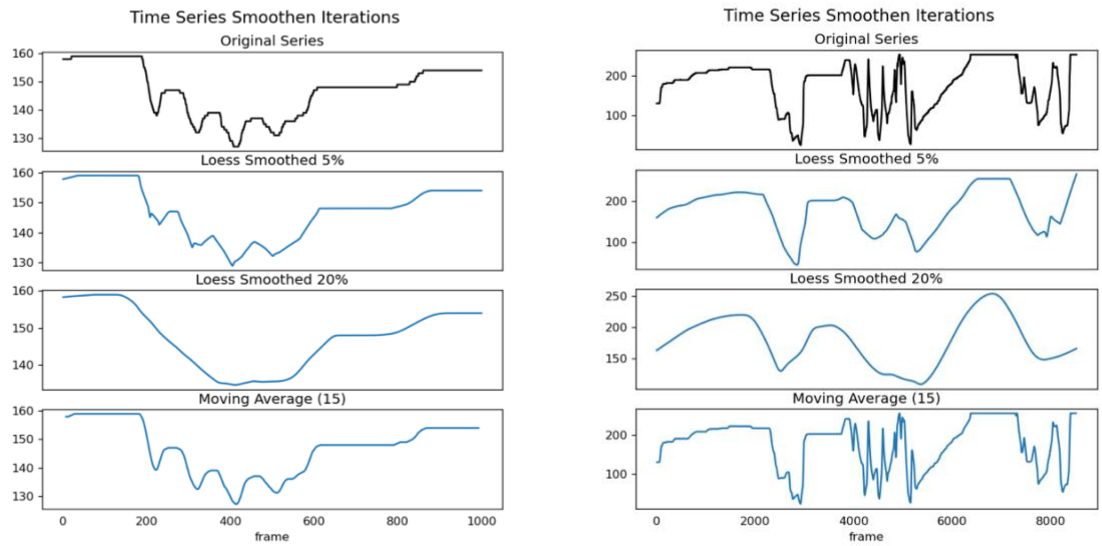
5.6 Results

With the small number of participants in this study (N = 5), no calculations were made to remove anomalous data and/or participants. Any irregularities found in participant data were analysed acknowledging its particularities and placed in context relating to the participant. Due to the limited number of participants, descriptive statistics were primarily used in place of inferential statistics, due to insufficient statistical power with a sample of only five participants. The goal of analysing these results was to provide an overview of the data and summarise general trends that address the hypotheses set out in Section 5.5. The data in this section were analysed from general to specific, examining trends shown between participants and between music types. Due to an error in processing and recording of data, some data from Participants 1-4 were lost. The remaining data that were collected from these participants are used in these analyses, and the entirety of Participant 5's data were available. In comparisons between the participants, equivalent time frames of data were used.

Due to the nature of the input device, when participants' inputs were between two values on the potentiometer, the values logged into the console often jittered between the two integers. For example, if a participant did not move the potentiometer and it was at an equal distance between 99 and 100, the recorded input would flit between the two values seemingly at random. To correct for this, all the data were manually cleaned by the following procedure: first, a line graph was generated for each trial and all one-, two-, and three-frame jitters were corrected to the surrounding values. If the jitters were of longer lengths, then the section in question was replaced with the median value found in the section. This transformation of the data was intended to recover the intentions of the participants' ratings more accurately by removing noise from the device. The data were additionally smoothed using a simple moving average (SMA) set at 15 points of data. This number was chosen to smooth the data in a way that captured the small and large changes made by participants while removing discrete edges found as an artefact from the 256 points of resolution. With the experiment running at 30 frames per second, this moving average of 15 data points (frames) encapsulated 0.5 seconds of participant responses. Consequently, the smoothing of the data did not dramatically affect the moment-to-moment ratings of the participants, and the performed data cleaning process captured participants' ratings while eliminating non-intentional movements. Examples of raw and edited smoothed data can be seen in Figure 5-5. The Loess smoothed results, even at small percentages, produce iterations that lack the resolution needed for accurate comparisons of the data. This can be seen especially in the right graphs of Figure 5-5, where many of the participant details are wholly lost to the Loess smoothing technique in the data range between 4000-6000 frames. Several other windows of moving average were investigated, and as previously described, 15 data points retained data fidelity used in this study.

Figure 5-5

Data smoothing visual examples



Note. Visualisations of smoothing techniques. The left example is of 1000 data points (33s) and the right example of 8531 (284s). The original series (top graphs) have already been manually cleaned and then were smoothed using Loess smoothing at 5%, 20%, and SMA set at 15 frames/points.

5.6.1 Generalised trends in variability

The first analysis of the data took a broad view of the relative standard deviations (RSD; calculated by dividing the standard deviation by the mean, *SD*/*M*). These calculations showed how the ratings of size and awe varied by participant. The expectation stated by hypothesis $H_{5\text{-}2}$ was that uncompressed music samples would result in larger variability than compressed samples. Examining data for size manipulations, the mean value of the relative standard deviations for uncompressed music was 0.276, and compressed music was 0.212, showing more variability in uncompressed music, as hypothesised. The data for variability in awe ratings followed the same trend, with variability of relative standard deviations for uncompressed music 0.202 and compressed music 0.133. These data lend support for $H_{5\text{-}2}$, but examining the data only through this broad approach obscures the nuances in the participant-generated data. Table 5-1 details the RSDs for results of both size and awe ratings. Four of the five participants show the expected trend and provide evidence to support $H_{5\text{-}2}$ and $H_{5\text{-}3}$.

Table 5-1

Relative standard deviations of ratings of musical size from uncompressed and compressed conditions

	Size		**Awe**	
Participant	**Uncompressed**	**Compressed**	**Uncompressed**	**Compressed**
1	0.573	0.482	0.318	0.143
2	0.012	0.020	0.003	0.015
3	0.125	0.023	0.202	0.142
4	0.189	0.180	0.093	0.046
5	0.483	0.355	0.395	0.320

The data of Participant 2 are unusual in comparison to the other participants, as can be seen in the considerably low RSDs reported for all conditions. Participant 2 expressed a heightened level of anxiety in performing the experimental tasks (further described in Section

5.6.3) and may explain their unusual data. As Participant 2 was the only participant that did not support the hypothesised trend of variance, it is reasonable to suggest that the trends seen across the other participants may be, at least, an indication of a larger trend and should continue to lend support for $H_{5\text{-}2}$.

In addition to the interpretation of data on a per participant basis, variability was also examined on a per music basis—Table 5-2 detailed these RSDs. These calculations showed that all pieces of music followed the expected trend: ratings for uncompressed music had higher variability than in compressed music. This expected trend was also seen in the variabilities for awe ratings.

Table 5-2

Relative standard deviations of ratings of musical awe from uncompressed and compressed conditions

	Size		**Awe**	
Music	**Uncompressed**	**Compressed**	**Uncompressed**	**Compressed**
'The Gnome'	0.258	0.241	0.295	0.178
'The Great Gate of Kiev'	0.167	0.133	0.261	0.191
'Ride of the Valkyries'	0.200	0.157	0.149	0.106
'Hoppípolla'	0.482	0.315	0.220	0.142

These four pieces of music all showed the same trend in variability, suggesting that regardless of the music used in the experiment, uncompressed music resulted in greater variability in ratings, lending support for $H_{5\text{-}4}$. The individual participant data for all the RSDs can be found in two tables in Appendix Table 5-1 and 5-2. To investigate whether the type of awe-related music influenced variability, the RSD data were separated by music type, positive and negative. ‘The Gnome’ and ‘Ride of the Valkyries’ comprised the negative-awe music group while ‘The Great Gate of Kiev’ and ‘Hoppípolla’ comprised the positive-awe group. Here, the same trends in variability were seen in both positive and negative groups. This lends support for H_{5-4}, showing that both positive and negative awe-related music share the same characteristics of rating variability between compression conditions. The RSD data for ‘Hoppípolla’ showed high RSD in size ratings than the other three pieces of music. This result may be explained by ‘Hoppípolla’ being more easily estimated in some way for ratings of size, perhaps due to the slower musical development of the piece that afforded more time for participants to make wider-ranging judgements of size. In general, the results for variability support the listed hypotheses and provide initial evidence of amplitude reduction reducing variability in perceptions of musical size and ratings of awe.

5.6.2 Correlations and causality of data

To examine the statistical relationship between ratings of musical size and awe, Pearson correlation coefficients were computed for each piece of music and then averaged. The mean correlations showed that, in general, uncompressed music had a higher level of correlation with ratings for awe than compressed music, with r values of 0.636 and 0.407, respectively. Examining this trend in more detail, the following analyses report the data of each of the pieces of music, and their corelation coefficients can be seen in Table 5-3.

Table 5-3

Average correlation coefficients from each piece of music in compressed and uncompressed conditions

Music	Uncompressed	Compressed
'The Gnome'	0.278	0.241
'The Great Gate of Kiev'	0.778	0.301
'Ride of the Valkyries'	0.583	0.264
'Hoppípolla'	0.903	0.820

Note. All calculations were averaged over the five participants. All of the correlations used to calculate the averages reached significance, $p < .001$.

A broad examination of the data showed that there is a general positive correlation between ratings of size and awe. Each of the pieces of music yielded a positive average correlation between size and awe, lending support for $H_{5\text{-}1}$. There also was shown to be a large difference in coefficients between pieces, e.g. 'Gnome' and 'Hoppípolla' with uncompressed coefficients of 0.278 and 0.903, respectively. Again, by only examining average correlation data between a small population, the detail of the ratings may have been obscured. A complete table of each participant's correlation coefficients can be found in the Appendix Table 5-3. From individual participant data, it is clear correlation data did not always follow the trend of uncompressed conditions yielding higher correlation coefficients than uncompressed conditions. Additionally, there was a minority of correlations that yielded a negative relationship between size and awe. These negative correlations were mostly found in the compressed conditions. The negative correlation in uncompressed conditions (found in Participant 3's data) could potentially be explained due to it being the first trial the participant encountered in the experiment. Overall, most of the data showed positive correlations between ratings for musical size and awe, with only seven of twenty correlations being negative. Notably, all of the correlations from the data of Participant 5 were highly positive. As mentioned, Participant 5 was the only participant with a complete dataset, and the negative correlations found in the data of other participants may be the result of missing data. To investigate the correlation data more thoroughly, the individual data from Participant 5 were isolated for analysis. As Participant 5 was the only participant with data collected from the entirety of each of the pieces of music, correlations from Participant 5 may be more suggestive of average correlations of ratings of size and awe throughout a piece of music. Furthermore, Participant 5 is arguably representative of an average participant's ratings based on their demographic data, with a middling level of musical education (12 years, including school musical education). Each of the size and awe correlations from the data of Participant 5 showed a strong and positive relationship in both compressed and uncompressed treatments.

Table 5-4

Participant 5 Pearson correlation coefficients from all 16 trials

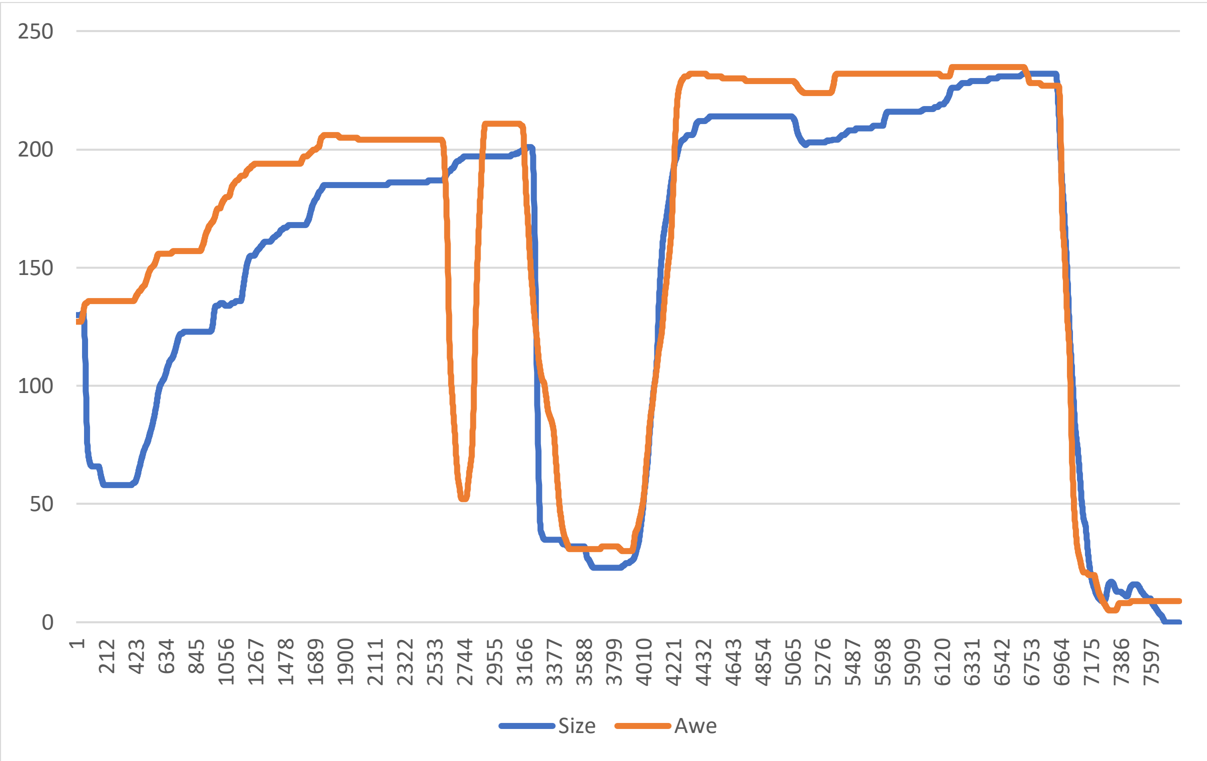
	Uncompressed		**Compressed**	
Music	***R***	***N***	***R***	***N***
‘The Gnome’	0.875	4918	0.865	4901
‘The Great Gate of Kiev’	0.944	9494	0.956	9488
‘Ride of the Valkyries’	0.704	8512	0.642	8506
‘Hoppípolla’	0.916	7805	0.847	7790

Note. All correlations reached significance (p < .001). Number of samples (N) do not match perfectly between uncompressed and compressed sample due to small errors in sampling. However, this small discrepancy of in data collection (e.g. six frames, in ‘The Great Gate of Kiev’) only accounts for a fraction of a second at thirty frames per second.

A visual representation of Participant 5’s ratings can be seen in Figure 5-6 where ratings of size and awe are shown together for the uncompressed condition of ‘Hoppípolla’. The uncompressed condition of ‘Hoppípolla’ was chosen to be visually reported because it yielded the highest mean positive correlation (0.903) between all participants as well as a high positive correlation in Participant 5 (0.828). This piece of music showed the clearest similarities between the ratings of size and awe. Size and awe ratings very closely mirrored each other throughout the duration of the two trials and showed a strong positive correlation, r(7803) = 0.92, p < .001. A notable difference in ratings was seen at the beginning of these trials where size ratings were immediately lowered. A stepwise increase was seen shortly thereafter, and the resulting incongruity can largely be ignored for purposes of the analysis. This is due to the same slider position at the beginning of each trial. It is reasonable for to participants to take several seconds to position the slider to the correct location for the start, thus rendering the first segments of data collection not expressive of participants' ratings. Excluding the first 250 data points (8.3 seconds), where the first data plateau began, yielded a higher correlation, $r(7403) = 0.93$, $p < .001$. The vast majority of the two graphs showed similar ratings, except for the span of time between the data points 2600–3000. Here there was a significant decrease and increase of awe ratings creating a dip spanning a 400 data point (13.3 seconds) window.

Figure 5-6

Size and awe ratings for 'Hoppípolla' (uncompressed) for Participant 5

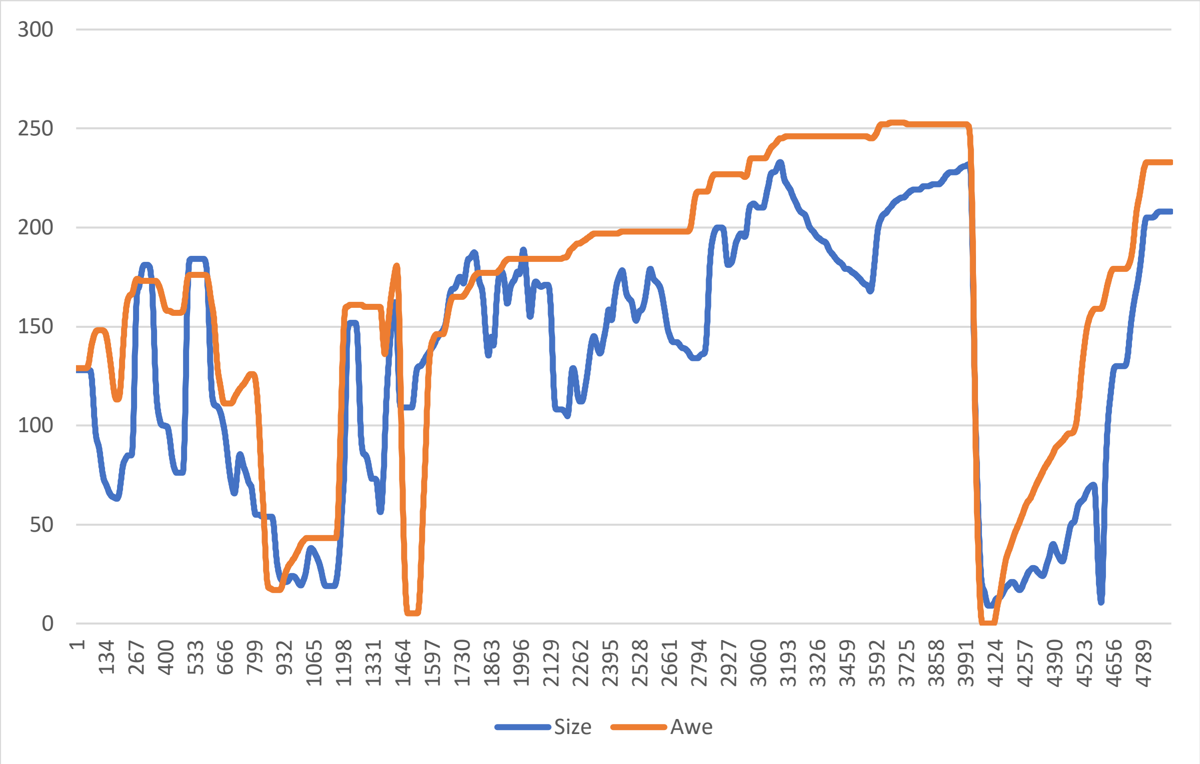


Note. Similar ratings for awe and size from Participant 5 over the duration of the uncompressed version of 'Hoppípolla'.

Examining Participant 5's data also revealed areas of interest in the music where dramatic changes in ratings for size and awe were found. These areas of interest were less prominent in the other participants' data due to missing values. The dramatic drop in awe ratings seen around point 2600 is most likely due to a brief drop in instrumentation. During this part of the music, the bass guitar, percussion, and backing strings abruptly stop playing for a measure before re-entering. This small region of music shows a dramatic textural change where the lower frequencies, driving rhythms, and dense chords are absent. A further analysis of sonic and musical features is more fully explored in the following chapter (Chapter 6, Section 6.5). To examine the differences in data between Participant 5's ratings of compressed and uncompressed conditions, visual representations of 'The Gnome' were produced for examination in Figures 5-7 and 5-8. Ratings for size and awe were highly positively correlated, $r(4918) = .88$, $p < .001$. Ratings for size were more variable than ratings of awe, but many of the same general shapes can be seen between both ratings. As an example of the similarities between the ratings, the first 1000 data points showed lower and higher ratings creating two *humps* in the data before diminishing. Often ratings for awe show a generalised or smoother version of the ratings for size. Between 4000-4500, the ratings for size ebbs and flows, growing in rating, but the ratings for awe increase over time expressing only the generalised trend of the size ratings.

Figure 5-7

Participant 5's size and awe ratings for 'The Gnome' (uncompressed)

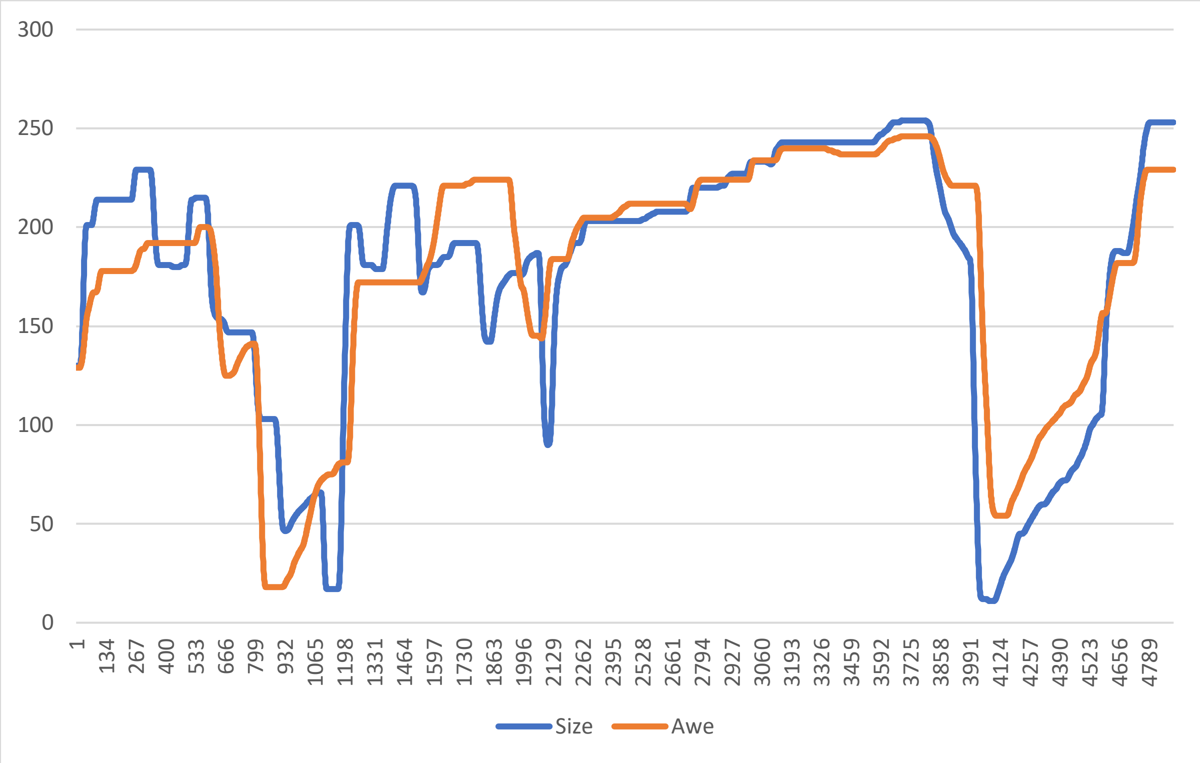


Note. Participant 5's ratings show more nuance in judgements of size than awe. Overall, similar trends in ratings are seen between the two experimental tasks.

In comparison with Figure 5-6, the size and awe ratings were smoother with many of the same generalised *shapes* in the data. This may suggest that many of the same types of cognitive assessments were made between compressed and uncompressed conditions. Similar to the uncompressed condition, ratings for size and awe were highly positively correlated $r(4901) = .87$, $p < .001$.

Figure 5-8

Participant 5's size and awe ratings for 'The Gnome' (compressed)



Note. Similar ratings for size and awe from Participant 5 over the duration of the compressed version of 'The Gnome'.

Examining differences between compression conditions showed there to be a reduction in specificity in ratings for size—see the blue lines in Figure 5-7 as they become less variable in Figure 5-8. The smoothing of the compressed ratings was hypothesised due to the decreased levels of amplitude fluctuation in the music, however even with controlling for the amplitude, there were notable differences in ratings for size. This suggests that musical size was related to other significant sonic or musical factors, and it was not bound strictly to amplitude (further discussion in Chapter 6, Section 6.5). However, data for awe ratings generally remain unchanged between compression conditions. The remaining visualisations of correlations for Participant 5's data can be found in the Appendix Figures 5-1 and 5-2.

With positive correlations shown between size and awe, an investigation into the patterns and causal relationship between the two factors was undertaken. To test if size influenced ratings of awe, Granger causality was used to probabilistically compare the two time series. Granger causality tests whether data points preceding an event in one time series can predict events in another relevant time series (Granger, 1969; Hoover, 2001). This technique is often used in econometrics as a forecasting tool to determine predictable results in one index in relation to another. The causality measured by this method is not *true* causality, but simply a method to determine the directionality of influence between multiple time series. As an example, imagine that you were interested in buying a stock called *AWE* that showed a seemingly random fluctuation in price nearly every day. There is also another stock called *SIZ* that seemed to fluctuate similarly to *AWE* but was more sensitive and dynamically varying in relation to market forces. *SIZ* increases its value, and then a day later *AWE* also shows an increase in value. *SIZ* may be a predictor of what *AWE* will do in the future. A Granger causality calculation assesses the usefulness of *SIZ* in predicting the behaviour of *AWE*. Edward Leamer described this type of causality as ‘precedence’, as Granger-caused data may or may not be suggestive of true causality (1985, p. 259). In what follows, the term, ‘G-caused’ is used to indicate Granger causation, so as to distinguish it from ‘true’ causation. These Granger tests were performed between the mean size and awe ratings of the participants in the study as well as on an isolated data set from Participant 5.

To properly use the experimental data for Granger causality calculations, participant data were restructured following established procedural steps (Cromwell et al., 1994). To ensure the data were free of problematic features that would render the causality tests ineffective, two confirmatory pre-tests were performed. Augmented Dickey-Fuller (ADF) tests were performed on each time series to identify any unit roots present in the data. Unit roots are indicators of stochastic processes in the data that can interfere with statistical test calculation.

Additionally, Kwiatowski-Phillips-Schmidt-Shin (KPSS) tests were performed to confirm the stationarity of the data. Both tests suggested that the data needed to be altered to be appropriate before Granger tests could be performed. The data were then transformed through two rounds of differencing. This was performed by subtracting each data point by the preceding data point in the time series. This transformation of the data produced new time-series data that centred around mean ratings and highlighted the changes in participant data. A visualisation of this transformation can be seen in the Appendix Figure 5-3. To determine how many pieces of data should be used in the Granger causality calculations (i.e. lag selection, or how many data points prior should be included in the prediction of the next datapoint), Hannan Quinn (HQ) estimations of optimal lag lengths were performed based on the number of observations in the dataset. The lag selection results did not coalesce around a single integer, rendering subsequent Granger tests inconclusive. To understand this problem the data were divided into smaller sections and reanalysed. Through these analyses it became apparent that the temporal resolution logged by the experiment (30 pieces of data per second) produced high level of heteroskedasticity, or covariance in the data, and the HQ lag selection method was not able to work well with the original data collected. However, the variance problem was corrected by selecting fewer data points at equal intervals. Several different intervals were tested, and by selecting every fifth data point a simplified and usable set of data were produced. The new data had a temporal resolution of six pieces of data per second of music, well within the temporal resolution needed to examine the participant trends. These new data were transformed and tested identically to the procedures previously described. The subsequent ADF and KPSS test results can be found in Appendix Table 5-4.

Granger causality tests were performed on the pairs of corresponding size and awe ratings for each piece of music to investigate whether size Granger causes awe. Bidirectionality of Granger causality was additionally calculated by mirroring the calculations, as detailed in Tables 5-5 and 5-6.

Table 5-5

Granger causality results for uncompressed music

Music (uncompressed)	**Size G-causing awe**		**Awe G-causing size**		
	F	***p***	***F***	***p***	***df***
'The Gnome'[2]	2.29	.023	4.25	< .001	171/ 179
'The Great Gate of Kiev'[3]	.694	.623	1.44	.213	180/185
'Ride of the Valkyries'[1]	6.59	< .001	0.20	.962	180/185
'Hoppípolla'[1]	2.00	< .043	0.76	.763	168/177

Note. Degrees of freedom are shown with and without lag. Indications of directionality were deduced from the comparison of the statistical significance of size G-causing awe and awe G-causing size for each piece of music. If both directions of Granger causality were statistically significant, an indication of bidirectionality was applied to the piece.

[1] Indicates that size G-causes awe

[2] Indicates bidirectionality

[3] Indicates no directionality

Table 5-6

Granger causality results for compressed music

Music (compressed)	Size G-causing awe		Awe G-causing size		
	F	***p***	***F***	***p***	***df***
'Gnome'[1]	6.12	< .001	1.40	.183	165/175
'The Great Gate of Kiev'[3]	0.96	.466	1.63	.119	171/179
'Ride of the Valkyries'[1]	4.25	< .001	1.73	.106	174/181
'Hoppípolla'[3]	0.76	.601	0.80	.574	177/183

Note. Degrees of freedom are shown with and without lag. Indications of directionality were deduced from the comparison of the statistical significance of size G-causing awe and awe G-causing size for each piece of music. If both directions of Granger causality were statistically significant, an indication of bidirectionality was applied to the piece.

[1] Indicates that size G-causes awe

[2] Indicates bidirectionality

[3] Indicates no directionality

These data show a general trend that suggests that ratings of size G-caused ratings of awe. This lends support to $H_{5\text{-}5}$ and suggests that even with a limited participant data set, the hypothesised trend is seen. However, not every evaluated pair of size and awe ratings showed this causality. Half of the tests indicated size ratings caused awe ratings, but the other half of the test either indicated bidirectionality or no Granger causation between pairs. Examining the data between uncompressed and compressed conditions, 'Ride of the Valkyries' showed statistically significant G-caused ratings of awe in both conditions: $F(180/\ 185) = 6.59$, $p < .001$; $F(174/\ 181) = 4.25$, $p < .001$, respectively. None of the compressed or uncompressed pieces of music showed that ratings for size were G-caused by ratings for awe, suggesting that the directionality between the ratings is from size influencing awe.

The data reported above is based on averages of all five participants. As Participant 5 was the only participant without any data loss, their data were used to investigate how causal directionalities may appear over the entire length of the music selections. Granger causality tests were performed on the complete dataset from Participant 5. The first 200 data points were excised from this dataset to account for the random variability at the start of experimental trials, when Participant 5 was moving the slider to account for what they first heard. This procedure was not performed for the average participant data because the data loss occurred at the beginning of the data input, so that the full data for these participants was all well after the start. Following this excision in Participant 5's data, the same data manipulations were performed: ADF tests and KPSS tests, and the corresponding Granger causality tables can be found in Table 5-1 and the Appendix Table 5-6. The results of these Granger causality calculations show that three of the eight pairs showed a directionality from size ratings to awe ratings. The strongest of these is seen in the compressed condition for 'The Great Gate of Kiev': $F(1831/\ 1839) = 18.83$, $p < .001$. Interestingly, the other results showed bidirectionality between ratings, with no instances of awe ratings G-causing size ratings.

