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Why We Listen to Sad Music: Effects on Emotion and Cognition

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Disputation:

21. Dezember 2016

In memory of Riccardo Taruffi

1922 - 2013

Eidesstattliche Erklärung

Hiermit erkläre ich an Eides statt,

- dass ich die vorliegende Arbeit selbständig und ohne unerlaubte Hilfe verfasst habe,
- dass ich mich nicht bereits anderwärts um einen Doktorgrad beworben habe und keinen Doktorgrad in dem Promotionsfach Psychologie besitze,
- dass ich die zugrunde liegende Promotionsordnung vom 02.12.2008 kenne.

Berlin, den 30.05.2016 Liila Taruffi

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English Summary

The appeal of artwork that evokes negative emotional experiences such as sadness, anger or fear - experiences typically avoided outside of artistic contexts - has been a controversial issue throughout the history of philosophy since the Ancient Greeks. With regard to music, sadness is one of the most commonly reported music-evoked emotions, and sad pieces are often considered the most beautiful and pleasurable music. Yet our understanding of the psychological and neural mechanisms underlying listening to sad music is rather limited and basic questions remain unresolved: Why do people deliberately choose to listen to sad music if sadness is inherently a negative emotion? What are the effects of sad music on emotion and cognition? Can particular personality traits modulate the perception as well as the enjoyment of sad music?

The present dissertation takes an interdisciplinary approach to the investigation of the enjoyment of sad music and utilizes a combination of behavioral and neuroimaging methods to examine emotional and cognitive experiences evoked by sad music. The theoretical part of the dissertation explores and integrates philosophical perspectives on the so-called "paradox of sad music" with findings from psychology and neuroscience. The studies presented in the empirical part of the dissertation aim to address several gaps and unanswered questions raised in the theoretical part. The first empirical study, consisting of a large online survey of 772 participants, shows that emotional responses to sad music are multifaceted, are modulated by personality traits, especially trait empathy, and are linked with a multidimensional experience of reward. Importantly, the study reveals that listening to sad music is associated with a wide range of beneficial emotional effects (e.g., regulation of negative moods and emotions as well as consolation), which in turn constitute the main motives for engaging with sad music in everyday life. The second empirical study used thought probing in conjunction with functional magnetic resonance imaging (fMRI) to demonstrate that sad music, compared with happy music, stimulates mind-wandering and that this is reflected on a neural level by the engagement of the so-called default mode network (DMN). The third study tackles the question to what extent the ability to recognize sadness, and other basic emotions, in music is related to individual differences in alexithymia, empathy, personality traits, and musical expertise. Alexithymia's factor *externally-oriented thinking* significantly influenced performance accuracy on a musical emotion recognition task, suggesting that alexithymia's perceptual deficits in recognition of facial and verbal expressions of emotion extend also to the musical domain. The fourth study combined ECM (eigenvector centrality mapping) and FC (functional connectivity) analyses to identify a distributed neural network engaged during listening to sad (compared with happy) music and associated with individual differences in trait empathy. This music-empathy network encompasses ventromedial prefrontal cortex (vmPFC), dorsomedial prefrontal cortex (dmPFC), primary visual cortex (V1), bilateral claustrum (CL), and cerebellum (CB), with the vmPFC acting as "computational hub" and the remaining brain areas as functionally connected nodes.

In sum, this dissertation provides a more thorough understanding as to (*i*) why people engage with sad music in their everyday life, (*ii*) the effects of sad music on spontaneous cognition, (*iii*) the role of listener characteristics in music-perceived and -evoked sadness, and (*iv*) the neural mechanisms underlying empathic responses to sad music. Together with evidence from various fields of research discussed throughout this work, the present findings show that pleasure in response to sad music is related to different psychological benefits and is the outcome of a complex interplay of personality traits, current mood, and contextual variables. In addition to emotional functions, sad music can also trigger an inwardly-oriented mentation mode, explaining why people often seek sad music for improving introspection and imaginative thinking. Taken together, these results offer novel possibilities for the use of sad music in therapeutic interventions promoting mental and emotional health.

Keywords: sad music, music-evoked emotions, reward, mind-wandering, default mode network, internally-oriented cognition, empathy, alexithymia, personality traits, emotion recognition, social cognition

Deutsche Zusammenfassung

Die Anziehungskraft von Kunstwerken, die negative emotionale Erfahrungen wie Traurigkeit, Wut oder Angst hervorrufen – Erfahrungen, die normalerweise außerhalb von Kunstkontexten vermieden werden – beschäftigt Philosophen seit den antiken Griechen. In der Musik zählt Traurigkeit zu den am häufigsten berichteten Emotionen, und oft sind es gerade traurige Stücke, die als am schönsten und angenehmsten empfunden werden. Unser Verständnis der psychologischen und neuronalen Mechanismen, die dem Hören trauriger Musik zu Grunde liegen, ist jedoch noch ziemlich begrenzt, und wesentliche Fragen bleiben ungeklärt: Warum hören Menschen bewusst traurige Musik, wenn Traurigkeit grundsätzlich eine negative Emotion ist? Welchen Effekt hat traurige Musik auf Emotion und Kognition? Beeinflussen bestimmte Persönlichkeitsmerkmale die Wahrnehmung und das positive Erleben von trauriger Musik?

Diese Dissertation untersucht in einer interdisziplinären Herangehensweise mit verhaltenspyschologischen Methoden und bildgebenden Verfahren der Neurowissenschaft die von trauriger Musik hervorgerufenen emotionalen und kognitiven Erfahrungen. Der theoretische Teil der Dissertation untersucht und integriert philosophische Perspektiven auf das “Paradox trauriger Musik” mit Ergebnissen aus der Psychologie und den Neurowissenschaften. Die im empirischen Teil der Dissertation vorgestellten Studien beschäftigen sich mit der Klärung einiger im theoretischen Teil diskutierter Fragen. Die erste empirische Studie, die aus einer Online-Umfrage mit 772 Teilnehmenden besteht, zeigt, dass emotionale Reaktionen auf traurige Musik vielseitig sind, von Persönlichkeitsmerkmalen gesteuert werden, insbesondere von Empathie, und mit einer multidimensionalen Erfahrung von Belohnung zusammenhängen. Die Studie zeigt, dass das Hören trauriger Musik mit einem breiten Spektrum von positiven emotionalen Effekten einhergeht (z.B. der Regelung negativer Stimmungen und Emotionen), die wiederum die Hauptgründe dafür sind, sich im Alltag mit trauriger Musik zu beschäftigen. Die zweite empirische

Studie benutzt *thought probing* zusammen mit funktioneller Magnetresonanztomographie (fMRT) um zu zeigen, dass traurige Musik im Vergleich zu fröhlicher Musik *mind-wandering* fördert, was sich auf neuronaler Ebene in der Aktivierung des so-genannten Default-Mode-Netzwerks (DMN) manifestiert. Die dritte Studie beschäftigt sich mit der Frage, inwieweit die Fähigkeit, Traurigkeit und andere sogenannte Basisemotionen in der Musik zu erkennen, mit individuellen Unterschieden in Alexithymie, Empathie, Persönlichkeitsmerkmalen und Musikkompetenz zusammenhängt. Dabei zeigte der Alexithymiefaktor *externally-oriented thinking* einen signifikanten Einfluss auf die Ergebnisse einer musikalischen Emotionserkennungsaufgabe. Dies legt nahe, dass sich Alexithymie-Wahrnehmungsdefizite in der Erkennung von Gesichts- und verbalen Emotionsausdrücken auch auf den Bereich der Musik übertragen lassen. Die vierte Studie kombiniert Methoden des *Eigenvector-Centrality-Mapping* (ECM) und der *Functional-Connectivity* (FC), um ein neuronales Netz zu identifizieren, das mit individuellen Unterschieden der Empathiefähigkeit zusammenhängt und während des Hörens trauriger (im Vergleich zu fröhlicher) Musik aktiviert ist. Dieses neuronale Netz umfasst den ventromedialen präfrontalen Kortex (vmPFC), den dorsomedialen präfrontalen Kortex (dmPFC), den primären visuellen Kortex (V1), das bilaterale Claustrum (CL), und das Kleinhirn (CB). Der vmPFC wirkt hier als “Schaltstelle” und die übrigen Hirnregionen als funktionell verbundene Untereinheiten.

Zusammenfassend trägt diese Dissertation zu einem besseren Verständnis folgender Fragestellungen bei: (*i*) warum beschäftigen sich Menschen in ihrem Alltag mit trauriger Musik, (*ii*) welche Effekte hat traurige Musik auf spontane Kognition, (*iii*) welche Rolle spielen Eigenschaften des Zuhörers in durch Musik hervorgerufener Traurigkeit, und (*iv*) welche neuronalen Mechanismen liegen empathischen Reaktionen auf traurige Musik zu Grunde. Zusammen mit Befunden aus verschiedenen Forschungsbereichen, die in dieser Arbeit diskutiert werden, zeigen die vorliegenden empirischen Studien, dass das positive Erleben trauriger Musik verschiedene psychologische Vorteile mit sich bringt und das Ergebnis eines komplexen Zusammenspiels von Persönlichkeitsmerkmalen, momentaner Stimmung

und Kontextvariablen ist. Neben emotionalen Funktionen kann traurige Musik nach innen gerichtete Denkprozesse herbeiführen. Dies könnte erklären, wieso Menschen sich oft trauriger Musik bedienen, um Introspektion und fantasiegeleitetes Denken zu fördern. Insgesamt zeigen die Ergebnisse dieser Dissertation neue Möglichkeiten für die Anwendung trauriger Musik in therapeutischen Interventionen auf, die zur Verbesserung der mentalen und emotionalen Gesundheit beitragen können.

Schlagwörter: traurige Musik, musik-evozierte Emotionen, Belohnung, Empathie, mind-wandering, Default-Mode-Netzwerk, nach innen gerichtete Kognition, Alexithymie, Persönlichkeitsmerkmale, Emotionserkennung, Soziale Kognition

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List of Abbreviations

AC	Anterior Commissure
ANOVA	Analysis of Variance
ASD	Autism Spectrum Disorder
BA	Brodmann Area
BFI	Big Five Inventory
BMRQ	Barcelona Music Reward Questionnaire
BOLD	Blood Oxygen Level Dependent
BPM	Beats per Minute
BVAQ	Bermond-Vorst Alexithymia Questionnaire
CB	Cerebellum
CL	Claustrum
dB	Decibel
DMN	Default Mode Network
dmPFC	Dorsomedial Prefrontal Cortex
ECM	Eigenvector Centrality Mapping
ECMs	Eigenvector Centrality Maps
ESM	Experience Sampling Method
FC	Functional Connectivity
FDR	False Discovery Rate
fMRI	Functional Magnetic Resonance Imaging
FOV	Field of View
FWHM	Full-Width at Half-Maximum
GEMS	Geneva Emotional Music Scale
GIM	Guided Imagery and Music
Gold-MSI	Goldsmiths Musical Sophistication Index
IFG	Inferior Frontal Gyrus
IRI	Interpersonal Reactivity Index
M	Arithmetic Mean
MER	Musical Emotion Recognition

MNI	Montreal Neurological Institute
mPFC	Medial Prefrontal Cortex
MRI	Magnetic Resonance Imaging
NAc	Nucleus Accumbens
PC	Posterior Commissure
PCA	Principal Component Analysis
PCC	Posterior Cingulate Cortex
PCu	Precuneus
PET	Positron Emission Tomography
PFC	Prefrontal Cortex
pIPL	Posterior Inferior Parietal Lobule
QIDS-SR	Quick Inventory of Depressive Symptomatology Self-Report
RMS	Root Mean Square
SD	Standard Deviation
TAS-20	Toronto Alexithymia Scale Twenty-Item Version
TE	Echo Time
TIPI	Ten-Item Personality Inventory
ToM	Theory of Mind
TR	Repetition Time
vmPFC	Ventromedial Prefrontal Cortex
V1	Primary Visual Cortex

List of Original Publications

The dissertation is based on the following articles. Occasionally, the text of the original articles has been slightly modified to facilitate reading of the dissertation.

A version of Chapters 2-4 is currently in press:

Taruffi, L., & Koelsch, S. Why we listen to sad music: Philosophical perspectives, psychological functions and underlying brain mechanisms. In Gouk, P., Prins, J., Thormaehlen, W., & Kennaway, J. (Eds.), *The Routledge Companion to Music, Mind and Wellbeing: Historical and Scientific Perspectives*.

The research reported in Chapter 5 is published in:

Taruffi, L., & Koelsch, S. (2014). The paradox of music-evoked sadness: An online survey. *PLoS One, 9*(10), e110490. http://dx.doi.org/10.1371/journal.pone.0110490

The research reported in Chapter 6 is currently under revision:

Taruffi, L., Pehrs, C., Skouras, S., & Koelsch, S. Sad music engages mind-wandering and the neural default mode network.

The research reported in Chapter 7 is published in:

Taruffi, L., Allen, R., Downing, J., & Heaton, P. (2017). Individual differences in music-perceived emotions: The influence of externally-oriented thinking. *Music Perception*, *34*(3), 253-266. http://dx.doi.org/10.1525/mp.2017.34.3.253

Finally, the research reported in Chapter 8 is a manuscript in preparation.

I

Theoretical Background

Chapter 1

Introduction

1.1 The Paradox of Sad Music

In 1976, Elton John's *Sorry Seems to Be the Hardest Word* climbed to No. 1 on the UK Singles Chart as well as to No. 2 on the Eurochart Hot 100. Back then, this heartrending song sold over 1 million copies within the US alone. Elton John's hit is just one example among hundreds of different sad songs that dominate the charts every year. Indeed, listeners from around the world deliberately turn to sad songs, despite the fact that the music and/or the lyrics evoke sorrowful memories or emotions usually thought to be undesirable. At the base of sad music's conundrum lies a crucial question which has puzzled philosophers since Antiquity and that has received much attention in recent thought (Aristotle, 1986; Burton, 2001; Davies, 1997; Gantillon, 1884; Hume, 1757; Kivy, 1989; Levinson, 1997; Robinson, 1997): If sadness is a negative emotion normally avoided in everyday life, why then are people so drawn to sadness in music? This is a relevant question because sad music indubitably plays an important role in our lives considering its popularity around the world. Interestingly, the appeal of sad music appears to be even more widespread nowadays. Recent research in music psychology (Schellenberg & von Scheve, 2012) showed that over the past half-century, the proportion of pop songs written using minor mode has doubled and that a song's average tempo has decreased, suggesting that popular hits have become more sad-sounding (minor mode and slow tempo are two important acoustical characteristics conveying sadness in music). Likewise, the lyrics of popular U.S. songs from 1980-2007 have become more self-focused and negative over time (DeWall, Pond, Campbell, & Twenge, 2011). What is it, then, that people seek out when listening to sad music?