In summary, Granger causality calculations suggested that ratings for size may often have statistical power in predicting ratings for awe. There were instances of bidirectionality between the ratings, but a unidirectional predictive relationship was never seen from awe to size. These results establish, at the very least, an inclination of directionality and a causal implication of perceptions of musical size affecting judgements of awe.

5.6.3 Familiarity, preference, and associated qualitative data

Between trials, participants were asked to rate their familiarity and preferences for each piece of music on a 1–10 scale. These data were gathered to examine the degree to which musical familiarity and preference potentially affected ratings of size and awe. Examining the mean values of familiarity, the only piece of music that was rated significantly familiar by participants was ‘The Ride of the Valkyries’, but the associated preference for this musical piece was similar to the ratings of other pieces of music. Ratings for preference spanned 5.5 to 7.5 (M = 6.51, SD = 0.60), and the data suggested that no piece of music was rated drastically differently to any other. Examining individual ratings, the lowest rated preference for a musical piece was *Hoppípolla* (M = 5.80). This low rating was due to the particularly low preference ratings of Participant 4, averaging only 3.0. Between uncompressed and compressed conditions, the data showed no significant trends and suggested that regardless of the compression, preference ratings remained consistent between the two conditions (M = 6.13 for uncompressed music and M = 5.80 for compressed music). Appendix Table 5-7 reports the mean ratings of familiarity and preference for all music, uncompressed and compressed.

After the experimental trials, participants were encouraged to report how they found the experiment, the difficulty of completing the experimental tasks, and other qualitative additions to better understand the data. Participant 1 found rating for size of the music to be ‘intuitive’ and seemed to be very quick and comfortable with assessing musical size. Participant 2 reported a general nervousness and anxiety with using the sliding hardware. This report is from the same participant with the low levels of variation in ratings, and this nervousness and anxiety may explain their idiosyncratic data through their hesitation in controlling the input device. Participant 4 reported that they sometimes felt ‘that [they were] anticipating rather than reacting to the music’. This points to a limitation arising from the within participant design, as participants will hear the same music and may anticipate what the music *will* do rather than simply reacting to the music as expected from the experiment. Participant 5 listed several sonic and musical concepts that influenced their ratings of size and awe. Novelty, repetition, momentum, [timbral] contrast, surprise, ascending passages were all reported to increase ratings of size and awe. Specifically, the timbre of strings and trills increased these ratings. Participant 5 also gave a thoughtful account regarding negatively-valenced music and rating for size. They said, '[I]t feels like you're in an orb, and it's coming into you. It feels like it's closing in on you rather than getting bigger'. This suggests that musical size may not simply be an abstract concept but is understood in relation to the individual as if they were sharing the same virtual space as the object. Participant 5 also reported that it was easier to adjust the slider input over longer spans when the music was more familiar, and that the task of adjusting on a micro and macro level was performed differently depending on familiarity. Finally, increases in awe ratings were reported to be driven by heavy bass sounds, the presence of crash cymbals, high strings, and the instrumentation being 'full'. These descriptions of sonic and musical factors speak to the relationship between size and awe, with these factors being related to the overall frequency and amplitude range experienced by the listener. They also add to a sense of musical and textural density (Harrington, 1980) through expanding range and timbre.

5.6.4 Summary of results: Study 6

The results of the Study 6 hypotheses are found below:

$H_{5\text{-}1}$: Ratings for size and awe were positively correlated in both uncompressed and compressed conditions. (supported)

$H_{5\text{-}2}$: Variability in ratings for size were lower in the compressed music conditions. (supported)

$H_{5\text{-}3}$: Variability in ratings for awe were lower in the compressed music conditions. (supported)

$H_{5\text{-}4}$: Music types (positive and negative) did not show differences in variability of ratings, but correlations did show higher ratings for positive music. (somewhat supported)

$H_{5\text{-}5}$: Directionality of Granger causality calculations showed that ratings for size often predicted ratings for awe, but some rating pairs showed bidirectionality in causality. (somewhat supported)

Examining the overall results for Study 6, ratings for size and awe share many similar characteristics and generally follow the hypotheses set out in this chapter.

5.7 Discussion

Even with its limited participant number this study suggests that perceptions of size and awe are connected in important ways for musical judgements. As previously theorised, judgements of size likely play a central and critical role for experiences of awe, and by establishing this relationship in the perception of music, this study takes an important step in demonstrating how musical awe might be empirically studied in a direct perceptual investigation.

5.7.1 Conclusion

The variability in the ratings for Study 6 showed that loudness is related to perceptions of size and awe. As such, loudness is an important perceptual attribute that aids in emotional evaluation and feelings of musical awe. A sudden increase in loudness is a powerful way to unconsciously excite the nervous system, especially the brain stem, to promote surprise (Juslin, 2013), and judgements of size and space may easily follow these increases and decreases in loudness. But without the influence of loudness, judgements of size and awe still functioned in much the same ways, likely due to the influence of other musical attributes.

The results suggest that judgements of size are often more quickly made and more variable than judgements of awe. This finding may be interpreted as evidence for a causal relationship between musical size and awe, but there may also be cognitive processing explanation for the delay in awe ratings from participants. It may be that judgements of size are less demanding than those of awe, and in turn, can be made more quickly. A cognitive explanation for the delay in response time and reduction in variability for judgements of awe comes from the load theory of attention (Ayres & Pass, 2012; Lavie, 2005, 2010; Lavie & Fockert, 2005). Cognitive demands (also known as cognitive load) are controlled by the difficulty of the tasks and by the complexity of a stimulus. Examining the musical materials, the judgements of musical size were likely altered by the complexity of music. The increasing volume (loudness), musical layers, and textural changes of the song could easily increase the cognitive load for listeners. Studies have shown how acoustic features such as loudness, pitch, and timbre have strong influences on cognitive load (Fagerlonn, 2007), with loudness being the most dominant of these features (Liljedahl & Fagerlonn, 2010). Aesthetic appraisals, like those used in judgements of awe, likely require a complicated appraisal process (a higher task difficulty) when compared to a cross-modal judgement of size. This difference in cognitive load may help to explain why when musical materials change, judgements of size may be easier to estimate while judgements of awe lag behind those of size and show a decrease in variability.

The positive correlation between musical size and awe supports the idea that these two judgements are related in awe-affording music—when there is an increase in perceived musical size, this is often where there is also an increase in the recognition of awe. The Granger causality analyses showed that judgements of size can often be used to predict judgements of awe. To clarify, it is not claimed here that the perceived size of musical material is solely responsible for generating experiences of awe, but that the perception of musical size and recognition of awe share similar characteristics. These characteristics are most likely due to the expansion and reduction of musical materials through increasing and decreasing layering of timbres and the span of frequencies and rhythms that modify the complexity of the music.

A judgement of size of course is not the only factor to produce awe, and it is hypothesised to work in tandem with accommodation (Keltner & Haidt, 2003; Shapshay, 2021). This process of failing to assimilate new experiences is related to ideas of novelty and re-contextualisation. The interplay between virtual sonic space and virtual object size may be an important and musically salient factor in the elicitation of musical awe, and when the musical space is recognised to be at odds with the musical size, these may be the instances where awe is more likely to be felt. How exactly musical spaces and sizes interact is an open question for continuing research.

5.7.2 Limitations

An obvious limitation of Study 6 was the small number of participants. The analyses following from this reduced sample size precluded any broad general trend claims, and a larger participant number (*N*) would help solidify the ideas highlighted by the reported results. Another potential limitation could be found in the compressed music conditions. The noticeable change through the compression of the music could have created a different way in how participants listened. Participant 4 noted that the ‘pumping’ of the compression (the audible increases in audio levels during quieter sections of the music to produce a constant loudness) was something they were actively listening to during the experiment. It is possible that this type of compression may be cognitively demanding on listeners, and that participants’ attention was drawn to the effects of the compression and away from the musical materials. A between-subjects design would mitigate this potential imbalance and isolate the compression effect by testing results from participants who only were exposed to either a compressed or uncompressed condition. The other main limitation of Study 6 arose from questioning how the recognition of awe was scored by the participants, and if these judgements of awe were actually separate from judgements of size. The nature of the experimental design meant that participants rated musical size and awe with two different on-screen measures, but the input for each was through the same hardware and with more or less identical tasks. It is possible that the concepts of size and awe became conflated in the minds of participants and that their ratings were not reflective of two separate judgements, but a combined size-awe hybrid. Though participants were explicitly told what to rate at the beginning of each trial, is possible that the concepts were not rated completely separately. Again, a between-subjects design could eliminate this concern in a future study.

5.7.3 Implications and continuing research

This chapter has explored how perceptions of musical size may relate to general associations of musical awe, and through the findings of Study 6, support the proposed ideas about awe and perceptions of size. With these findings, the first links between size and awe have been tested and suggest that a perception of large size (or vastness) may be a prerequisite for experiences of awe. However, the *feelings* reflecting the emotional experience of musical awe should be acknowledged as separate from recognition of awe tested in Study 6. This distinction is important for future work, as there remains a gap in the research between how perceptions of size are directly related to the *experience* of musical awe. To experimentally test the relationship between size and experiential musical awe would be challenging, as it would require actually inducing awe in the participants. The discussion around these ideas is developed in Chapter 6, Section 6.5 and Chapter 7, Section 7.5 to address how continuing research might evolve from these ideas. Nonetheless, if awe is the felt or the perceived emotion being tested, they both share a fundamental commonality: the musical characteristics of the pieces. The following chapter takes this idea and examines the sonic and musical features shared in these types of music, and, consequently, what is important in the music evocative of musical awe.

6 Study 7: Feature extraction and musical material analyses of awe-associated music

6.1 Introduction

The previous two chapters have explored how participants perceive awe-associated music in relation to contrasting visual representations of awe, relevant emotional and conceptual associations, and to perceptions of musical size in a virtual environment. What has yet to be investigated are the kinds of sonic and musical qualities that may be responsible or influential for these perceptions and associations. Of course, the features of the music itself are only a part of the complicated assemblage of factors that may lead to the experiences of awe, but it is an important area of research to explore, since it may reveal shared sonic and musical associations important for many listeners. The effects of an individual's personality and the environment in which they find themselves may be equally important musical awe-related areas, but the qualities of the music must be regarded as a principal eliciting factor, and insights found through exploring what is *in* the music may provide valuable insights into what contributes to the listeners' experience of musical awe. To explore these musical qualities in an objective and systematic manner, the features from the music can be extracted and analysed through the process of 'feature extraction', a common technique in the field of music information retrieval (MIR). Extracting these features of the music may prove helpful for a wide variety of data-based explorations of awe-related music. These include, but are not limited to, assessing which musical features are important in awe-related music, how awe-related music differs from non-awe-related music, and which sonic and musical features are affiliated with perceptions of musical size and novelty, two important factors in the elicitation of awe (Keltner & Haidt, 2003; Konečni, 2005; Shapshay, 2021). Musical novelty is closely linked with the process of accommodation. As novelty refers to newness, dissimilarity, originality, and/or unusualness, accommodation refers to how previously existing cognitive schema must be revised to make sense of something not understood, unknown, or beyond the normal. Thus, the more novel an auditory stimulus, the more likely it is to trigger a type of cognitive adaptation (or accommodation) in the listener. This chapter explores these ideas using MIR techniques and analyses the sonic and musical data to explore the acoustic character of awe-related music. These findings point to a variety of important sonic and musical components that may help instigate feelings of awe in the listener. Along with sonic and musical features, MIR data relating to emotions and novelty are also examined. Lastly, this chapter contextualises these feature extraction results and places them in dialogue with their associated musical materials, novelty data, and their relationship to musical size to examine a piece of awe-affording music from the perspective of the musical listener.

6.2 Feature extraction and supporting research

6.2.1 Music information retrieval

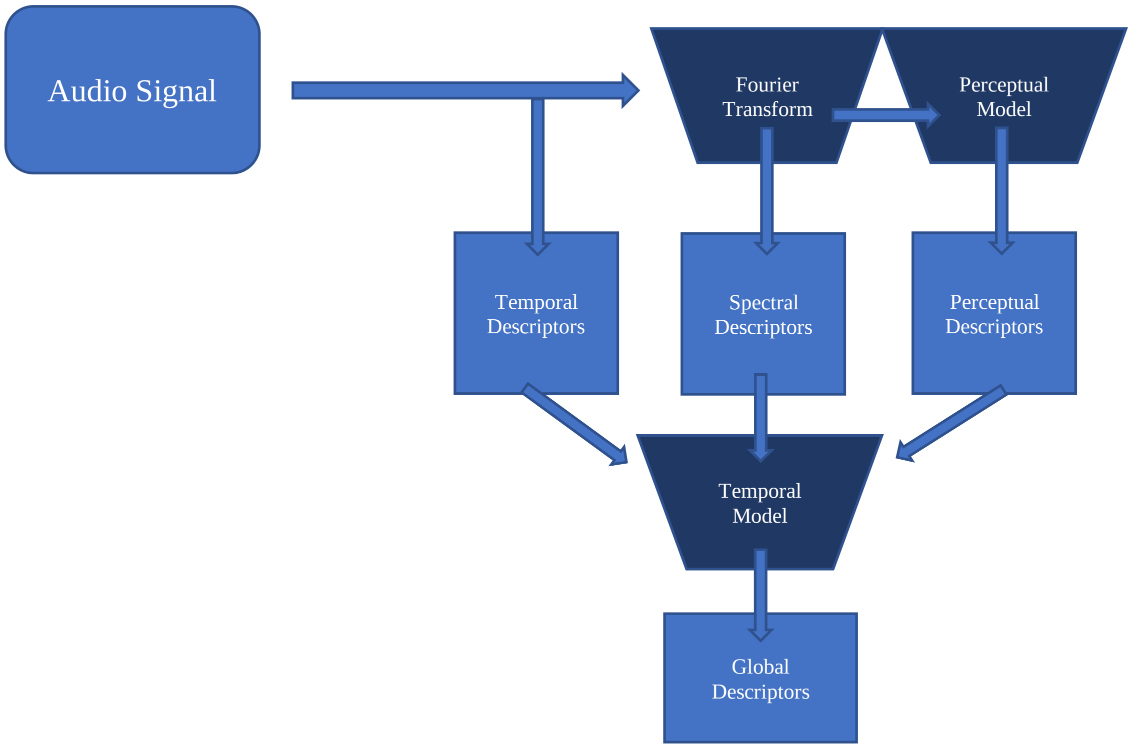
Music information retrieval (MIR) is a multidisciplinary area of research within the larger branch of information retrieval that is focused on the extraction and interpretation of musical features (Schedl, Gómez, & Urban, 2014, p. 128). Using techniques from musicology, psychoacoustics, computer science, and several other disciplines, MIR builds computational systems to read and evaluate components of music (Futrelle & Downie, 2003). A principal aim of MIR is not only to extract relevant sonic and musical features from an audio input, but to categorise and access music in a manner similar to text-based search engines (Downie, 2008, p. 247). With a library of musical features and the ability to query them, MIR systems are able to evaluate music and in turn to inform and enable a host of new technological applications.

These include, but are not limited to, audio alignment (Dixon & Widmer, 2005; Müller, Mater, & Kurth, 2006), song identification (Serra et al., 2010), query by humming (Kosugi et al., 2000), music recommendations (Celma, 2010; Zhang et al. 2012), playlist generation (Pohle et al., 2007; Reynolds et al., 2007), and music visualisation (Müller & Jiang, 2012).

Feature extraction is the process by which the content of an audio signal (in e.g. wav, mp3, and flac files) is described by an automatic system to produce meaningful information about the sound. This information is classified according to three criteria: level of abstraction, temporal scope, and musical features (Gouyon et al., 2008; Leman et al., 2002). The level of abstraction in feature extraction can be understood as a spectrum of descriptors from low to high. The low-level features and their descriptions are those computed directly from the audio signal, usually related to the loudness and timbre of the music. The data generated from low-level features are often of limited value to researchers, but is an important step in producing higher-level features, which are often used in more complex machine learning models. The feature data that are produced describes temporal, energetic (amplitude), spectral, harmonic, and perceptual features of the music. Figure 6-1 illustrates a standard and widely employed method by which an audio signal is processed to produce low-level musical feature data.

Figure 6-1

Signal processing model of musical feature extraction



Note. The signal processing diagram details a map for low-level feature extraction (adapted from Geoffroy Peeters, 2004). The audio signal is first divided (or windowed) into frames. From these frames, temporal descriptors are generated. The frames of audio also are applied to spectral and perceptual models to produce the corresponding descriptors. These descriptors are then interpreted through a temporal model resulting in global descriptors of the music.

The descriptors that are generated by this method include data for the zero-crossing rate (ZCR), describing percussive sounds; root mean square of amplitude (RMS), relating to volume or intensity; log attack time, relating to the duration and onset of sounds; and the temporal centroid, detailing how long sounds are sustained. Spectral descriptors include spectral moments (statistical distributions), spectral roll-off (proportion of high-frequency energy), spectral flatness (smoothness of spectral data), and spectral flux (rate of change from a spectrogram). Finally, perceptual descriptors include data for the loudness and brightness (i.e. percentage of energy above a specific frequency) of sounds. All of these low-level descriptors are commonly used in timbre representation (e.g. Peeters et al., 2011) and general extraction data for high-level musical features, like rhythm and genre.

Moving up the layers of abstraction in feature extraction descriptors, pitch is an important quality of music that is of interest to MIR research. With the notable exceptions of missing fundamentals and inharmonic sounds, pitch is a perceptual correlate of the fundamental frequency of a musical tone (Schmuckler, 2004), an easily accessible feature for a MIR system to compute. The collection and cataloguing of these pitches generate the chroma feature data. By analysing which pitches are present and their relative frequencies in an audio sample, other important descriptions of musical audio can be generated, e.g. melody, harmony, and tonality. An example of the applications of these techniques can be found in MELODIA (Salamon & Gómez, 2012), a software plug-in that automatically extracts the melody from audio and provides visualisations of corresponding pitches. Pitch content descriptors are also an important and influential subdiscipline of MIR, but these techniques of pitch extraction are mostly beyond the scope of the analyses in this chapter. For a more comprehensive explanation of the techniques used in pitch descriptor generation, see the review of techniques in Gómez, Klapuri, and Meudic (2003). Higher-level music analyses use pitch information to generate descriptions of key (Krumhansl, 2001), and through those analyses, predictions of basic emotions can be calculated (e.g. Eerola, Lartillot, & Toiviainen, 2009).

Novelty and similarity are other important higher-level features whose quantitative exploration is made possible through MIR techniques. These analyses use data to compare audio with itself or other audio-based data to detect similarities and likenesses in the audio signals. Novelty analyses compare an audio signal to itself and examine sudden increases in acoustical parameters, like amplitude (Bello et al., 2005). Self-similarity analyses are concerned with repetition and variation within the same audio signal, and these types of analyses provide useful descriptions of the structure of the music (Jun, Rho, & Hwang, 2015). Similarity data may also be used to find differences between two pieces of music and between large corpora. These analyses are used to classify a piece of music as belonging to a particular genre or style based on acoustically derived information.

These techniques for analysing audio and music are primarily designed to process the audio signals so as to classify some specific parameter of the music, be it the amplitude of the signal, or a more complex process of determining to which genre the music might belong. As previously mentioned, low-level audio processing produces data that are largely unconnected to how we describe music in everyday settings. It is usually higher-level musical features that are culturally important to the music listener through which we distinguish or classify what sounds we hear and why they matter. Determining which features are important to study has largely been the purview of music theorists, and the development of technologies around MIR have generally followed Western music theorists' prescriptions. Therefore, the interests of MIR often mirror the interests of Western music analysis. Though there may be cultural biases in MIR systems and their resulting analyses, they remain powerful tools in the exploration of audio data for music aimed at discovering similarities and differences between pieces of music.

6.2.2 Audio feature extraction software and MIRtoolbox

There are many pieces of software that have been designed to perform MIR tasks and extract information about music through signal processing procedures, as previously discussed. An evaluation of audio feature extraction toolboxes showed that many systems perform well in low- and high-level feature extraction, with some of the main differences being computation time and programming environment (Moffat, Ronan, & Reiss, 2015). A commonly used software is MIRtoolbox, an open source and state-of-the-art software package developed for Matlab for the purpose of musical feature extraction (Lartillot, Toiviainen, & Eerola, 2008). This package provides a robust set of integrated and modular functions to compute quantitative data for musical features, specifically timbre, tonality, rhythm, and musical form. Along with its development as an overall feature extraction system, it was also developed to investigate musical features and their relationship with music-induced emotions (Eerola, Lartillot, & Toivainen, 2009). The MIRtoolbox has received regular updates and has been consistently developed since its inception in 2008; as of August 2022, it is in version 1.8.1. MIRtoolbox includes over 50 audio and music extractors, making it widely applicable for many disciplines interested in audio information. This feature extraction toolbox has been successfully used in many studies in a wide area of musicology and acousmatic research, including the communicative musicality of infants (Alessandroni et al., 2020), emotion detection through machine learning (Chin et al., 2014), tempo estimation (Lartillot & Grandjean, 2019), and the classification of pitch features from environmental sounds (Yang & Kang, 2016).

Feature extraction can often serve as a method of exploratory analysis for examining general trends in a musical corpus. As examples of how these techniques are used in musicological research, a recent publication examined trends in Spotify's top-50 songs in Mexico and provided evidence suggesting that several features may be influential in the number of streaming plays for these tracks, including statistically significant findings for 'energy', 'valence', and 'danceability', calculated from Spotify's API (Pérez-Verdejo et al., 2021, pp. 158–159). Another study using MIR techniques on corpora explored the classification of string quartets as composed by Mozart or Haydn based on their musical features—mainly pitch, intervals, and sonata-based features relating to the overall form of a piece (Kempfert & Wong, 2020). These two examples demonstrate that extracting musical features from a corpus of music enables a variety of useful analyses, involving the description, presence, and frequency of sonic features; relationships to other corpora; and general classifications relating to musical genre.

6.2.3 Music information retrieval and musical awe

Applying MIR techniques to research into musical awe allows for the extraction of information that may prove useful in describing which musical features are important for music related to experiences of awe. Many of the low-level descriptors produced by MIR are not accessible to conscious experience but may nevertheless inform high-level emotional concepts or general feelings about and appraisals of the music. Study 1 in Chapter 3 accumulated experiences of musical awe from participants, and in this chapter the music from those experiences, organised into the Musical Awe Corpus (MAC_1, described in Chapter 4, Section 4.4.1), will serve as the data set for feature exploration using the MIRtoolbox. Furthermore, the MAC_1 dataset has previously been divided into two perceptually different valence groups, positive and negative. To examine these two groups, the important musical features to be explored in this chapter will comprise dissonance, timbre, dynamics, spectral distribution, event frequency, key clarity, pulse clarity, and tonality. Together these features provide a robust body of information for MIR to deliver meaningful characterisations of the music samples. Furthermore, these features identified in the music can be used to determine the probability of emotions perceived by the listener and provide additional emotion data related to the valence, tension and activity of the music (Eerola, Lartillot, & Toiviainen, 2009).

A summary of musical features by Gabrielsson and Lindström (2010, pp. 384–387) lists dozens of musical factors (and multiple sub-factors for each entry) that they consider important for emotional expression. These include information relating to mode, rhythm, tempo, dynamics, articulation, timbre, and phrasing. MIR should be able to capture many of these features, and computer science investigations into genre classification have reduced the categories of important musical features to four principal ones: dynamics, rhythm, timbral/spectral features, and tonal (e.g. Baniya & Lee, 2016, p. 3015; Ma et al., 2021). These four categories offer multiple avenues for exploration, and the following feature extractors found in MIRtoolbox are explored in this chapter to produce descriptors of awe-related music. Study 7, detailed in this chapter, explored nine primary features of the MAC: four timbral/spectral, two rhythmic, two tonal, and one dynamic. The selection of these nine criteria was previously used to provide robust and wide-ranging MIR dataset for genre classification in a NordicSMC Winter School at the RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion, led by Olivier Lartillot, the lead developer of the MIRtoolbox software. Together these criteria provide a broad selection of features to accurately describe the components of the awe-associated music. The relevant extraction tools and their descriptions through MIRtoolbox are listed below.

Mirroughness extracts timbral data related to the estimated perceptual roughness in an audio signal through averaging the frequency closeness of pairs of simultaneous sounds (Sethares, 1998). This perceived ‘roughness’ is calculated based on sensory dissonance and measures the distance between simultaneous sounding frequencies, based on the premise that the closer they are to each other, the greater the roughness (Plomp & Levelt, 1965). *Mirbrightness* extracts data on the quantity and proportion of high-frequency sounds in an audio signal. The frequency in the signal at 85% (Tzanetakis & Cook, 2002) or 95% (Pohle, Pampalk, & Widmer, 2005) of the total energy of an audio signal is logged to denote the quality of as high-frequency sounds in the signal for this timbral feature[12]. *Mirentropy* and *Mircentroid* extract and calculate statistical information relevant to spectral features in the music. *Mirpulseclarity* extracts information on the strength of the beats in the audio to construct a value for pulse clarity (Lartillot et al., 2008). *Mireventdensity* extracts information regarding

[12] Both of these thresholds were investigated in Study 7.

the number of salient events per second in the audio; the calculation counts amplitude pulses and computes the corresponding frequencies for the music sample. *Mirkey* extracts information to give an estimation of key clarity in the audio sample. *Mirmode* provides an estimate of how major- or minor-sounding the music is, based on its strength and quality of key. *Mirrms* measures the global energy of an audio signal in 50ms windows. This energy is the root-mean-square (RMS) of the amplitude in the signal and describes the dynamic level of the music. Together these nine features provide a general description of the music in the MAC$_1$. In addition to these nine features, the *mirnovelty* feature detects homogeneous segments in the audio signal and compares them to preceding and following sections in the audio (Lartillot et al., 2013). This produces a novelty value that represents the degree of change between moments in the music sample. This extraction is important for this study due to the relationship between novelty and the '*need* for accommodation' (Keltner & Haidt, 2003, p. 304, emphasis in original). Naturally the MIRtoolbox feature for novelty cannot replicate all the cognitive components in the mind of the listener, but it can approximate which sections of music are more or less different from each other as a starting point for investigation. There are currently no MIR studies into awe-related music, so this chapter serves as an initial exploration into some basic classifications and categorisations, exploring a few selected features to establish fundamental differences between types of awe-related and non-awe-related music, aiming to uncover the sonic and musical characteristics that are distinctive for positive and negative awe-associated music. In comparing awe-related music to non-awe music types, it should be noted that the non-awe music type is only one specific type of music—namely Muzak—that had previously been shown to elicit aesthetic judgements that were not related to perceptions of awe (detailed in Chapter 4, Studies 3, 4, and 5). However, in labelling the Muzak excerpts as 'non-awe', this study does not claim that these music excerpts are representative of all non-awe-related music, or aesthetically neutral music, and the term is only used as a shorthand for this small selection of music that has previously been used in experimentation. There is likely to be a diverse array of music types—not accounted for not rest in this study—that would achieve similar results in eliciting the non-awe characteristics.

6.3 Aims

The aims of this study are to provide an exploratory investigation into general features of awe-related music. By examining spectral/timbral, rhythmic, tonal, and dynamic features of music in the MAC, the study assesses features that are important for positively- and negatively-valenced versions of musical awe. The study will assess which basic emotional categories are related to these excerpts of music, and how music types are differentiated through novelty data. The three main hypotheses are listed here to guide the exploration of the musical corpus.

$H_{6\text{-}1}$: Feature extraction data will show a differentiation between the two types of awe-associated music and non-awe-associated music.

$H_{6\text{-}2}$: The computed emotion predictions for awe-related music types will align with their valence category.

$H_{6\text{-}3}$: Novelty calculations will show a significant difference in awe-related music when compared to non-awe music types.

After the technical analyses of the musical features, the last inquiry in this chapter (Section 6.5) explores the musical materials present in a selection from the MAC. This final section aims to begin to bridge the gap between computational principles and musical materials to present a listener-based understanding of how musical features may relate to an experience of awe. Furthermore, these musical features are directly connected to the novelty data and incorporated into the musical size findings of Study 6 (Chapter 5). Taken together this provides a more comprehensive analysis of several of the factors important for musical awe from the perspective of the listener.

6.4 Feature explorations of the Musical Awe Corpus

6.4.1 Methodology

As mentioned in Section 6.2.3, this study investigated features extracted from the music in the MAC_1. The same thirty excerpts of music used in Studies 3, 4, and 5 were used for feature exploration. Ten of the thirty excerpts were associated with positively-valenced versions of awe, ten with negatively-valenced versions of awe, and the final ten were from excerpts of non-awe-related music. A full explanation of these music types and their delineations can be found in Chapter 4, Section 4.4.1. Features were extracted from awe-related samples and non-awe-related music to be compared to each other. Non-awe, or 'neutral' music samples were used as a point of comparison for the awe-related music excerpts. All music feature extraction was performed by MIRtoolbox. 1.8.1 and analysed in SPSS version 27. Features of interest, as detailed in 6.2.3, were extracted as well as a large array of pre-set features found through the *mirfeatures* command to provide a wider understanding of the music categorised by 26 musical and sonic elements. Spectral data pertaining to mel-frequency cepstral coefficients (MFCC)[13], delta (DMFCC), and double delta (DDMFCC) were not used in the following analyses, as their information content was less relevant to a general exploration and evaluation of associated musical features.

Kruskal-Wallis *H* tests (Kruskal & Wallis, 1952) were used as the primary statistical analysis to examine if the three music types (positive, negative, neutral) were statistically different. Following these tests, Mann-Whitney *U* tests for pairwise comparisons were performed to assess which of these groups were significantly different from one another. These non-parametric tests were chosen due to the small number of samples ($N = 30$, 10 in each music

[13] MFCC and its derivates are numeric representations of the power spectrum of sounds. For a review of its computation see Molau et al. (2001).

type) and the non-normally distributed data of many of the extracted features. The statistical tests compared the extracted feature values of each music excerpt between the three music type categories. These comparisons examined differences between positive and negative awe-related music as well as with non-awe-related (or neutral) music. Where statistical differences were found between music types, additional pairwise comparisons were reported to further clarify the reported differences. The Kruskal-Wallis *H* tests and Mann-Whitney *U* pairwise comparisons for each of the musical features are reported below.