A way to understand the appeal of sad music is to consider sadness and pleasure as two coexisting facets of the emotional response to sad music. A piece of sad music can move us to tears, but those tears are often felt as pleasurable or bittersweet. For instance, Robert Burton, in his *Anatomy of Melancholy*, observed that “many men are melancholy by hearing music, but it is a pleasing melancholy that it causeth” (Burton, 2001, part 2, p. 118). Outside of aesthetic contexts this would not be possible, but through music as well as other art forms, sadness can become part of a pleasurable experience, justifying the appeal of sad music across the world. But how can sad music evoke pleasurable emotions at all? Is music-evoked sadness different from “everyday” sadness? What are the emotional and cognitive effects of listening to sad music? And can the recent advances made by neuroscience shed light on a topic that has always belonged to the purview of philosophy? To obtain a full understanding of the emotional, cognitive, and aesthetic experiences underlying listening to sad music, it is necessary to draw on a wide range of investigations encompassing several disciplines. Along these lines, the present dissertation takes a unified approach to the phenomenon of enjoyment of sad music by bringing together philosophical perspectives and empirical findings from psychology and neuroscience.

1.2 What is Sad Music?

Sad music can be defined objectively, as music with certain acoustical and musical properties, and subjectively, as music that conveys sadness (Sachs, Damasio, & Habibi, 2015). According to the first definition, sad music generally features low pitch, narrow pitch range, falling pitch contour, minor mode, slow tone attacks, slow tempo, dull and dark timbres, low sound level, little sound level variability, little high-frequency energy, microstructural irregularity, and legato articulation (Huron, 2008; Juslin & Laukka, 2003; Post & Huron, 2009; Turner & Huron, 2008)[1]. According to the second definition, the emotional content of sad music can be described, for example, on the two dimensions of valence and arousal (Russell, 1980; see section 3.1 for alternatives to the two-dimensional model of emotion). Moreover, music can be classified as sad based on either the emotion that is perceived or the emotion that

1 These studies refer mainly to classical music, but also include folk music, Indian ragas, jazz, pop, rock, children's songs, and free improvisations.

is evoked, which do not necessarily overlap (see section 3.2). Importantly, the lyrics of songs can additionally contribute to characterize a piece of music as sad, because, for example, they can be linked to sad memories of the listener. The present work employs both definitions of sad music. In particular, Studies 2 and 4 adopt the subjective definition of sad music, which was operationalized by directly asking participants to focus on the emotions felt during listening to the music; Study 3 follows the same approach, but participants were asked to focus on perceived, rather than felt, emotions. Study 1 uses instead a different operationalization of sad music, which relies on both objective (i.e., analysis of acoustical and musical features of sad music examples provided by participants) and subjective (i.e., analysis of participants' music examples through the tagging system supported by the online music database www.last.fm) parameters.

Different musical systems have different structures and ways of conveying emotions. For instance, in Western music major and minor modes are associated with happiness and sadness, respectively (Gagnon & Peretz, 2003). However, in a number of non-Western cultures (especially those in Middle East), the minor mode does not have sad connotations. Hence, sad music's acoustical and musical properties differ across various musical systems and there is a considerable influence of culture on the emotional experience evoked by sad music. Despite culture-specific features, hints at universal cues to sadness in music (as well as to other basic emotions[2]) come from a study of the Mafa tribe in Northern Cameroon (Fritz et al., 2009). In this study, Mafas, who had no prior exposure to Western music, recognized sad (as well as happy and fearful) excerpts of Western music above chance. Furthermore, another study showed that Western listeners can reliably judge whether pieces of Kyrghistani, Hindustani, and Navajo Native American music are happy or sad based on their tempo (Balkwill & Thompson, 1999), highlighting that some universal indicators of emotion (e.g., tempo) appear to work across cultural boundaries[3].

2 For a description of basic emotions see section 3.1.

3 Most cultures share the same acoustical characteristics of happy and sad speech. For example, happy speech is fast and loud, whereas sad speech is slow and subdued. Importantly, music research have brought evidence of parallels between affective cues in speech and music (Bowling, Gill, Choi, Prinz, & Purves, 2010; Juslin & Laukka, 2003), suggesting that people are able to identify the emotional tone of music (from an unfamiliar tonal system) based on its association

Sad music is not only a Western phenomenon typically illustrated by classical music. Fado, a form of Portuguese folk music, is a great example of a musical genre based entirely on both sad acoustical and musical features (e.g., slow tempo, legato articulation, low pitch) as well as sad imagery/lyrics. The essential element of Fado is indeed the so-called *saudade*, a Portuguese word with no direct translation in English that describes an emotional state of melancholy and profound longing for unrealized dreams (similar to the German *Sehnsucht*). Moreover, according to Indian aesthetics, sadness is one of the eight *rasas* or aesthetic essences (specifically the *karuna rasa*). Rasas are defined as the emotional impact[4] that an artwork, such as a piece of music, aims to evoke in the listener (Thampi, 1965). Thus, the widespread presence[5] of sad music and sadness as an aesthetic category suggest that, despite obvious differences due to culture and musical systems, the emotional experience underlying this type of music might tap into important aspects of human emotion. This idea dates at least as far back as Aristotle, who believed that tragic experiences sublimated by art could help people achieve a better state of well-being (see section 2.1).

1.3 Music-Evoked Sadness as "Utilitarian" or "Aesthetic" Emotion

In the field of music psychology, much debate focuses around whether music evokes the same emotions as other stimuli such as faces or speeches (Swaminathan & Schellenberg, 2015). Some researchers support the view that music elicits "utilitarian" or "everyday" emotions (e.g., happiness, sadness), while others argue that music-evoked emotions are artificial and "not real" (e.g., wonder, awe), and thus should be strictly defined as "aesthetic" emotions. "Utilitarian" emotions are goal-oriented cognitive appraisals that motivate adaptive action tendencies, and therefore have obvious material effects on the individual's well-being (Scherer, 2004; Scherer & Zentner, 2008). Instead, "aesthetic" emotions are assumed not to have such effects on

with emotional speech.

4 In Indian aesthetics, the word *rasa* refers to both production and perception of art. *Rasa* expresses the continuity of the subjective experience of the artist with the final consummation and enjoyment of the art piece from the audience.

5 While in Western and Eastern cultures sad music is a ubiquitous phenomenon, a number of African cultures, for example the Mafa, do not have music with acoustic properties that resemble sad Western music.

the individual's well-being.

The enjoyment of sad music has been used as an argument to support the view that music cannot evoke “real” emotions. In everyday life, sadness is experienced as an unpleasant emotion; instead, people usually do not turn off their radio when a sad song is played (Zentner, Grandjean, & Scherer, 2008). Although music-evoked sadness does not appear to overlap with “everyday” sadness at least with regard to its aversive aspects such as grief, empirical evidence from psychology and neuroscience is actually consistent with the position that music can elicit “everyday” emotions. For example, the fact that highly pleasurable music activates subcortical emotional circuits (e.g., Blood & Zatorre, 2001; Menon & Levitin, 2005) offers some confidence that music can arouse “real” emotions (although more nuanced or complex emotional responses to music are likely to involve also cortical processes). Moreover, music can trigger physiological processes that reflect “everyday” emotions (Krumhansl, 1997; Lundqvist, Carlsson, Hilmersson, & Juslin, 2009; for details see section 2.2). Ultimately, “the issue of whether music activates real emotions can only be resolved when we truly understand what real emotions are” (Panksepp, 2009, p. 231). The present work informs the debate on “utilitarian” versus “aesthetic” emotions by empirically investigating the effects of sad music on cognition and emotion and by challenging the assumption that “aesthetic” emotions do not have obvious material effects on the individual's well-being.

1.4 Overview and Research Aims of the Dissertation Project

The current dissertation explores psychological and neural mechanisms underlying listening to sad music and evaluates the role of a number of listener attributes in the enjoyment and perception of sadness induced and expressed by music. The overall aims of this work are to provide a comprehensive understanding of the emotional and cognitive effects of listening to sad music and to contribute to the discussion around what motivates people to seek sad music. Although the paradoxical enjoyment of sad music has recently attracted increasing attention within the field of music and emotion (e.g., Garrido & Schubert, 2011a; Sachs et al., 2015; Vuoskoski & Eerola, 2012), this subject is still poorly understood and there is a lack of a unified theory that accounts for theoretical, psychological, and neuroscientific perspectives.

The next three chapters (Chapters 2-4) provide the theoretical background of the work. They emphasize how theoretical and empirical approaches are interconnected and can benefit from dialogue with each other. The questions raised by sad music encompass such an intricate network of human experiences (emotional, cognitive, social, and aesthetic), that substantial progress in answering these questions can only be achieved through an interdisciplinary approach to research. Chapter 2 reviews the most influential philosophical positions on the enjoyment of sad music, such as Aristotle's theory of *catharsis*, the debate between cognitivists and emotivists, and Levinson's theory on music and negative emotion. Although these philosophical accounts left behind a heterogeneous view of the phenomenon of sad music, they are still capable of informing the current debate. Chapter 3 describes fundamental concepts and theories of emotion, which are necessary to frame the present work in the context of music and emotion research. Moreover, this chapter presents an overview of the current psychological research on sad music and personality traits. In Chapter 4, the intriguing yet complicated relationship between sadness and pleasure in music is considered from a neuroscience perspective. Specifically, the chapter examines neuroimaging research that has identified brain structures involved in music-evoked sadness and “chill” experiences.

The four empirical studies that were conducted for the current dissertation are presented in the empirical part of the thesis (Chapters 5-8). Detailed descriptions of the methods employed in each empirical study are provided in their corresponding chapters.

Study 1 (Chapter 5) aims to clarify previously under-investigated aspects of why people seek sad music through the use of a web-based survey. Specifically, the survey examines the rewarding aspects of music-evoked sadness, the emotions evoked by sad music, the different principles/mechanisms through which sadness is evoked, and the relative contribution of listener characteristics as well as situational factors to the enjoyment of sad music. Furthermore, a comparison between the motivations for listening to sad and happy music is carried out, which helps to clarify the unique emotional and cognitive experiences associated with sad music. The findings from this study reveal sad music's potential for regulating negative moods and emotions as well as for providing consolation, and draw a comprehensive picture of the situational factors of exposure and the personality traits contributing to the enjoyment of sad music.

Study 2 (Chapter 6) builds on the finding that one reason why people choose to engage with sad (but not happy) music is to enhance introspection (Study 1). Introspection requires internally-oriented cognition, which is typical of mind-wandering. Therefore, the goal of this study is to test whether sad music, compared with happy music, stimulates mind-wandering (Experiment 1) and engages the brain's default mode network (Experiment 2), which has been consistently indicated as the neural substrate of mind-wandering. Experiment 1 employs a thought sampling paradigm and Experiment 2 uses fMRI. The findings from these two experiments are the first to show effects of music-evoked emotion on specific type of mental activity such as mind-wandering, opening a novel and highly relevant line of future research.

Listener characteristics are further explored in Study 3 (Chapter 7), which specifically addresses whether the perception of sadness (as well as other basic emotions) in music is modulated by individual differences in empathy, alexithymia, personality traits, and musical expertise. Importantly, the findings of this study suggest that alexythimia is associated with difficulties in the perception of emotions conveyed by music.

Study 4 (Chapter 8) extends Study 1 by testing whether individual differences in trait empathy are associated with the spontaneous recruitment of empathy-related brain regions while participants listened to sad, compared with happy, music. Using eigenvector centrality mapping (ECM) in combination with functional connectivity (FC) analyses, the findings reveal a distributed network of brain areas encompassing ventromedial prefrontal cortex (vmPFC), dorsomedial prefrontal cortex (dmPFC), primary visual cortex (V1), bilateral claustrum (CL), and cerebellum (CB). These findings inform current neural models of empathy and provide novel evidence for a role of the claustrum in music-empathy.

Lastly, Chapter 9 discusses the results of the four empirical studies and their implications for the use of sad music in both healthy individuals and clinical populations. Based on the findings of this dissertation a novel heuristic model of listener characteristics and contextual factors contributing to emotional responses and psychological effects of sad music is proposed (the SADMUS model). The SADMUS model summarizes the state-of-the-art in this field of research and can be used to generate hypotheses for future research on the topic of sad music.

Chapter 2

Philosophical Perspectives[1]

When talking about aesthetic and emotional responses to nominally sad music, there are two main questions philosophers have been concerned with. The first question, which is referred to as the “paradox of sad music”, asks: Why do people find pleasure in sadness through music, given that in everyday life sadness is generally avoided? This paradox is one particular variant of the more general “paradox of tragedy”, which relates to all art forms and is one of the oldest philosophical problems still under debate. The second question, the so-called “paradox of fiction”, expresses puzzlement over how people can experience emotion at all in response to artworks given that they are fully aware that the works are fictional, and therefore that there is no one who is actually undergoing the emotional experiences expressed by the work. To phrase the question in another way, do people feel genuinely sad when they listen, for example, to Mahler's *Adagietto* from the *5th Symphony*? It is important to disentangle the “paradox of tragedy” from the “paradox of fiction”, since they refer to related yet not overlapping issues. On the one hand, there is the question regarding the enjoyment of negative emotions through art (“paradox of tragedy”) and on the other hand, the question about people's emotional capabilities with regard to art (“paradox of fiction”). This chapter examines the most important philosophical stances taken throughout the centuries on both questions, with examples mainly from music, but also from other art forms.