6.4.2 Musical feature exploration

The results reported below highlight the features of interest and further investigate what these differences in the data mean for understanding awe-associated music. Table 6-1 details the comparisons of the MIR data between music types.

Table 6-1

Summary of Kruskal-Wallis tests and their significance values for the extracted 26 features

Type	**Feature**	***H***	***p***
Dynamics	*mirrms***	1.969	.374
Rhythm	*mirpeak* (fluctuation)	10.320	.006*
	mirtempo	6.743	.034*
	mirattacktime	3.408	.182
	mirattackslope (rhythmic)	18.583	< .001*
	*mireventdensity***	3.770	.152
	*mirpulseclarity***	9.685	.008*
Timbre and spectral	*mirzerocross*	14.093	.001*

	mirespectralflux	9.943	.007*
	mirlowenergy	1.032	.597
	*mircentroid***	3.259	.196
	*mirbrightness***	8.415	.015*
	mirspread	7.172	.028*
	mirskewness	5.437	.066
	mirkurtosis	5.112	.078
	mirrolloff (85%)	2.795	.247
	mirrolloff (95%)	4.281	.118
	*mirentropy***	13.133	.001*
	mirflatness	7.683	.021*
	*mirroughness***	17.422	< .001*
	mirirregularity	6.305	.043*
Tonal and pitch	*mirkey* (key clarity)**	10.640	.005*
	*mirmode***	3.920	.141
	mirhcdf	6.511	.039*
	mirchromagram (peak)	7.249	.027*
	mirchromagram (centroid)	15.068	.001*

* Indicates test statistics that reach significance ($\alpha = .05$)

** Indicates features of primary interest

Only one dynamic feature was examined in this analysis. The *mirrms* data measured the dynamic differences between the different music types; however, it was not found to be statistically significant between the music types, $H(2) = 1.969$, $p = .374$, with median values of

0.942 for positive awe music, 0.948 for negative awe music, and 0.923 non-awe music. This result suggests that mean differences in amplitude are not a defining characteristic between awe- and non-awe-associated music.

To examine the differences in rhythmic content, several features were extracted. A Kruskal-Wallis test showed that *mirpeak* (fluctuation) data were significantly different between music types, $H(2) = 10.320$, $p = .006$, with non-awe music showing higher values ($Mdn = 4.199$) than both positive awe music ($Mdn = 2.773$) and negative awe music ($Mdn = 2.523$). A pairwise post-hoc Mann-Whitney U test with Bonferroni adjustments showed that there was a significant difference between the positive awe music and the non-awe music, $U = -10.800$, $z = -2.743$, $p = .018$, and between the negative awe music and the non-awe music, $U = -11.100$, $z = -2.819$, $p = .014$. There was no statistically significant difference between the two awe-based music types, $U = .300$, $z = 0.076$, $p = 1.000$. It was also found that there was a statistically significant difference in tempo between music types, $H(2) = 6.743$, $p = .034$, with non-awe music showing lower values ($Mdn = 105.323$) than both positive awe music ($Mdn = 123.427$) and negative awe music ($Mdn = 124.891$). These data point to the awe-related music being differentiated from the non-awe music through higher tempi. However, after applying Bonferroni corrections in the comparisons, none of the music types reached statistical significance in the pairwise comparisons, though the comparison between the negative awe and non-awe music did approach significance, $U = 9.000$, $z = 2.286$, $p = .067$. Significant differences were found in the rhythm *mirattackslope*, a descriptor for the average slope of the attack phase of events, $H(2) = 18.583$, $p < .001$, with non-awe music showing higher values ($Mdn = 4.868$) than both positive awe music ($Mdn = 2.570$) and negative awe music ($Mdn = 3.224$). The post-hoc Mann-Whitney U test adjusted by the Bonferroni correction showed that there was a significant difference between the positive awe music and the non-awe music, $U = -16.100$, $z = -4.089$, $p < .001$, and between the negative awe music and the non-awe music, U

= -12.700, z = -3.226, p = .001. There was not a significant difference between positive awe and negative awe music, U = -3.400, z = -0.864, p = 1.000. These results suggest that the attack slopes of musical events between positive and negative awe-related music are similar and are lower than those of non-awe music. Another rhythmic feature of interest was the density of events in the excerpts (*mireventdensity*). This feature showed no statistically significant differences between the music types, $H(2)$ = 3.770, p = .152, with similar values for positive awe music (*Mdn* = 1.652), negative awe music (*Mdn* = 3.146), and non-awe music (*Mdn* = 2.600). Examining the data further, it is notable that the negative music type showed a wider range of data (*SD* = .749) compared to the non-awe music type (*SD* = .097), suggesting that the pieces in the negative music group were more heterogenous, with little agreement between the negative awe music excerpts for this feature. The final rhythmic feature extracted was *mirpulseclarity*. The extracted data showed a statistically significant difference between music types, $H(2)$ = 9.685, p < .008, with non-awe music showing higher values (*Mdn* = 0.246) than both positive awe music (*Mdn* = 0.090) and negative awe music (*Mdn* = 0.140). The post-hoc comparisons with Bonferroni corrections revealed the nature of these differences, with positive awe music values being significantly lower than the non-awe music type, U = -11.700, z = -2.972, p = .009. Differences in negative awe and non-awe music only approached significance, U = -9.000, z = -2.286, p = .067, and no differences were found between positive and negative awe-related music, U = -2.700, z = -0.686, p = 1.000.

Timbral and spectral feature data showed many significant differences in the dataset. The first feature in this category was *mirzerocross*. This feature describes the number of times the audio signal changes sign, an indication of the noisiness and possible percussive elements of the audio sample. The zero-cross data analysis showed significant differences between music types, $H(2)$ = 14.093, p = .001, with non-awe music (*Mdn* =540.985) showing lower values than the positive awe music (*Mdn* = 860.963) and the negative awe music (*Mdn* =

1150.401). The post-hoc Mann-Whitney *U* tests adjusted by the Bonferroni correction showed that there was a significant difference between the positive awe music and the non-awe music, $U = 11.300$, $z = 2.870$ $p = .012$, as well as between the negative awe music and the non-awe music, $U = 13.900$, $z = 3.531$, $p < .001$. There were higher values for positive ($M = 1030.517$, $SD = 462.957$) and negative ($M = 1120.229$, $SD = 345.062$) awe-related music compared to non-awe (M = 535.913, $SD = 157.529$), but examining these differences showed no significant differences between the positive and negative awe-related music, $U = -2.600$, $z = -0.660$, $p = 1.000$. Spectral flux values described the change in spectrum data across successive frames of music, and this feature was statistically significant between music types, $H(2) = 9.943$, $p = .007$, with negative awe music ($Mdn = 655.171$) showing higher values than both positive awe music ($Mdn = 497.633$), and non-awe music ($Mdn = 448.856$). The post-hoc comparisons showed that there was no significant difference between the positive awe music and the non-awe music, $U = 1.700$, $z = 0.432$, $p = 1.000$. However, there was a significant difference between the negative awe music and the non-awe music, $U = 11.500$, $z = 2.921$, $p = .010$, and between the two awe-related music types, $U = -9.800$, $z = -2.489$, $p = .038$. This finding suggests that a high value of spectral change may be an important timbral feature of negative awe-related music. Data describing the spectral centroid (*mircentroid)* was a feature of interest, but no significant differences were found between music types, $H(2) = 3.259$, $p = .196$, with positive awe music ($Mdn = 497.633$), negative awe music ($Mdn = 655.171$), and non-awe music ($Mdn = 448.856$) showing similar values. *Mirbrightness* data showed significant differences between music types, $H(2) = 8.415$, $p = .015$, with non-awe music ($Mdn = 0.220$) showing lower values than positive awe music ($Mdn = 0.304$) and negative awe music ($Mdn = 0.397$). Post-hoc Mann-Whitney *U* tests adjusted by the Bonferroni correction showed that there was no significant difference between the positive awe music and the non-awe music, $U = 6.300$, z = 1.600, p = .329. There was a statistically significant difference between the negative awe music and the non-awe music, $U = 11.400$, $z = 2.896$, $p = .011$. The data from the positive and negative awe music types failed to reach significance, $U = -5.100$, $z = -1.295$, $p = .586$. These findings suggest that a high level of brightness is a distinctive feature for the negative variant of awe, but not for the positive variant. Spectral entropy calculations showed statistically significant differences between music types, $H(2) = 13.133$, $p = .001$, with negative awe music values (*Mdn* = 0.752) higher than positive awe music (*Mdn* = 0.682) and non-awe music values (*Mdn* = 0.651). Post-hoc Mann-Whitney *U* tests adjusted by the Bonferroni correction showed that there was not a significant difference between the positive awe music and the non-awe music ($U = 3.400$, $z = 0.864$, $p = 1.000$), but there was difference between the negative awe music and the non-awe music, $U = 13.700$, $z = 3.480$, $p < .002$. There was also a significant difference between positive and negative awe music types, $U = 10.300$, $z = -2.616$, $p < .027$. These findings suggest that higher levels of spectral entropy are a defining characteristic for the negative awe music type. *Mirroughness* data showed a statistically significant difference between music types, $H(2) = 17.422$, $p < .001$, with negative awe music values (*Mdn* = 37681.007) the highest, followed by positive awe music (*Mdn* = 30489.318), and non-awe music with lower values (*Mdn* = 16861.791). Further pairwise comparisons showed a statistically significant difference between the negative awe and non-awe music types, $U = 16.400$, $z = 4.166$, $p < .001$. No statistically significant differences were found between positive and negative awe music types, $U = -7.300$, z = -1.854, p = .191, and positive awe and non-awe music types only approached significance, $U = 9.100$, $z = 2.311$, $p = .062$. The timbral and spectral features were also used to investigate spectral irregularity—this feature measures the variation of successive peaks calculated from the audio spectrum. The *mirirregularity* data showed a statistically significant difference between the music types, $H(2) = 6.305$, $p < .043$, with lower values for negative awe music (*Mdn* = 0.528) and higher values for non-awe music (*Mdn* = 0.630) and positive awe music (*Mdn* = 0.670). Post-hoc Mann-Whitney *U* tests adjusted by the Bonferroni correction revealed a significant difference between the positive awe music and the negative awe music, $U = 9.700$, $z = 2.464$, $p = .041$), but no other comparisons reached significance (all p values > 0.296).

The final group of features investigated tonal and pitch qualities of the music. The first feature extracted was *mirkey* which provided data on the degree of key clarity found in the music. Kruskal-Wallis tests showed a statistically significant difference between music types, $H(2) = 10.640$, $p = .005$, with positive awe music showing higher vales ($Mdn = 0.730$) compared to non-awe music ($Mdn = 0.579$) and negative awe music types ($Mdn = 0.549$). Post-hoc Mann-Whitney U tests adjusted by the Bonferroni correction showed significant differences between positive awe and non-awe music types, $U = 11.500$, $z = 2.921$, $p = .010$, with positive awe showing higher values for key clarity. Positive awe values were also higher than negative awe music types ($U = 10.700$, $z = 2.718$, $p = .020$). No differences were found between negative awe and non-awe music types ($U = .800$, $z = 0.203$, $p = 1.000$). These results suggest that a higher level of key clarity is more indicative of the positive awe music type. Related to the *mirkey* data, *mirmode* extracted data related to mode, the major or minor association based on the key data. This feature showed no statistically significant differences between the music types, $H(2) = 3.920$, $p = .141$, with similar values for positive awe music ($Mdn = 0.012$), negative awe music ($Mdn = -0.021$), and non-awe music ($Mdn = -0.028$). Examining the data further, the positive awe music type ($SD = 0.064$) spanned a larger range of values than negative awe ($SD = 0.034$) and non-awe music types ($SD = 0.019$). The span seen in the positive awe music accounted for positive (major) and negative (minor) values, suggesting both major and minor modes present across the music excerpts. The *mirhcdf* feature is a Harmonic Change Detection Function (HCDF) and describes changes in tonal centroid (Harte & Sandler, 2006). The Kruskal-Wallis test showed a statistically significant difference between music types, $H(2) = 6.511$, $p = .039$, with higher values for negative awe music (*Mdn*

= 0.158) and non-awe music (*Mdn* = 0.153), and lower values for positive awe music (*Mdn* = 0.102). After applying Bonferoni corrections to the post-hoc Mann-Whitney tests, none of the comparisons between different music types showed statistically significant differences. Investigating tonal features further, the final two features of this section described the peak values and centroid calculations of *mirchromagram*. This feature extraction tool retrieved data detailing the pitch classes associated with an audio signal. The peak chromagram values showed a statistically significant difference between music types, $H(2) = 7.249$, $p = .027$, with higher values for positive awe music (*Mdn* = 61.097), middling values for negative awe music (*Mdn* = 56.881), and lower values for the non-awe music (*Mdn* = 53.176). The post-hoc tests adjusted by the Bonferroni correction showed significant differences between positive awe and non-awe music types ($U = 10.600$, $z = 2.692$, $p = .021$), but no other comparisons reached significance (all p values > 0.535). The centroid chromagram data, detailing the geometric centre of the data, showed a similar trend with significance found between the music types, $H(2) = 15.068$, $p = .001$, with positive awe music showing higher values (*Mdn* = 65.354), than negative awe music (*Mdn* = 63.744), followed by non-awe music (*Mdn* = 56.522). The centroid data also showed statistically significant differences after Bonferroni correction between the positive awe and non-awe music types ($U = 14.800$, $z = 3.759$, $p = .001$), as well as between the negative awe and non-awe music types ($U = 10.700$, $z = 2.718$, $p = .020$). No statistically significant differences were found between the positive and negative awe-related music types ($U = 4.100$, $z = 1.041$, $p = .893$). This finding suggests that excerpts in the positive awe music group are composed of higher frequency tones than negative and non-awe music types.

With the multitude of features tested, a summary of the findings is provided to simplify the results and describe the features based on the dynamic, rhythmic, timbral, and tonal qualities. Significant differences in group comparisons are summarised in Table 6-2.

Table 6-2

Summary of statistically significant findings between music groups

Type	Feature	Data trend
Rhythm	*mirpeak* (fluctuation)	Both awe groups showed lower values than non-awe music.
	mirattackslope	Non-awe music showed a higher value than both awe groups.
	pulseclarity	Positive awe music showed a lower value than non-awe music.
Timbre and spectral	*mirzerocross*	Both awe groups showed higher values than the non-awe music.
	mirbrightness	Negative awe music showed a higher value than non-awe music.
	mirentropy	Negative awe music showed a higher value than both positive awe and non-awe music.
	mirroughness	Negative awe music showed a higher value than non-awe music.
	mirregularity	Positive awe music showed a higher value than negative awe music.
Tonal and pitch	*mirkey* (clarity)	Positive awe music showed a higher value than negative and non-awe music.
	mirchromagram (peak)	Positive awe showed a higher value than non-awe music.
	mirchromagram (centroid)	Both awe groups showed higher values than non-awe music.

No differences were found in average dynamic content between the music types in this study. The *mirrms* data showed the average amplitude values were similar between awe- and non-awe associated music. Rhythmic differences were seen in the *mirpeak* fluctuation, *mirattackslope*, and *pulseclarity* data between the music types. Timbral differences were seen in the data for *mirzerocross*, *mirspectralflux*, *mirbrightness*, *mirentropy*, and *mirroughness*. Zero-cross data showed a high level of noisiness (associated with percussive elements) from both the positive and negative awe music types. Spectral flux, spectral entropy, roughness, and brightness were higher for the negative awe music type. Tonal differences between music types were found in the features key clarity, and the peak and centroid data from *mirchromagram*. Music in the positive awe music type had a higher level of key clarity and leaned more toward a major-sounding mode. Finally, both the peak and centroid data showed low values for the non-awe associated music type, differentiated from both the positive and negative awe music types.

In sum, awe-associated music can be generally differentiated from non-awe associated music types through the use of less rhythmically salient elements, higher levels of percussion, and the frequent use of higher pitches. Positive awe-associated music, in general, can be described as having low clarity of pulse, infrequent timbral changes, a high degree of key clarity, and the use of high pitches. Negative awe-associated music, in general, can be described as having high levels of brightness and roughness and having frequent timbral changes.

6.4.3 Emotion prediction exploration

Following from the feature extraction, emotional data prediction analyses for the music excerpts were performed. These were done using the *miremotion* prediction model (Eerola, Lartillot, & Toivianinen, 2009) found inside the MIRtoolbox version 1.3. The *miremotion* prediction model uses musical features to calculate numerical data for two paradigms of emotion description, basic emotions and dimensional emotion components. Data for five basic emotions (happy, sad, tender, anger, and fear) are generated as well as three dimensional components (activity, valence, and tension). Each of these generated predictions is based on five contributing MIRtoolbox features. For example, the prediction for happy consists of maximum values for fluctuation, spectral spread, standard deviation of the maximum chromagram, key clarity, and averaged mode data. Each of the emotional and dimensional components has a unique combination of five contributing features. Eerola, Lartillot, & Toivianinen (2009) provide a full list of contributing factors for each emotional and dimensional component, and the computation procedure for the predictions. This predictive model analysed each of the musical excerpts and outputted data relating to their emotional content. Similar to the music feature analysis performed in Section 6.4.1, these computations generated values relating to the same three music types (positive awe, negative awe, and non-awe). Table 6-3 summarises the comparison test values, and which emotional data reached statistical significance between the music types.

Table 6-3

Summary of Kruskal-Wallis tests and their significance values for miremotion data

Type	Emotion feature	*H*	*p*
Basic emotion	Happy	6.111	.047*
	Sad	1.866	.393
	Tender	11.992	.002*
	Anger	13.272	.001*
	Fear	13.752	.001*
Emotion dimension	Activity	15.997	< .001*
	Valence	15.037	.001*
	Tension	14.712	.001*

* Indicates test statistics that reach significance ($\alpha = .05$)

Of the five basic emotions, four showed significant differences between music types, with sadness being the only emotion to not reach significance. Each of the basic emotion analyses that reach significance were further explored through post-hoc Mann-Whitney *U* tests adjusted by the Bonferroni corrections. A summary of basic emotion data is shown in Table 6-4.

Table 6-4

Summary of Mann-Whitney tests for basic emotions

	Positive awe vs. negative awe			Positive awe vs. non-awe			Negative awe vs. non-awe		
Basic emotion	***U***	***z***	***p***	***U***	***z***	***p***	***U***	***z***	***p***
Happy	8.800	2.235	.076	8.000	2.032	.126	-0.800	-0.203	1.000
Tenderness	8.400	2.134	.099	13.500	3.429	.002*	5.100	1.295	.586
Anger	-9.700	-2.464	.041*	-14.000	-4.556	.001*	-4.300	-1.092	.824
Fear	-9.700	-2.464	.041*	-14.300	-3.632	.001*	-4.600	-1.168	.728

* Indicates test statistics that reach significance ($\alpha = .05$)

Though the Kruskal-Wallis test showed a significant difference in happiness values, $H(2) = 6.111$, $p < 0.047$, the Mann-Whitney tests did not show any significant differences between positive awe and non-awe music types, $U = 8.000$, $z = 2.032$, $p = .126$. Similarly, no statistical significance was seen between the negative awe and non-awe music types, $U = -.800$, $p = 1.000$, or between the positive and negative awe music types, $U = 8.800$, $p = .076$. Comparisons for tenderness showed a strong difference between positive awe and non-awe music types, $U = 13.500$, $z = 3.429$, $p = .002$, with positive awe music values (*Mdn* = 4.616) significantly higher than the non-awe music (*Mdn* = 1.838). No differences were found between negative awe and non-awe music types, $U = 5.100$, $z = 1.295$, $p = .586$, nor between positive awe and negative awe comparisons, $U = 8.400$, $z = 2.134$, $p = .099$. Mann-Whitney test of anger data showed an expected directionality of significant differences between positive awe (*Mdn* =1.568) and negative awe (*Mdn* =2.968), $U = -9.700$, $z = 2.464$, $p = 0.041$, with negative awe music showing higher values. When compared to non-awe music, positive awe music again showed a statistical difference, $U = -14.000$, $z = -3.556$, $p < 0.001$, with non-awe music showing higher values ($Mdn = 4.055$) than positive awe ($Mdn = 1.568$). No significant differences were found between negative awe and non-awe, $U = -4.300$, $z = -1.092$, $p = 0.824$. Examining the fear data, Mann-Whitney tests with Bonferroni corrections showed significant differences in fear values between positive awe and negative awe music, $U = -9.700$, $z = -2.464$, $p = 0.041$, with positive awe ($Mdn = 0.340$) lower than negative awe ($Mdn = 3.207$). Similar differences were shown between the positive and non-awe music types, $U = -14.300$, $z = -3.632$, $p = .001$, with higher values for non-awe music ($Mdn = 4.139$). No statistical differences were found between negative awe and non-awe music types, $U = -4.600$, $z = -1.168$, $p = .728$.

All three of the emotional dimensions analyses showed statistically significant differences, and post-hoc Mann-Whitney *U* tests with Bonferroni corrections highlight the nature and direction of these differences. A summary of the emotional dimension data is shown in Table 6-5.

Table 6-5

Summary of Mann-Whitney tests for emotional dimensions

	Positive awe and negative awe			Positive awe and non-awe			Negative awe and non-awe		
Emotional dimension	***U***	***z***	***p***	***U***	***z***	***p***	***U***	***z***	***p***
Activity	-6.800	-1.727	.252	-15.700	-3.988	< .001*	-8.900	-2.261	.071
Valence	9.500	2.413	.047*	15.100	3.835	< .001*	5.600	1.422	.465
Tension	-7.700	-1.956	.151	-15.100	-3.835	< .001*	-7.400	-1.880	.180

* Indicates test statistics that reach significance ($\alpha = .05$)

The data for activity showed significant differences between positive awe and non-awe music types, $U = -15.700$, z = 3.988, $p < .001$, with positive awe values (*Mdn* = 5.601) lower than non-awe (*Mdn* = 8.378). No differences were found between the negative awe and non-awe music types, $U = -8.900$, z = 2.261, $p = .071$, or between the positive awe and negative awe music types, $U = -6.800$, $z = 1.727$, $p = .252$. Significant differences for valence were found between positive awe and non-awe music types, $U = 15.100$, $z = 3.835$, $p < .001$, with positive awe values (*Mdn* = 5.095) higher than non-awe (*Mdn* = 2.743). A statistically significant difference was also found between positive awe and negative awe music types, $U = 9.500$, $z = 2.413$, $p = .047$, with higher values for positive awe (*Mdn* = 5.095) than for negative awe (*Mdn* = 3.346). Statistically significant differences were not found between negative awe and non-awe music types, $U = 5.600$, $z = 1.422$, $p = .465$. The final emotional dimension of tension showed significant differences between positive awe and non-awe music types, $U = -15.100$, $z = 3.835$, $p < .001$, with positive awe values (*Mdn* = 2.194) lower than non-awe music (*Mdn* = 5.746). Analyses between negative awe and non-awe music types, $U = -7.400$, $z =$

-1.880, p = .180, and positive awe and negative awe music types, U = -7.700, z = -1.956, p = .151, did not reach significance.

In sum, these data suggest that emotional differences are readily found between awe-related music and non-awe-related music. The basic emotions of happiness and sadness were not found to distinguish between the two forms of awe-related music, but several other categorisations were evident. The positive awe music type was characterised by high levels of tenderness, and low values for anger and fear, while music in the negative awe music type was characterised with the opposite, contrasting associations. The emotional dimensions calculations showed music in the positive awe music type to be of low activity, high valence (i.e. positive), and with low levels of tension. The negative awe music showed lower levels of valence, but higher levels of activity and tension. The non-awe associated music showed similarities to the negative awe music type in many aspects, notably in the anger and fear data. This may be due in part to the non-awe music type having lower values in key clarity (*mirkey*), which is a common constituent factor used in many of these emotional predictions.

6.4.4 Novelty exploration

The final data extraction through MIRtoolbox was performed to estimate levels of novelty between the music types. These novelty values were computed for all 30 of the samples comprising the three different music types. The comparative analysis examined the mean values of novelty between the positive awe, negative awe, and non-awe music types. The Kruskal-Wallis test showed no statistically significant differences between the music types, $H(2)$ = 1.494, p = .474, with similar values for positive awe (*Mdn* = 0.044), negative awe (*Mdn* = 0.059), and non-awe (*Mdn* = 0.050). A second novelty extraction was performed by adjusting the frame divisions used in the *mirnovelty* command. *Mirnovelty* compares audio sections to one another to generate values of the degree of difference between each sample, and with a small default frame length there may not be enough information on each side to appropriately compare musical information. This was resolved by finding the computationally informed natural divisions in the music samples using the *mirsegment* operator in MIRtoolbox. This process selects the frames for novelty analysis based on peaks in the mel-spectrum of the audio signal. The comparative analysis was performed again, but this version also did not show a statistically significant difference between the music types, $H(2) = 3.933$, $p = .140$.

No significant difference was found between the three groups tested, and this may be due to the small number of excerpts used in this study. As the novelty data are generated by comparing neighbouring segments of music, having a longer representative sample of awe-associated music, spanning contrasting musical sections, might have yielded larger values for certain music types. This study tested music samples of approximately 30 seconds, which may have limited the ability of *mirnovelty* to compare contrasting sections.

6.5 Musical materials and interpretation of musical size

With the body of information from the musical features extracted through MIRtoolbox, there remains a gap between how these data relate to the listener's experience of musical materials in a piece of music. This section examines one piece of awe-related music and analyses the musical materials present in the composition to interpret how these materials relate to the findings of the novelty feature data. As well as detailing the materials present in the music, these musical materials are synthesised to form an interpretation of musical size, connecting with ideas from the previous chapter. Chapter 5 explored ideas of musical size and their perceptual relationship with musical awe, but these findings only captured information about participants' judgements of size and not how they were formed. Study 6 did not explore the processes leading to size ratings and what the listeners may have been responding to when making their judgements of musical size. To connect the musical materials to these findings, a more detailed and nuanced account of how judgements of musical size are made by a music listener is needed. This section provides the author's own analysis of how the musical materials may contribute to the listener's judgements of musical size and novelty.

This analysis focuses on the song 'Hoppìpolla' by Sigur Rós, one of the pieces of music used in Study 6. Though the piece is stylistically different from other pieces used in previous studies, in particular due to the inclusion of lyrics, 'Hoppìpolla' has been used in a previous investigation into experiences of music awe (van Elk et al., 2016), and in addition was chosen for this analysis due to the researcher's familiarity with the stylistic conventions of the genre. The examination of the piece is based on the researcher's analysis of the sectional structure of the music, the relevant musical materials, and how these may influence ideas of size and awe. This section describes the musical and sonic characteristics of the music, the progression of these characteristics through the piece, and the relationship between the musical materials, their progression, and how they may affect the listener's ideas of size and space. For this exercise, the music was repeated multiple times to note each significant change in musical materials and how these changes may affect perceptual judgements of size.

To begin, the general character of this style of music should be explained. Edward D. Miller describes the sound of Sigur Rós as follows:

> [M]usic is slow in tempo, a lush mix of ecstasy and melancholia that can build to thunderous symphonic crescendos complete with pounding drums, supplemented by a frantic string section. Guitars are often played by violin bows to stretch out notes tinged with feedback, and simple keyboard chord progressions are embellished by discordant blurbs and bleebs [*sic*]. The melodies are repetitive and folk-like and, in uncanny fashion, sound instantly familiar. And importantly, the vocals are mostly sung in Jónsi's falsetto range. (Miller, 2003, para. 3)

This description of the band's sound is also an appropriate portrayal of the track 'Hoppìpolla', as it shares many of these features, particularly the orchestration and vocal technique. The musical genres most associated with Sigur Rós, and this song in particular, are the categories of post-rock and dream-pop. Both of these subgenres are primarily concerned with timbral features, sonic textures, and atmosphere (Bogdanov et al., 2001, p. ix). The song is sung in Icelandic and 'Hopelandic' (also known as 'Vonlenska'), a 'form of gibberish vocals that fits to the music and acts as another instrument', as described on the band's website (Webb, 2008). Table 6-6 presents an itemisation of 13 sections of the song describing the changes in musical texture throughout the piece.

Table 6-6

Time-based musical materials description of the song 'Hoppìpolla'

Segment	Time	Musical materials
1	00:00–00:13	Reverb-bathed piano arpeggios
2	00:13–00:33	Higher octave piano doubles the arpeggios and develops the melody, swell of reversed electronic instruments and string backing chords including prominent lower voice (cello).
3	00:33–00:51	Soft driving quaver percussion and bass guitar entrance that crescendos. String backing morphs into a counter line.
4	00:51–01:28	Voice enters singing in Icelandic. Breathy, doubled, and rhythmically similar to the percussion. String line drops in volume (loudness) to double the quavers in the percussion before going back into a counter line and backing chords.
5	01:28–01:30	Arrangement falls away completely whilst the voice line falls in pitch over one beat. Reverberating cymbal crash in the newly created empty space.
6	01:30–01:31	The original piano arpeggio and melody return, now doubled with glockenspiel.

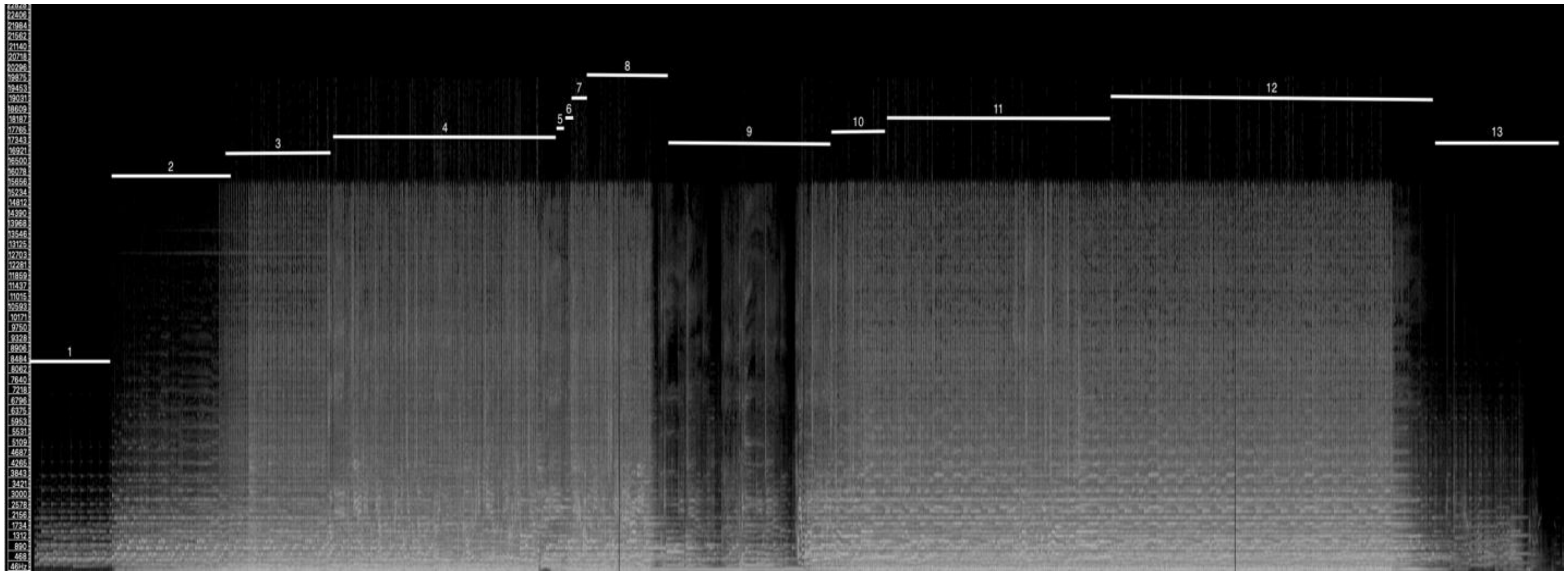
7	01:31–01:34	Percussion, bass guitar, and strings re-enter softly and start to crescendo.
8	01:34–01:48	Arrival point with full instrumentation.
9	01:48–02:15	Arrangement falls away as the song enters a softer section. The vocals remain and the reversed electronics layer is now prominent with the piano and glockenspiel arpeggios. Prominent bass guitar, playing a significantly reduced version of its previous part emphasising chord changes with long tones.
10	02:15–02:25	The driving quavers return in the bass guitar and percussion. Vocals become stronger, other singers join with counter melodies. String harmonies swell.
11	02:25–03:03	String melody increases in loudness accompanied by vocalist singing falsetto. Brass section enters with simple counter lines. Arrival point for the second time with full and dense instrumentation. Brass lines build.
12	03:03–03:58	Continuation of previous instrumentation, now with an increasingly prominent brass line that often doubles string melody. Bass and percussion driving eighth notes throughout the section.
13	03:58–04:30	Dramatic dissolution of the musical texture. Cymbals, bass guitar and strings ring out over several beats. Remnants of the original piano line, now metrically scattered and paired with the reversed electronic texture. Slow and high vocal

		line ascends and dissolves; fragmented brass lines enter and fade away as the song ends.

Figure 6-2 illustrates the thirteen sections detailed above in Sonic Visualiser 4.4 (Cannam, Landone, & Sandler, 2010). The increase in visual density of the lines in marked areas corresponds to an increase in the levels of activity in the music. This visual density is indicative of the many differences that can be seen between the sections in the music. Compare the scant and lightly concentrated lines in the beginning of the song (Segment 1) where a piano is playing sparse notes to the density found in Segments 11 and 12 when many more instruments have entered and are playing at greater volume (loudness).

Figure 6-2

Annotated spectrogram of ‘ Hoppìpolla ’

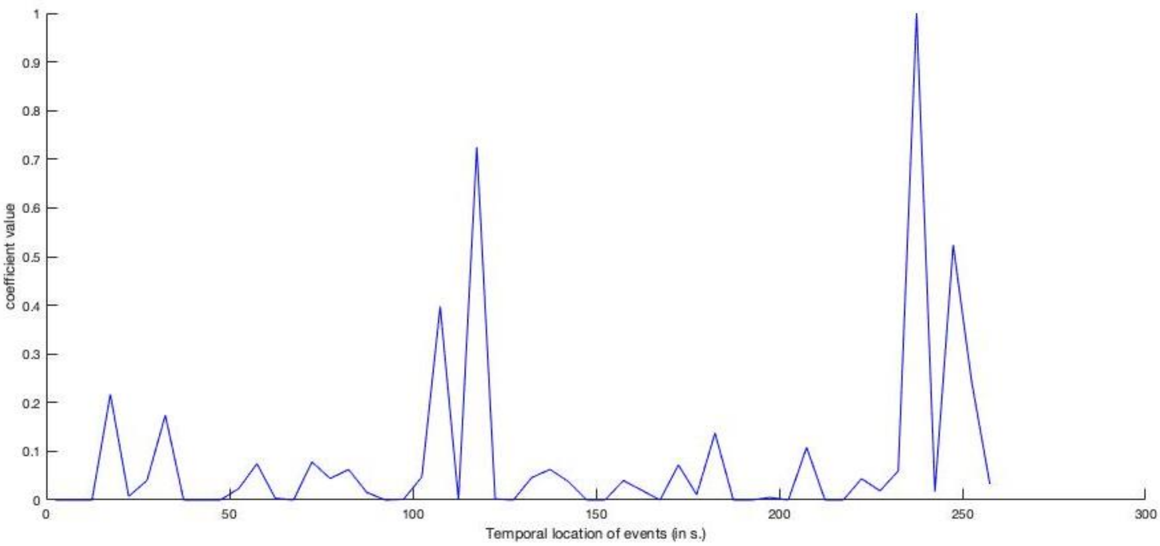


Note. Overlaid in white lines on the spectrogram are the temporal details of the 13 segments listed in Table 6-6. In the figure, the time of the piece progresses horizontally from left to right, and frequency information is detailed vertically on the spectrogram: the higher the frequencies, the higher up the spectrogram is marked. The vertical position of the segments follows a generalised overview of the sense of musical size and space previously described in Table 6-6. These show that some of these segment divisions (e.g. 1, 2, 9, and 13) are visible due to the differences in the signal strength between sections, while other sections are due to musical or sonic elements indistinguishable in the spectrogram.

To explore these differences, *mirnovelty* calculations were performed on the song in its entirety. With a frame resolution of five seconds, three points in the song show increases in novelty: beginning middle and end. These differences are due to changes in the musical materials, as previously detailed. Importantly, these areas are of particular interest in a musical awe context because of their associations with changes in musical size, and they denote places where new musical features appear. These new musical features, if substantially different and unexpected, may trigger a need for accommodation by the listener.

Figure 6-3

Novelty values of 'Hoppìpolla' (5s window)



Note. Novelty values taken for each five second frame show peaks in the data at the beginning middle, and end of the piece (around 20s, 100s, and 230s, respectively). Each of these spikes in the data signal dramatic changes in the music, as seen in Figure 6-2 and described in Table 6-6.

The following description offers an account of how these segments may interact with the listener's sense of musical size and how new musical information may be incorporated into their overall understanding of the piece of music. 'Hoppìpolla' begins with a lone piano in Segment 1: here perceptions of musical size would be small as the reverberant quality of the recording sets the piano as a small sonic element in a much larger space. Segment two shows increasing musical size due to the introduction of new instrumental layers with string voices filling out harmonies that increase the sonic density of the music. Segment 3, starting at 0:33, is where forward momentum in the rhythm section guides the music from the introduction into the song proper. The addition of the rhythmic pulse increases the perception of musical size not only through the rising loudness and the accumulation of percussive elements but also through the addition of new low frequencies in the bass guitar that ground the harmonic changes. When the singer's voice enters in Segment 4, it becomes the focal point of the music slightly expanding the musical size once again whilst the strings line falls into the background with its arpeggiated quavers mirroring the piano line. During the first few measures of this section, starting at 0:51, there is a simple semitone movement in the bass guitar from D# to E (tuned slightly flat) that expands the sense of musical size through a crescendo (with the percussion) and the harmonic movement drives to the following downbeat landing on the tonic B. This type of tension and release through the harmonic components and emphasis of new parts creates a sense of expansion and contraction of musical size, and with the addition of new musical textures, the music creates moments of heightened novelty that aid in a sense of musical progression. Since the harmonic progression of the whole song is a single repeated harmonic progression, the amplitude and textural changes take centre stage in the ear of the listener. Segment 5 starts with stripping away the dense instrumentation that had been slowly established and builds up the instrumental layers once again in the same manner. Once the instrumentation is fortified with additional layers it produces a thick or dense sonic environment that feels large, strong, and stable. This is the 'arrival point' at Segment 8, 1:34. The track uses a similar textural change with the dropping of instrumentation seen in Segment

9, where the music moves into a contrasting section. Here the space created by the strong downbeat and the ringing of cymbals creates a type of sonic void where the vocalist is presented inside a large, and now empty, space. This sense of empty space is surprising to the listener and is highlighted with the effervescent swirling sounds of reversed electronics around fragmented arpeggios in the piano and glockenspiel. Though there is an expansion of the space in which the music exists, the musical materials sound rather small and frail, and the backing vocals in this section sound only slightly louder than a whisper. This section is brief, and in Segment 10 (starting at 02:15), the lead vocal line seems to expand the size the music with the accompaniment of the driving quavers in the percussion and bass guitar. The size of the music increases with the swelling of the string lines to another arrival point at Segment 11. The size of the music seems to fill the sonic space created through the return of the density of sound at full force. At this arrival point, the music seems unable to expand any further, but with the string section taking control of the vocal melody and with the integration of novel brass lines, the music erupts and does expand after all. The vocalist's upper register falsetto singing blends and weaves into the melody played between the strings and brass sections. Together the horn and string lines feel like a natural and ecstatic extension of the vocals that go beyond what the singer's voice could achieve by itself and grow the sense of musical size further still. The final section, Segment 13, starts with a strong downbeat where many of the instrumental parts ring out. This brings the piece to an end with a gestural sigh, stripping away many of the dense timbral layers and leaving the singer's voice seemingly stranded in the sonic environment. The decelerating piano sputters out the last of its notes while fragments of brass lines enter and exit with consonant harmonies. This ending creates the same kind of void as previously described in Segment 9: the musical elements begin to collapse, fading to silence, resulting in a progressive reduction of musical size.

This description of musical materials in terms of size is primarily motivated by increasing or decreasing layers of instrumentation in the music. Importantly, the rhythm section (bass guitar and percussion) often played a significant role in preparing these increases in musical size through ostinati and their gradual building of intensity. However, not every change in musical size can simply be attributed to changes in loudness. In Segment 12 the brass section breaks into high pitched counter lines. This is interpreted as an increase in musical size even though the loudness in this section remains constant. The span or range of notes within parts extends and is perceived as more musically complex and dense. This sense of density can be understood through a few different lenses—the layering of musical materials together (without affecting the amplitude of the sound), the increase in complexity of a given music feature or part, or the expansion of the range of individual parts in the music.

In this interpretation of the musical materials and musical size, several descriptions of the sonic environment relate to the spacialisation of sounds in 'Hoppìpolla'. This type of environment-based ecological understanding is important to estimations of size because without the context of a sonic environment, the absolute size of a musical element is hard to assess. For example, the experience of hearing the sound of a trumpet played in a small acoustically treated room is perceptually different from the experience of the same instrument's sound produced in a large stone cathedral. Both examples might be understood as musically large in some way, but the interplay between the sound and the space in which it is situated may grant a different relationship to the listener. This type of relational size, that is a judgement of how large the music is when compared to the space afforded, has important parallels in the context of musical awe. The fundamental idea of an 'encounter with a large object', the experience of vastness, that underlies much of our understanding of the awe is due to the object being understood as something larger than *us.* The listener, in the case of music, encounters sound that fills the auditory space established by sonic and musical features. Participant 5 in the previous chapter described this relation to size as an 'orb' and that the listener is inside the space created by the music. Here the music grows and shrinks *at* the listener. There is a perspective granted through this interpretation in which the listener adopts the musical space as their own environment with the consequence that when the musical materials interact with those spaces, they are also interacting with the listener.

6.6 Discussion

Through analyses of musical features, several elements were found to be significant for awe-related music. Explorations into these features pointed to some general descriptions of sonic and musical qualities associated with musical awe and related emotional data. The aims of this chapter set three guiding hypotheses related to feature extraction and are evaluated below.

$H_{6\text{-}1}$ stated that the feature extraction data would show a differentiation between the two types of awe-associated music and non-awe-associated music. This is supported in part, and to fully discuss the meaning of the results an explanation of each of the features will be reviewed. Though many features did show a differentiation between music types, 10 of the 26 features (38%) did not show any statistically significant differences. It was not surprising that *mirrms* values showed no differences between music types, as this may be explained from the music in the MAC_1 being normalised for volume. Each sample was previously set to the same maximum dB level to ensure equal listening conditions in previous experimentation. However, amplitude differences would likely be found in more ecologically realistic music listening settings. As an example, the dynamic range would be much more varied in a concert hall performance compared to the Muzak excerpts often only heard through an on-hold telephone call. The rhythmic differences found in the analyses point to specific areas of interest. Rhythmic fluctuation in *mirpulseclarity* revealed a lower level of musical pulse in awe-associated music than with the non-awe group, and *mirpeak* in the fluctuation field showed awe-related music had lower values for rhythmic qualities than the non-awe music. This can be broadly understood as the lack of rhythm or pulse is a crucial factor for awe-related types of music. This trend can also be seen reflected in the tempo data, though the data only approached significance. The timbral differences are the most interesting and perceptually relevant features found through these analyses. The zero-crossing rate suggests that awe-related music has more noise and/or percussive elements. The brightness values in the awe-related music showed higher frequencies than non-awe-related music, possibly from a greater number of harmonics present or simply the result of higher fundamentals in those excerpts. Roughness data showed high values for the negative awe music type. This characterises negative awe music as having a higher level of dissonance. Higher rates for changes in spectral qualities were attributed to the negative awe types, signifying that sudden spectral changes occur more often. Spectral entropy again revealed high levels for the negative awe music type. This describes the music in the negative group as statistically more uncertain and may be interpreted as more surprising for the listener. Tonal attributes showed that key clarity is an important feature for positive awe but not for music in the negative awe category. This summary extends to the findings from the chromagram results as well, where positive awe music scores were shown to be significantly higher, suggesting this type of music is strongly tonal and associated with higher pitches. In total, how could one describe the features of each of these two types of awe-related music? Based on these analyses, positive awe music would be associated with tonal music that utilises a higher register, lower emphasis of pulse, and is relatively consonant. Negative awe music would be characterised by increased roughness in sound, irregular timbral changes, less clarity of key, and lower fundamental pitches. Care must be taken in generalising these attributes to all types of awe-related music, but they outline the distinguishing general attributes of the music found within the MAC.

The second hypothesis (H_{6-2}) was that computed emotional data would yield distinguishing features between positive and negative awe-related excerpts. This finding was largely supported, and mirrors the valence divide previously explored in Chapter 4 (Studies 3 and 4). The one notable difference from Study 7 was that there were no significant differences between positive and negative awe for happiness and sadness. Previous studies in this project showed contrastive associations with emotional terms, with music in the positive awe category associated with positively valenced emotions, and negative awe music associated with negatively valenced emotions. The experience of awe may not be as directly related to these basic emotions (previously discussed in Chapter 4, Section 4.6.4). The conventional example of awe as an overwhelming experience may have little to do with the emotions of sadness or happiness. If we assume that the qualities of music are in some way mirrored in our emotional experiences of that music, then the values for tenderness and fear may be more appropriate for describing experiences of awe and its associated music. It is counterintuitive that non-awe-related music showed high values for negative emotions. The values for negative valence, fear, and anger suggest that the Muzak and background music samples may be associated with particularly negative characteristics. However, in Studies 3, 4, and 5, participants consistently rated this type of music as having low associations for these features.

The third hypothesis (H_{6-3}) was that novelty scores would be significantly higher for awe-related music; however, this was not seen in the data. The values for novelty did show higher mean values for the negative awe music type, but these differences did not reach significance. Several factors may explain this finding. First, both the positive and negative music types have widely varying data, with several excerpts showing very low levels of novelty. Second, this type of novelty may not be a principal feature for awe-related music. One instance of surprise for a listener in a sea of banality may be an important trigger for an experience of awe. It may even be counterproductive for the induction of awe to have continuously novel musical segments being presented over a short amount of time, as perceptions of novelty may be diminished from overexposure. Third, the non-awe music is not devoid of musical interest and differentiation. Most of the Muzak samples in this category share similarities to jazz and have moderate values for novelty. Some excerpts in the negative awe group showed higher average novelty values than non-awe excerpts, but high levels of variation in these data yielded no statistically significant differences.

The exploration into musical materials showed that there were many musical features that can be used to manipulate judgements of musical size and space, e.g. crescendi and instrumental layering. The accompanying novelty ratings may reveal places of interest for dramatic musical size changes, but there is a substantial cognitive component to assessing how the music fills in the virtual spaces created by its sonic qualities. It is not as simple as finding musical features that directly specify musical size. There is flexibility in how one interprets musical size from musical features, and this is fundamentally dependent on the listener and their personal interpretations. However, that is not to say that no generalisations can be made. The account in Section 6.5 described the listening experience of someone familiar with the conventions of the genre and the specific musical artist to present a fuller picture of the associations available to the listener. This extends from the sonic and musical features, to what they may *mean* in terms of musical size, and how they work together to possibly evoke musical awe. The layering of musical voices, and the ebb and flow of timbral density as prominent musical features is proposed as a common and salient feature to which many listeners pay particularly close attention.

6.6.1 Conclusion

Music information retrieval and an exploration into musical materials have shown to be a productive way to explore musical awe: the attributes of the music, and what they may *mean* to the listener. Of course, these data and analyses are based on the music in the MAC_1, and a primary limitation to a more comprehensive feature analysis of awe-associated music is the number and type of musical excerpts. With a wider and more diverse catalogue of awe-associated music, new associations will undoubtedly be found that will expand and possibly challenge these findings. This chapter has made use of generalisations about the kinds of musical features that constitute awe-related music, presenting a limited selection of examples of awe-related music and their features of interest. This concludes the final empirical chapter in the research project. In the following chapter, the results and analyses found in this study will be used to draw conclusions about the psychological associations between awe-associated music and the nature and experience of musical awe itself.

7 Conclusion

Through the seven studies presented in this project, several of the fundamental and establishing ideas concerning the experience and occurrence of musical awe have been investigated. These studies have shown commonalities between accounts from those experiencing awe instigated by music, and through diverse and appropriate methods these studies have tested perceptual components associated with these experiences. These studies not only help to establish and affirm the psychological production models for awe but also examine the nature of the phenomenon itself within a Eurocentric understanding of musical awe. This project makes no claim to provide a comprehensive explanation of all aspects of musical awe, but it does shed light on a dimly lit area of research. This chapter concludes by placing the findings of these studies in the larger context of the research project, emphasising the contributions made to the areas of music psychology and affect/emotion research, evaluating how these findings fit within psychological models of awe, and proposing a novel framework for musical awe through an integrated model of musical awe (IMMA). Finally, the chapter concludes by setting out future directions for the study of musical awe to expand on this work and the knowledge of the field.

7.1 Project overview and summary

The overarching aim of this research project was to detail and decipher experiences of musical awe through systematic psychological research methodologies. The studies presented in this project took a number of different empirical approaches, and through their investigations more is now known about the experience, characterisations, and occurrence of musical awe. Starting from a review of theoretical psychological models for the occurrence of awe, these models were used to evaluate first-hand accounts of awe and the related associated perceptions found in the awe-evoking music. This section provides an overview of each of the studies and their main findings and contributions.

The first study (Chapter 3, Study 1) acted as the empirical grounding for this project through its investigation of personal accounts of experiences of musical awe. Through an online survey and questionnaire, a diverse array of musical awe experiences from the general public was collected and analysed. Participants were asked to recall a past experience of musical awe, name the piece of music present at the time, and rate and answer several questions relating to psychological aspects of the experience. The results of this study showed that experiences of musical awe fit very well with Gabrielsson's exploration of strong experiences with music (SEM; Gabrielsson, 2011), where meaningful events with music remained vivid in participants' minds, often connected with their sense of identity, and held a quasi-religious status for the listener. Participants reported musical awe as a pleasurable and joyful experience, often associated with surprise. The factors reported for the induction of awe fell into three broad categories: musical, personal, and contextual. Participants listed dozens of musical features important for their awe response, including harmonic changes, dynamic differences, changes in instrumentation, and changes in tempo. Results from questions adapted directly from Keltner and Haidt's (2003) model showed that participants' experiences of musical awe were understood as vast and elicited a need for accommodation. Musical awe was generally characterised as beautiful, supernatural, virtuosic, virtuous, and safe (i.e. not associated with threat).

The second study (Chapter 3, Study 2) investigated previously recorded accounts of musical awe found within the Listening Experience Database (LED). Through an examination using natural language processing (NLP) techniques, word frequencies and emotional sentiments were analysed to deduce commonalities in general expressions concerning musical experiences. Instances in the database using the words 'awe' and 'sublime' shared similar characteristics, namely their affinity for positive affect, where joy was found to be the most frequently expressed sentiment for both awe and sublime accounts. Interestingly, the texts also showed increased usage of terms ‘great’, ‘grand’, and ‘good’, relating not only to the positivity expressed within these accounts but also the relational quality of size. The investigation of these experiences of emotions from musical listening situations revealed shared features between occurrences of both awe and the sublime, suggesting a close relationship between the two phenomena and corroborating the findings of Study 1.

The third, fourth, and fifth studies (together comprising Chapter 4) built from the generalised characteristics found in the first two studies and investigated perceptual and emotional components related to awe-affording music listed from the participant experiences in Study 1. Importantly, these three studies moved away from retrospective methodologies that relied on participants’ memories of events and experiences, and directly tested the associations of awe-related music through experimental methods. Study 3 had participants rate awe-related music to images associated with two forms of awe and found a valence-based bifurcation in awe-related music. Study 4 found that this difference was principally characterised by perceptions of valence. Though awe-related music took two forms (i.e. positive and negative), there was common ground between these forms in the ratings of the emotion terms of awe and amazement. Positive and negative awe-related music differed in the ratings of threat, positive affect, and negative affect. Study 5 examined the same awe-related music and how it affected participants’ ratings of conceptual appraisal terms. The results showed that the positive and negative music types were largely dissimilar for many of these associations. Positive awe-related music was more closely associated with beauty and virtue, whilst negative awe-related music was strongly associated with threat. Ratings for vastness and power remained relevant associations for both types of awe-associated music.

The sixth study (Chapter 5, Study 6) investigated perceptions of musical size and the role of amplitude in awe-related music through a time series experiment. Participants listened to awe-related music whilst continuously providing ratings for perceptions of musical size and perceptions/feelings of awe as expressed by the music. Experimental conditions had participants listen to uncompressed or compressed versions of the music so as to explore the role and function that intensity/volume fluctuation plays in its relations to judgements of size and awe. The results of this study suggested that judgements of size play a central role in perceptions of awe-related music, and through the Granger causality calculations, judgements of size were shown to often precede, and therefore G-cause, judgements of awe. Differences in volume (loudness) did not lead to direct differences in musical size ratings, demonstrating that associations of size are not solely responsible for judgements of awe but are best understood as one piece of a complex emotional assemblage.

The final study (Chapter 6, Study 7) investigated the musical and sonic features in awe-related music through music information retrieval (MIR) techniques. Comparing the positive and negative valence types of awe-associated music, notable differences were found in several musical features relating to rhythm, timbre, and tonal qualities of the music. These data suggest that awe-associated music differs from non-awe-associated music in some significant ways, and that the most salient features that distinguish between the valence variants of musical awe are the rate of timbral change, and spectral brightness and roughness, with the negative awe variant associated with higher levels of the three. Other calculations using MIR data compared novelty values for awe-associated music and non-awe-associated music, but these did not show any statistically significant differences. However, through the researcher's assessment of musical materials in the songs 'Hoppípolla', a similarity was found that linked novelty with musical textures. Large changes in the calculated novelty values were associated with significant points of arrival in the music, primarily understood through addition or reduction of instrumental layers.

Taken together these seven studies provide the first sustained and systematic empirical evidence for the nature and occurrence of musical awe. Before these studies, there was no systematic empirical basis for the production and experience of musical awe, as previous understandings of musical awe were extrapolated from psychological models largely based on other modalities. These findings do not definitively explain all aspects of the nature of musical awe, but they do provide a platform of empirically grounded results on which to build explanations and interpretations relating to our experiences of musical awe. A principal finding in the first two studies was the ubiquity with which people spoke about feeling awe from music. It may seem like a common experience shared by many music listeners—and one that might have been anticipated, even without extensive research—but having data to support awe's incidence through music is an important first step. Secondly, that the music associated with these experiences can be understood through their emotional associations provides an explanation for why some forms of musical awe may be dramatically different from others. Associations of size are a large part of theoretical explanations of the sublime and experiences of awe, and to have data supporting this idea strengthens these theories through empirical evidence. Finally, broad musical feature analyses were shown to distinguish between awe-related music and non-awe-associated music types. These findings provide a general mapping for musical features such as brightness and roughness to the delineated positive and negative variants of musical awe. Together, these findings help to confirm or question the validity of psychological models for the production of awe and contribute to the development of an empirically driven model for musical awe (proposed in Section 7.3) that is able to more thoroughly explain these experiences.

7.2 Contributions to research

The primary contributions of this project to the research areas of music and emotion and the psychology of awe include the confirmation of the incidence of awe in music listening, the creation of the Musical Awe Corpus (MAC and MAC_1), the detailing of the emotional and perceptual assessments of awe-related music, and providing support for the claim of the influence of musical size and vastness as an important component of musical awe. With research into awe gaining traction in recent years, it is important to begin to establish the causes and occurrences of musical awe. Without a strong empirical basis for how this music may work to produce feelings of awe, problems and confusions may occur to the detriment of future research. For example, without understanding the two valence-based varieties of musical awe, researchers might unintentionally omit a significant component of musical awe and be led to erroneous conclusions. The selection of musical excerpts that induce awe should be chosen with care, those used in this study being based on first-hand accounts of experiences of musical awe and tested thoroughly, making them better candidates for musical stimuli in future research. The following sections expand on the main findings of this project, interpret these findings through their application into other areas of music and emotion research, and assess previously proposed models of awe.

7.2.1 Discussion of findings across studies

The design of the studies was deliberately and explicitly cumulative. Participants' accounts from Study 1 were used to build the corpus of awe-related music tested in Studies 3, 4, 5, 6 and 7. Study 3 proposed two different forms of music related to awe experiences, and Studies 4 and 5 examined what characterised these forms. This demarcation of two forms of musical awe was also used as the basis for Studies 6 and 7. Since many of these studies are directly connected to each other, an examination across the studies is needed to fully appreciate some of the main contributions of this research project. This section examines many of the general findings of these studies and interprets them in the context of other relevant studies. The connections drawn from Study 1 to later studies in the project help to generalise experiences of awe from first-hand accounts to general perceptions and associations. These connections show the commonalities between experiences of musical awe and the associations of the music itself devoid of additional context (musical and environmental), illustrating the perceptual and cognitive substance underlying experiences of musical awe.

Study 1 and Study 2 had an analogous objective—to obtain first-hand accounts of musical awe and to evaluate them for similarities. Both the participant and historical accounts showed a positive evaluation of both the music and the awe experience. The negative, or threat-based, form of awe can therefore be understood as a rarer experience from music, or at the very least, one that is not reported to the same extent as the positive variant. This echoes much of the previous psychological research on experiences of awe which highlights the positively valenced version of the emotion (e.g. Piff et al., 2015, Yaden et al., 2019). In common parlance, terms 'awe' and 'awesome' are virtually always used to describe a positive feeling, even despite prominent definitions mentioning its relationship to fear and dread (e.g. Cambridge English Dictionary, n.d.; Merriam-Webster, n.d.; and Oxford English Dictionary, n.d.). Therefore, it is reasonable to expect positive associations reported through retrospective responses concerning experiences of awe.

The questionnaire in Study 1 and the perceptual experiments in Studies 4 and 5 gathered parallel data relating to emotional and ancillary or peripheral appraisals of experiences of awe and awe-associated music. The questionnaire found that participants retrospectively rated their understanding of musical size as overwhelmingly 'vast or grand', and Study 5 similarly showed high ratings for vastness from the awe-associated music. This association in Study 5 held true for both the negative and positive variants of awe-associated music, but with higher ratings for negatively valenced music. Study 1 gathered data from a variety of emotional states (from the Geneva Appraisal Questionnaire; Scherer, 2001) and showed high ratings for pleasure, joy, and surprise, whilst the negatively valenced emotions were rated significantly lower. The findings of Study 4 used a similar set of emotions derived from Gordon et al. (2017) and showed that emotional associations from positive awe-associated music showed amazement, wonder, awe, warmth/tenderness, and joy were rated higher, whilst the negative emotions were rated lower. Though the GAQ and the list of emotions in Study 4 are not identical, they do share several similar emotional sentiments. The results of Study 4 showed that positive awe-related music is positively associated with emotional terms like happiness, joy, and wonder. These associations of positive valence were also found in many of the self-reported experiences of musical awe found in Study 1. Conversely, the negatively valenced awe-associated music relate to contrasting emotional perceptions to those found in Study 1. In these evaluations, fear, distress, nervousness, and amazement, were most highly rated, and joy, and warmth/tenderness were the lowest rated. This implies that many of the experiences of awe are in response to the positively-valenced type of music and/or that the experiences of musical awe re-contextualise negative sentiments into more pleasant and enjoyable experiences. The phenomenon of finding pleasure in negatively valenced stimuli is often mediated by feelings of being moved (Vuoskoski & Eerola, 2017) and further interweaves the concepts of musical awe and being moved.

The peripheral appraisals proposed by Keltner and Haidt (2003) were also tested for their associations in Studies 1 and 5. These five appraisals were threat, beauty, exceptional ability, virtue, and the supernatural. The findings of Study 1 showed that each of these appraisals except for fear was a prominent characteristic for musical awe. Study 5 was once again divided between positive and negative awe-associated music types and showed beauty, ability (assessed as ‘skilfulness’), and virtue as highly rated associations for the positive music type. By contrast, the negative music type showed high ratings for threat but also for ability. These high ratings for ability were also seen in the non-awe-associated music group. The similarity of ratings suggest that ability is an important evaluation for awe-associated music, and moreover, that ability may be a prominent and relatively ubiquitous evaluation for music in general. Furthermore, appraisals of beauty and virtue characterise positive awe-associated music while threat characterises negative awe-associated music. The self-reported participant experiences detailed in Study 1 largely focused on positive awe-associated music and therefore diverged from the appraisals of the negative awe-associated music in Study 5. This raises the question of whether there are significant connections to be made between the negatively valenced awe-associated music and its relationship to the experiences found in Study 1, or whether these two types are too dissimilar for there to be common ground. Study 5 showed that negatively valenced awe-associated music had high ratings for threat and ability as well as high ratings for power and vastness. These commonalities suggest a hierarchical understanding of appraisals for musical awe where assessments of size, vastness, and power—all of which reference a similar experience (especially in the light of Edmund Burke's conception of the sublime)—exist at the higher and more general level of musical awe. The differentiation of other appraisals, like threat, then can specify the particular type of musical awe. This hierarchy is also seen in Keltner and Haidt's (2003) theoretical model and is more fully realised in the integrated model proposed in Section 7.3 of this chapter.