2.1 The Tragedy Paradox: Aristotle’s Catharsis

In its general form, the “paradox of tragedy” is concerned with how we can experience delight from fictional works representing unpleasant events, given that we

1 A version of chapters 2-4 will be published as a book chapter: Taruffi, L., & Koelsch, S. (in press). Why we listen to sad music: Philosophical perspectives, psychological functions and underlying brain mechanisms. In Gouk, P., Prins, J., Thormaehlen, W., & Kennaway, J. (Eds.), *The Routledge Companion to Music, Mind and Wellbeing: Historical and Scientific Perspectives*.

don't do so when such events are “real”. For instance, we generally avoid things or situations that are upsetting or fear-inducing. Similarly, no one would take pleasure in the loss of a loved one. On the contrary, “people apparently take great delight in watching and hearing about people in hideously unhappy situations and undergoing terrible suffering” (Robinson, 1997, p. 18). As an example, consider the tale of Antigone written by Sophocles in 441 BC. Antigone's brother, Polyneices, was killed in the battle to conquer Thebes and was not granted a funeral ceremony by his uncle Creon, king of Thebes. Antigone, moved by love for her brother and convinced of the injustice of her uncle Creon’s decision, buried her brother secretly. For this reason, Creon ordered her execution. She was confined to a cave, where she finally hanged herself. Because people for centuries have engaged with similar tragic artworks with a sense of pleasure (not only tragedies, but also music, dance, movies, novels, paintings, etc.), it is important to explain what “tragic pleasure” is.

Before David Hume offered the classic formulation of the “paradox of tragedy”[2], central aspects of this conundrum were already identified centuries before by Aristotle, who briefly wrote about it in his *Poetics* (1986). Aristotle’s approach to the “paradox of tragedy” - the so-called theory of *catharsis* - consists of interpreting the quest for sorrow as an attempt to find relief from negative emotions. In other words, the function of tragedy is to release a certain amount of negative emotion that was evoked by the tragedy itself in the first place. Scholars have generally used the term *purgation* to highlight the psychological and therapeutic effects of *catharsis*: The expressive emotional features of tragedy offer people the possibility of venting negative emotion that they are afflicted with, thus improving their overall well-being (Lear, 1988; Nussbaum, 1992; Rorty, 1992; Shelley, 2003). As Study 1 shows (see Chapter 5), people report to commonly use sad music to achieve different self-regulatory goals, including venting of negative emotions and moods. In this regard Michael Trimble wrote that “crying in such settings (aesthetic contexts) brings

2 “It seems an unaccountable pleasure, which the spectators of a well written tragedy receive from sorrow, terror, anxiety, and other passions, that are in themselves disagreeable and uneasy. The more they are touched and affected, the more are they delighted with the spectacle; and as soon as the uneasy passions cease to operate, the piece is at an end.” (Hume, 1757, *Dissertation III Of Tragedy,* p. 187)

pleasure and relief, and seems to have been doing so for well over 2,000 years" (Trimble, 2012, p. 5). Through the release of sorrow or other negative emotions, the emotional equilibrium can be restored.

2.2 The Cognitivist Take on Music-Evoked Sadness

Another answer to the longstanding philosophical discussion on the "tragedy paradox" was provided by the "cognitivist" philosophers in the last century, and it specifically dealt with musical emotions. Cognitivists argued that when we listen to nominally sad music, we do not experience genuine sadness at all, but we merely recognize the sadness depicted by the music (Kivy, 1990; Scruton, 1999). In other words, the cognitivists' position on the "paradox of sad music" stems indirectly from their stance on the "paradox of fiction". That is, by denying that listeners respond emotionally to sad music, the problem of the enjoyment of sadness through music is consequently eliminated (if I am not saddened by sad music then it is not paradoxical that I enjoy it). So, what really happens when we listen to sad music? As Peter Kivy explained (1989), listeners misunderstand the emotional qualities portrayed by the music with their felt emotion (i.e., they falsely attribute "felt" to "perceived" emotion, see section 3.2). To better illustrate this idea, in the *Corded Shell* (1980) he distinguished between being "expressive of" (perceived emotion) and "expressing" (felt emotion). For instance, most people see the face of a Saint Bernard as melancholic, because the corners of its eyes are typically turned down. However, the fact that the dog's face is "expressive of" melancholy does not imply that the dog feels melancholic, something which we cannot assert. Instead, a person scowling and shouting is said to "express" genuine anger, because the person is actually angry. Similarly, sad music is "expressive of" sadness, rather than "expressing" sadness[3]. In this sense, the cognitivist theory relies on the fact that sad music's expressive properties resemble verbal expressions of sadness and bodily movements experienced when such emotion is evoked. For example, acoustic properties of sad music, like low volume, slow tempo, or minor mode, imitate the sadness expressed in the voice and/or behavior of people (Juslin & Laukka, 2003). However, even if listeners

3 According to Kivy, "felt" and "perceived" sadness are independent of each other.

misunderstand the sadness depicted in Barber's *Adagio for Strings* with their own sadness, how can Kivy's theory account for intense emotional responses, such as crying, often reported by listeners? Kivy acknowledged that people can still feel deeply moved by a piece of sad music; however, such feeling of "being moved" is due to the beauty of the music rather than to its emotional quality (e.g., being sad or happy).

The opposite view of cognitivism is "emotivism". Emotivists agreed that when perceiving music we react affectively and that there is a link between perception and induction of emotion[4]; most importantly, sad music induces an emotion similar to "real" sadness, although it is not clear to what extent they overlap (Levinson, 1997; Robinson, 1994). As mentioned in the previous chapter, "utilitarian" emotions are goal-oriented and have an intrinsic significance (i.e., a survival value) for people's lives. For instance, in the case of a failure in something personally relevant, sadness enhances our rational understanding of things and allows us to rest and adapt to the difficult circumstance. Given the relevance of sadness to our lives as biological organisms, does music-evoked sadness have the same significance? In this regard, empirical research showed that listeners not only recognize expressions of musical sadness, but they also undergo physiological changes (Krumhansl, 1997) and facial muscle activity (specifically activity over the muscle region of *corrugator supercilii*, which is used when frowning; Lundqvist et al., 2009) during listening to sad music. Such autonomic and muscolar activity are important components of emotion[5]. In particular, Krumhansl (1997) found that listening to sad music is linked to a decrease in heart rate, skin conductance, and temperature, consistently with the physiological response patterns of non-crying "real" sadness (Kreibig, 2010). Therefore, the manifestation of such physiological and expressive components of emotion during listening to sad music strongly supports the emotivist position in the debate on the

4 Specifically, the recognition of an emotion in music may often lead, although not necessarily, to the arousal of the same emotion in the listener.

5 According to Scherer (2000, 2005) emotions are manifested in the following components: *subjective feelings* (subjective experiences of emotional states), *physiological responses* (bodily symptoms of the undergoing emotion), *expressive behaviors* (facial or vocal expressions of a specific emotion), *action tendencies* (preparation and direction of motor responses), and *cognitive appraisals* (evaluations of the events and circumstances behind the emotional state experienced).

authenticity of music-evoked sadness ("paradox of fiction").

2.3 Rewards of Negative Emotions: Levinson

A different solution to the problem of sad music was provided by Jerrold Levinson (1997), who shared a view close to the emotivists. He indeed agreed that, even though there is a difference between music-evoked sadness and ordinary sadness, we nevertheless feel "sad" when listening to sad music; thus, the paradox still deserves an explanation. He proposed that eight different types of reward explain sad music's appeal[6]. First, he shared Goodman's observation (1968) that sad and emotionally intense responses to music facilitate our grasp of the expressive qualities of a musical work. Second, he acknowledged the Aristotelian theory of *catharsis,* that sad music can have a therapeutic effect, consisting in venting sadness and sorrow. To understand the remaining rewards of sad music, it is necessary to explain that, according to Levinson, music-evoked sadness is not a full-fledged emotion but rather an "etiolated" one, because it does not have an intentional content (i.e., an object to which the emotion is directed to). For instance, to feel sad in "ordinary life", one must know that there is something (an intentional object) that is painful or sorrowful, such as the death of a loved one. Instead, when we are saddened by sad music, we are not sad about "something" (that is, nothing has happened in "real-life"). Therefore, the difference between ordinary sadness and music-evoked sadness lies in the absence of a cognitive component of emotion in music-evoked sadness, or more precisely in the absence of "real-life" implications. In fact, "there is still a cognitive dimension to this emotion (i.e., music-evoked sadness), but it has an indeterminate focus: I imagine that there is something I am sad about and that I believe some situation or other to be unfortunate, but there is nothing in *particular* I am sad about nor is there any *particular* situation that I believe to be unfortunate" (Robinson, 1997, p. 19). Despite such differences, the qualitative experience of music-evoked and ordinary sadness, including its subjective feeling and the correlated bodily sensations, are still comparable. Therefore, because of its lack of "real-life" implications, we are able to

6 These rewards apply also to any other type of music evoking negative emotion, such as fearful- or angry-sounding music.

enjoy music-evoked sadness by: 1) savoring the qualitative aspects of sadness for its own sake, as a sommelier does when tasting wines (*reward of savoring feeling*); 2) understanding the feeling of sadness more clearly on its own (*reward of understanding feeling*); 3) reassuring ourselves about our ability to feel intense emotions (*reward of emotional assurance*). Furthermore, in Levinson's view, evocation of sadness through music is possible through empathic processes, largely based on the ability to imagine the music as a person[7]. As Levinson explained: "When we identify with music that we are perceiving - or perhaps better, with the person whom we imagine owns the emotions or the emotional gestures we hear in the music – we share in and adopt those emotions as our own, for the course of the audition" (Levinson, 1997, p. 228). Therefore, because the evocation of sadness is linked to imaginary processes, we are able to take pleasure in music-evoked sadness by: 1) deriving a sense of control and mastery that arises from identifying ourselves with sad music that resolves happily (*reward of emotional resolution*); 2) identifying with the music to the point of imagining oneself to have the same richness and spontaneity of the sadness expressed by music (*reward of expressive potency*); 3) sharing the sadness of another human being such as the composer (*reward of emotional communion*). At present, it is unknown whether Levinson's eight benefits are actually experienced by listeners during exposure to sad music. To address this question, Study 1 (Chapter 5) features an empirical test of Levinson's theory. Furthermore, Study 4 (Chapter 8) examines empathic responses to sad music from a neuroscience perspective.

7 This refers to the hypothesis of a "musical persona", which is the sad person "in the music" with whom I am identifying when listening a sad musical piece.

Chapter 3

Psychological Research[1]

This chapter provides the background necessary to place the current work in the context of music and emotion research. The prominent models of emotions are outlined and discussed in terms of their relevance to research on sad music. The concepts of “perceived” and “felt” emotions are presented along with a description of the different principles of emotion evocation by music. The chapter concludes with an overview of the empirical research on sad music. Even though the “paradox of sad music” is not new, only recently psychologists have started to investigate the subject, focusing in particular on the role of individual differences in personality traits in the enjoyment of sad music (Garrido & Schubert, 2011a; Vuoskoski & Eerola, 2012; Vuoskoski, Thompson, McIlwain, & Eerola, 2012).

3.1 General and Music-Specific Emotion Models

An important issue to consider in the investigation of the emotional experiences underlying listening to sad music involves the structure and the classification of emotions. The two dominant emotion models in music and emotion research are the discrete (or basic) and the dimensional models (Eerola & Vuoskoski, 2011; Zentner & Eerola, 2010). The first asserts that emotions are discrete and fundamentally different constructs, while the second characterizes emotions on different core dimensions.

The discrete model of emotion is based on the notion of “basic emotions”, a small number of innate and universal emotions, such as fear, anger, sadness, happiness, surprise and disgust, from which all other “complex” emotions derive (Ekman, 1977, 1992, 1999; Izard, 2007). For instance, contempt derives from the combination of the two basic emotions of anger and disgust. The discrete approach to

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emotion is tightly related to the idea that each basic emotion is linked to a separate neural system, and thus has evolved as an hardwired psychological mechanism associated with a biological function (Panksepp, 1998, 2005). In this regard, the discrete model of emotions builds on Charles Darwin's evolutionary perspective on emotion. In his book *The Expression of the Emotions in Man and Animals* (1872), Darwin portrayed emotions as a set of different mechanisms enhancing the fitness and the reproductive value of an organism, which have evolved by natural selection. According to this approach, each emotion holds an important adaptive function. For example, sadness, which is the response to the loss of an object or a person to which we were very attached (Ekman & Cordaro, 2011), encourages re-evaluation, recovery as well as detail-oriented thinking and attracts social support (Izard, 2000). In music and emotion research, the discrete model has been often adapted to better represent the affective responses to music (Eerola & Vuoskoski, 2011). In particular, disgust, which is not a common music-evoked emotion, is generally replaced by tenderness (Balkwill & Thompson, 1999; Eerola & Vuoskoski, 2011). Nevertheless, it has been suggested that basic emotions are not adequate to capture the richness and complexity of emotional responses to music and that music appears capable of inducing a much more nuanced range of affective states (Zentner et al., 2008).

According to the dimensional model of emotion, basic emotions are not core affective building blocks and can be further dissociated in a number of continuous dimensions (Russell, 1980, 2003; Watson, Wiese, Vaidya, & Tellegen, 1999). The first dimensional model of emotion was put forward by Wilhelm Wundt in 1896 and was based on the three dimensions of valence (positive-negative), arousal (calm-excited), and tension (relaxed-tense). The two-dimensional model of emotion comprising the orthogonal dimensions of valence and arousal (often referred to as “circumplex” model; Posner, Russell, & Peterson, 2005; Russell, 1980) is however the most common dimensional model in emotion research, and in general the inclusion of a third dimension has been inconsistent (e.g., Osgood, Suci, & Tannenbaum, 1957; Schlosberg, 1954). Despite their wide acceptance in emotion research (Bigand, Vieillard, Madurell, Marozeau, & Dacquet, 2005), dimensional models can sometimes be problematic for the understanding of the complexity of musical expressivity

(Collier, 2007), similarly to discrete models. Consider for example nostalgia, which is a mixed emotion featuring both positive and negative facets, often evoked in response to music (Zentner et al., 2008). According to the dimensional approach, the only way to map nostalgia onto a bipolar valence dimension is to place it in the middle of the scale making it, however, indistinguishable from a neutral affective state (Larsen & Stastny, 2011). A similar problem applies to music-evoked sadness, whose valence tends to be blended.