Assessments of size were also examined in Study 6. In Study 1, participants were asked to retrospectively estimate the conceptual size of their experiences of musical awe, and the majority of participants associated their awe experiences as being large and vast. Study 6 asked participants to rate musical size throughout pieces of music and the results showed continuously variable ratings characterised by changes in volume (loudness), changes in instrumentation, and an expansive sonic envelope. Together, these findings suggest that experiences of awe are significantly coloured by specific points in the music that are associated with musical elements that relate to large musical size.

Study 7 found that brightness, roughness, and irregularity were among the sonic and musical features that distinguished awe-related music from the neutral musical excerpts. Comparing these findings to the list of those reported in the collected musical features found in Chapter 3 Section 3.4.2.4, which was derived from the personal accounts of musical awe, several commonalities present themselves. The brightness of the music, calculated from an elevated presence of higher frequencies, relates to the ‘sharpness’ mentioned in the production subcategory, ‘ascension of strings’, and the ‘rising melody’ in the pitch subcategory. Roughness relates to the features of ‘tense chords’, ‘unusual harmonies’, and ‘discordant guitar’ in the pitch subcategory. And irregularities or dramatic changes in the music can be found in nearly every subcategory: dynamic changes, tempo variability, textural and instrumentation changes, and key changes are prominent examples listed in Study 1. Though there are dozens of musical features listed from participants in Study 1, many of these are outside of the purview of the findings of Study 7, due to the breadth of topics and particularities listed by participants. For example, the ‘interweaving of themes’ and ‘mimicking sounds from nature’ are not possible features found within the methodology of Study 7, and thus many of the features listed undoubtedly fall outside of scope of the feature extraction analyses performed. However, many of the more general features mentioned by participants share commonalities with those features from Study 7, as detailed above.

Comparing the findings of Studies 4 and 5 with those of Study 6 may not yield especially fruitful insights due to differences in method. The time series analyses in Study 6 showed that assessments of musical size and perceptions of awe largely occur together, with size ratings often coming just before those of awe. Studies 3 and 4 examined which emotional and conceptual terms were closely related with awe-associated music. The only commonality between these studies can be seen with the high ratings for awe in Study 4 and the high ratings for both power and vastness in Study 5. Judgements of power and size are important for musical awe, and this is reflected in both studies. However, without time-series information relating the other associations tested in Studies 4 and 5, it is difficult to derive any further insights for this discussion.

Though there were no studies that directly tested the relationship between sonic components and emotional ratings, taking the findings of Studies 3, 4 and 5 and relating them to Study 7 suggests possible connections. As heightened levels of roughness directly relate to musical dissonance (Johnson-Laird, Kang, & Leong, 2012), dissonance can also be associated with negatively valenced emotions and concepts, like those seen in the negative awe-associated music in Studies 3, 4, and 5. These connections suggest sonic associations especially important for negatively valenced awe-associated music and require future studies to examine these specific relationships.

Lastly, the musical feature findings of Study 7 bear some relation to the evaluation of musical size in Study 6. An exploration in the previous chapter (Section 6.5) engaged in an evaluation of musical materials and their relation to musical size. This assessment focused on the addition and subtraction of musical layers as being a principal driver of assessments of size. In general, the addition of musical parts and voices resulted in perceptions of larger musical size. An evaluation of timbral characteristics like brightness, roughness, and the sonic density in these changes of musical layers may further explain the relationship between musical materials and musical size, but this project did not present a bespoke study to examine these possible comparisons.

In summary, the interrelated findings across this project present several areas of interest that relate different studies to each other and offer a higher-level analysis of musical awe. However, these crossover associations may require their own investigations to fully explore the postulated connections. The methodological differences between these studies renders direct comparisons between them difficult, but they do suggest several areas of future investigation.

7.2.2 Applications to music and emotion

Synthesising the findings of the studies reaffirms that musical awe shares many characteristics of the feeling of being moved by music and its connected physiological component of chills or shivers. Starting with musically induced chills, survey research has shown that chills often occur from changes in intensity or volume, the presence of the human voice, and abstracted concepts like a sense of unity (Bannister, 2018). Recent empirical research has also tested the relationship between chills and volume, brightness, and roughness (Bannister, 2020; Bannister & Eerola, 2018). These have shown a positive relationship between the intensity of chills and volume, brightness, and roughness. These explorations into chills seem to mirror many of the findings of Chapter 6 and suggest that musical chills are a physiological response strongly associated with musical awe (also reported in Study 1). As chills are a bodily response to sonic and aesthetic qualities found in music, they are one part of the psychological construct of being moved, proposed by Menninghaus et al. (2015).

Being moved is a complex emotional state related to deep emotions often connected with significant life events, pleasurable sadness, and nostalgia. Empirical research into being moved has also shown it to be a mixed emotion, with positive and negative accounts both present in collected experiences. It is also associated with feelings of warmth, softness, roundness, and wideness. The sketch of a psychological construct for being moved (Menninghaus et al., 2015) presents awe as a related emotion and shares many of the same characteristics and emotional associations of the positive variant of awe. Features like crying from music (Cotter, Silvia, & Fayn, 2018) or being moved (Menninghaus et al, 2015) are related to a positive aesthetic form of awe. In fact, in these cases of awe, so many features are shared, that they may be considered the same experience. Looking back to Study 1, the ways in which certain participants expressed their experience of awe, it would be difficult to claim that these experiences belong only to the category of awe and not that of being moved. If it were not for the negatively valenced version of awe, it may be appropriate to equate many experiences of musical awe and being moved by music, though the threat and fear components associated with awe distance it from being moved in a significant way. However, these two emotional states share sufficient commonalities to claim that musical awe could be considered a *sister emotion* to being moved by music. Together with chills, being moved and awe form Vladimir Konečni's Aesthetic Trinity (2005). His description of a three-part relationship prescribed rigid and fixed definitions for each component, and these prescriptions do not accurately reflect the findings of the research in this thesis and other studies (further discussed in Section 7.2.3). Nonetheless the three components are meaningfully related. A more flexible application of this idea would show that there may be no clearly defined lines between being moved and awe, but that these experiences fall within a psychological space with common dimensions, and may best be described as partially overlapping emotional phenomena. The main distinction between being moved and the experience of awe can be seen in the negatively valenced variant of musical awe, where its emotional associations are distinctly dissimilar to those of being moved. However, the appreciation of their similarities will help future investigations of awe to use ideas from research on chills and being moved to promote a more integrated approach moving forward.

Another important area that this project highlights is the connection between transcendent religious experiences and musical emotions. Though none of the studies presented in this project explicitly sought to examine experiences of religion, many similarities with religious experience can be observed. Whilst examining the frameworks for experiences of awe, these strong responses to music with the power to emotionally move the listener are not unlike those of reported transcendent religious or spiritual experiences. Transcendence refers to the experience of something beyond normal human limits, or an out of body experience (Gabrielsson, 2011, p. 159), and are often reflected in spiritual and religious writing. Study 5 provided evidence of the supernatural being a valuable appraisal for awe-associated music, and with the additional relation to vastness, associations with transcendence and spiritual experiences could reasonably be expected. Of course, the purpose of much religious (or sacred) music is, in part, to move the listener to an experience of awe and to reflect the sublime nature of the divine through similarly sublime music. A contemporary example of this can be seen with Christian Contemporary Music (CCM) used in evangelical protestant services in the United States (e.g. Bowler & Reagan, 2014) and South Korea (Yoon, 2016). This music often induces strong emotions in the congregants, and is deliberately employed to facilitate transcendent experiences for those in attendance (Wagner, 2017). This is often done through lyrical and musical content that emphasises vastness, personal freedom, and the divine (Yoon, 2016, pp. 334–335).

Musical experiences related to contemplative practices, transcendent qualities, and "sacrality" (Saliers & Saliers, 2017, p. 12), would benefit from this empirical grounding in the psychology of musical awe. There is an obvious similarity between these kinds of transcendent and religious experiences and those of musical awe, and exploring this relationship should provide fertile ground for future research.

In its totality, this project has shown that musical awe is an important area for emotional and musicological research and has used an array of empirical methods to probe its psychological makeup. It has presented some of the first research that bridges theories concerning the psychology of awe with those in the field of music and emotion. It has shown that many of the theoretical appraisals hypothesised for experiences of awe are relevant to musical awe and has allowed for a more nuanced view of awe as a complex emotion. It therefore establishes a conceptual relationship between different forms of awe-affording music and has begun to piece together how the psychological components of awe may best be understood to provide an empirically based model for the emotion (further detailed in Section 7.3). The following section directly examines the findings of this project in relation to previous models of awe-production and evaluation.

7.2.3 Assessment of preceding models of musical awe

One of the principal goals of this project was to assess the theoretical claims made in the influential model of awe developed by Keltner and Haidt (2003). The two principal components of their claim, the perception of vastness and the need for accommodation, were largely supported by the findings of this project. Notably, using music as the eliciting stimulus causes some difficulty when assessing the perceptions of vastness and size, as music exists largely outside the visual domain. However, the positive associations of size and vastness reported in Studies 1, 2, 4, 5, and 6 show that this association is a prevalent and important feature in the experience and perceptions of musical awe. The need for accommodation was preliminarily assessed in Study 1 where 75% of participants agreed that their experience of musical awe 'changed the way they experienced and/or understood the music'. Though this wording was not precisely the same as that of the Kelter & Haidt model, a 'change in understanding' speaks to the same function as does accommodation. This appraisal was also evaluated through a variety of studies examining computed novelty values (Chapter 6, Study 7) and participant ratings for amazement (Chapter 4, Study 1) and surprise (Chapter 3, Study 2). Though this component was not tested directly, novelty and surprise are elements that would increase the propensity for accommodation in the listener and can therefore be regarded as proxies. It was found that there were clear associations made between novelty and surprise, rendering accommodation a likely component of awe.

With the two central appraisals of the Keltner and Haidt model shown to be reasonably supported, a second stage of evaluation comes in assessing the peripheral or ancillary appraisals (i.e. threat, beauty, ability, virtue, and the supernatural) (2003, p. 305). Assessing the five peripheral components of musical awe through the studies showed significant differences from the proposed model. Firstly, music as an eliciting stimulus for awe was not explicitly considered suitable for all five appraisals. Only the appraisals of beauty and ability were granted as appraisals of music that are usually made by listeners. As previously discussed in Chapter 4, the assigned list of affordances to music appeared inadequate, and indeed it was shown to be insufficient, as all the peripheral appraisals were important for participant responses to awe-associated music. Even viewing the proposed model as only relevant to the positively-valenced variant of musical awe, virtue—an appraisal not considered—was seen to be a highly rated and consistent appraisal for this type of music. This suggests that these peripheral features have stronger associations with musical awe than the Keltner and Haidt model for music proposed, and that all five should be recognised as influential features. The only one of these peripheral features that may be regarded as lesser are judgements of the supernatural. From Study 5, it appears this feature is not as widely applicable as the others. However, judgements of the supernatural were seen, but only with pieces of music that are more associated with negative valence. Therefore, a more nuanced approach may delineate the two forms of musical awe, assigning central features to both, while dividing the peripheral features between the music types. Positive-valenced variants of musical awe would include the features of beauty, ability, and virtue, and negative-valenced variants would include threat, ability, and the supernatural.

The focus of Keltner and Haidt's framework was to propose a generalised explanation of awe through several different modalities. However, in their generality they have overlooked and underrepresented the wealth and complexity of cognitive evaluations afforded to the music listener. Their evaluation of music as an awe-eliciting stimulus with limited appraisals underestimates the many associations shown through the studies of this project. Furthermore, music's use and role as accompaniment to other awe-eliciting stimuli was unexamined. Take as an example Studio Drift's *Drifter*[14], in which a massive concrete block 4 x 2 x 2 meters was uncannily suspended in a room as if by magic. This very situation, that of seeing a levitating object, falls under the category of 'cognitive elicitors' in Keltner and Haidt's model, and a peripheral appraisal of the supernatural is afforded to this situation (and threat is denoted as a possible appraisal). However, when paired with music, further appraisals become important for the viewer. In the adjoining room to where the concrete block was floating and slowly listing, the Stedelijk Museum also hosted the short film *Forever Drifting*[15] by DRIFT, Don Diablo, and Sil van der Woerd. This film used the same concrete object as the subject of the film and paired it with appropriate awe-associated music—similar to modern film music with large sonic envelopes, choral singers, and prominent synthesised bass—not dissimilar to some of the music reported by participants in Study 1. This music (and the cinematography) afforded more peripheral features that *coloured* the awe experience of the viewer. As a patron during this exhibit, I immediately recognised a feeling of awe and sat there thinking about how my feelings changed from simply encountering the mysterious object in a bare room, to seeing it depicted on film[16]. With the addition of music, the object was recast in my mind with many more emotional associations and afforded the peripheral appraisals included in Keltner and Haidt's model. Awe-related elicitors when paired together may have an additive,

[14] https://studiodrift.com/work/drifter
[15] https://studiodrift.com/nft/nft-forever-drifting/
[16] A walkthrough of this exhibition can be found at https://studiodrift.com/film/walkthrough-stedelijk-museum-studio-drift-coded-nature/

multiplicative, combinatorial, or some other type of interaction effect between their peripheral features. This recognition of the multimodality of awe elicitors is not accounted for in previous models, but it is important to acknowledge due to the tendency of music to be paired with other artistic and social functions. Overall, the Keltner and Haidt (2003) model describes many of the important appraisals for experiences of awe, and this project confirms its components as appropriate to that of musical awe. However, it does not attribute many of the peripheral appraisals to the presence of music and should be expanded to reflect the breadth of appraisals afforded to the music listener. Furthermore, without an appreciation of valence-differentiated forms of awe, this model lacks the nuance needed to develop a more precise explanation for the occurrence of musical awe.

Another influential emotional model concerning musical awe conceived by Vladimir Konečni (2005) views musical awe (referred to as a type of 'aesthetic awe') as one of three components of the prototypical experience of the sublime: awe, being moved, and thrills (i.e. chills or frisson). Together this Aesthetic Trinity helps describe and articulate experiences of awe and was developed to replace the 'imprecise and misleading references to "aesthetic emotions" and "musical emotions"' (Konečni, 2005, p. 28). Though this research project was not devised to fully interrogate this trinitarian complex, the findings of the studies can shed light on several of the theoretical claims. Firstly, the connection to being moved is indeed closely related to the experience of awe. As previously discussed in Section 7.2.2, these two exist in a shared psychological space with many similarities, especially in the positively-valenced music types. Chills were also reported as a common physiological phenomenon associated with musical awe. However, in Konečni's proposed explanation, he makes more specific claims about music's role in inducing awe that are problematic. The idea of grandeur (i.e. vastness) as a necessary component for awe is understood by Konečni's model as only referring to physical grandeur. Therefore, the assertion is made that music can only achieve this status ‘by being performed in vast architectural spaces that have not only excellent acoustic qualities, but are also of extraordinary beauty’ (2005, p. 37). This narrow view of vastness ties musical awe only to those spaces that are acoustically and aesthetically similar to cathedrals and concert halls. Not only does this contradict reports found in participant accounts from Study 1—experiences of musical awe were found in a wide variety of settings and environments—but it relegates musical awe to an experience only afforded by the acoustics of performance spaces, and not the musical materials or perceptual/cognitive activities of the listener. These spaces with their reverberant qualities certainly lend a multitude of sonic affordances to the listener that are influential for judgements of grandeur and vastness, but there is much more required than these sonic qualities alone for the experience of musical awe. These spaces can be said to provide a fertile environment for certain experiences of musical awe, but much like any analysis of emotions, the occurrence of musical emotions is multifaceted. Personal disposition, the qualities of the music, and the environment in which they are encountered may all play significant roles in how emotions are induced.

Looking to philosophical descriptions and resultant models of the sublime, there are significant parallels between those philosophical claims and the findings of this project. Edmund Burke’s analysis of the sublime sought to differentiate the beautiful from the sublime, separating the two and aligning sublime experiences with more dramatic associations of fear and horror. Does this separation between beauty and sublimity correspond to the perceptual valence divide found in the musical excerpts? Burke’s beauty and positive musical awe share many similarities. They are both associated with pleasantness and afford joy, but the vastness that Burke attributes exclusively to the sublime is also seen in positively valenced musical awe. If the sublime and beautiful were more mutually exclusive phenomena, as Burke understood them, it is odd that the positive variant of musical awe is also associated with vastness in the Burkean sublime. Though the positive variant does not seem to map well to Burke’s ideas, the negatively valenced variant of musical awe does align well with Burke's view of the sublime. The strong associations of fear, surprise, power, and vastness all mirror the Burkean sublime rather closely.

As discussed in Chapter 2, Kant also distinguished between two types of awe-associated sublime experiences—the dynamically sublime and the mathematically sublime. A comparison of these two forms somewhat aligns with the valence divide found in musical awe, but as Kant related both the dynamically and mathematically sublime to displeasure, this comparison corresponds rather imperfectly with the empirical findings of this project. In Study 3 the two images used to demarcate between positive and negative associations of musical awe somewhat resembled the Kantian forms of the sublime. The aurora borealis floating listlessly in the sky at an indeterminate height mirrors the descriptions of the mathematically sublime as infinite and immeasurable, something difficult to comprehend and goes beyond our common experiences and methods of understanding. One can imagine the mysterious streaks of pink and green colours waving through the sky for hours producing a sense of beauty and wonder for those who encounter this natural phenomenon. This evaluation differs from the Kantian idea of the mathematically sublime, as this sublime stimulus would be due to the viewer failing to fully comprehend the size and distance of the aurora borealis and in turn, this would yield displeasure in the viewer. Equally dissimilar is the aroura borealis and its positively-valenced characteristics to that of the dynamically sublime. The dynamically sublime does not rely upon comprehension or comparisons of size, but rather it is based on encountering something with great power that makes one feel powerless in response. This form of the sublime is incongruous with the positively valenced situations and emotional associations afforded by the image of the aurora borealis. Certainly, the limitlessness and infinitude associated with the dynamically sublime could be associated with pleasantness and other positive qualities, but this reinterpretation strays significantly from the Kantian understanding of the dynamically sublime. To further this point, Study 5 showed strong associations of beauty and virtue and weaker associations of threat, this provided a different appraisal-based fingerprint than would be expected if the mathematically sublime and positive awe were describing the same claims.

There is not a clear analogue to the positive variant of awe in the Kantian sublime, but Kant's ideas of the sublime do find a closer connection between the negatively awe-associated music and the dynamically sublime. The dynamically sublime describes the experience of fear and terror from nature, such as a potentially dangerous cliff edge or a lightning strike. This form of the sublime lacks (or at least deemphasises) the non-estimable or infinite qualities of the mathematically sublime and emphasises the security one feels from not actually being in the danger these settings imply. The supercell thunderstorm used in Study 3 is an archetypal example of this version of the sublime: a dangerous situation is triggered in the imagination of the viewer whilst being safely outside of potential harm. Clearly, the associations of fear, distress and anxiety were reflected in the negative awe-associated music (as seen in Study 4), as well as power, vastness, and threat (Study 5). Interestingly, Kant also aligns the dynamically sublime with negative moral implications, and Study 5 also produced findings showing that listeners made similar moral associations to negatively valenced awe-associated music. This version of the sublime echoes many similarities between those found in negatively valenced awe-associated music and therefore may be folded into the same descriptive category.

The final model of awe and the sublime to be examined in this section is the recent work by Sandra Shapshay (2021). This two-tiered theory proposed two routes for experiences of the sublime. The first, known as the *Thin Sublime,* is the aesthetic awe response composed of the two fundamental claims by Keltner and Haidt (2003): perceived vastness and the need for accommodation. This *Thin Sublime* only describes the immediate feeling and physiological awe-related response. In contrast the *Thick Sublime* is a more cognitive process that requires the *Thin Sublime* and the addition of lingering on the awe-eliciting experience and the attempt to fulfil the need for accommodation. Both the *Thin* and *Thick Sublimes* are of interest to the experiences of musical awe. Firstly, the *Thin Sublime* provides the initial musical moment that causes a listener to engage with an experience of awe. As seen in Study 7 there may be several sonic and musical cues for this, such as changes in spectral and timbral qualities of the music. This may spark a feeling of awe in the listener, and as the music develops the listener attempts to fulfil and resolve those musical ideas with what the music proceeds to deliver to the listener. This process can be understood as an awe-specific application of David Huron's ITPRA model detailing the cognition of musical anticipation in the listener (2006, 2020). In Shapshay's two-tiered system, the *Thin Sublime* may act as Huron's (R) Reaction component that feeds into the larger cognitive appraisals and prompts the imagination to seek out a resolution to the accommodation process. Another useful parallel between these two models can be found in the role of self-reflection in prediction making. The 'reflection on awe response' and 'the attempt to fulfil the need for accommodation' required for the *Thick Sublime* (Shapshay, 2021, p. 133) can be seen as detailing the appraisal processes for experiences of awe and the sublime through the ITPRA model. Though the studies presented in this project did not deliberately test the distinction between these two forms of the sublime, this separation appears useful and relevant to musical awe and should be incorporated into future work. The *Thick Sublime* more closely matches the descriptions of participant experiences of musical awe in Study 1, and its self-reflective process as described by Shapshay is likely to be a critical aspect of musical awe.

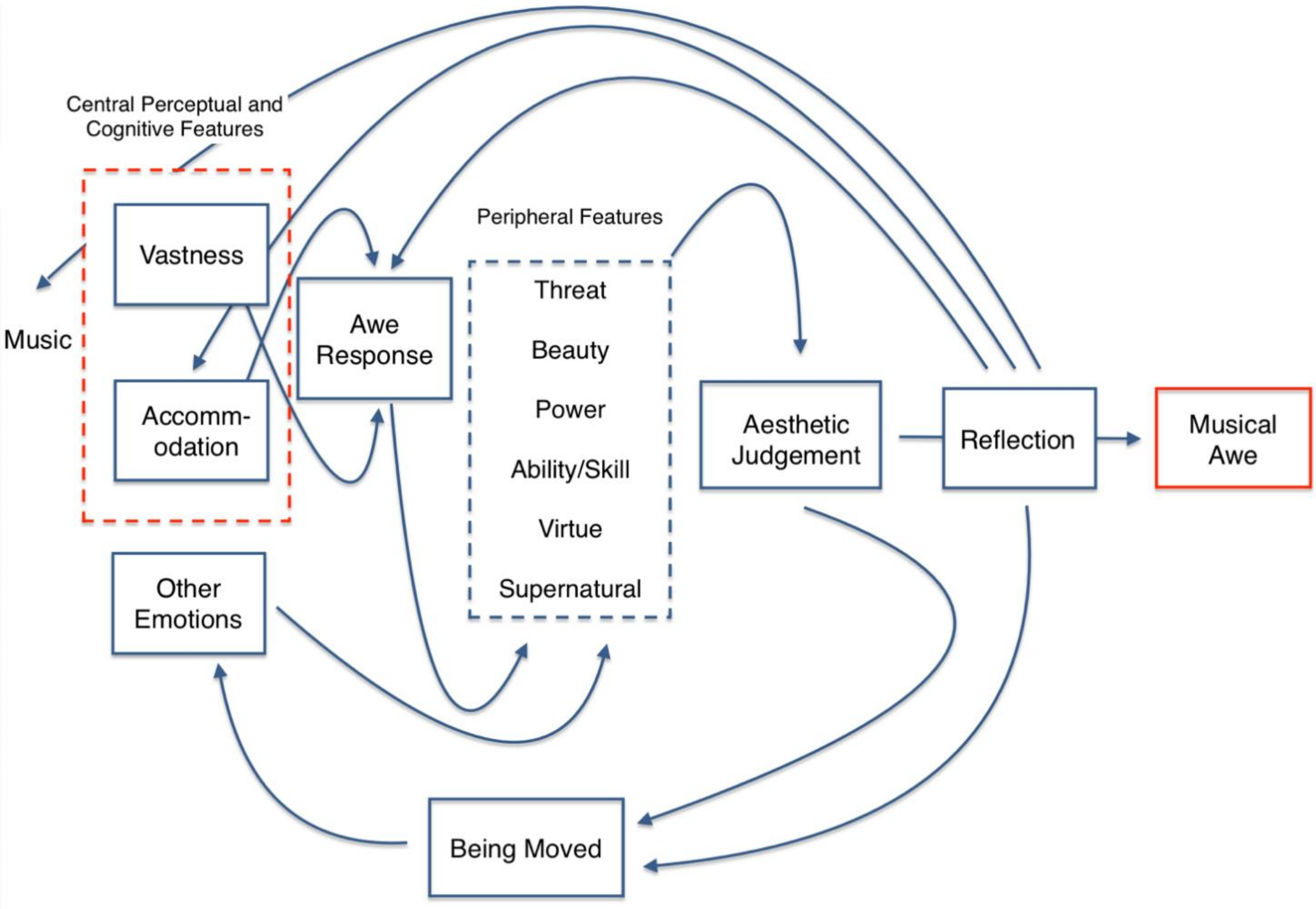
In conclusion, previous models of the sublime and awe do not precisely match the findings of this project, but many of the preceding ideas for describing the occurrence and onset of awe are still significant for describing and detailing the cognitive associations and modelling psychological processes involved in musical awe. The disagreement between the project's interpretation of data and theoretical conceptions of the sublime does not necessarily deem those previous models incorrect or invaluable, but they may not be as useful in explaining and detailing musical awe as other models with higher agreeability. The previous theoretical models with higher agreeability to the findings of this project were used as guiding frameworks to be incorporated into a new model of musical awe in the following section.

7.3 An integrated model of musical awe

This section proposes an integrated model for musical awe (IMMA) that seeks to combine the efforts of previous philosophical and theoretical models detailing the sublime with the psychological models for awe and musical emotions. In the last section, many of the models for awe and sublime provided guides to the cognitive processes of the music listener and are married with Patrik Juslin's aesthetic judgement process in music listening (Juslin, 2013, p. 248). Figure 7-1 presents an integrated process model that attempts to describe the principal factors involved in the experience of musical awe for a Western listener.

Figure 7-1

A schematic of the integrated model of musical awe (IMMA)



The IMMA combines three psychological models describing awe (Keltner and Haidt, 2003), the sublime (Shapshay, 2021), and musical emotions (Juslin, 2013). The schematic is to be read starting with ‘Music’ at the left side of the figure and terminating at ‘Musical Awe’. Following the arrows, the model navigates through different perceptual, cognitive, and emotional psychological components to show a complex psychological pathway that may result in the experience of musical awe. Though the nature of the process model diagram may suggest a time-based series of events, the IMMA does not strictly prescribe an ultimate order of events, as many of the components require retrospective judgements and may influence previous cognitive processes. This proposed model illustrates the connections and appraisals most associated with experiences of musical awe through several important keystone psychological mechanisms detailed below.

The beginning of the model starts with ‘Music’, where a listener hears a potentially awe-affording musical stimulus. That musical stimulus is then assessed for the perceptual and cognitive features of ‘Vastness’ and ‘Need for Accommodation’, visually gathered together in the area demarcated by the red dotted line. These two features proposed by Keltner and Haidt (2003) were supported by the findings of Studies 1, 2, and 6. Vastness and the need for accommodation also mirror perceptual and cognitive inputs in Patrik Juslin’s aesthetic judgement process in music listening (2013, p. 248). The assessment of vastness here could take many forms. It could be something as simple as a perceptual cue relating to musical size, a prominent and loud instrumental voice in composition. It may also be something more complex, like the growing and changing of musical textures producing a sense of environmental size and scale. Vastness may also be of another form, one of recognition and realisation of the relationship between the listener and the music and feeling small within the vastness of the music. The need for accommodation is understood as being in response to a sense of disorientation in the listener. This may come about from the sense of vastness perceived in the music or from another musical or extramusical source. An example of a musical source may be in the surprise caused by a change in the music that leaves the listener unsure how to contextualise what they are hearing. The need for accommodation may also arise from the novelty of hearing a piece of music for the first time (Tugade, Shiota, & Kirby, 2016, p. 364). The arrows coming from the ‘Vastness’ and ‘Accommodation’ boxes intersect each other to indicate that these two processes can be interrelated, as vastness may trigger an accommodative process in the mind of the listener.

The following ‘Awe Response’ is the result of the two central awe-related features having been met which then primes the listener to evaluate the music for additional conceptual features. This awe response is the same *Thin Sublime* as described by Shapshay (2021). This awe response is also analogous to the ratings for awe seen in the participant responses in Study 6, where participants rated the degree or prominence of awe in the music in a time-based experiment. Study 6 showed this feeling to occur quickly after perceptions of music size, which are strongly linked to the concept of vastness.

Following from the awe response are the appraisals and judgements of several awe-related features that constitute the ‘Aesthetic Judgement’. This process acts much like the set of filtering aesthetic criteria listed in Juslin’s model and incorporates the peripheral features from Keltner and Haidt’s description of how variants of awe may occur. The list of peripheral features in the IMMA is not limited to only Threat, Beauty, Power[17], Ability/Skill, Virtue, and Supernatural causation, but these were shown to be prominent features to judge the type of awe experiences in Studies 3, 4, and 5. Sprouting from these associations an aesthetic judgement is then made about the music using the central and peripheral features. The outcome of this assessment colours the experience through the multitude of associations from the listener and

[17] Power was not one of the peripheral features listed by Keltner and Haidt (2003), but it was tested for its associations in Study 5 (see Chapter 4, Section 4.6.5).

grants a positive or negative valence association. The aesthetic judgements are not only limited to the those detailed in the schematic, but other aesthetic conceptions may be added while some may be removed or to account for cultural and personal attitudes that inform awe-associated aesthetic features. It should be recognised that the aesthetic features listed in the IMMA schematic detail a Western understanding of aesthetics, and what constitutes other relevant aesthetic judgements for populations outside this project's largely Eurocentric assessment of musical awe remains an open question. The assessment of these features may also include input from other emotions perceived in the music and generated from other systems of emotion production. The other mechanisms of music and emotion can be applied to 'Other Emotions', i.e. brain stem reflex, rhythmic entrainment, evaluative conditioning, emotional contagion, visual imagery, episodic memory, and musical expectancy (Juslin & Västfjäll, 2008, detailed in Chapter 2, Section 2.4). Along with the 'Other Emotions' a circular and self-referential process may stem from the 'Aesthetic Judgement' leading to the state of being moved. Being moved then feeds into 'Other Emotions' that may influence continuing aesthetic judgements of the music.

The process of 'Reflection' then interprets and transforms the aesthetic judgements the listener has made in several ways. Each of these pathways helps to recontextualise the emotional experience bringing depth and meaning through a heightened level of engagement with the musical materials, the self, and the music listener's own experiences (Shapshay, 2021). The first of these reflection pathways requires the listener to engage with the music in a more mindful manner, and this reflective process affords new ways of understanding not only the musical materials but also the listener's attempts to fulfil the need for accommodation through evaluation of their own awe response, and/or feelings of being moved. Through these multiple routes afforded by reflection, the responses to the music may fully coalesce and thicken into the experience of musical awe. The schematic presented in Figure 7-1, highlights 'Musical

Awe' as the endpoint of this process, but due to the reflective process through which musical awe must travel, the feelings of awe may also be cast back to 'Other Emotions' and effect future judgements one has about the music.

The IMMA should be understood as a generalised abstracted model that maps the cognitive processes relevant to experiences of musical awe broadly understood from a Western perspective of aesthetics and emotional categorisation. Bodily components of emotion production would be found within the 'Awe Response' section; however, physical manifestations of musical awe were outside of the scope of this project, but further investigations into these would be helpful to paint a more detailed picture of the process model. In the larger field of music and emotions, the IMMA can be seen as an example of how one type of musical emotion may emerge. Having specific process models for a multitude of aesthetic emotions would be beneficial for the research field to compare similar systems and provide a greater abundance of reasons why listeners feel the way they do when listening to music. Furthermore, the IMMA, though focused on musical experiences, may also be applied to other artistic modalities—such as visual art. Its descriptive processes could be applied to many different areas that include similar perceptual responses and judgements. However, no empirical evidence is presented in the project the comment on the applicability of the IMMA's descriptive framework to these other modalities. The proposed model is best situated—and currently most appropriate—for descriptions of musical experiences of awe due to the incorporation and expansion of aesthetic musical emotions (Juslin, 2013) used in the IMMA. Juslin's framework for aesthetics emotions was based on emotions from music, and through there may be significant parallels in other modalities, to assume their applicability to other domains without rigorous empirical support would be unfounded. Many of the areas highlighted by the IMMA have been explored in this project, but there is still a vast amount of research to be undertaken for each of the sections presented. The final section of this chapter

(Section 7.5) elaborates the future directions for this area of research and proposes which areas of the IMMA are most suitable for future investigation.

7.4 Project limitations

Through the seven studies explored in this project, many insights into the nature of musical awe have been revealed. However, there are several broad limitations to this project that must be acknowledged to provide an accurate interpretation of the findings and conclusions relating to a general understanding of musical awe. The following list goes beyond sample size and time constraints to emphasise the particular limitations relevant to this research project.

The first general limitation originates from the inherent and unavoidable semantic difficulty with the use of descriptions of emotions through language. The terms 'awe', 'sublime', and 'musical awe', as we have seen in Study 1, hold a variety of meanings and associations. As there are different experiences of awe ranging from the fearful and frightening to the tear-filled states of wonder, it is difficult for two people to agree on a single definition of awe, especially in their own lived experiences of the emotion. To mitigate this limitation and help mesh these distributed understandings into a more coherent idea, this project has used a classical environmental example of a situation where feelings of awe and the sublime may likely be encountered. The description of 'a feeling you might have after hiking up a cliff side to see a [beautiful] valley far below' was used as shorthand for these accounts, but this description, though common, is not a universal experience. Through the individual interpretations of this prompt, one should expect differences to emerge that may influence the self-reported and experimental data. Though this limitation exists, it is also present in much of emotion research; using language to describe and comment on emotions is inherently problematic, as conceptions and assessments of internal feelings may be subject to individualised interpretations, understandings, and expressions.

The second general limitation can be seen in the overlooked emotionally biased language used in a participant prompt for Study 1. The word ‘beautiful’ was used in a prompt to help inform participants of the types of experiences of musical awe in which this project was interested. Having noticed its potential for biasing participants, later prompts omitted the word ‘beautiful’ (see Study 6, Section 5.4.4) to achieve a more aesthetically neutral presentation in participant direction. This use of ‘beautiful’ therefore may be responsible for a higher incidence of reported positively-valenced accounts of musical awe in Study 1 and the higher incidence of positively associated music in the MAC. Though the issue of positive language influenced the proportion of positively valenced musical pieces comprising the MAC, the experimentally tested pieces (i.e. MAC_1) were independently selected for their association from a group of expert listeners unfamiliar with the Study 1 prompt. The immediate influence of this use of language may have largely been contained to the first study of this project, though this error in language provides a limitation to the project as the musical selections comprising the MAC have been influenced by positive associations of ‘beauty’ in the Study 1 prompt.

The third general limitation comes in appreciating the differences between experiences of musical awe and the associations of awe-affording music. Studies 1 and 2 gathered data about experiences of musical awe whilst Studies 3, 4, 5, 6, and 7 examined how music can be understood and related to those experiences. None of these studies directly investigated induced experiences of musical awe and the associations made during those experiences. This difference is important when comparing results across studies because perceptions and associations found in real world experiences of musical awe are not necessarily equivalent to those understood only through listening to music associated with these experiences in laboratory settings. This limitation of ecological validity is relatively commonplace, however, there is a recurring characteristic running through this work to bridge this gap: the music. It is reasonable to assign associations made from the music itself onto the experiences of awe, as the music was sourced from real world experiences of musical awe. As previously discussed, the music alone may not be the only factor responsible for feelings of awe in these cases, but it is a principal source, and the commonalities found between experimental listening conditions can be justifiably applied to more natural instances of real-world musical awe. This bridging of the phenomenological gap is not perfect, but it does advance our understanding of musical awe by linking experiences with general musical associations.

A further limitation can be found in the lack of lyrical content and vocal music present in this project. Many of the reported instances of musical awe centred around singing, even the example detailed in the introduction (Chapter 1) had vocal and lyrical content. Often psychological investigations into music set vocal and lyrical components aside while focusing on other aspects of the instrumental components, but the effects of lyrics have a complicated contributing effect on emotional perception in music (Ali & Peynircioğlu, 2006) even when the lyrics are in a foreign language (e.g. Barradas & Sakka, 2022; Moir & Iwagana, 2013). The music selected from Study 1 that was used in following studies throughout the project deliberately selected instrumental music without vocal or lyrical content[18]. This approach was a methodological strength as it narrowed the focus of this project, but a more widespread understanding of musical awe would include investigations into the impact of vocal and lyrical factors on these experiences.

The final general limitation of the project can be seen in its Western bias as seen through the background research, musical examples used, the participants, and their selection processes. The background research was based on and driven by Western philosophical

[18] 'Hoppípolla' in Study 6 was the only music used in the project that had lyrical content, and the lyrics in that piece of music were in a foreign language that was unfamiliar to all of the participants.

theories, and those theories, in turn, significantly influenced much of the modern psychology research examining awe and the sublime. Though this reliance on Western philosophy as the foundation for investigation is not necessarily an incorrect approach, it does limit the universal application and understanding of the main ideas, various findings, and the conclusions drawn from them. The project did not set out to be a cross cultural study, and assuredly a wider cultural exploration into these ideas would be needed for a fully comprehensive understanding of musical awe. The participants used for these studies were primarily based in the United Kingdom and the United States due to the location and background of the researcher, the regional hosting platforms for online studies (including participant recruitment), and the use of English for all instructions and information. As expected, Western participants were more exposed to Western music, and therefore the reported experiences of musical awe in Study 1 were almost entirely descriptions of musical awe in response to Western music. Though there was a wide range of genres reported, there was not a representative global sample of musical awe experiences by any means. Furthermore, these reported examples of musical awe were used as the basis for the following studies in the project, thus this project is best seen as detailing investigations into Western experiences of musical awe and the features and associations of Western awe-affording music. With a Eurocentric foundation of awe and Western participants used throughout the various studies, the findings of this thesis describe a particular version of musical awe, one largely indelibly shaped by the social and cultural attitudes present in Western listening preferences and aesthetics.

It would be outside the scope of this project to explore all the potential avenues of musical awe, and the limitations described here place this project in its proper context. There is much yet to be discovered from research into the topic, and one of the exciting features of these limitations is that each of them inspire studies into new areas of musical awe not yet explored.

7.5 Future directions for research into musical awe

Currently the state of research into musical awe is perhaps best seen as an old garden allotment that is now being taken up by new owners to grow some remarkable produce. To continue the metaphor, the plot has been long neglected, and through the years, all the wild vegetation has composted to make strong and rich soil for future crops. This project has weeded and tilled a large patch of earth, experimentally planted a few seeds, and now looks out to the surrounding wilds to plan the next steps for cultivation of the land. As musical awe is a new area of research, there are innumerable studies that shoot forth from this project, enough to build a life-long career. The following section details several proposed studies closely related to this project.

The first, and most specific, proposal for future research is to use the AWE-S model (Yaden et al., 2019) for a follow-up questionnaire study on musical awe. This awe experiences scale was published after the data collection for Study 1, but it would be another complementary tool to examine how musical awe is understood. The model gives six factors relating to personal experiences of awe (altered time perception, self-diminishment, connectedness, perceived vastness, physical sensations, and need for accommodation), and future studies should seek to use this model to probe into experiences of musical awe.

A future qualitative study should investigate the phenomenological inner experience of musical awe. This project investigated experiences of musical awe in Studies 1 and 2 as the starting points to gather general attitudes, commonalities in experiences, and musical examples to be used in experimentation. A more in-depth qualitative interview-based study focused on compiling musical awe experiences would provide rich personal-informed data that would help flesh out and provide more substantive examples to the skeletal process detailed in the IMMA. Through this study, the differences in personal experiences of musical awe could also be highlighted. The studies in the project were mainly concerned with commonalities in experiences and evaluations of music, but through an appreciation of the differences in experiences of musical awe, a broader understanding of musical awe could be derived. Through a broader experience-based approach peripheral ideas relating to the identity, the role of empathy in awe, the influence of the human voice in music, and the similarities to flow states could all be explored.

Another fertile area for a complimentary investigation would examine the occurrence and experience of musical awe in real-time, in-vivo musical settings. Instead of approaching musical awe from a laboratory listening environment, a study that focused on audience experiences could provide important data regarding real life scenarios of musical awe. Concert attendees could take part in surveys, short answer questionnaires, and interviews. This more direct approach would provide data on personal experiences of musical awe that were less influenced by time and retrospective memory. This approach could reveal important information about extramusical features, and comment on the setting, environment, and crowd at the time of musical awe as well as the role of listeners' motivations and individual expectations. Similar to this type of study, a fruitful direction for future research can be found through investigating the relationship between musical awe and religious experiences. As previously seen, the experiences of awe and the sublime often share similar descriptions to those of religious and/or spiritual transcendence, and investigations into this realm could help provide important personal and contextual information around musical awe. Continuing with experiences of musical awe, another area for future investigations may be found in *big data* through examining the language and music used around experiences of awe and the sublime found in large repositories from social media sites and online streaming platforms. Expanding from Study 2, this could be achieved by combing through thousands of social media posts, and through sentiment analyses and natural language processing methods new data from a wide range of people and places could be examined for terms of interest, e.g. 'music', 'awe', and ‘sublime’. Through this method a preliminary finding about the cross-cultural similarities of musical awe could also be drawn from global and geographically diverse data.

As discussed at length in this project, a key feature in awe production is its relation to size and power. To examine this relationship further, awe-related representations in film and virtual realties may be productive settings for inducing awe in laboratory conditions, in turn producing valuable repeatable experimental conditions. Study 6 began to explore this cross-modal relationship, but there remains a host of future research to be conducted. As film music often serves the role of explicating the emotion the director wishes to convey on the screen, developing a set of scenes to be paired with awe-affording music would be a helpful tool for a variety of awe-related investigations. Consumer behaviour research would also benefit from examining musical awe more closely, as certain products and brands want to be characterised with an awe-inducing atmosphere (Holt, 2003). Future research into the types and uses of music in awe-related marketing could provide contemporary examples into the uses of musical awe in everyday life. Furthermore, virtual reality environments (like those used by Chirico et al., 2018) could be used for musicological research, and with the MAC and other media, awe might be reliably induced in participants. This would open an entire world for experimental study. To this goal, research into awe would benefit from examining film and/or stage productions and their accompanying musical scores that sought to induce a sense of awe in the audience. This could be extended to other media formats as well; again, virtual reality may be a particularly useful space for inspiring awe whilst in laboratory conditions. Inside of these virtual environments, awe-eliciting situations could be experienced. Instead of simply *imagining* being on the edge of a cliffside looking down into a beautiful valley, participants could experience a setting in which they do just that.

Future research into the relationship between size and awe would benefit from experimentation interested in how amplitude affects judgements of musical size. A simple way to test the effects of volume would be to springboard off of Study 6 and use multiple levels of compression as experimental variable to evaluate the relationship between the degree of amplitude change and the degree of change in the resultant ratings. With several levels of compression, an experiment could target how the reduction of amplitude variability affects our conceptualisation of musical size. This same multi-level approach could be applied to investigations interested in perceptions of awe, and with the use of physiological measurements (e.g. skin conductance and pupillometry), further connections to general emotion research could be explored. In future studies, incorporating non-awe-based music as a control condition would be beneficial for differentiating how judgements of size and awe are assessed in different types of music. Presumably non-awe-related music would have lower ratings of awe, but ratings for size would be as dynamic across many types of music. The size and musical materials analysis explained in Section 6.5 could be a helpful template for future investigations of participant-based qualitative research. With a broader understanding of the relationship between how listeners conceptualise musical size and space, new and models could be established to evaluate the places within musical pieces where experiences of awe are likely to emerge.

There are several areas of research inside and outside systematic musicology that would be attracted to the emerging work on musical awe. Extending musical awe's reach into a diverse range of complimentary research would help build a network of research to not only better understand the phenomenon from a music listener's perspective but also to further comprehend its role through applied research, its use in composition, and its relation to musical preferences.

7.6 Concluding remarks

In total, this research project was successful in providing many of the first empirical studies on the experiences and associated judgements of musical awe. It has challenged previous ideas that limited the extent of musical-based awe experiences and has expanded musical awe into a distinct area of research worthy of further exploration. In proposing a novel psychological model for musical awe, the project not only combines previous theoretical ideas, but integrates its own findings to create a more comprehensive model for understanding the occurrence and experience of musical awe in the listener. Importantly, these new insights raise further questions about the ways in which we may experience musical awe, and it paves the way for future interdisciplinary collaboration and experimentation. In its methodological variety, this project has demonstrated a range of research skills, and has provided a novel and multi-factor approach to a complex research topic. The project increases the pool of knowledge around awe as a psychological topic, and through its studies has helped to introduce a musicological perspective into the domain of awe-based research. The future of research into musical awe is bright. With an empirically based understanding of the phenomenon and its psychological production, continuing research will be able to build on the findings of this project to paint a fuller picture of instances of musical awe.

As we ascend the mountain of insight into musical awe, the very first views of the great valley below have been seen. Through the foliage and fog, remarkable and fascinating sights have slipped into view, fleeting but marvellous. We can imagine what the landscape might look like from here, but its completeness remains obscured. We now continue the climb to the mountain's summit, to the highest vantage point where we shall look down and view the great cleft in the Earth, the vast surrounding topography, and an entire ecosystem, natural and man-made, where we might feel its splendour and better know our place within it.

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Chapter 4 Appendix

Appendix Table 4-1

Musical Awe Corpus music list

Excerpt	**Title**	**Composer/Artist**	**Timestamp**	**Excerpt Length**	**URL**
1	Tears of Unicorn	Masayoshi Fujita	2:55–3:25	00:30	https://www.youtube.com/watch?v=U58uG8O0bYg
2	All -Night Vigil, op. 37, Bogoroditse Devo	Sergei Rachmaninoff			https://www.youtube.com/watch?v=InMhSNBlIg8
3	Miserere Mei Deus	Gregorio Allegri			https://www.youtube.com/watch?v=4lC7V8hG198
4	Mass for Five Voices	William Byrd			https://www.youtube.com/watch?v=4ZSB0WTyIrg
5	Cello Suite No. 1 in G major	Johann Sebastian Bach	4:20–4:50	00:30	https://www.youtube.com/watch?v=mGQLXRTl3Z0
6	Hoppípolla	Sigur Rós			https://w

					ww.youtube.com/watch?v=mZTb8WxEW78
7	Sun Hands	Local Natives			https://www.youtube.com/watch?v=r39d5d4MYsY
8	I Remember You	Paul White			https://www.youtube.com/watch?v=tOVDILCxHSk
9	Promenade	Modest Mussorgsky	0:24–0:54	00:30	https://www.youtube.com/watch?v=R1GwvPzzK1k
10	The Great Gate of Kiev	Modest Mussorgsky	3:21–3:53	00:32	https://www.youtube.com/watch?v=b8gs4TozJbQ
11	The Old Castle	Modest Mussorgsky	1:09–1:31	00:22	https://www.youtube.com/watch?v=QSomvC6rwgU
12	The Gnome	Modest Mussorgsky	1:41–2:10	00:29	https://www.youtube.com/watch?v=jGZD6tJ2Lw4
13	Catacombs	Modest Mussorgsky	0:13–0:44	00:31	https://www.yout

					ube.com/watch?v=mESYHyo5Xnc
14	Music for 18 Musicians	Steve Reich	16:32–17:01	00:29	https://www.youtube.com/watch?v=ZXJWO2FQ16c
15	Catching Shadows	Ivan Treviño	1:47–2:17	00:30	https://www.youtube.com/watch?v=7lktMLiKaes
16	La Cathédrale Engloutie	Claude Debussy	2:54–3:23	00:29	https://www.youtube.com/watch?v=cVMGwPDP-Yk
17	Moondance	Van Morrison			https://www.youtube.com/watch?v=z3S5RgDO9EE
18	Sinfonetta	Leoš Janáček	1:49–215	00:26	https://www.youtube.com/watch?v=gbncXDimwbQ
19	○ (Circle)	Boredoms			https://www.youtube.com/watch?v=U6f9BV-8yAw
20	Bluebeard's	Béla Bartók			https://w

	Castle				ww.youtube.com/watch?v=GoImjQOEp-Q
21	Barcarolle	Jacques Offenbach	1:24–1:46	00:22	https://www.youtube.com/watch?v=g7czptgEvvU
22	Violin Sonata No. 1 in G minor, BWV 1001	Johann Sebastian Bach	0:24–0:53	00:29	https://www.youtube.com/watch?v=FTUWCr3IXxw
23	Fanfare for the Common Man	Aaron Copeland	0:23–0:53	00:30	https://www.youtube.com/watch?v=4NjssV8UuVA
24	Ride of the Valkyries	Richard Wagner	1:40–2:10	00:30	https://www.youtube.com/watch?v=GGU1P6lBW6Q
25	Drunken in the Morning Sunrise	Globe Unity Orchestra			https://www.youtube.com/watch?v=_uMhfDPDjKU
26	Plate Element 2	Substance	01:00:00–1:30	00:30	https://www.youtube.com/watch?v=zLj1SUhrRAI
27	Metastasis	Iannis Xenakis	1:53–2:22	00:29	https://www.youtube.com/

					watch?v=SZazYFchLRI
28	Flying High	Captain Hollywood Project			https://www.youtube.com/watch?v=eVQHDF0L2tQ
29	Symphony No. 6 'Pathétique'	Pyotr Ilyich Tchaikovsky	13:22–13:54	00:32	https://www.youtube.com/watch?v=uZmLx4w2VHo
30	The Flying Dutchman	Richard Wagner	3:50–4:13	00:23	https://www.youtube.com/watch?v=HqezCR_XzaI
31	Siegfried and Gotterdammerung	Richard Wagner	5:42–6:12	00:30	https://www.youtube.com/watch?v=a53s4jyCqqU
32	Dream of Gerontius	Edward Elgar			https://www.youtube.com/watch?v=K55d9a8j8WE
33	Symphony No. 2	Gustav Mahler			https://www.youtube.com/watch?v=tf5fM1i3MGQ
34	Symphony No. 3	Gustav Mahler			https://www.youtube.com/watch?v

					=9Yr720ftjaA
35	Zero Signal	Fear Factory			https://www.youtube.com/watch?v=HNvqcwIV8B0
36	Strapping Young Lad	Underneath the Waves			https://www.youtube.com/watch?v=tiDHtKlFIw0
37	Dead Can Dance	Host of the Seraphim			https://www.youtube.com/watch?v=7iqxzURgQWg
38	Hel	Allseits	5:00–5:25	00:25	https://www.youtube.com/watch?v=-WDjdLPezRU
39	The Synarchy of Molten Bones	Deathspell Omega			https://www.youtube.com/watch?v=_pa-gruFS1Q
40	777 — Cosmosophy	Blut Aus Nord			https://www.youtube.com/watch?v=mYB8ThL0c-Y
41	Dead As Dreams	Weakling			https://www.youtube.com/watch?v=mnjH-

					ZYe59c
42	Five Variants of "Dives on Lazarus"	Ralph Vaughan Williams	7:00–7:30	00:30	https://www.youtube.com/watch?v=RQoP9iLwoos
43	Conrad	Ben Howard			https://www.youtube.com/watch?v=OYR6A47DK-Q
44	A Car, a Torch, a Death	Twenty One Pilots			https://www.youtube.com/watch?v=hrxXZ5o8nx8
45	Sequence for All Saints, op. 75: V. Finale	Kenneth Leighton			https://www.youtube.com/watch?v=bx2RkJViHLI
46	Tristan and Isolde, Overture	Richard Wagner	7:34–8:04	00:30	https://www.youtube.com/watch?v=J-qoaioG2UA
47	Vicki's Visit	Leon Willet	0:44–1:11	00:27	[Downloaded from source]
48	Vortex Temporum	Gérard Grisey	2:37–3:06	00:28	https://www.youtube.com/watch?v=rXaNFBzgDWI

49	Symphony No. 3, 'The Song of the Night'	Karol Szymanowski			https://www.youtube.com/watch?v=LFExkkNdVCc
50	Clocks and Clouds	Gyorgy Ligeti			https://www.youtube.com/watch?v=yfVnazeA3zw
51	Le Sacre du Printemps	Igor Stravinsky	10:24–10:51	00:27	https://www.youtube.com/watch?v=5UJOaGIhG7A
52	Requiem	Gabriel Fauré			https://www.youtube.com/watch?v=UnilUPXmipM
53	You Won't Know	Brand New			https://www.youtube.com/watch?v=u5mm8ex8Vd4
54	O Magnum Mysterium	Morten Lauridsen			https://www.youtube.com/watch?v=Q7ch7uottHU
55	Into You	Ariana Grande			https://www.youtube.com/watch?v=1ekZEVeXwek
56	Amazing Grace	Joseph Burwick			https://www.yout

					ube.com/watch?v=bq54jb_5WCI
57	Petite Messe Solenelle, 2nd movement)	Gioachino Rossini			https://www.youtube.com/watch?v=-HxmlRrUlKo&feature=youtu.be&t=8m7s
58	Ein deutsches Requiem, 1st movement	Johannes Brahms			https://www.youtube.com/watch?v=eOnSQzIPXa4
59	Ein deutsches Requiem, 2nd movement	Johannes Brahms			https://www.youtube.com/watch?v=WbO-IrX0Mgk
60	Ein deutsches Requiem, 6th movement	Johannes Brahms			https://www.youtube.com/watch?v=XTvw8r34eug
61	Karelia Suite, op. 11, 2nd movement, ‘Ballade’	Jean Sibelius	4:43–5:04	00:21	https://www.youtube.com/watch?v=vh7dXPfEtXw
62	Hallelujah	Leonard Cohen			https://www.youtube.com/watch?v=ttEMYvpoR-k

63	High Hopes	Pink Floyd			https://www.youtube.com/watch?v=BGBM5vWiBLo
64	Erbarme dich, mein Gott	Johann Sebastian Bach			https://www.youtube.com/watch?v=BBeXF_lnj_M
65	Requiem, op. 47, 4th movement, 'Pie Jesu'	Gabriel Fauré			https://www.youtube.com/watch?v=s6PmrZDTfw
66	Lincolnshire Posy	Percy Grainger	3:43:0–4:13	00:29	https://www.youtube.com/watch?v=K1FDk8__Nv4
67	Black Lake	Björk			https://www.youtube.com/watch?v=YGn1pJIpZw8
68	The Wizard	Adam Sutherland	3:02–2:36	00:25	https://www.youtube.com/watch?v=0hyWoEa3Hu4
69	Always Returning	Brian Eno	1:32–2:02	00:30	https://www.youtube.com/watch?v=dcWwtQmAt7E&list=PLJNbijG2

					M7OwxdBm5URAIicQitqEedbtq
70	How Great Thou Art	Based on a traditional melody, performed by Wintley Phipps			https://www.youtube.com/watch?v=kQVZBq2JUc4
71	Handlebars	Flobots			https://www.youtube.com/watch?v=HLUX0y4EptA
72	Requiem	Giuseppe Verdi			https://www.youtube.com/watch?v=1PdcmFvZvuI
73	Sleeping Sun	Nightwish			https://www.youtube.com/watch?v=UGfKMV5AbMI
74	The Kiss	Trevor Jones			https://www.youtube.com/watch?v=yB6S3c7f8XA
75	Barbarian Horde	Hans Zimmer	40:56–41:26	00:26	https://www.youtube.com/watch?v=I1-uzsfFjss
76	Iron	Woodkid			https://www.youtube.com/

					watch?v=vSkb0kDacjs
77	Dolo (Nightmare)	Kid Cudi			https://www.youtube.com/watch?v=MqI_O3kIFHM
78	The Great Misconceptions of Me	W.A.S.P.			https://www.youtube.com/watch?v=boptcdvX27E
79	Baba Yetu	Christopher Tin			https://www.youtube.com/watch?v=IJiHDmyhE1A
80	Death is the Road to Awe	Clint Mansell	7:37–8:07	00:30	https://www.youtube.com/watch?v=C3skXjCmvVc
81	9th Symphony, 4th movement	Ludwig van Beethoven			https://www.youtube.com/watch?v=XeT17YeUj5k
82	Requiem	Hector Berlioz			https://www.youtube.com/watch?v=hZfDbANFL88
83	Requiem	Wolfgang Amadeus Mozart			https://www.youtube.com/watch?v=sPlhKP

					0nZII
84	Piano Concerto No. 5, ‘Emperor’	Ludwig van Beethoven	0:31–0:59	00:28	https://www.youtube.com/watch?v=hDXWK3W477w
85	Dead Flag Blues	Godspeed You! Black Emperor			https://www.youtube.com/watch?v=9thvHDskYvA
86	Lux Aeterna	Clint Mansell			https://www.youtube.com/watch?v=bbS-Zhz31CA
87	Eat The Sun (Møme Remix)	Tora			https://www.youtube.com/watch?v=CkZAEMC_Lu8
88	Empire of Ants	Gorillaz			https://www.youtube.com/watch?v=C-yP9f0gadU
89	Star Citizen Main Theme	Pedro Macedo Camacho			https://www.youtube.com/watch?v=poG3Wvb8FU8
90	Star Wars Main Theme	John Williams	0:41–1:10	00:29	https://www.youtube.com/watch?v

					=_D0ZQPqeJkk
91	Making of a Cyborg	Kenji Kawai			https://www.youtube.com/watch?v=q0z08OpmEPc
92	Requiem	Geinoh Yamashirogumi			https://www.youtube.com/watch?v=YKvtbH8qUWU
93	The Unsung War	Keiki Kobayashi, Hiroshi Okubo, Junichi Nakatsuru, Tetsukazu Nakanishi			https://www.youtube.com/watch?v=mjY6awCr2_c
94	Avalon	Tetsukazu Nakanishi, Keiki Kobayashi, Hiroshi Okubo, and Junichi Nakatsuru.	1:27–1:56	00:29	https://www.youtube.com/watch?v=wV_5dXjygEU
95	Zero	Keiki Kobayashi			https://www.youtube.com/watch?v=vGjwXI0n5-I
96	Megalith (Agnus Dei)	Keiki Kobayashi			https://www.youtube.com/watch?v=T1sIqCQFKVo
97	Session	Testukazu Nakanishi and Hiroshi Okubo	0:12-0:40	00:28	https://www.youtube.com/watch?v=ER8uB

					cP4lug
98	Beyond The River of Time	Tanaka Kouhei	2:11–2:41	00:30	https://www.youtube.com/watch?v=bReOxVkHVLc
99	Flight of the Nazgûl	Summoning	3:10–3:40	00:30	https://www.youtube.com/watch?v=dHAzaU4wLlA
100	Deep Space	Steve Roberg	0:00–0:30	00:30	https://www.youtube.com/watch?v=eLF4NMFAe5U

Appendix Table 4-2

Musical Awe Corpus with neutral excerpts (MAC₁)

MAC number	**Condition tag**	**Title**	**Artist**	**Timestamp**	**Duration**
		Positive Excerpts			
1	Pos01	Tears of Unicorn	Masayoshi Fujita	2:55–3:25	00:30
10	Pos02	The Great Gate of Kiev	Mussorgsky	3:21–3:53	00:32
14	Pos03	Music for 18 Musicians	Steve Reich	16:32–17:01	00:29
18	Pos04	Sinfonetta	Leoš Janáček	1:49–215	00:26
21	Pos05	Barcarolle, from 'The	Offenbach	1:24–1:46	00:22

		Tales of Hoffmann'			
23	Pos06	Fanfare for the Common Man	Copeland	0:23–0:53	00:30
47	Pos07	Vicki's Visit	Leon Willet	0:44–1:11	00:27
48	Pos08	Vortex Temporum	Gérard Grisey	2:37–3:06	00:28
69	Pos09	Always Returning -- Apollo: Atmosphere and Soundtracks	Brian Eno	1:32–2:02	00:30
100	Pos10	Deep Space	Steve Roberg	0:00–0:30	00:30
Negative Excerpts					
12	Neg01	The Gnome	Mussorgsky	1:41–2:10	00:29
13	Neg02	Catacombs	Mussorgsky	0:13–0:44	00:31
24	Neg03	Ride of the Valkyries	Wagner	1:40–2:10	00:30
27	Neg04	Metastasis	Xenakis	1:53–2:22	00:29
29	Neg05	Symphony No. 6, 'Pathétique'	Tchaikovsky	13:22–13:54	00:32
30	Neg06	The Flying Dutchman	Wagner	3:50–4:13	00:23
38	Neg07	Hel	Allseits	5:00–5:25	00:25
51	Neg08	Le Sacre du Printemps	Stravinsky	10:24–10:51	00:27
75	Neg09	Barbarian	Hans	40:56–41:26	00:26