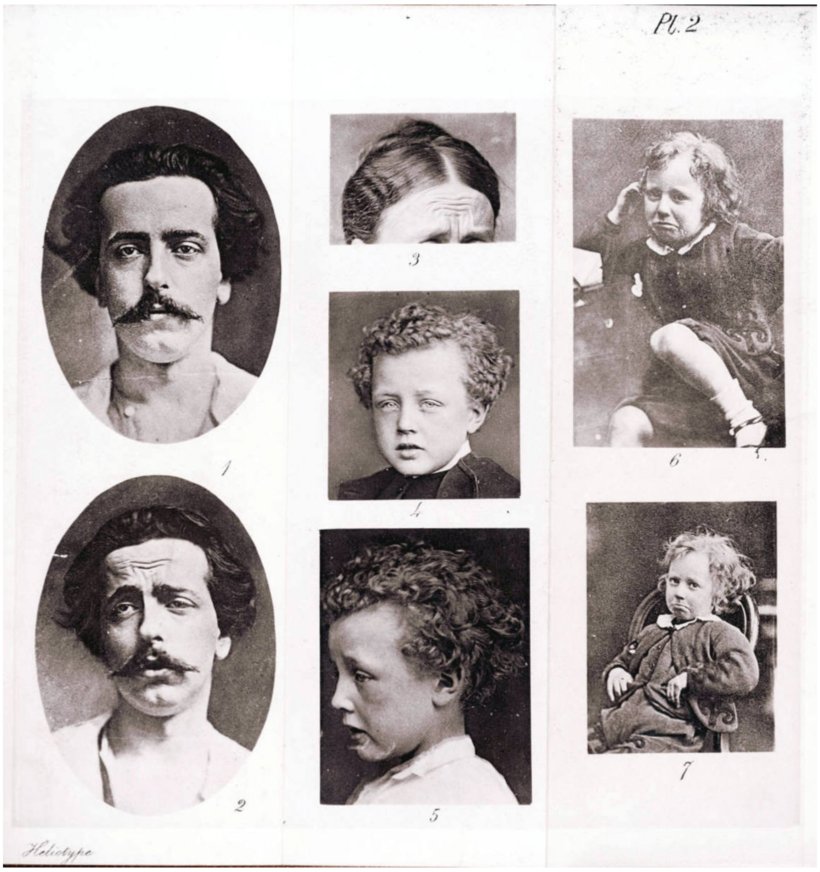

Figure 3.1. *Illustrations of grief from Darwin's book "The Expression of the Emotions in Man and Animals".*

A valuable contribution to the understanding of music-specific affects is the Geneva Emotional Music Scale (GEMS; Zentner et al., 2008), which provides more nuanced information about music-evoked emotions compared with the domain-general models described above (Eerola & Vuoskoski, 2011). This model is the result of a series of field and laboratory experiments, in which listeners were asked to rate the emotions evoked in response to different styles of music on an extensive list of adjectives. The GEMS includes the following nine emotion categories: wonder, transcendence, tenderness, nostalgia, sadness, peacefulness, power, joyful activation, and tension. These categories condense into three main factors named sublimity, vitality, and unease. While vitality and unease can be more easily linked to the dimensions of arousal and valence, sublimity appears to be highly specific to the aesthetic domain (Trost, Ethofer, Zentner, & Vuilleumier, 2012). The GEMS may be particularly useful for the investigation of the affective responses to sad music, because anecdotal evidence suggests that sad music is generally experienced as one of the most beautiful types of music (Gabrielsson & Lindström, 1993), thus having strong aesthetic connotations. Interestingly, Trost and colleagues (2012) investigated the neural substrates of "aesthetic" emotions induced by music, as measured by the GEMS. By using parametric regression analyses based on the intensity of the experienced emotions, they found a differentiated recruitment across emotions of networks linked to reward, memory, self-reflection, and sensori-motor processes (Trost et al., 2012)[2]. These findings are of particular importance because they illustrate the impact of music-evoked emotions on brain systems that are not primarily "emotion" areas. In this regard, Study 2 (Chapter 6) extends the findings of Trost and colleagues (2012) by showing that sad music engages a large-scale brain network such as the default mode network (DMN).

In the present work, the GEMS was chosen to assesses emotional responses to sad music in everyday life (Study 1). The use of this model allowed to unveil that emotional experiences in response to sad music involve also a range of pleasurable, sublime emotions. To compare the effects of music evoking sad and happy feelings on mind-wandering (Study 2), the combined use of the discrete and dimensional models was instead preferred. Likewise, a combination of the discrete and dimensional models[3] was chosen to investigate empathic processes in response to sad music (Study 4). Finally, the discrete model was employed to examine the role of individual differences in the recognition of happiness, sadness, tenderness, fear, and anger

2 For a more detailed discussion of the results of Trost et al. (2012) see section 4.1.
3 In Studies 2 and 4, the focus was only on the two emotions of sadness and happiness.

conveyed by excerpts of film music (Study 3).

3.2 "Perceived" and "Felt" Sadness

In music and emotion research, it is important to distinguish "perceived" from "felt" emotion. The first term refers to the emotion expressed by the music, and consequently perceived and interpreted by the listener, whereas the second refers to the emotion evoked in the listener by the music. Perceived and felt emotion do not always overlap. For example, a music piece conveying sadness may not necessarily evoke sadness. Therefore, perceived and felt emotions can have a "positive" relationship (a listener feels sad in response to sad music) or a "negative" relationship (a listener does not feel sad in response to sad music) (Gabrielsson, 2002). The latter possibility was investigated by a study in which participants listened to three excerpts of sad music (defined as music in minor key) and rated their perceived and felt emotions (Kawakami, Furukawa, Katahira, & Okanoya, 2013). The results revealed a dissociation between perceived and felt emotions, with perceived emotions being mostly characterized by "tragic" feelings and felt emotions by "romantic" feelings. These findings indicate that felt emotions (compared with perceived emotions) are more ambivalent in terms of valence, and support the argument that sad music can elicit pleasurable affective experiences.

3.3 The Principles Underlying Emotion Evocation by Music

Juslin and Västfjäll (2008; see also Juslin, Liljeström, Västfjäll, & Lundqvist, 2010) suggested six mechanisms or principles responsible for the evocation of emotion with music: 1) *brain stem reflexes* (the acoustic properties of the music signal to the brain stem a potentially important and urgent event), 2) *evaluative conditioning* (a process of evoking emotion with music that has been paired repeatedly with other positive or negative stimuli – i.e., learned associations), 3) *emotional contagion* (the listener internally mimics the emotion expressed by a piece of music), 4) *visual imagery* (music evokes images with emotional qualities), 5) *episodic memory* (music evokes a memory of a particular event in the listener's life), 6) *musical expectancy* (the listener's expectations on the unfolding of a music piece are either confirmed, violated, or suspended; this principle was firstly proposed by Leonard Meyer in 1956 in the book *Emotion and Meaning in Music*).

Additional principles were later on suggested and include, for example, *cognitive appraisal* (the evaluation of the music's implications for the goals, needs and well-being of the listener; Juslin et al., 2010; Scherer, 2000), *rhythmic motor entrainment* ("a biological mechanism that synchronizes body oscillators to external rhythms, including music"; Scherer & Zentner, 2008, p. 596), and *social functions* (music making, and to a certain extent also music listening, involve a number of social functions such as contact, social cognition, co-pathy, communication, coordination, cooperation, and social cohesion; Koelsch, 2012).

As for the specific case of evocation of sadness by music, it still remains to be specified whether there are core sadness-induction principles among the ones highlighted above. This issue is addressed in Study 1 of this dissertation (see Chapter 5).

3.4 Personality Traits

When it comes to sad music, people tend to express a variety of different opinions. Many listeners report enjoying sad music, while other people express aversion to it (Garrido & Schubert, 2011a). Likewise, the susceptibility to music-evoked sadness appears to change according to personal factors: Some people often cry while listening to the main theme from *Schindler's List*, others don't. Thus, the investigation of personality variables can provide a more comprehensive view of the phenomenon of enjoyment of sad music.

A previous study found that the trait dimension of absorption predicts the enjoyment of sad music (Garrido & Schubert, 2011a). This trait describes a propensity to become absorbed in mental imagery, much similar to daydreaming or mind-wandering. Absorption allows an individual to fully commit to an attentional object[4] and to disengage with the "external" situation or conditions that are unrelated to that object. The cognitive component of this personality dimension is characterized

4 It can also be an imaginary object.

by an ability to create vivid mental representations and to empathetically engage with them (Tellegen & Atkinson, 1974). Similarly, absorption correlates with a fantasy-prone personality (Roche & McConkey, 1990) and can facilitate consciousness alteration (Studerus, Gamma, Kometer, & Vollenweider, 2012). The relation between the cognition mode typical of absorption and the enjoyment of sad music is particularly interesting because it points to possible effects of this type of music on mental processes (which are discussed in detail in Chapter 6).

The trait empathy (a personality trait that characterizes individuals with a tendency to experience empathy more readily than others across different situations) also appears to play a role in both the enjoyment of and the sensitivity to sad music. For instance, individuals with high empathy scores[5] enjoy sad music more and experience sadness more intensively through music compared with individuals with low empathy scores (Vuoskoski & Eerola, 2012; Vuoskoski et al., 2012). Vuoskoski and colleagues (2012) proposed that both aspects (i.e., enjoyment of sad music and music-evoked sadness) are related to empathy in the following manner: Sad music induces stronger emotional experience in empathic people, which in turn leads to greater enjoyment. According to this view, the pleasurable aspects of sad music listening are related to a change in emotional arousal. Although one would actually expect that empathic individuals, who are particularly vulnerable to portrayals of suffering, would be especially likely to avoid this type of entertainment, Vuoskoski's proposal (2012) is instead consistent with previous findings from cinema research (de Wied, Zillmann, & Ordman, 1995). Specifically, de Wied and colleagues (1995) showed that individuals with high empathy experienced more empathic distress while watching a drama than individuals with low empathy, but also enjoyed the film as a whole more than individuals with low empathy did.

The above-mentioned studies focused only on felt sadness. However, the influence of personality traits on perceived sadness remains unknown. Study 3 aims to close this gap in the literature. Aside from investigating the relationship between personality traits and enjoyment of sad music, it is also important to examine possible

5 Empathy was measured by the self-report questionnaire Interpersonal Reactivity Index (IRI; Davis, 1980).

factors modulating this link. In this regard, Study 1 investigates whether the association between enjoyment of sad music and trait empathy varies according to the current mood of the listener. Finally, an examination of the neural correlates of trait empathy can help identify core psychological processes underlying this ability, which may be particularly triggered by sad music as suggested by the correlation between trait empathy and music-evoked sadness (Vuoskoski & Eerola, 2012; Vuoskoski et al., 2012). Thus, Study 4 tests whether individuals with the predisposition to empathize (as measured by the IRI) exhibit neural activity in brain regions involved in empathy in response to sad music.

Chapter 4

Brain Imaging Studies[1]

The advent of modern neuroimaging methods, in particular fMRI, has opened a new chapter in the study of music and emotion, by offering a non-invasive methodology for investigating affective processes in the brain evoked in response to music. For instance, neuroimaging studies have already proven a great deal about the nature of musical reward. However, the relationship between music-evoked sadness and pleasure has not yet been addressed in a unified experimental paradigm. This chapter reviews the findings from two areas of investigation: music-evoked sadness and reward. The chapter also underlines how the examination of brain networks underlying listening to sad music promises novel insights into emotional and cognitive experiences evoked by music.

4.1 Neural Correlates of Music-Evoked Sadness

Over the past ten years, a number of functional neuroimaging studies have used sad and happy music[2] to investigate neural correlates of music-evoked sadness and happiness (Brattico et al., 2011; Caria, Venuti, & de Falco, 2011; Green et al., 2008; Khalfa, Schon, Anton, & Liégeois-Chauvel, 2005; Mitterschiffthaler, Fu, Dalton, Andrew, & Williams, 2007; Trost et al., 2012). These studies have pointed to a number of key emotion-related structures, which may play a major role in music-evoked sadness. For instance, Mitterschiffthaler and colleagues (2007) found that music-evoked sadness was related to increased BOLD signal responses in limbic structures such as the hippocampus and amygdala. Activity in the hippocampus during music-evoked sadness was corroborated by Trost and colleagues (2012).

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2 Music stimuli encompassed excerpts of instrumental music inducing sad and happy emotional states, participants-selected sad and happy music, melodies in minor and major mode, and famous excerpts of sad and happy Western classical music.

Furthermore, contrasting sad music with lyrics with sad music without lyrics (Brattico et al., 2011) revealed activity in the bilateral amygdala and the right parahippocampal cortex, consistent with the results of Mitterschiffthaler et al. (2007). Moreover, contrasting sad with neutral music also revealed activity in the bilateral insula (Caria et al., 2011). Finally, the processing of sad music also correlated with activity in cortical structures. In particular, activations of the anterior medial prefrontal cortex (BA 9/10) were reported for minor music in contrast to major music (Green et al., 2008; Khalfa et al., 2005) and for sad music with lyrics in contrast to sad music without lyrics (Brattico et al., 2011). Further, activation of the ventromedial prefrontal cortex was reported in response to excerpts of classical music evoking sadness (Trost et al., 2012).

Despite the fact that these findings certainly point to a number of relevant brain structures, it should be mentioned that several methodological inconsistencies and problems of the above-mentioned studies make it difficult to compare their results and to disentangle the effects of music-evoked sadness from other factors. For example, the use of well-known excerpts of Western classical music such as the *Adagio in G minor* of Albinoni (Mitterschiffthaler et al., 2007) is problematic because familiarity with the music was not assessed. Familiarity can easily mediate extra-musical associations and has been proven to strongly affect emotional experiences underlying music listening (Pereira et al., 2011), thus it is an important variable to consider in such studies. Moreover, although a few studies used major and minor mode to convey happiness and sadness (Green et al., 2008; Khalfa et al., 2005), overall sad- and happy-sounding stimuli were not matched for important acoustical properties such as tempo or timbre (Brattico et al., 2011; Khalfa et al., 2005; Mitterschiffthaler et al., 2007) and, therefore, largely differ among their acoustical and musical properties, making it difficult to estimate the contribution of minor and major mode to music-evoked sadness and happiness.