		Horde	Zimmer			
94	Neg10	Avalon	Tetsukazu Nakanishi, Keiki Kobayashi, Hiroshi Okubo, and Junichi Nakatsuru.	1:27–1:56	00:29	
Neutral Excerpts						URL
101	Ntl01	The Elevator Bossa Nova	Bensound	0:01–0:29	00:28	https://www.bensound.com/royalty-free-music/track/the-elevator-bossa-nova
102	Ntl02	In All Honesty, I Do	Nocturnal Spirits	2:50–3:16	00:26	https://www.youtube.com/watch?v=Qcbyhst2Gyk
103	Ntl03	Night by Night	Bladverk Band	10:05–10:36	00:31	https://www.youtube.com/watch?v=Qcbyhst2Gyk
107	Ntl04	Background Instrumental Concentration Music for Work and Study	Relax Music	23:27–23:51	00:24	
108	Ntl05	Background Instrumental Concentration Music	Relax Music	26:50–27:20	00:30	

		for Work and Study				
110	Ntl06	Background Instrumental Concentration Music for Work and Study	Relax Music	39:34–39:58	00:24	
112	Ntl07	Café Deluxe Chill Out Nu Jazz, Lounge Vol.1	Broken beats jazzy stuff	44:08–44:33	00:25	https://www.youtube.com/watch?v=sg0QHuTi4Oo
114	Ntl08	Cafe Music!! Jazz instrumental Music!	Café Music BGM Channel	19:24–19:41	00:27	
118	Ntl09	Soft Background Instrumental Music	Lounge Channel	7:24–7:51	00:26	
119	Ntl10	Relaxing JAZZ For WORK - Soft Background Instrumental Music - Concentration Music for Work and Study	Lounge Channel	11:19–11:49	00:30	https://www.youtube.com/watch?v=Qcbyhst2Gyk

Appendix Table 4-3

Descriptive statistics and t-test results for individual positive music excerpts

Excerpt	AB Rating	SCT Rating	Difference	*t*
Pos_{01}	4.90	1.54	3.36	15.97***
Pos_{02}	4.62	3.45	1.17	3.74***
Pos_{03}	3.9	2.17	1.73	5.73***
Pos_{04}	3.86	3.04	0.82	2.92*
Pos_{05}	4.92	1.89	3.03	11.47***
Pos_{06}	4.69	2.76	1.93	6.70***
Pos_{07}	5.28	2.49	2.79	10.06***
Pos_{08}	3.23	3.76	-0.53	1.57
Pos_{09}	5.24	1.73	3.51	14.36***
Pos_{10}	5.94	2.35	3.59	15.82***

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix Table 4-4

Descriptive statistics and t-test results for individual negative music excerpts

Excerpt	AB Rating	SCT Rating	Difference	*t*
Neg_{01}	2.70	4.75	-2.05	7.22***
Neg_{02}	3.45	4.21	-0.76	2.46*
Neg_{03}	2.87	4.93	-2.06	6.28***
Neg_{04}	1.92	5.31	-3.39	13.69***
Neg_{05}	2.32	5.55	-3.23	13.08***
Neg_{06}	2.92	5.52	-2.60	8.83***
Neg_{07}	2.94	5.83	-2.89	10.60***

Neg_{08}	2.52	5.97	-3.45	13.82***
Neg_{09}	2.11	6.15	-4.04	15.53***
Neg_{10}	3.41	5.66	-2.25	8.54***

**p < 0.05, ** p <0.01, *** p < 0.001*

Appendix Table 4-5

Descriptive statistics and t-test results for individual neutral music excerpts

Excerpt	AB Rating	SCT Rating	Difference	*t*
Ntl_{01}	2.24	1.24	1.00	4.14***
Ntl_{02}	2.34	1.23	1.11	4.87***
Ntl_{03}	2.80	1.34	1.46	6.32***
Ntl_{04}	2.24	1.21	1.03	4.43***
Ntl_{05}	2.62	1.18	1.44	5.97***
Ntl_{06}	2.55	1.17	1.38	5.82***
Ntl_{07}	1.82	1.28	0.54	2.83**
Ntl_{08}	2.1	1.14	0.96	4.98***
Ntl_{09}	2.27	1.24	1.03	4.70***
Ntl_{10}	2.38	1.21	1.17	5.32***

**p < 0.05, ** p <0.01, *** p < 0.001*

Appendix Table 4-6

Descriptive statistics and Cronbach's α for all categories of Study 3

	Music Type	*M*	*SD*	*N*	Cronbach's α
AB Rating	$Positive_{AB}$	4.66	1.01	71	0.77
	$Negative_{AB}$	2.72	1.11	71	0.84

	Neutral$_{AB}$	2.34	1.50	71	0.96
SCT Rating	Positive$_{SCT}$	2.52	0.87	71	0.75
	Negative$_{SCT}$	5.39	0.90	71	0.77
	Neutral$_{SCT}$	1.22	0.53	71	0.92

Note. AB = aurora borealis, SCT = supercell thunderstorm

Appendix Table 4-7

One-way repeated measures ANOVAs for comparisons of image ratings

Source	***SS***	***df***	***MS***	***F***	***p*****
AB	220.26	1.67*	131.64	102.55	< 0.001
Error_AB	1.50.35	117.12*	1.28		
SCT	645.16	2	322.58	714.54	< 0.001
Error_SCT	63.20	140	0.45		

Note. AB = aurora borealis, SCT = supercell thunderstorm

*Sphericity correction: Huynh-Feldt ($\varepsilon = 0.67$)

**Adjustment for multiple comparisons: Bonferroni.

Appendix Table 4-8

Planned contrasts: Pairwise comparisons

					95% Confidence Interval for Difference**	
		Mean Difference	**Std. Error**	**Sig.****	**Lower Bound**	**Upper Bound**
Aurora Borealis	Positive x Negative	1.94*	0.14	< 0.001	1.61	2.27
Supercell Thunderstorm	Positive x Negative	-2.87	0.12	< 0.001	-3.15	-2.59

* The mean difference is significant at the .05 level

** Adjustment for multiple comparison: Bonferroni

Appendix Table 4-9

Descriptive statistics and Cronbach's α for all categories of Study 4

Emotional Term	**Music Type**	***M***	***SD****	***N*****	**Cronbach's *α***
Amazement	Positive	4.03	1.03/ 1.94	49	0.80
	Negative	3.69	1.46/ 2.03	49	0.92
	Neutral	1.92	1.10/ 1.34	49	0.94
Anger	Positive	1.35	0.34/ 0.85	49	0.66***
	Negative	3.12	1.05/ 1.83	49	0.86
	Neutral	1.07	0.19 /0.27	49	0.89

Anxiety	Positive	2.10	0.59/ 1.63	49	0.77
	Negative	4.25	1.15/ 1.94	49	0.87
	Neutral	1.22	0.32/ 0.55	49	0.81
Awe	Positive	3.87	1.30/ 1.99	49	0.89
	Negative	3.71	1.46/ 2.01	49	0.92
	Neutral	1.71	0.82/ 1.09	49	0.91
Distress	Positive	1.93	0.55/ 1.58	49	0.68***
	Negative	4.29	1.21/ 2.05	49	0.87
	Neutral	1.26	0.71/ 0.82	49	0.96
Fear	Positive	1.74	0.44/ 1.41	49	0.66***
	Negative	4.25	1.13/ 1.98	49	0.87
	Neutral	1.09	0.22/ 0.36	49	0.81
Happiness	Positive	3.07	0.85/ 1.75	49	0.77
	Negative	1.48	0.38/ 0.97	49	0.65***
	Neutral	3.98	1.22/ 1.65	49	0.91
Nervousness	Positive	2.09	0.60/ 1.63	49	0.68***
	Negative	3.92	1.13/ 1.97	49	0.84
	Neutral	1.29	0.36/ 0.67	49	0.77

Joy	Positive	3.15	0.74/ 1.91	49	0.64***
	Negative	1.53	0.42/ 1.11	49	0.65***
	Neutral	3.66	1.31/ 1.74	49	0.92
Sadness	Positive	2.15	0.64/ 1.69	49	0.74
	Negative	2.00	0.77/ 1.30	49	0.83
	Neutral	1.76	0.69/ 1.11	49	0.85
Warmth/ Tenderness	Positive	3.31	0.85/ 1.99	49	0.72
	Negative	1.31	0.38/ 0.66	49	0.79
	Neutral	4.23	1.33/ 1.82	49	0.92
Wonder	Positive	4.13	1.21/ 1.97	49	0.85
	Negative	3.26	1.21/ 1.89	49	0.87
	Neutral	2.14	0.97/ 1.32	49	0.90

* Standard deviations of participant mean values (left) and all individual data points produced from each participant.

** Forty-nine participants' average ratings over 10 excerpts.

*** Alpha values did not reach the 0.70, the guiding threshold for exploratory research

Appendix Table 4-10

Paired samples t-tests for the mean values of positive and negative composite ratings

Emotional Term	*M* for Positive	*M* for Negative	*df*	*t*	*p*
Amazement	4.03	3.69	48	2.52	0.015*
Anger	1.35	3.12	48	13.38	< 0.001*
Anxiety	2.10	4.25	48	17.10	< 0.001*
Awe	3.87	3.71	48	1.30	0.200
Distress	1.93	4.29	48	13.46	< 0.001*
Fear	1.74	4.25	48	17.43	< 0.001*
Happiness	3.07	1.48	48	15.17	< 0.001*
Nervousness	2.09	3.92	48	12.80	< 0.001*
Joy	3.15	1.53	48	16.11	< 0.001*
Sadness	2.15	2.00	48	1.44	0.157
Warmth/ Tenderness	3.31	1.31	48	18.28	< 0.001*
Wonder	4.13	3.26	48	5.78	< 0.001*

* Denotes significance at an alpha level of 0.05.

Appendix Table 4-11

Kruskal-Wallis H Test and mean values of positive and negative composite ratings

Emotional Term	*M* for Positive**	*M* for Negative**	*df*	X^2**	*p***
Amazement	4.03/ 3.79	3.69/ 3.43	1	2.36/ 2.60	0.125/ .107
Anger	1.35/ 1.35	3.12/ 3.03	1	55.97/ 44.05	< 0.001*
Anxiety	2.10/ 2.07	4.25/ 4.10	1	58.12/ 47.85	< 0.001*
Awe	3.87/ 3.64	3.71/ 3.46	1	0.57/ 0.70	0.451/ 0.403
Distress	1.93/ 1.95	4.29/4.16	1	58.10/ 46.21	< 0.001*

Fear	1.74/ 1.76	4.25/ 4.15	1	67.78 / 56.43	< 0.01*
Happiness	3.07/ 3.08	1.48/ 1.51	1	61.82/ 50.89	< 0.001*
Nervousness	2.09/ 2.07	3.92/ 3.81	1	46.97/ 36.40	< 0.001*
Joy	3.15/ 3.07	1.53/ 1.56	1	63.78/ 51.35	< 0.001*
Sadness	2.15/ 2.14	2.00/ 1.97	1	1.47/ 1.72	0.225/ .190
Warmth/ Tenderness	3.31/ 3.25	1.31/ 1.31	1	71.01/ 58.70	< 0.001*
Wonder	4.13/ 3.87	3.26/ 3.06	1	10.62/ 58.70	0.001*/ 0.004*

* Denotes significance at an alpha level of 0.05.

** Results from the complete dataset (left) and from the reduced set from the excision of eight shared participants (right)

Appendix Table 4-12

Composite awe score

Music Type	***M***	***SD***	***Cronbach's α***
Positive	4.01	1.18	0.94
Negative	3.56	1.39	0.90

Paired samples t-test

df	***t***	***p***
126	5.56	< 0.001

Appendix Table 4-13

Composite threat score

Music Type	***M***	***SD***	***Cronbach's α***
Positive	1.98	0.57	0.87
Negative	4.14	1.14	0.87

Paired samples t-test

df	***t***	***p***
126	23.32	< 0.001

Appendix Table 4-14

Positive Affect Composite

Music Type	***M***	***SD***	***Cronbach's α***
Positive	3.175	0.81	0.78
Negative	1.44	0.41	0.82

Paired samples t-test

df	***t***	***p***
126	27.96	< 0.001

Appendix Table 4-15

Negative affect composite

Music Type	***M***	***SD***	***Cronbach's α***
Positive	1.81	0.62	0.73
Negative	3.14	1.39	0.69

Paired samples t-test

df	*t*	*p*
126	11.07	< 0.001

Appendix Table 4-16

Descriptive statistics and Cronbach's α for all categories of Study 5

Appraisal Term	Music Type	*M*	*SD**	*N***	Cronbach's α
Beautiful	Positive	4.61	0.97/ 1.78	51	0.837
	Negative	3.32	1.45/ 1.95	51	0.932
	Neutral	4.59	1.26/ 1.60	51	0.951
Powerful	Positive	4.20	0.80/ 1.84	51	0.773
	Negative	5.84	0.79/ 1.32	51	0.843
	Neutral	2.50	1.07/ 1.41	51	0.924
Skilful	Positive	4.87	0.98/ 1.51	51	0.862
	Negative	4.88	0.98/ 1.63	51	0.892
	Neutral	4.85	1.07/ 1.41	51	0.926
Supernatural	Positive	2.94	1.05/ 2.11	51	0.833
	Negative	3.44	1.29/ 1.96	51	0.893
	Neutral	1.31	0.41/ 0.72	51	0.769
Threatening	Positive	1.90	0.43/ 1.55	51	0.597***
	Negative	4.94	1.05/ 1.84	51	0.848
	Neutral	1.10	0.22/ 0.38	51	0.774

Vast	Positive	4.26	1.15/ 1.92	51	0.837
	Negative	4.93	1.15/ 1.70	51	0.880
	Neutral	2.69	1.24/ 1.50	51	0.912
Virtuous	Positive	4.15	1.29/ 2.00	51	0.895
	Negative	2.72	1.31/ 1.85	51	0.922
	Neutral	3.46	1.48/ 1.77	51	0.957

* Standard deviations of participant mean/aggregate values (left) and all individual data points produced from each participant.

** Fifty-one participants' average ratings over 10 excerpts.

*** Alpha values did not reach the 0.70, the guiding threshold for exploratory research

Appendix Table 4-17

Mauchly's test of sphericity for appraisal terms

Appraisal Term	**Mauchly's *W***	χ^2	***df***	***p***	**Huynh-Feldt**
Beautiful	0.872	6.732	2	0.035	0.916
Powerful	0.495	34.455	2	< 0.001	0.676
Skilful	0.698	17.619	2	< 0.001	0.788
Supernatural	0.868	6.922	2	0.031	0.914
Threatening	0.363	49.665	2	< 0.001	0.618
Vast	0.658	20.534	2	< 0.001	0.763
Virtuous	0.837	8.724	2	0.013	0.887

Appendix Table 4-18

Pearson Correlations between appraisal term ratings

	Beautiful	**Powerful**	**Skilful**	**Supernatural**	**Threatening**	**Vast**	**Virtuous**
Beautiful	1	.070*	.493**	-.028	-.357**	.268**	.544*
Powerful	.070*	1	.373**	.147**	.428**	.593**	.049
Skilful	.493**	.373**	1	0.26	.054	.399**	.337**
Supernatural	-.028	.147**	0.26	1	.428**	.256**	-.113**
Threatening	-.357**	.428**	.054	.428*	1	.225*	-.430**
Vast	.268**	.593*	.399**	.256**	.225*	1	.291**
Virtuous	.544*	.049	.337**	-.113**	-.430**	.291**	1

Note. N = 1020, 20 awe-related MAC_1 responses for 51 participants

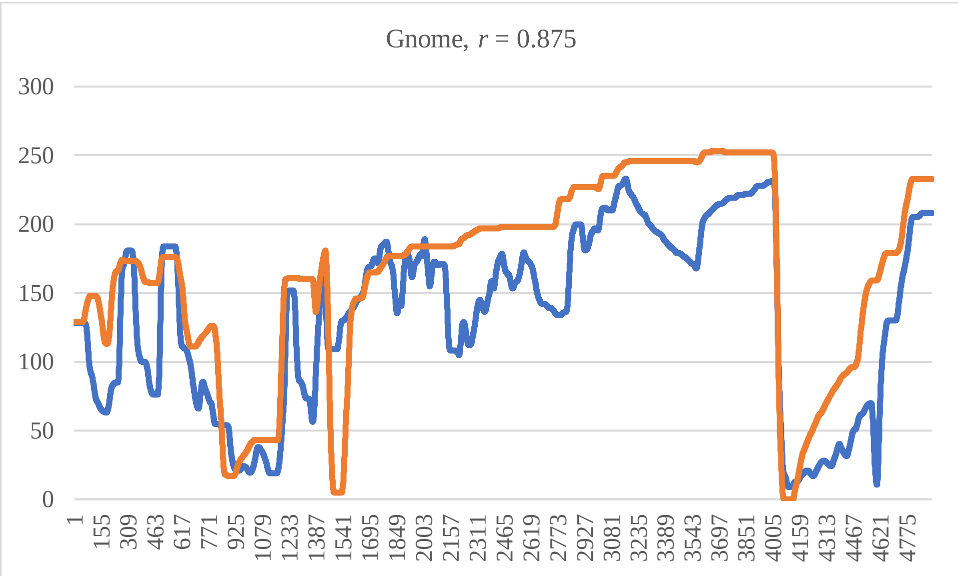
* Correlation is significant at the 0.05 level (2-tailed)

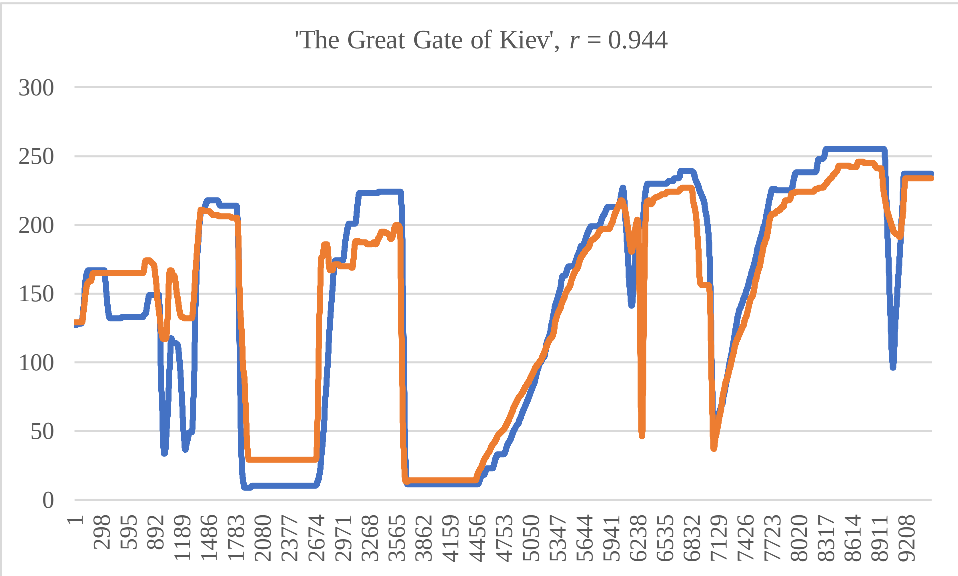
** Correlation is significant at the 0.01 level (2-tailed)

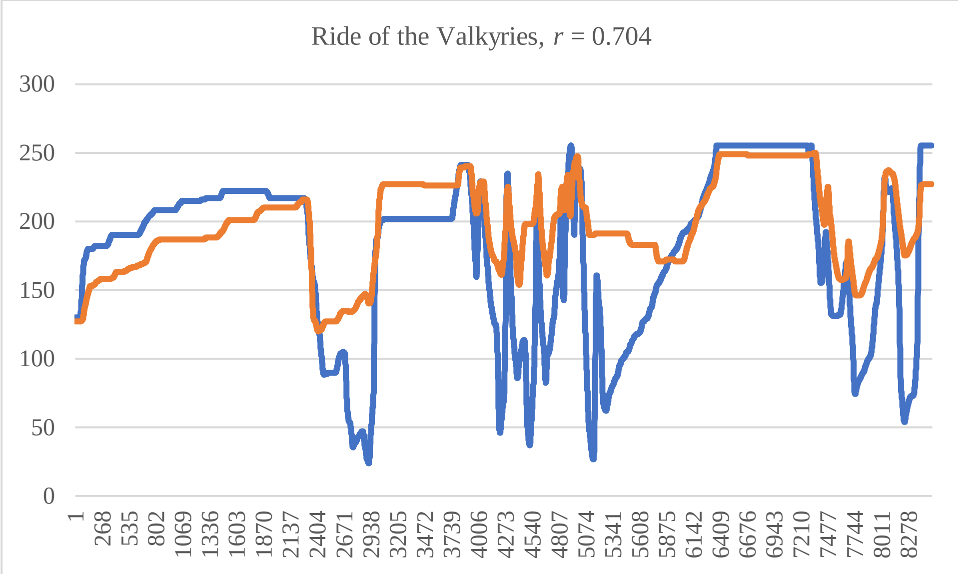
Chapter 5 Appendix

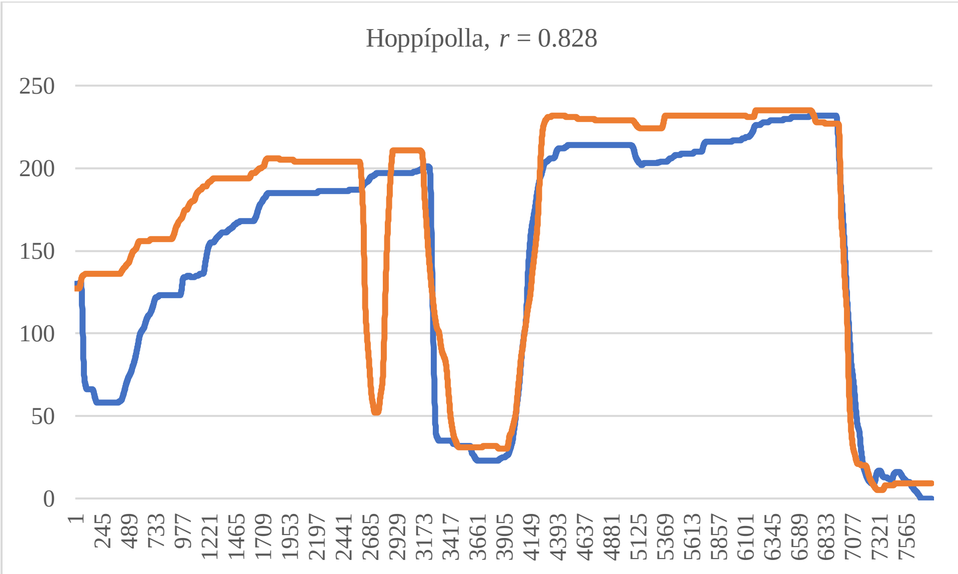
Appendix Figure 5-1

Correlation visualisations of Participant 5 (uncompressed)





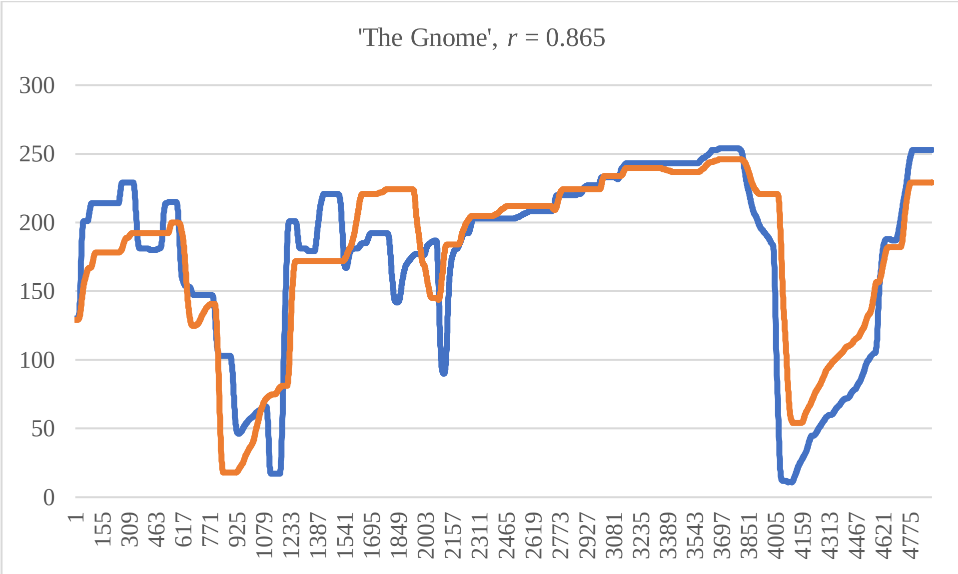


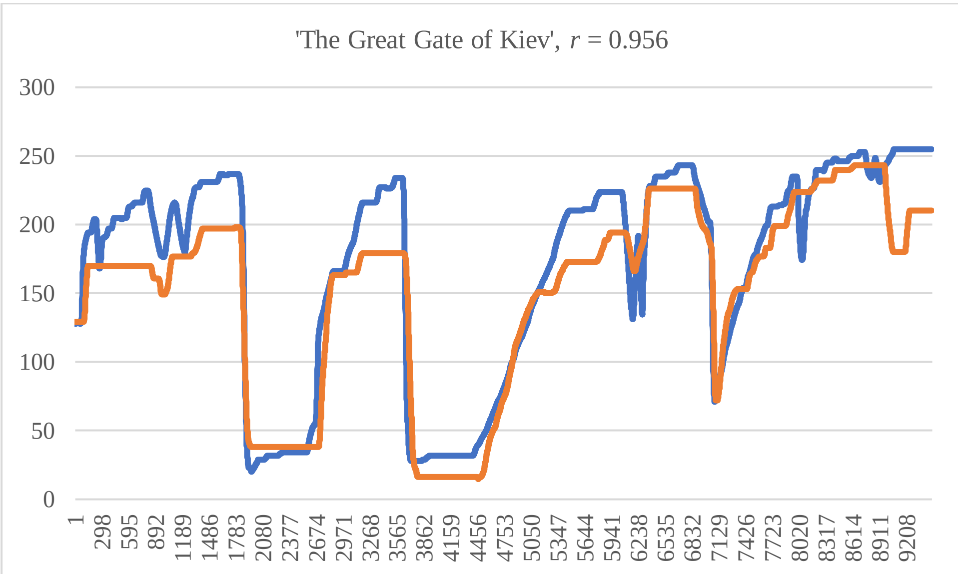


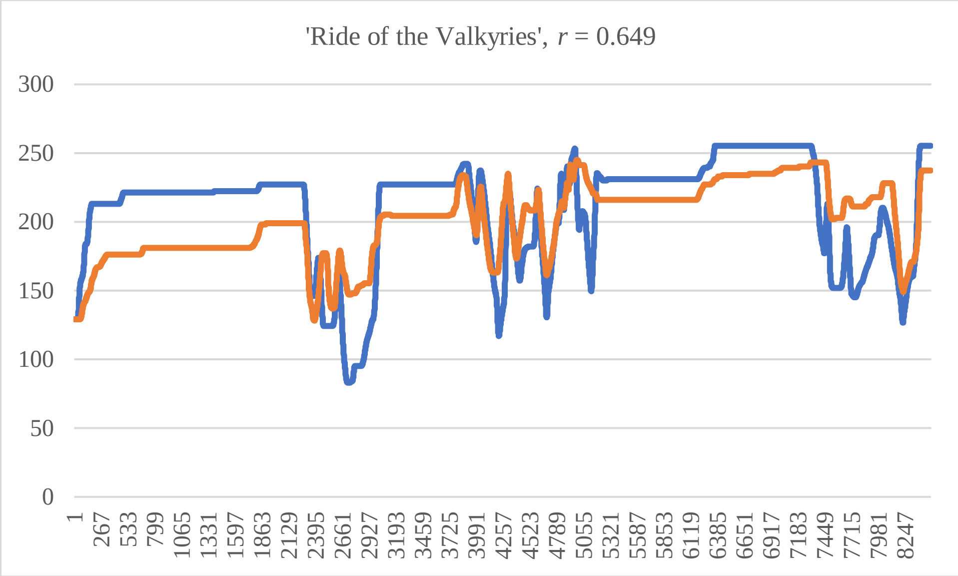
Note. Visualisations of size (blue) and awe (orange) ratings of all uncompressed music pieces.