Box 1. Functional Magnetic Resonance Imaging (fMRI)

The brain consumes 20% of the body's oxygen uptake; it does not store oxygen and only little glucose. Most of the brain's oxygen and energy needs are supplied from the local blood supply. When the metabolic activity of neurons increases, the blood supply to that region increases to meet the demand, and oxygenated blood is converted to deoxygenated blood (oxygen is carried by the hemoglobin molecule in red blood cells). Differently from oxyhemoglobin (hemoglobin carrying oxygen), deoxyhemoglobin (hemoglobin that has dispensed its oxygen) has strong paramagnetic properties and can introduce distortions in local magnetic fields. fMRI is a non-invasive method that records such temporary changes in brain physiology, which are associated with cognitive functions, by taking advantage of the earlier MRI scanning technology as well as the different magnetic properties of oxygenated and deoxygenated blood. Specifically, fMRI measures regional levels of blood oxygen by detecting magnetic changes in red blood cells when they become deoxygenated. The measurement of this blood oxygen level-dependent (BOLD) signal allows for an indirect assessment of neuronal activity. The way that the BOLD signal evolves over time in response to an increase in neural activity is called the hemodynamic response function (HRF). Compared to other non-invasive methods, the spatial resolution of fMRI is relatively high (around 1 mm depending on the size of the voxel); however, the temporal resolution is constrained by the time needed to measure the signal (generally 1-3 seconds for an image of the whole brain). One disadvantage of fMRI is that some brain regions (e.g., the orbitofrontal cortex that is near to the sinuses) are hard to image and are susceptible to distortions because their tissues have different magnetic properties. Other difficulties are the noisy environment and artifacts due to small movements of the participants.

Despite such limitations, most of the brain structures highlighted by this literature have been found to correspond to the neural correlates of sadness elicited in response to stimulus material other than music (i.e., faces, pictures, and recall of personal sad events; Côté et al., 2007; Damasio et al., 2000; George et al., 1995; Liotti et al., 2000; Pelletier et al., 2003; Posse et al., 2003; Schneider, Habel, Kessler, Salloum, & Posse, 2000; Wang, McCarthy, Song, & LaBar, 2005). Nevertheless, further research is required to understand how such structures functionally interact with each other[3]. Specifically, it will be important to clarify whether their functional relationship

3 In the analysis of neuroimaging data, functional connectivity is defined as the correlation between spatially remote neurophysiological events. In other words, the concept refers to the connectivity

is the same for music-evoked sadness and "real" sadness. By addressing this issue, a substantial contribution can be made to the current debate about the nature of musical emotions, whether they are "aesthetic" or "real" emotions (Konečni, 2008; Noy, 1993; Scherer, 2004; see section 1.3).

4.2 Functional Networks Underlying Listening to Sad Music

The investigation of brain networks underlying listening to sad music may also unveil precious information about the emotional and cognitive processes at play when people listen to sad music. Previous behavioral research has pointed to a wide range of functions of music listening in everyday life, including social, emotional, aesthetic and cognitive functions (Chamorro-Premuzic & Furnham, 2007; Schäfer, Sedlmeier, Städtler, & Huron, 2013). However, it still needs to be specified how these uses of music change according to the type of music. For example, the uses of sad and happy music are likely to differ to a large extent, given their contrasting acoustical properties. Similarly, the different functions associated with sad and happy music are likely to be represented on a neural level by the engagement of fairly different neural networks in the brain. In this regard, the current dissertation puts forward the idea that an "introspective" use of sad music corresponds on a neural level to the engagement of the DMN (see Chapter 6). The DMN is a network of brain regions associated with internal mentation[4]; it was originally identified by its consistent activity increases during passive states as compared with various active tasks (Greicius, Krasnow, Reiss, & Menon, 2003; Gusnard & Raichle, 2001; Raichle et al., 2001). The DMN exhibits strong negative activity correlations with brain systems dedicated to focused external attention (see Fig. 4.1), suggesting that the brain shifts between an "internal" and an "external" mode of information processing (Buckner, Andrews-Hanna, & Schacter, 2008). The different neuroimaging approaches employed to identify the DMN, including block and event-related paradigms (Mazoyer et al., 2001; Shulman et al., 1997) and intrinsic activity correlations (Fox et

between brain regions that share functional properties.

4 "Internal mentation" describes a cognitive state in which the attention is primarily focused on internal objects such as thoughts and feelings, while "external mentation" describes a cognitive state in which the attention is primarily focused on the external environment.

al., 2005), have provided similar estimates about its anatomy and suggest that the DMN comprises multiple interacting hubs and subsystems (Buckner et al., 2008). Andrews-Hanna and colleagues (2010b) directly examined the intrinsic functional architecture of the DMN by using resting state functional connectivity, graph analysis and hierarchical clustering techniques. They found that the DMN features a midline core (posterior cingulate and anterior medial prefrontal cortex) and two distinct subsystems (medial temporal lobe and dorsomedial prefrontal cortex). The DMN is known to be involved in spontaneous self-generative thought or mind-wandering (Andrews-Hanna, Reidler, Huang, & Buckner, 2010a; Christoff, Gordon, Smallwood, Smith, & Schooler, 2009; Mason et al., 2007; Mittner et al., 2014), including introspection as well as memory-based constructions/simulations (Andrews-Hanna et al., 2010b; O'Callaghan, Shine, Lewis, Andrews-Hanna, & Irish, 2015). In sum, fMRI data analyses aiming at unveiling brain networks, such as functional connectivity or eigenvector centrality mapping (ECM; see Box 2), may yield a great deal of information about the various functions achieved through music listening especially when the ecological validity of the experimental settings is kept similar to that of everyday music listening experiences (e.g., long blocks of music).

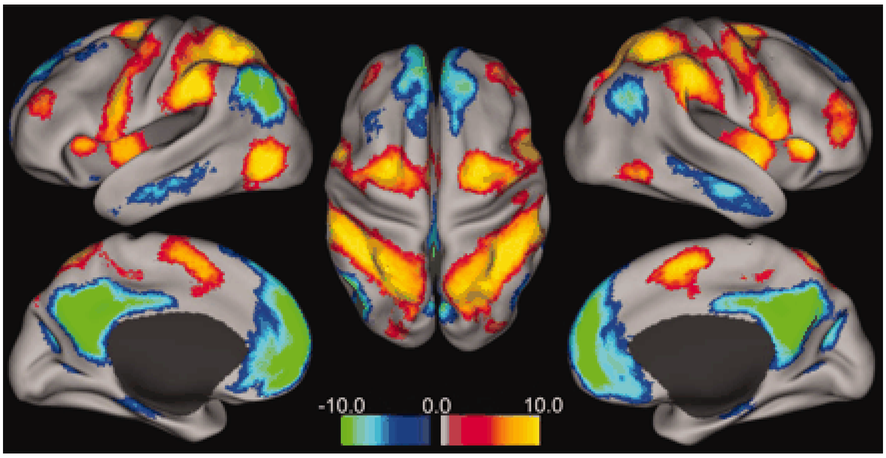

Figure 4.1. *Resting state functional connectivity reveals two widely distributed anticorrelated brain networks reflecting internal and external mentation modes.* The task-negative/default mode network, shown in cool colors, consists of regions routinely exhibiting task-related deactivations; the task-positive network, shown in warm colors, consists of regions routinely exhibiting task-related activations. Taken from Fox et al. (2005), Fig. 3.

Box 2. Eigenvector Centrality Mapping (ECM)

ECM is a graph-based network analysis technique for fMRI data (Lohmann et al., 2010). It is a data-driven and model-free method, which measures the importance of network nodes. ECM attributes a value to each voxel (3x3x3 mm) in the brain such that a voxel receives a larger value if it is more strongly correlated with many other voxels which are themselves central within this network. ECM is computationally fast and does not depend on a pre-specified threshold for correlation values; it can capture small-world characteristics of the human brain, which other methods (e.g., degree centrality) cannot. ECM can be applied to the whole brain or to a set of regions of interest. This analysis produces a map in which each location has a centrality value; such map can be used for further analysis, like functional connectivity or psycho-physiological interaction (PPI) analyses. One requirement of ECM is that experimental trials need to be quite long (in the range of minutes); this makes ECM particularly suitable to be employed in emotion research (emotions and moods require a certain time to unfold).

4.3 Musical Reward

It is now well established that listening to pleasurable music engages the core reward network of the brain (the mesolimbic dopaminergic reward pathway). The first empirical evidence of such a phenomenon was presented by Blood and Zatorre (2001). In this PET study, the authors investigated neural correlates of highly pleasurable responses to music (i.e., the so-called “chills” or “musical frissons”) evoked by listening to favorite music (compared with neutral music) and reported activity in the left ventral striatum, specifically in the nucleus accumbens (NAc). This brain structure is partly innervated by dopaminergic brainstem neurons, thus suggesting the involvement of the dopamine pathway in music-evoked pleasure. Moreover, the NAc plays a major role in both primary rewards (biologically significant stimuli such as food, sex, social contact) and secondary rewards (money). The results of Blood and Zatorre (2001) were consistently corroborated by a number of other neuroimaging studies employing different paradigms and music stimuli (Koelsch, Fritz, Cramon, Müller, & Friederici, 2006; Menon & Levitin, 2005; Trost et al., 2012). For example, Koelsch and colleagues (2006) used consonant and dissonant music to evoke pleasant (not "chills" response) and unpleasant responses. In a seminal study combining PET and fMRI (Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011), it was further illustrated that dopamine is released not only in the ventral striatum (NAc), but also in its dorsal component (caudate), during the peak experience of "chills" and the anticipatory moment before "chills", respectively. Thus, this study provided the first evidence for a dissociation of dopamine neurotransmitter activity during the "anticipatory" and "consummatory" stages of music-evoked pleasure. Chills were evoked through self-selected music pieces and were measured by asking participants about their experience of pleasure while listening to the music, as well as by assessing their physiological correlates (i.e., heart rate, respiration, skin conductance, temperature, and blood volume pulse amplitude).

Most of the stimulus sets used in the above-mentioned neuroimaging studies featured a number of well-known sad music pieces (for example, Barber's *Adagio for Strings* was employed by Blood & Zatorre, 2001 and by Salimpoor et al., 2011), indicating that sad music can be obviously experienced as highly pleasurable. However, at the moment not many conclusions regarding the nature of the reward experienced during sad music listening can be drawn from the neuroimaging literature on music-evoked pleasure (for example, whether pleasurable states elicited by sad music are related to empathic and imaginative processes as Levinson suggested; see section 2.3). The pleasurable states evoked by various types of self-selected music in the above-mentioned studies likely have to do with mechanisms of emotional expectation. In other words, when we listen to music, we are prone to anticipate what comes next; the confirmation, violation, or delay of our musical expectations are the key mechanisms involved in the evocation of different music-evoked emotions and musical meaning (Meyer, 1956; Huron, 2006; Juslin & Västfjäll, 2008). According to Meyer, who was the first to provide an exhaustive theory on expectation, the continuous play with expectations[5] in music is paramount to the associated affective and aesthetic response. In line with this framework, the anticipatory stage (or wanting) described by Salimpoor et al. (2011) corresponds to

5 Musical expectations have been previously related to tonal contexts (melodies or chord progressions) as well as rhythm, and can rely on long-term knowledge or be totally unrelated to previous knowledge.

the creation of a musical expectation (by listening to specific patterns of tones, melodies or rhythms) and the consummatory stage corresponds to the fulfillment of such expectations (referred to as the liking phase). Although expectation mechanisms apply to sad music as well as to any other type of music (meaning that it does not depend on the emotional content of the music, but rather its structure), Levinson (1997) proposed that sad music evokes different types of rewards (see section 2.3). Consequently, it would be interesting to empirically test whether (*i*) listeners report to experience such rewards while listening to sad music, and (*ii*) these rewards are associated with different neural networks. The first point is addressed by Study 1 (Chapter 5), which characterizes the different pleasurable experiences reported by participants into four dimensions of reward. Studies 2 and 4 contribute instead to the second point by investigating the neural networks that are spontaneously engaged while participants listen to sad music.

II

Empirical Part

Chapter 5

Study 1 - The Paradox of Music-Evoked Sadness: An Online Survey[1]

> “Many men are melancholy by hearing music, but it is a pleasing melancholy that it causeth, and therefore to such as are discontent, in woe, fear, sorrow or dejected, it is a most present remedy: it expels cares, alters their grieved minds and easeth in an instant.”
>
> — R. Burton, *The Anatomy of Melancholy*

5.1 Abstract

This study explores listeners’ experience of music-evoked sadness. Sadness is typically assumed to be undesirable and is therefore usually avoided in everyday life. Yet the question remains: Why do people seek and appreciate sadness in music? We present findings from an online survey with both Western and Eastern participants ($N = 772$). The survey investigates the rewarding aspects of music-evoked sadness, as well as the relative contribution of listener characteristics and situational factors to the appreciation of sad music. The survey also examines the different principles through which sadness is evoked by music, and their interaction with personality traits. Results show 4 different rewards of music-evoked sadness: reward of imagination, emotion regulation, empathy, and no “real-life” implications. Moreover, appreciation of sad music follows a mood-congruent fashion and is greater among individuals with high empathy and low emotional stability. Surprisingly, nostalgia rather than sadness is the most frequent emotion evoked by sad music. Correspondingly, memory was rated as the most important principle through which sadness is evoked. Finally, the trait empathy contributes to the evocation of sadness via contagion, appraisal, and by engaging social functions. The present findings indicate that emotional responses to

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sad music are multifaceted, are modulated by empathy, and are linked with a multidimensional experience of pleasure. These results were corroborated by a follow-up survey on happy music, which indicated differences between the emotional experiences resulting from listening to sad versus happy music. This is the first comprehensive survey of music-evoked sadness, revealing that listening to sad music can lead to beneficial emotional effects such as regulation of negative emotion and mood as well as consolation. Such beneficial emotional effects constitute the prime motivations for engaging with sad music in everyday life.

5.2 Introduction

5.2.1 "Everyday" sadness and the paradox of music-evoked sadness

Transient sadness is a so-called basic emotion that can be observed in people, independent of cultural background (Ekman, 1992). Sadness is characterized by low physiological and physical activity, tiredness, decreased interest in the outer world, low mood, rumination, decreased linguistic communication, and a withdrawal from social settings (Izard, 2000; Schwartz, Weinberger, & Singer, 1981; Shields, 1984; Sobin & Alpert, 1999). Moreover, sadness is particularly associated with the awareness of an irrevocable separation, the loss of an attachment figure or of a valued aspect of the self, as well as the breaking of social bonds (Ellsworth & Smith, 1988; Keltner, Ellsworth, & Edwards, 1993; Lazarus, 1991; Rivers, Brackett, Katulak, & Salovey, 2007; Scherer, Schorr, & Johnstone, 2001). Thus, the experience of sadness is typically assumed to be undesirable and is therefore usually avoided in everyday life. Hence, the question arises as to why people seek and appreciate sadness in music. The appeal of sad music has always been a crucial issue in aesthetics from ancient (Aristotle, 1986) to modern times (Davies, 1997; Kivy, 1989; Levinson, 1997; Robinson, 1994). It is remarkable that, despite so much philosophical debate, there is still broad disagreement about this fundamental aspect of the aesthetic experience. Nevertheless, both the scientific and the philosophical literature have consistently reported that, in addition to sadness, sad music also elicits pleasurable emotions, ranging from a sense of relief to a state of profound beauty

(Gabrielsson & Lindström, 1993; Kawakami et al., 2013; Kivy, 1989). However, it is difficult to draw conclusions concerning the nature of the pleasure experienced in response to sad music (e.g., whether this is due to the appraisal of musical and acoustical features or to other types of cognitive or emotional processes) due to the lack of empirical research on the topic. The study of the relationship between sadness and pleasure has been largely neglected by psychological research on music and emotion, which predominantly has focused on other aspects of the problem such as the role of individual differences (Garrido & Schubert, 2011a; Vuoskoski & Eerola, 2012; Vuoskoski et al., 2012) or the relationship between felt and perceived emotion in response to sad music (Kawakami et al., 2013).

5.2.2 Pleasurable experiences underlying music-evoked sadness

If music-evoked sadness is, at least for some individuals, a rewarding or valuable experience, what, then, are the rewarding aspects of such an experience? In the field of philosophy, Levinson (1997) investigated this problem, suggesting reward as a key concept to explain the attraction to negative emotions, and in particular to sadness, in music. He proposed that eight types of reward contribute to the appreciation of music-evoked sadness. Two are external contributions: The first, *apprehending expression*, is linked to the observation that negatively valenced responses to music facilitate our grasp of the expression in a musical work (Goodman, 1968). The second consists of the Aristotelian theory of *catharsis* (Aristotle, 1986) applied to the musical domain. According to this theory, the negative emotional tone of sad music offers listeners the possibility of a controlled purification from a certain amount of a negative emotion afflicting them. The other six rewards are divided into two groups. The first group includes the following rewards: *savoring feeling* (i.e., savoring the qualitative aspects of sadness for its own sake); *understanding feeling* (i.e., sadness is perceived and appraised more clearly); and *emotional assurance* (i.e., music-evoked sadness allows listeners to reassure themselves about their ability to feel intense emotions). These rewards share the characteristic of being detached from contextual implications. This means that music-evoked sadness is not directed at any extra-musical ("real-life") circumstance that could evoke sadness, and, therefore, is deprived of its aversive aspects (e.g., grieving due to the loss of a loved one). The second group includes other three rewards: *emotional resolution* (i.e., a sense of mastery and control listeners derive from identifying themselves with sad music resolving happily); *expressive potency* (i.e., identifying with the music to the point of imagining oneself to have the same richness and spontaneity of the sadness expressed by music); and *emotional communion* (i.e., sharing the sadness of another human being such as the composer). These last rewards are closely connected to the ability to imagine oneself in the emotional condition portrayed by the music. According to Levinson's theory, imagination and freedom from "real-life" implications mediate the passage from music-evoked sadness to music-evoked reward. However, such rewards have not yet been empirically investigated.

Preliminary evidence for the rewards of music-evoked sadness can be found in studies which showed that pleasant emotions, such as blitheness and wonder, are elicited in response to sad music (Kawakami et al., 2013; Trost et al., 2012; Vuoskoski et al., 2012; Zentner et al., 2008). Because it is well established that pleasure refers to the subjective hedonic component of reward (Berridge, Robinson, & Aldridge, 2009; Kringelbach & Berridge, 2009), the pleasant emotions evoked in these studies may be, for instance, the outcome of any combination of the above-mentioned rewards of music-evoked sadness.

In addition to Levinson's theory, Panksepp (1995) found that sad music is more effective for arousing "chills" (i.e., intensely pleasurable responses to music) than happy music. Consequently, he argued that the neural substrate of social loss might entail similar neurochemicals (e.g., oxytocin or opioids) involved also in the "chill" response (Panksepp, 1995, 1998). Furthermore, Huron proposed that the pleasure experienced through sad music is due to the consoling effects of prolactin, a hormone usually released when people are sad or weeping (Huron, 2011). However, no direct evidence is yet available for a role of prolactin, and there is a lack of empirical data supporting any of the proposed theories (Huron, 2011; Levinson, 1997; Panksepp, 1995).

5.2.3 Situational factors and listener characteristics modulating the appreciation of sad music

Although the existing literature reports a wide range of responses to sad music, varying from "like" to "dislike" or even "hate" (Garrido & Schubert, 2011a; Huron, 2011; Vuoskoski et al., 2012), very little is known about which factors modulate the appreciation of sad music. Nevertheless, situational factors and listener characteristics might explain a significant portion of the variance in the emotional and aesthetic responses evoked by sad music.

With regard to situational factors, music-evoked emotions are strongly influenced by the situational conditions of exposure to music (Egermann et al., 2011; Juslin, Liljeström, Västfjäll, Barradas, & Silva, 2008; Liljeström, Juslin, & Västfjäll, 2013), as well as by the purpose that music serves in a given situation (Sloboda & O'Neill, 2001). Thus, the investigation of the situational factors underlying engaging with sad music is important to understand why sad music is appreciated (if individuals actively choose to listen to sad music, then we can assume that they appreciate such music). Although no direct evidence has been published concerning the situations in which people engage with sad music, two qualitative studies identified a number of explicit functions achieved by listening to sad music, such as *re-experiencing affect*, *cognitive*, *social*, *retrieving memories*, *friend*, *distraction*, and *mood enhancement* (Garrido & Schubert, 2011b; Van den Tol & Edwards, 2011). However, because these studies are limited by their small sample sizes (for example, only five participants were recruited by Garrido & Schubert, 2011b), further research should extend their findings to a broader population.

With regard to the listener characteristics, individual differences in personality traits can help to clarify why some listeners strongly appreciate sad music while others avoid it. Surprisingly, relatively few studies have specifically assessed the contribution of personality to the inclination of listening to sad music (Garrido & Schubert, 2011a; Vuoskoski & Eerola, 2012; Vuoskoski et al., 2012). Vuoskoski and colleagues (2012) discovered that *openness to experience*, global *empathy* and its subscales, *fantasy*, and *empathic concern* significantly correlate with liking of sad music and intensity of emotional responses evoked by sad music. Moreover, Vuoskoski and Eerola (2012) found that global *empathy* and its subscales, *fantasy*, and *empathic concern* contribute to sadness evoked by unfamiliar music, while only *fantasy* plays a role in the case of familiar music. On the other hand, Garrido and Schubert (2011a) showed that *absorption* and *musical empathy* predict enjoyment of negative emotions in response to music. Thus, although more empathic individuals seem to appreciate sad music more than less empathic individuals, further studies could help to specify the nature of the association between the trait empathy and the appreciation of sad music (e.g., whether it is due to a specific use of sad music in more empathic individuals). Another factor representing a good candidate for modulating the appreciation of sad music is mood. Moods are affective states lower in intensity and longer in duration than emotions, and usually not directed at any specific object (Larsen, 2000). A number of studies reported mood-congruent effects on liking of sad music (Hunter, Schellenberg, & Griffith, 2011; Schellenberg, Peretz, & Vieillard, 2008). For example, Schellenberg and colleagues (2008) statistically eliminated the typical preference for happy music over sad music after a demanding distractor task (which aimed to induce a negative mood in the participants). Moreover, Hunter and colleagues (2011) were able to attribute this effect to sad mood, by showing that liking of sad music increases when listeners are in a sad mood.

5.2.4 Principles underlying the evocation of sadness by music

Emotions can be evoked by music in different ways. Several researchers (Juslin & Västfjäll, 2008; Juslin, Harmat, & Eerola, 2013; Koelsch, 2012) theoretically introduced a number of principles, or mechanisms, through which music listening may evoke emotions. The principles underlying emotional responses to music encompass e.g., *appraisal*, *evaluative conditioning*, *contagion*, *memory*, *expectancy*, *imagination* or *visual imagery*, *rhythmic entrainment*, and *social functions* (Juslin et al., 2013; Koelsch, 2012). To date, no evidence has been published indicating the most relevant principles through which sadness is usually evoked. Moreover, it still needs to be established whether different personality types contribute to elicit sadness through specific principles.

5.2.5 The present study

The aim of this study was to provide a better understanding of why people engage with sad music. We collected responses from a large multi-ethnic sample of participants, covering diverse age groups, through means of an online survey. In particular, we focused on the rewarding aspects of music-evoked sadness suggested by Levinson (1997), as well as the relative contribution of listener characteristics (e.g., mood and personality) and situational factors to the appreciation of sad music. Because our knowledge of how many listeners experience sadness in response to sad music is largely based on very limited data, and because emotions other than sadness can also be elicited by sad music (Kawakami et al., 2013; Vuoskoski et al., 2012), another purpose was to identify the most frequent emotions experienced in response to sad music. Furthermore, we also examined the role of the above-mentioned principles (Juslin et al., 2013; Koelsch, 2012) in evoking sadness as well as their interaction with personality traits. Because we obtained responses from a multi-ethnic sample of participants, we further compared the Western and Eastern participants' responses to investigate whether broad cultural differences influence the reward and/or the emotional experiences associated with listening to sad music. Finally, to further discriminate which uses and rewards are specific to sad music compared with other types of music (e.g., happy music), we distributed a second survey on happy music to another sample of participants.

5.3 Method

5.3.1 Participants

Data were obtained from 772 individuals: 495 female (64.1%) aged 16–78 years ($M = 28.3$, $SD = 9.0$) and 277 male (35.9%) aged 16–68 years ($M = 28.6$, $SD = 8.1$). 408 participants grew up in Europe (52.8%, 266 female), 224 (29.1%, 128 female) in Asia, 122 (15.8%, 88 female) in North America, 10 (1.3%, 7 female) in South America, 6 (0.8%, 5 female) in Australia, and 2 (0.2%, 1 female) in Africa. With respect to their musical training, 40 (5.2%, 31 female) respondents reported to be professional musicians, 66 (8.5%, 31 female) semi-professional musicians, 230

(29.8%, 143 female) amateur musicians, and 436 (56.5%, 290 female) non-musicians. With regard to their musical engagement, 500 (64.8%, 319 female) participants reported being music lovers, 262 (33.9%, 168 female) liking music, and 10 (1.3%, 8 female) not being music lovers. All participants gave informed consent according to the procedures approved by the ethics committee of the Psychology Department of the Freie Universität Berlin.

5.3.2 Materials

Data were collected using an online survey. In total, the survey featured 76 items. Participants were instructed to complete the survey individually, and in a quiet environment without listening to any music. The survey was programmed and administered online between the 3rd of February and the 3rd of June 2013, using the software *Unipark* (www.unipark.com). The average duration to survey completion was 20 minutes. The survey was divided into seven sections (further details are explained below): (1) *core details*; (2) *musical training and musical engagement*; (3) *sad music*; (4) *principles underlying the evocation of sadness by music*; (5) *rewarding aspects of music-evoked sadness*; (6) *favorite sad music*; and (7) *personality questionnaires*. Items were randomized among each section.

Core details, musical training, and musical engagement. The first two sections consisted of items used to obtain demographic data, details about musical training, subjective relevance of music, and preferred musical genre(s).

Sad music. The third section comprised items on sad music listening habits, including: frequency of listening to sad music; situation-related factors and their importance for listening to sad music; liking of sad music according to the listener's mood (positive and negative); and emotions evoked by sad music (see Appendix, Table S.1 for the full list of items). Participants provided quantitative ratings on 7-point Likert scales for the first three items. In addition to the ratings, the item related to the situational factors was designed as an open-ended response where participants were asked to provide one or more examples of situations in which they engage with sad music. The explanatory nature of the open response was adopted to be able to draw conclusions on the motivations for selecting sad music with regard to the situational factors. For the last item, "emotions evoked by sad music", participants were asked to indicate the emotions that they frequently experience when listening to sad music. They could select either one or more emotions from the nine emotions listed in the GEMS (Zentner et al., 2008), or add their own alternative responses. Furthermore, participants were given the opportunity to answer that sad music does not evoke any particular emotion in them. The GEMS was selected as ideal instrument to measure the subjective emotional experience of participants, because it provides a nuanced assessment of music-evoked emotions (Eerola & Vuoskoski, 2011; Zentner et al., 2008). It comprises nine categories (wonder, transcendence, tenderness, nostalgia, peacefulness, power, joyful activation, tension, and sadness), which condense into three main factors: sublimity; vitality; and unease.

Principles underlying the evocation of sadness by music. The fourth section consisted of a 7-item questionnaire designed to evaluate the role of different principles underlying the evocation of sadness in listeners (Juslin et al., 2013; Koelsch, 2012). However, not all of these principles were suitable to be translated into clear statements. Thus, the present study used only those which could have been reasonably operationalized by the use of self-reports (i.e., *memory*, *imagination*, *contagion*, *appraisal*, and *social functions*; see Appendix, Table S.2 for the list of items). Ratings were given on a 7-point Likert scale (1 = "strongly disagree" and 7 = "strongly agree").

Rewarding aspects of music-evoked sadness. Participants were then presented with 13 items devised to explore possible rewarding aspects of music-evoked sadness. These items (see Appendix, Table S.3) were designed on the basis of Levinson's theory on negative emotions (1997) and integrated with three items indicated by previous studies on sad music and emotion regulation (Clore & Huntsinger, 2007; Huron, 2011; Saarikallio & Erkkilä, 2007; Van den Tol & Edwards, 2011; Van Goethem & Sloboda, 2011). All ratings were provided on a 7-point Likert scale (1 = "strongly disagree" and 7 = "strongly agree").