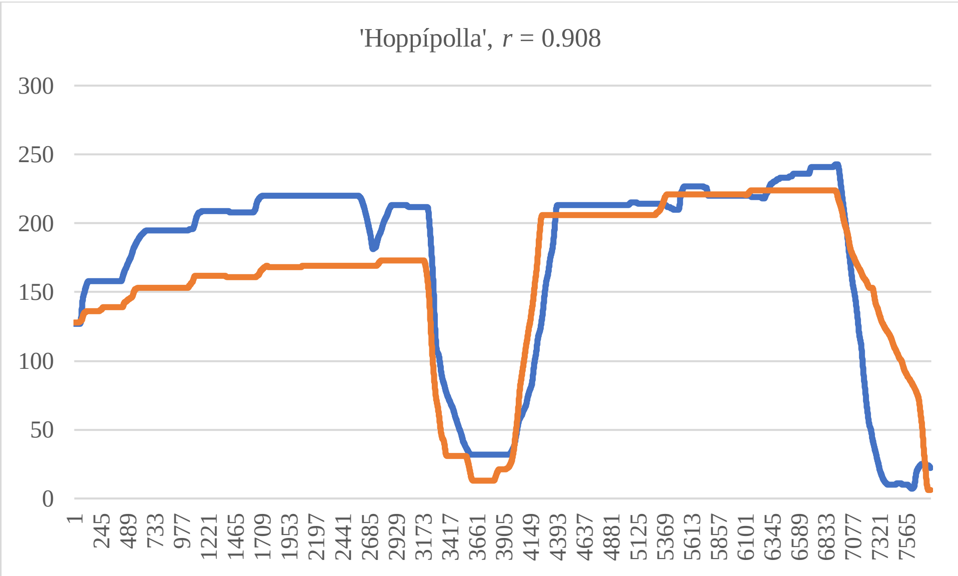
Appendix Figure 5-2

Correlation visualisations of Participant 5 (compressed)





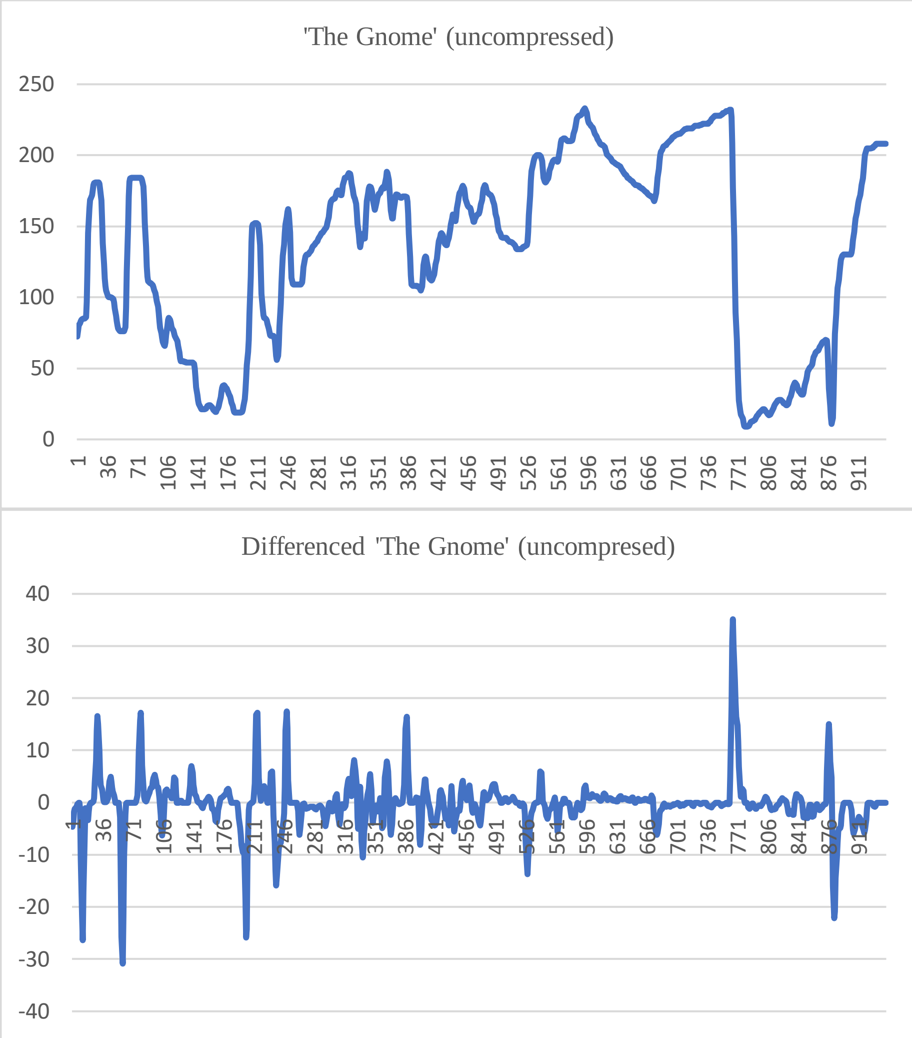




Note. Visualisations of size (blue) and awe (orange) ratings of all compressed music pieces.

Appendix Figure 5-3

Data transformation to first difference



Note. An example of Participant 5 data that were transformed from participant input data (top) to stationary time series (bottom) by way of differencing.

Appendix Table 5-1

Mean values of variations in size ratings in per participant and music

Music per participant	**Uncompressed**	**Compressed**
Participant 1		
'The Gnome'	0.67901179	0.66537338
'The Great Gate of Kiev'	0.21254785	0.16275261
'Ride of the Valkyries'	0.59478103	0.54445681
'Hoppípolla'	0.80586944	0.55469087
Participant 2		
'The Gnome'	0.02878068	0.02706905
'The Great Gate of Kiev'	0.00971644	0.01429204
'Ride of the Valkyries'	0.00968149	1.00/0.00*
'Hoppípolla'	0.00607727	0.03168476
Participant 3		
'The Gnome'	0.02915267	0.02812099
'The Great Gate of Kiev'	0.00426464	0.01570747
'Ride of the Valkyries'	0.02186764	0.01853052
'Hoppípolla'	0.44652743	0.0283288
Participant 4		
'The Gnome'	0.06157437	0.10983414
'The Great Gate of Kiev'	0.01210569	0.02659522
'Ride of the Valkyries'	0.03032292	0.03241462
'Hoppípolla'	0.64967343	0.55033978
Participant 5		

‘The Gnome’	0.48915865	0.3769764
‘The Great Gate of Kiev’	0.59829291	0.44626147
‘Ride of the Valkyries’	0.34189928	0.18911487
‘Hoppípolla’	0.50377186	0.40746654

Note. * Indicates a calculation that divides by zero and results in a non-value. For the purposes of this table, these values are treated as 0.00, as they represent sections of participant responses where there was no change in ratings over the course of the recorded experiment.

Appendix Table 5-2

Mean values of awe ratings per participant and music

Music per participant	**Uncompressed**	**Compressed**
	Participant 1	
‘The Gnome’	0.43447302	0.16855398
‘The Great Gate of Kiev’	0.17068037	0.03550847
‘Ride of the Valkyries’	0.34283846	0.17412059
‘Hoppípolla’	0.32598453	0.19543678
	Participant 2	
‘The Gnome’	0.00169091	0.0039928
‘The Great Gate of Kiev’	0.00459785	0.00271733
‘Ride of the Valkyries’	0.00729624	0.01856852
‘Hoppípolla’	1.00/0.00*	0.03446473
	Participant 3	
‘The Gnome’	0.56960906	0.32297319

‘The Great Gate of Kiev’	0.51271366	0.44739529
‘Ride of the Valkyries’	0.193255	0.16223559
‘Hoppípolla’	0.0285909	0.06013889
Participant 4		
‘The Gnome’	0.04337899	0.05972992
‘The Great Gate of Kiev’	0.02127124	0.02318377
‘Ride of the Valkyries’	0.0312517	0.04042905
‘Hoppípolla’	0.2758996	0.06054745
Participant 5		
‘The Gnome’	0.42532662	0.33328486
‘The Great Gate of Kiev’	0.59829291	0.44626147
‘Ride of the Valkyries’	0.17040069	0.13582996
‘Hoppípolla’	0.4710089	0.36181192

Note. * Indicates a calculation that divides by zero and results in a non-value. For the purposes of this table, these values are treated as 0.00, as they represent sections of participant responses where there was no change in ratings over the course of the recorded experiment.

Appendix Table 5-3

Correlations of size and awe ratings for each participant

Music per participant	**Uncompressed**	**Compressed**
Participant 1		
‘The Gnome’	0.28009995	-0.4807734
‘Great Gate of Kiev’	0.55169215	0.73319425
‘Ride of the Valkyries’	0.74354276	-0.6807852
‘Hoppípolla’	0.9794518	0.74125211
Participant 2		
‘The Gnome’	0.37242225	0.29663235
‘Great Gate of Kiev’	0.88469994	0.55893107
‘Ride of the Valkyries’	0.96183562	0.47360972
‘Hoppípolla’	1.00/0.00*	0.62683974
Participant 3		
‘The Gnome’	-0.3288389	-0.4221188
‘Great Gate of Kiev’	0.55822057	-0.6520885
‘Ride of the Valkyries’	0.54589386	0.05828398
‘Hoppípolla’	0.72640576	0.83735801
Participant 4		
‘The Gnome’	0.19126044	0.94814021
‘Great Gate of Kiev’	0.95350589	-0.0930945
‘Ride of the Valkyries’	-0.0402573	0.82033331
‘Hoppípolla’	0.97959977	0.98633829
Participant 5		

‘The Gnome’	0.87490672	0.86478993
‘Great Gate of Kiev’	0.94385255	0.95648296
‘Ride of the Valkyries’	0.70439608	0.6492836
‘Hoppípolla’	0.82801189	0.9077821

Appendix Table 5-4

ADF and KPSS test results in differenced mean data

Music	Augmented Dickey-Fuller	KPSS Level
1	-6.7159	0.023779
2	-5.2972	0.043537
3	-5.6385	0.029852
4	-7.0315	0.097458
5	-7.455	0.027906
6	-7.9219	0.01709
7	-7.0592	0.035083
8	-7.4692	0.077576
9	-7.6861	0.020634
10	-5.4269	0.025901
11	-5.9886	0.046045
12	-6.7761	0.041559
13	-5.8007	0.027133
14	-6.0752	0.030712
15	-7.3803	0.027875
16	-7.9541	0.053321

Note. All value Dickey-Fuller values reached significance of < 0.01, confirmed the lack of unit roots present in the data. All KPSS values failed to reach significant (> 0.100), rejecting the tested hypothesis of non-stationarity and accepting data as stationary.

Appendix Table 5-5

ADF and KPSS test results in differenced Participant 5 data

Music	**Augmented Dickey-Fuller**	**KPSS Level**
1	-11.955	0.0054267
2	-13.398	0.0030268
3	-15.085	0.0028005
4	-14.276	0.0045624
5	-11.887	0.0042318
6	-15.149	0.0028223
7	-14.858	0.0026619
8	-13.263	0.0083043
9	-11.157	0.010481
10	-15.194	0.0022415
11	-15.931	0.0029779
12	-11.576	0.0062673
13	-10.491	0.0054183
14	-12.923	0.0038136
15	-13.589	0.0040159
16	-12.891	0.0092316

Note. All value Dickey-Fuller values reached significance of < 0.01, confirmed the lack of unit roots present in the data. All KPSS values failed to reach significant (> 0.100), rejecting the tested hypothesis of non-stationarity and accepting data as stationary.

Appendix Table 5-6

Granger causality for Participant 5

Music	**Size G-causing awe**		**Awe G-causing size**		
	F	***p***	***F***	***p***	***df***
Music (uncompressed)					
'The Gnome'[2]	3.01	.002	2.24	.023	917/ 925
'The Great Gate of Kiev'[2]	3.37	.005	11.74	< .001	1841/ 1846
'Ride of the Valkyries'[2]	20.00	< .001	6.83	< .001	1645/ 1650
'Hoppípolla'[1]	5.151	< .001	1.22	.280	1489/ 1498
Music (compressed)					
'The Gnome'[2]	5.84	< .001	2.14	.019	907/ 917
'The Great Gate of Kiev'[1]	18.83	< .001	1.40	.193	1831/ 1839
'Ride of the Valkyries'[2]	14.10	< .001	3.77	< .001	1637/ 1644
'Hoppípolla'[2]	8.09	< .001	9.96	< .001	1497/ 1503

Note. Granger causality results for uncompressed and compressed music rated by Participant 5. Degrees of freedom are shown with values with and without lag.

[1] Indicates that size G-causes awe

[2] Indicates bidirectionality

Appendix Table 5-7

Average familiarity and preference ratings

Music	**Familiarity**	**Preference**
Music (uncompressed)		
‘The Gnome’	3.8	6.3
‘The Great Gate of Kiev’	6.2	7.5
‘Ride of the Valkyries’	8.0	6.5
‘Hoppípolla’	6.5	6
Music (compressed)		
‘The Gnome’	4.2	6.8
‘The Great Gate’	5.2	6.6
‘Ride of the Valkyries’	8.2	6.9
‘Hoppípolla’	5.6	5.5

Note. Average ratings of all participants for familiarity and liking of each piece of music.

Appendix Documents

Appendix Document 3-1

Information sheet for Study 1

Appraisals and Experience of Musical Awe

PARTICIPANT INFORMATION SHEET

Ethics Approval Reference: R49154/RE001

1. ***Background and aims of the study***

This study hopes to collect, summarize, and analyse experiential information regarding accounts of musically-induced awe, a profound emotional response generally characterized by a combination of appreciation of beauty, surprise, and fear.

This study is part of an on-going DPhil research project.

2. ***Why have I been invited to take part?***

All participants above the age of 18 are welcome to participate.

3. ***Do I have to take part?***

If you do agree to participate, you may withdraw yourself and your data from the study at any time, without giving a reason and without penalty, by advising the researchers of this decision.

4. ***What will happen in the study?***

5. If you are happy to take part in the study, you will be asked to answer several questions regarding an experience of awe brought on by music.

This should take approximately 20-30 minutes.

The study will take place online.

There may be follow-up audio-recorded interviews conducted at the will of the participant.

6. *Are there any potential risks in taking part?*

There are no direct risks in taking part in this research. If you are uncomfortable answering any questions, you are free not to answer.

There are no specific preparatory requirements for this study.

In order to mitigate any potential risks, the researchers will ensure that all data is collected anonymously.

7. *Are there any benefits in taking part?*

There will be no direct benefit to you from taking part in this research.

8. *What happens to the data provided?*

Your responses will be anonymised.

Personal / sensitive data will be stored confidentially using password-protect software.

Only the researcher will have access to research data.

We will ask all participants for their permission to use direct quotes from their responses.

All research data and records will be stored for a minimum retention period of 1 year after publication or public release of the work of the research.

9. *Will the research be published?*

The research may be published.

The University of Oxford is committed to the dissemination of its research for the benefit of society and the economy and, in support of this commitment, has established an online archive of research materials. This archive includes digital copies of student theses successfully submitted as part of a University of Oxford postgraduate degree programme. Holding the archive online gives easy access for researchers to the full text of freely available theses, thereby increasing the likely impact and use of that research.

If you agree to participate in this study, the research will be written up as a thesis. On successful submission of the thesis, it will be deposited both in print and online in the University archives, to facilitate its use in future research. The thesis will be published open access.

10. *Who has reviewed this study?*

This study has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee (reference number: R49154/RE001).

11. Who do I contact if I have a concern about the study or I wish to complain?

If you have a concern about any aspect of this study, please write to the relevant researcher landon.peck@music.ox.ac.uk or speak their supervisor +44 01865 276137, who will do their best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how they intend to deal with it. If you remain unhappy or wish to make a formal complaint, please contact the relevant chair of the Research Ethics Committee at the University of Oxford who will seek to resolve the matter in a reasonably expeditious manner:

Chair, Social Sciences & Humanities Inter-Divisional Research Ethics Committee; Email: ethics@socsci.ox.ac.uk; Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD

12. Contact Details

If you would like to discuss the research with someone beforehand (or if you have questions afterwards), please contact:

Landon Peck
Faculty of Music
St Aldates
Oxford,
OX1 1DB
Tel: +44 01865 276125
Email: landon.peck@music.ox.ac.uk

Appendix Document 3-2

Consent form for Study 1

Landon Peck
Music Faculty
DPhil Student
01865 276125
landon.peck@music.ox.ac.uk

PARTICIPANT CONSENT FORM

CUREC Approval Reference: RE49154/RE001

Appraisals and Experience of Musical Awe

Purpose of Study: to collect, summarize, and analyse experiential information regarding accounts of musical awe

1 I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

2 I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, and without any adverse consequences or academic penalty.

3 I understand that research data collected during the study may be looked at by designated individuals from the University of Oxford where it is relevant to my taking part in this study. I give permission for these individuals to access my data.

4 I understand that this project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee.

5 I understand who will have access to personal data provided, how the data will be stored and what will happen to the data at the end of the project.

6 I understand how this research will be written up and published.

7 I understand how to raise a concern or make a complaint.

8 I consent to being audio recorded (only for interview)

9 I agree to take part in this study.

Appendix Document 4-1

Information sheet for Study 3

Online Study of Study on Music and Emotions

General Information

The aim of this study is to collect data related to the perceptual features of specific types of music. These data will be analysed to understand commonalities in participant responses in the production of musical emotions. We appreciate your interest in participating in this experiment. You have been invited to participate as you are aged 18+, with normal or corrected-to-normal hearing. Please read through these terms before agreeing to participate by ticking the ‘yes’ box below You may ask any questions before taking part by contacting the researcher (details below). We, the University of Oxford are investigating emotional perception associated with musical features. You will be asked to listen to for musical excerpts and answer questions on its appropriateness to emotional terms. It should take about 20 minutes. No background knowledge is required. A £50 Amazon gift card will be given to one participant in a randomised prize draw upon the completion of this study. To take part, please leave us your email address so we can contact you if you win.

Do I have to take part?

Please note that your participation is voluntary. You may withdraw at any point during the questionnaire for any reason, before submitting your answers, by pressing the ‘Cancel’ button.

How will your data be used?

Your answers will be pseudonymised by the researcher, and we will use all reasonable endeavours to keep them confidential. We will ask for your name, age, gender, email address (to contact you for the prize draw) and musical listening preferences. Your personal data will be destroyed immediately after analysis, and email addresses only kept until the prize draw has been completed. Your data will be stored in a password-protected file and may be used in academic publications. Your IP address will not be stored. All questions are optional. Other research data will be stored for a minimum of three years after publication or public release.

Who will have access to your data?

The University of Oxford and JATOS (through AWS) are the data controllers with respect to your personal data, and as such will determine how your personal data is used in the study. The University will process your personal data for the purpose of the research outlined above. Research is a task that we perform in the public interest. We would like your permission to use your anonymised data in future studies, and to share data with other researchers (e.g. in online databases). Any personal information that could identify you will be removed or changed before files are shared with other researchers or results are made public. Responsible members of the University of Oxford, funders may be given access to data for monitoring and/or audit of the study to ensure we are complying with guidelines, or as otherwise required by law. This study is for a DPhil project. The principal researcher is Landon Peck, who is attached to the Faculty of Music at the University of Oxford. This project is being completed under the supervision of Professor Eric Clarke. This project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee [R59691/RE001].

What if there is a problem?

If you have a concern about any aspect of this project, please speak to the researcher Landon Peck landon.peck@music.ox.ac.uk/+44(0)1865276137 or their supervisor Professor Eric Clarke eric.clare@music.ox.ac.uk/+44(0)1865276137, who will do their best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how they intend to deal with it. If you remain unhappy or wish to make a formal complaint, please contact the relevant Chair of the Research Ethics Committee at the University of Oxford. Chair, Social Sciences & Humanities Inter-Divisional Research Ethics Committee; Email: ethics@socsci.ox.ac.uk; Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD]. The Chair will seek to resolve the matter in a reasonably expeditious manner. Please note that you may only participate in this survey if you are 18 years of age or over.

I certify that I am 18 years of age or over.

If you have read the information above and agree to participate with the understanding that the data (including any personal data) you submit will be processed accordingly, please select the relevant button below to get started.

Appendix Document 4-2

Information sheet for Study 4

Online Study on Music and Appraisal Terms

General Information

The aim of this study is to collect data related to the perceptual features of specific types of music. These data will be analysed to understand commonalities in participant responses in the production of musical emotions. We appreciate your interest in participating in this experiment. You have been invited to participate as you are aged 18+, with normal or corrected-to-normal hearing. Please read through these terms before agreeing to participate. You may ask any questions before taking part by contacting the researcher (details below). We, the University of Oxford are investigating emotional perception associated with musical features. You will be asked to listen to for musical excerpts and answer questions on its appropriateness to appraisal terms. It should take about 20 minutes. No background knowledge is required. The Mechanical Turk completion code will be provided at the end of the study.

Do I have to take part?

Please note that your participation is voluntary. You may withdraw at any point during the questionnaire for any reason, before submitting your answers, by pressing the 'Cancel' button.

How will your data be used?

Your answers will be pseudonymised by the researcher, and we will use all reasonable endeavours to keep them confidential. We will ask for your name, age, gender, email address (to contact you for the prize draw) and musical listening preferences. Your personal data will be destroyed immediately after analysis, and email addresses only kept until the prize draw has been completed. Your data will be stored in a password-protected file and may be used in academic publications. Your IP address will not be stored. All questions are optional. Other research data will be stored for a minimum of three years after publication or public release.

Who will have access to your data?

The University of Oxford and JATOS (through AWS) are the data controllers with respect to your personal data, and as such will determine how your personal data is used in the study. The University will process your personal data for the purpose of the research outlined above. Research is a task that we perform in the public interest. We would like your permission to use your anonymised data in future studies, and to share data with other researchers (e.g. in online databases). Any personal information that could identify you will be removed or changed before files are shared with other researchers or results are made public. Responsible members of the University of Oxford, funders may be given access to data for monitoring and/or audit of the study to ensure we are complying with guidelines, or as otherwise required by law. This study is for a DPhil project. The principal researcher is Landon Peck, who is attached to the Faculty of Music at the University of Oxford. This project is being completed under the supervision of Professor Eric Clarke. This project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee [R59691/RE001].

What if there is a problem?

If you have a concern about any aspect of this project, please speak to the researcher Landon Peck landon.peck@music.ox.ac.uk/+44(0)1865276137 or their supervisor Professor Eric Clarke eric.clare@music.ox.ac.uk/+44(0)1865276137, who will do their best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how they intend to deal with it. If you remain unhappy or wish to make a formal complaint, please contact the relevant Chair of the Research Ethics Committee at the University of Oxford. Chair, Social Sciences & Humanities Inter-Divisional Research Ethics Committee; Email: ethics@socsci.ox.ac.uk; Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD. The Chair will seek to resolve the matter in a reasonably expeditious manner. Please note that you may only participate in this survey if you are 18 years of age or over.

I certify that I am 18 years of age or older.

If you have read the information above and agree to participate with the understanding that the data (including any personal data) you submit will be processed accordingly, please select the relevant button below to get started.

Appendix Document 4-3

Information sheet for Study 5

Online Study on Music and Appraisal Terms

General Information

The aim of this study is to collect data related to the perceptual features of specific types of music. These data will be analysed to understand commonalities in participant responses in the production of musical emotions. We appreciate your interest in participating in this experiment. You have been invited to participate as you are aged 18+, with normal or corrected-to-normal hearing. Please read through these terms before agreeing to participate. You may ask any questions before taking part by contacting the researcher (details below). We, the University of Oxford are investigating emotional perception associated with musical features. You will be asked to listen to for musical excerpts and answer questions on its appropriateness to appraisal terms. It should take about 20 minutes. No background knowledge is required. The Mechanical Turk completion code will be provided at the end of the study.

Do I have to take part?

Please note that your participation is voluntary. You may withdraw at any point during the questionnaire for any reason, before submitting your answers, by pressing the 'Cancel' button.

How will your data be used?

Your answers will be pseudonymised by the researcher, and we will use all reasonable endeavours to keep them confidential. We will ask for your name, age, gender, email address (to contact you for the prize draw) and musical listening preferences. Your personal data will be destroyed immediately after analysis, and email addresses only kept until the prize draw has been completed. Your data will be stored in a password-protected file and may be used in academic publications. Your IP address will not be stored. All questions are optional. Other research data will be stored for a minimum of three years after publication or public release.

Who will have access to your data?

The University of Oxford and JATOS (through AWS) are the data controllers with respect to your personal data, and as such will determine how your personal data is used in the study. The University will process your personal data for the purpose of the research outlined above. Research is a task that we perform in the public interest. We would like your permission to use your anonymised data in future studies, and to share data with other researchers (e.g. in online databases). Any personal information that could identify you will be removed or changed before files are shared with other researchers or results are made public. Responsible members of the University of Oxford, funders may be given access to data for monitoring and/or audit of the study to ensure we are complying with guidelines, or as otherwise required by law. This study is for a DPhil project. The principal researcher is Landon Peck, who is attached to the Faculty of Music at the University of Oxford. This project is being completed under the supervision of Professor Eric Clarke. This project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee [R59691/RE001].

What if there is a problem?

If you have a concern about any aspect of this project, please speak to the researcher Landon Peck landon.peck@music.ox.ac.uk/+44(0)1865276137 or their supervisor Professor Eric Clarke eric.clare@music.ox.ac.uk/+44(0)1865276137, who will do their best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how they intend to deal with it. If you remain unhappy or wish to make a formal complaint, please contact the relevant Chair of the Research Ethics Committee at the University of Oxford. Chair, Social Sciences & Humanities Inter-Divisional Research Ethics Committee; Email: ethics@socsci.ox.ac.uk; Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD. The Chair will seek to resolve the matter in a reasonably expeditious manner. Please note that you may only participate in this survey if you are 18 years of age or over.

I certify that I am 18 years of age or older.

If you have read the information above and agree to participate with the understanding that the data (including any

Appendix Document 4-4

Consent form for Studies 3, 4, and 5

Participant Consent Form

CUREC Approval Reference: R59691/RE001

Investigation of Perceptual Features Associated with Specific Music

Purpose of Study: This research projects seeks to collect data related to the perceptual features of specific types of music. These data will be analysed to understand commonalities in participant responses in the production of musical emotions.

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, and without any adverse consequences or academic penalty.

3. I understand that research data collected during the study may be looked at by designated individuals from the University of Oxford where it is relevant to my taking part in this study. I give permission for these individuals to access my data.

4. I understand that this project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee.

5. I understand who will have access to personal data provided, how the data will be stored and what will happen to the data at the end of the project.

6. I understand how this research will be written up and published.

7. I understand how to raise a concern or make a complaint.

8. I agree for research data collected in this study to be given to researchers, including those working outside of the EU, to be used in other research studies. I understand that any data that leave the research group will be fully anonymised so that I cannot be identified.

9. I agree to take part in this study.

If you consent to *all* the above statements click the relevant option below.

Appendix Document 5-1

Information Sheet for Study 6

Investigation of Perceptual Features Associated with Musical Awe

PARTICIPANT INFORMATION SHEET FOR LABORATORY STUDY

Ethics Approval Reference: R59691/RE001

13. *What is the purpose of this research*

This research projects seeks to collect data related to the perceptual features of specific types of music. These data will be analysed to understand commonalities in participant responses to the production and occurrence of musically-induced awe.

This study is part of an on-going DPhil research project that hopes to answer what types of musical and acoustic factors are influential and common to experiences of musical awe.

14. *Why have I been invited to take part?*

You have been invited because you are 18 years of age or older with normal or corrected-to-normal hearing. There are no specific preparatory requirements for this study.

15. *Do I have to take part?*

No. You can ask questions about the research before deciding whether or not to participate. If you do agree to participate, you may withdraw yourself from the study at any time, without giving a reason, by advising the researchers of this decision.

16. *What will happen to me if I take part in the research?*

If you are happy to take part in the study, you will be asked to rate musical samples for perceptual features and associate them with images.

This should take approximately 60 minutes.

The study will take place in a quiet setting for the purpose of listening to music clearly.

If you are happy to take part in the research, you will be asked to complete a single computer-based experiment.

17. *Are there any potential risks in taking part?*

There are no direct risks in taking part in this research. If you are uncomfortable answering any questions, you are free not to answer. In order to mitigate any potential risks, the researcher will ensure that data is anonymised.

18. *Are there any benefits in taking part?*

There will be no direct benefit to you from taking part in this research.

19. *What happens to the data provided?*

The information you provide as part of the study is the **research data**. Any research data from which you can be identified (e.g. age, gender, email address, listening habits), is known as **personal data**. It does not include data where the identity has been removed (anonymous data). I will minimise our use of personal data in the study as much as possible.

Your responses will be **anonymised**. The **research data** and any **personal** data will be stored confidentially using password-protect servers and software. The personal data will be destroyed immediately after analysis, and email addresses only kept until the prize draw has been completed.

The researcher will have access to research and personal data.

We will ask all participants for their permission to use direct quotes from their responses in the study.

All other research data and records will be stored for a minimum retention period of 3 year after publication or public release of the work of the research.
Your personal data may be transferred to, and stored at, a destination outside the European Economic Area. We will make sure that identifiable data is removed whenever possible and that any data transfer is done securely and with a similar level of data protection as required under UK law.

We would like your permission to use anonymised data in future studies, and to share data with other researchers (e.g. in online databases). All personal information that could identify you will be removed or changed before information is shared with other researchers or results are made public.

20. *Will the research be published?*

The research may be published in academic publications.

The research will be written up as a DPhil thesis. On successful submission of the thesis, it will be deposited both in print and online in the University archives, to facilitate its use in future research. The thesis will be openly accessible.

21. *Who is organising and funding the research?*

The research is being organised by the researcher at Faculty of Music at the University of Oxford.

22. *Who has reviewed this study?*

This study has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee **[reference number: R59691/RE001]**

23. *Who do I contact if I have a concern about the study or I wish to complain?*

If you have a concern about any aspect of this study, please write to the relevant researcher landon.peck@music.ox.ac.uk or speak their supervisor, Professor Eric Clarke, +44 01865 276137, who will do their best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how they intend to deal with it. If you remain unhappy or wish to make a formal complaint, please contact the relevant chair of the Research Ethics Committee at the University of Oxford who will seek to resolve the matter in a reasonably expeditious manner:

Chair, Social Sciences & Humanities Inter-Divisional Research Ethics Committee; Email: ethics@socsci.ox.ac.uk; Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD

24. *Data Protection*

The University of Oxford and JATOS (an online survey tool) are the data controller with respect to your personal data, and as such will determine how your personal data is used in the study. The University will process your personal data for the purpose of the research outlined above. Research is a task that we perform in the public interest. Further information about your rights with respect to your personal data is available from http://www.admin.ox.ac.uk/councilsec/compliance/gdpr/individualrights/.

25. *Contact Details*

If you would like to discuss the research with someone beforehand (or if you have questions afterwards), please contact:

Landon Peck
Faculty of Music
St Aldates
Oxford,
OX1 1DB
Tel: +44 01865 276125
Email: landon.peck@music.ox.ac.uk

Appendix Document 5-2

Consent form for Study 6

Faculty of Music
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UNIVERSITY OF OXFORD

Landon Peck
Christ Church, St Aldates, Oxford OX1 1DP
DPhil Student
Telephone number: +44 (0)1865 276125
Oxford e-mail: landon.peck@music.ox.ac.uk
Supervisor: Professor Eric Clarke

PARTICIPANT CONSENT FORM

CUREC Approval Reference: R59691/RE001

Investigation of Perceptual Features Associated with Musical Awe

Purpose of Study: This research projects seeks to collect data related to the perceptual features of specific types of music. These data will be analysed to understand commonalities in participant responses to the production and occurrence of musically-induced awe.

Please initial each box

1	I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2	I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, and without any adverse consequences or academic penalty.	
3	I understand that research data collected during the study may be looked at by designated individuals from the University of Oxford where it is relevant to my taking part in this study. I give permission for these individuals to access my data.	
4	I understand that this project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee.	
5	I understand who will have access to personal data provided, how the data will be stored and what will happen to the data at the end of the project.	
6	I understand how this research will be written up and published.	
7	I understand how to raise a concern or make a complaint.	
8	I agree for research data collected in this study to be given to researchers, including those working outside of the EU, to be used in other research studies. I understand that any data that leave the research group will be fully anonymised so that I cannot be identified.	
9	I agree to take part in this study.	

Name of Participant	Date	Signature
Name of person taking consent	Date	Signature