Favorite sad music. In the sixth section participants were asked to provide one or more example(s) of their favorite sad music (either instrumental or with lyrics). This question was included because respondents were provided with neither a definition of sad music nor examples of sad music in the survey, but were instead instructed to focus on “self-identified sad music” (as in Van den Tol & Edwards, 2011). Given that “self-identified sad music” may represent music that does not sound “sad” to any other listener (for example, because of personal associations with the music, such as the break up of a relationship), we examined the examples of sad music provided by participants to determine whether they are consistent with the Western cultural conventions of representing sadness in music. Specifically, we made use of the tagging system supported by the online music database www.last.fm. In addition, we retrieved a number of acoustical and musical features of the instrumental pieces named by the participants (for details see the Results section).

Personality questionnaires. The final part of the survey included two measures of individual differences in trait empathy and personality factors. Empathy was assessed via the Interpersonal Reactivity Index (IRI; Davis, 1980). The IRI includes 28 items, divided in four subscales measuring the following related aspect of emotional empathy: *fantasy*; *perspective-taking*; *empathic concern*; and *personal distress*. As a means of limiting the experimental procedure to a maximum of 20 minutes, personality traits were assessed by the Ten-Item Personality Inventory (TIPI; Gosling, Rentfrow, & Swann, 2003). This is a brief version of the Big Five Inventory (BFI; John & Srivastava, 1999) and it covers the following five personality domains: *extraversion*; *agreeableness*; *conscientiousness*; *emotional stability*; and *openness to experience*.

5.4 Results

5.4.1 Which are the rewarding aspects of music-evoked sadness?

A principal component analysis (PCA) with oblique rotation (direct oblimin) was carried out on the ten items describing the rewarding aspects of music-evoked sadness (in the preliminary analysis three items were excluded because of their low correlations). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO = .83, and all KMO values for individual items were > .76, which is well above the acceptable limit of .5 (Field, 2009). Bartlett’s test of sphericity showed that correlations between items were sufficiently large for a PCA, $\chi^2(45) = 3402.65$, $p < .001$. An initial analysis was computed to obtain eigenvalues for each dimension in the data. Four dimensions had eigenvalues over Jolliffe's criterion of 0.7 and, in combination, explained 76.6% of the variance. Given the large sample size, and the convergence of the scree plot and Jolliffe's criterion on four dimensions, these four dimensions were retained in the final analysis. Table 5.1 shows the factor loadings after rotation. The items that cluster on the same dimensions suggest to interpret dimension 1 as the *reward of imagination*, where music-evoked sadness has pleasurable effects due to the engagement of imaginative processes (e.g., "I imagine I have the same rich expressive ability as present in the music"). Dimension 2 represents the *reward of emotion regulation*, which includes statements about the rewarding effects derived from regulation of negative moods and emotions (e.g., "Experiencing sadness through music makes me feel better after listening to it, and thus has a positive impact on my emotional well-being"). Dimension 3 represents the *reward of empathy*, which includes statements about the pleasurable effects of music-evoked sadness due to mood-sharing and virtual social contact through the music (e.g., "I like to empathize with the sadness expressed in the music, as if it were another individual"). Dimension 4 represents the *reward of no "real-life" implications*, which includes statements about the pleasure listeners can take in music-evoked sadness due to its lack of contextual implications (e.g., "I can enjoy the pure feeling of sadness in a balanced fashion, neither too violent, nor as intense as in real-life"). With regard to the consistency of the extracted factors, *imagination* had high reliability (Cronbach's $\alpha > .92$) and *no "real-life" implications*, *emotion regulation* and *empathy* had good reliability (Cronbach's $\alpha > .7$).

Table 5.1. *Factor loadings for explanatory factor analysis with direct oblimin rotation of the items describing the rewarding aspects of music-evoked sadness (N = 772).*

	Rotated Factor Loadings			
Item	**Imagination**	**Emotion Regulation**	**Empathy**	**No "Real-Life" Implications**
Expressive Potency 1	.914			
Expressive Potency 2	.943			
Expressive Potency 3	.892			
Under. Feelings				.805
Emotional Assurance				.844
Savoring Feeling				.581
Mood Enhancement		.927		
Catharsis		.787		
Emot. Communion			.849	
Empathic Responses			.860	
Eigenvalues	3.24	2.22	2.31	2.88
% of variance	41.57	16.85	10.44	7.75
A	.92	.73	.71	.71

Note. For the items' content see Appendix, Table S.3.

A repeated-measures ANOVA, with type of reward (four levels) as within-subjects factor, was conducted to identify the most important rewards for the listeners. A significant main effect of type of reward was found, $F(2.65, 2041.97) = 37.28$, $p < .0001$, $\omega^2 = .99$. Bonferroni pairwise comparisons showed that there were significant differences between the mean ratings for all four factors. Figure 5.1 shows that *no "real-life" implications* turned out to be the most important source of reward for the listeners.

Only 31 participants (4% of all participants) took the opportunity to add their own alternative responses concerning other possible rewards that were not included in the list provided by the questionnaire. Due to the low number of responses, these answers did not provide representative information, and were therefore not further analyzed. However, to generate hypotheses for future studies, these answers are reported in Table S.4 (Appendix).

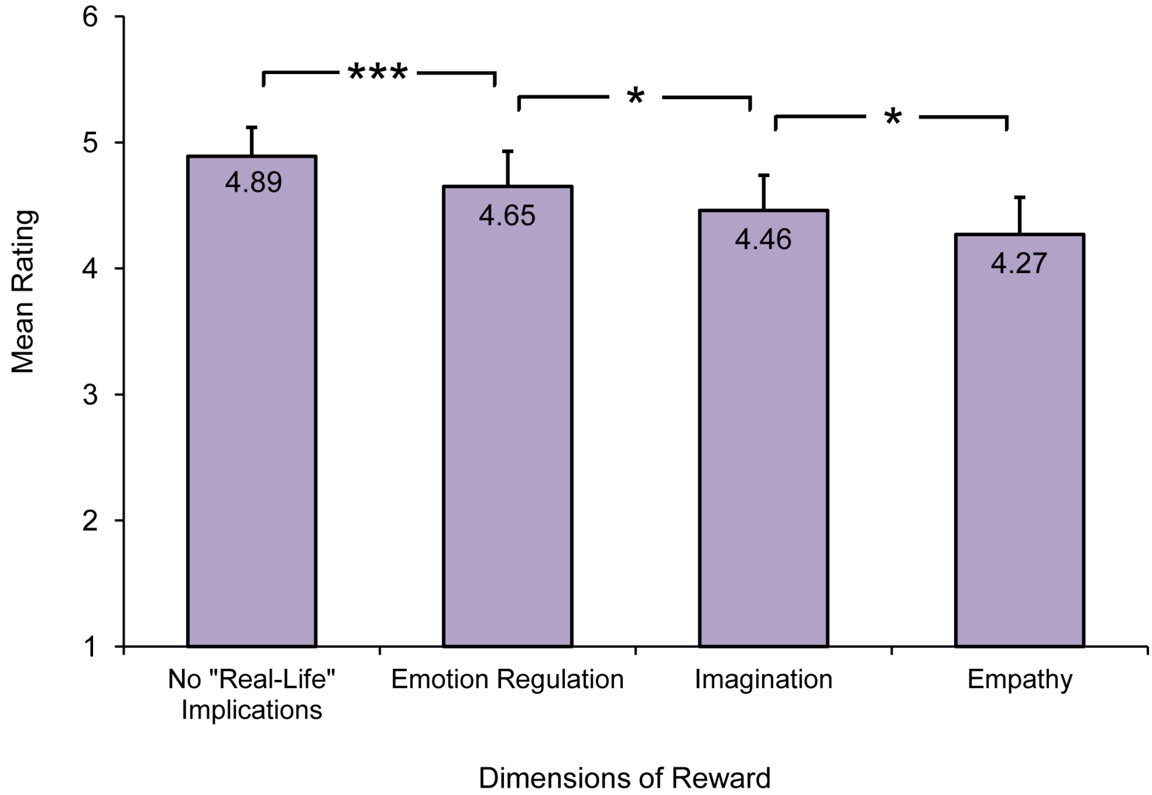

Figure 5.1. *Mean ratings for each of the four dimensions of reward identified.* Error bars indicate SEM, *** indicates a *p*-level of < .001, and * indicates a *p*-level of < .05.

5.4.2 In which situations do listeners engage with sad music?

Results indicate that situation-related factors play a significant role in the engagement with sad music. With regard to the following item, "How much do specific situations influence your choice to listen to sad music?", ratings showed that situational factors are highly relevant to the choice to listen to sad music (M = 4.74, SD = 1.84, on a 7-point Likert scale ranging from 1 = "not at all" to 7 = "a lot"). 61.7% of participants (477 out of 772) provided ratings ≥ 5. To examine this issue further, an open-ended follow-up question asked participants to provide one or more examples of circumstances in which they engage with sad music, and to describe the function that sad music serves in those situations. A content analysis of the free responses revealed that there are several situations in which listeners engage with sad music, which are intrinsically linked to a wide spectrum of functions (i.e., emotional, social, cognitive, and aesthetic) that listening to sad music may potentially fulfill. Based on the previous literature (Garrido & Schubert, 2011b; Van den Tol & Edwards, 2011), the responses concerning the situational factors were grouped into the following categories (Table 5.2): *emotional distress*; *social*; *memory*; *relaxation and arousal*; *nature*; *musical features*; *introspection*; *background*; *fantasy*; *avoiding sad music*; *intense emotion*; *positive mood*; and *cognitive*. The category *emotional distress* includes situations in which the listeners are in a negative emotional state due to different reasons such as, for example, the loss of a loved one. In these circumstances, sad music is used as a tool for mood-enhancement (achieved, for example, through venting of negative emotion or cognitive reappraisal), consolation, or simply because it reflects the current mood. The category *social* comprises statements on social attachment and social bonding (e.g., people engage with sad music when they feel lonely or when they need to be accepted or understood), and is therefore linked to a consolatory use of sad music (achieved through mood-sharing or virtual social contact through the music). The category *memory* refers to situations in which sad music is chosen to retrieve autobiographical memories of valued past events or people. The category *relaxation and arousal* represents situations in which sad music is used as a tool to regulate arousal (e.g., quieting down before going to bed). The category *nature* refers to situations such as traveling, and being in contact with nature as well as to specific times of the day (i.e., evening) or of the year (i.e., winter). The category *musical features* is related to the aesthetic appreciation of sad music focused on the formal properties of the music, rather than on perceptions of emotional content. The categories *fantasy*, *cognitive*, and *introspection* represent situations in which sad music is chosen because of cognitive as well as self-related functions: Sad music is used respectively to engage creativity, to improve focus during work or while studying, and to cope with a personal problem by organizing thoughts and feelings. The category *background* refers to situations such as driving, reading or working, where sad music represents an optimal musical background. The category *avoiding sad music* comprises all the answers that stress a clear dislike for sad music, regardless of the different situational factors. The category *intense emotion* includes a number of situations in which listeners engage with sad music to experience intense emotions. Finally, the category *positive mood* includes the answers of the participants who reported to engage with sad music only when being in a positive emotional state, and, consequently, to avoid sad music when being in a negative emotional state. According to these respondents, sad music does not have any positive effect on emotional distress, but it rather contributes to perpetuate this negative affective state.

The number of nominations for the different situational categories is provided in Figure 5.2. As can be seen, listeners reported to engage with sad music especially when experiencing emotional distress. For instance, there is a striking difference between the frequency with which participants reported the situation-related category *emotional distress* (470 nominations) and the reported frequencies of all other categories (all fewer than 184 nominations). Emotional distress is a broad concept that refers to a variety of situations. To specify this concept, we reported the most popular examples given by the participants for *emotional distress*: “when feeling sad” (109 nominations); “when experiencing love-sickness or a break up” (108); “when grieving for a loss” (51); “when experiencing stress at work/university” (48); “when feeling angry after an argument” (44); “when experiencing frustration and being disappointed with myself” (41); “when needing to release negative feelings” (29); “when feeling melancholic” (22); and “when feeling like crying” (17). Furthermore, a considerable number of participants (184 out of 772) reported engaging with sad music when they feel lonely (i.e., category *social*), whereas a small number (16) reported engaging with sad music only while experiencing a positive emotional state (i.e., category *positive mood*).

Table 5.2. *Summary of the situations in which participants engage with sad music and functions of listening to sad music in those circumstances.*

Situation Category	Situation Description	Function
Emotional distress	Argument, failure, frustration, death, love-sickness or break up, need to cry, and stress	Emotional: mood enhancement (venting and cognitive reappraisal), consolation, reflection of the current mood
Social	Homesickness, feeling lonely, missing someone, need to be accepted and understood	Social and emotional: consolation due to mood-sharing and contact
Memory	Retrieving memories of valued past events	Sad music as a memory trigger
Relaxation and arousal	Relaxing and getting new energy, quieting down before going to bed	Emotional: mood and arousal regulation
Nature	Traveling, being in contact with nature, during specific times of the day (evening) or of the year (winter)	Sad music as a reflection of the environment
Musical features	Engaging with sad music not because of its emotional content but rather for the musical features of the piece	Aesthetic
Introspection	Contemplating, organizing, and reappraising personal experiences	Cognitive: improve personal introspection
Background	While doing a parallel activity such as driving, reading, working	Sad music provides a pleasant background
Fantasy	Creative thinking, looking for inspiration	Cognitive: engage creative thinking
Avoiding sad music	Preference for other types of music	-
Intense emotion	Seeking a touching emotional experience	Emotional: experience intense emotions
Positive mood	Listening to sad music only when being in a positive mood or emotional state	Emotional: mood control
Cognitive	Improving rational thinking, obtaining a better focus	Cognitive: engage rational thinking

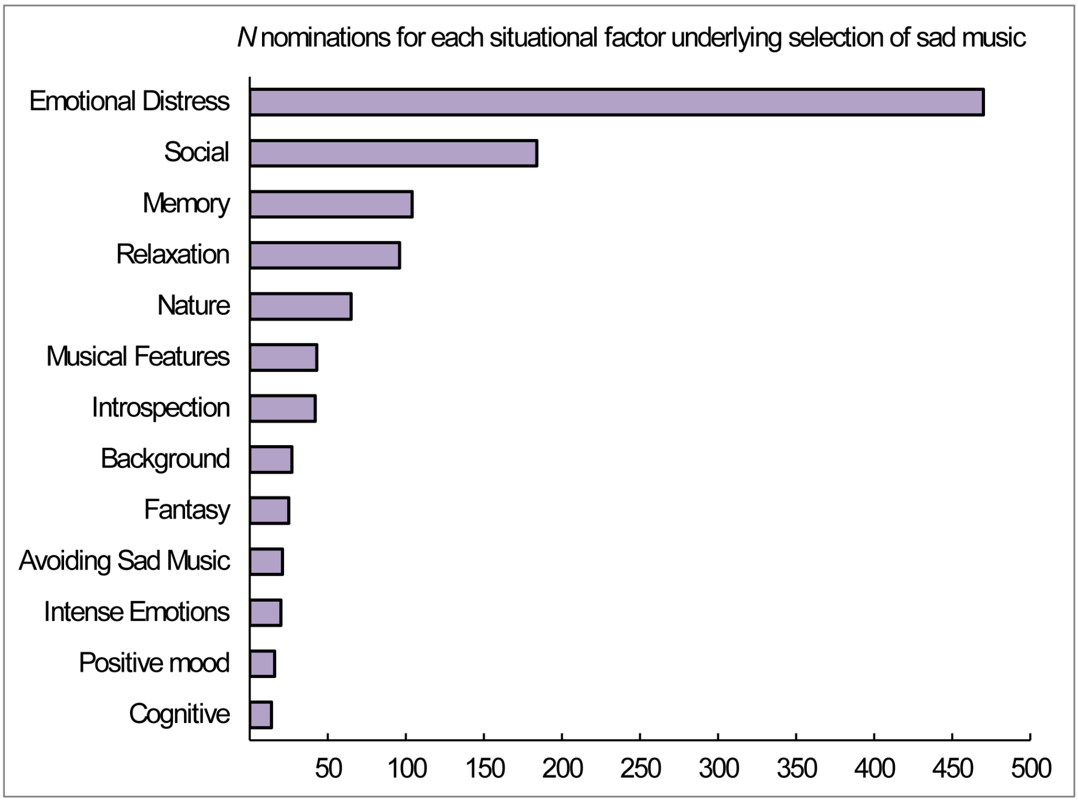

Figure 5.2. *The amount of nominations for each situation-related factor underlying listening to sad music.*

5.4.3 Do mood and personality modulate the liking of sad music?

Both the engagement with, and the liking of sad music occur more frequently in a mood-congruent fashion. For instance, 54.4% of participants (420 out of 772) provided ratings ≥ 5 on a 7-point Likert scale (1 = "never", 7 = "always") in response to the statement "When I am in a sad mood I like to listen to sad music" ($M = 4.44$, $SD = 1.80$). On the other hand, 32.7% of participants (253 out of 772) provided ratings ≥ 5 on a 7-point Likert scale (1 = "never", 7 = "always") in response to the statement "When I am in a positive mood I like to listen to sad music" ($M = 3.60$, $SD = 1.56$). A paired-samples *t*-test revealed that the difference between the ratings for the two items is significant, $t(771) = 10.141$, $p < .0001$, $r = .34$.

A correlation analysis between the personality factors and the subscales of *empathy* with the variables of liking of sad music was performed to evaluate whether personality traits can modulate the liking of sad music. A Bonferroni correction for multiple tests was applied. Because significant correlations were weak ($r < .2$), the results (summarized in Table 5.3) should be interpreted with caution. However, to generate hypotheses for future studies, we also report these results. The mood-congruent liking of sad music positively correlated with global *empathy* ($r = .114$, $p < .01$) and its subscales, *fantasy* ($r = .160$, $p < .01$), and *personal distress* ($r = .108$, $p < .01$). A similar pattern was observed for the mood-incongruent liking of sad music, which positively correlated with global *empathy* ($r = .109$, $p < .01$) and its subscales, *fantasy* ($r = .116$, $p < .01$), and *perspective taking* ($r = .142$, $p < .01$), but not with *personal distress* ($r = -.052$, $p > .05$). Moreover, the mood-congruent liking of sad music negatively correlated with *emotional stability* ($r = -.123$, $p < .01$).

Table 5.3. *Correlations between the mean ratings for the liking of sad music and personality traits as measured by the TIPI and IRI.*

	Liking of sad music	
	Mood-congruent	**Mood-incongruent**
Emotional Stability	-.123**	.033
Global Empathy	.114**	.109**
Fantasy	.160**	.116**
Personal Distress	.108**	-.052
Perspective Taking	-.036	.142**

Note. ** indicates a *p*-level of < .01.

5.4.4 Which emotions are most frequently experienced in response to sad music?

The survey featured an item in response to which participants indicated the most frequent emotions evoked by sad music. They could select more than one option and/or add their response alternatives (free responses are reported in the Appendix, Table S.5). Figure 5.3 reports the number of nominations for each emotion. Surprisingly, nostalgia (76% of nominations), and not sadness (44.9%), was indicated as the most frequent emotion evoked by sad music. Moreover, participants also reported experiencing positive emotions, such as peacefulness (57.5%), tenderness (51.6%), and wonder (38.3%). Conversely, the percentage of nominations for joyful activation (6.1%) was low compared with the other emotions. Interestingly, the average number of emotions that participants reported to have experienced in response to sad music (M = 3.33, SD = 1.56) correlated positively with both variables of mood-incongruent liking of sad music (r = .323, p < .01) and mood-congruent liking of sad music (r = .273, p < .01).

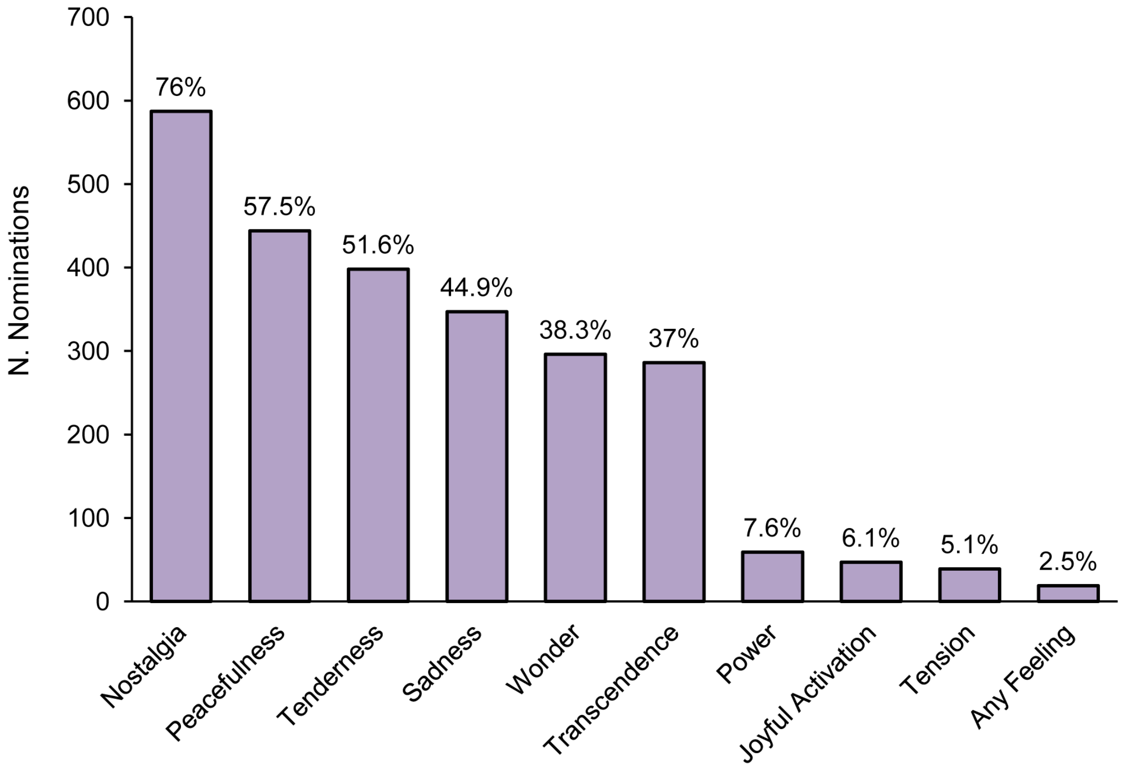

Figure 5.3. *The most frequent emotions evoked in response to sad music.*

5.4.5 What is the importance of the theoretically discussed principles underlying the evocation of sadness?

Participants who reported frequently experiencing sadness in response to sad music (N = 347) also rated to what extent they agreed/disagreed with each of the seven items (see Appendix, Table S.2) describing five of the principles underlying the evocation of sadness through music (i.e., *memory*, *imagination*, *contagion*, *appraisal*, and *social functions*). First, ratings were averaged across different items describing the same principle. Second, a repeated-measures ANOVA was conducted on the mean ratings for each principle, with principle type represented as a within-subjects factor, to establish which principles are most important in evoking sadness. A significant main effect of the type of principle was found, $F(3.37, 1165.01) = 39.41$, $p < .0001$, $\omega^2 = .22$. Bonferroni pairwise comparisons showed that there were significant differences between mean ratings for all five principles, with the exception of three non-significant differences between the mean ratings given on *imagination* and *social functions*, *imagination* and *appraisal*, as well as *appraisal* and *contagion*. *Memory* was rated as the most important principle underlying the evocation of sadness. However, all the principles were judged to be relevant (all means > 4.5, on a 7-point Likert scale from 1 = "strongly disagree" to 7 = "strongly agree"). Figure 5.4 shows the mean ratings given to each of the five principles ranked in descending order.

The data also revealed gender differences for *contagion*. On average, *contagion* was rated higher by females ($M = 5.40$, $SE = 0.74$) than by males ($M = 4.92$, $SE = 0.14$), with this difference being significant, $t(167.12) = 3.004$, $p = .003$, $r = .24$ (Bonferroni-corrected).

To investigate whether differences in sadness-evocation styles might be associated with personality traits, a Pearson correlation analysis of the subscales' scores of IRI and TIPI with the principles' ratings was conducted. A Bonferroni correction for multiple tests was applied. The results (summarized in Table 5.4, only $r > .2$ are reported) revealed an association between *empathy* (total score plus all subscales) and sadness induced via *contagion* ($r = .348$, $p < .001$), via engagement in *social functions* ($r = .399$, $p < .001$), as well as via *appraisal* ($r = .262$, $p < .001$). Note that, although not reported in Table 4 (because $r < .2$), global *empathy* also significantly correlated with sadness induced via *imagination* ($r = .184$, $p < .005$) and via *memory* ($r = .187$, $p < .001$). Finally, *contagion* negatively correlated with *emotional stability* ($r = -.296$, $p < .001$).

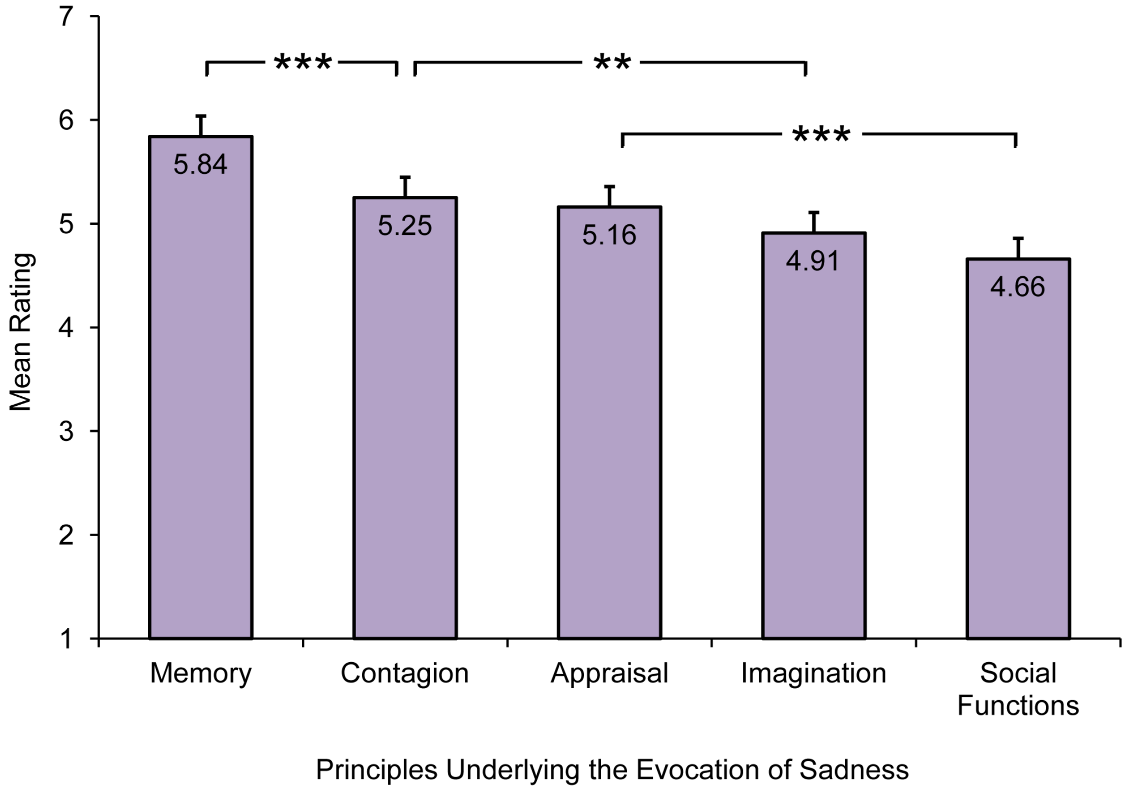

Figure 5.4. *Mean ratings for each principle underlying music-evoked sadness.* Error bars indicate SEM, *** indicates a p-level of < .001, and ** indicates a p-level of < .01.

Table 5.4. *Correlations between the mean ratings for the principles underlying the evocation of sadness and personality traits as measured by the TIPI and IRI.*

	Contagion	**Social Functions**	**Appraisal**
Emotional Stability	-.269**	-.054	-.072
Global Empathy	.348**	.399**	.262**
Empathic Concern	.261**	.326**	.227**
Perspective Taking	.122*	.229**	.111*
Fantasy	.309**	.319**	.242**

Note. Only r > .2 are reported. * indicates a p-level of < .05 and ** indicates a p-level of < .01.

5.4.6 Are emotional responses to sad music the same across cultures?

Eastern respondents provided lower overall ratings compared with Western respondents for all items featured in the survey, with the exception of ratings for the principle of *social functions*. The following significant difference was found: Western participants reported significantly ($t(143.49) = 3.061$, $p = .003$, $r = .25$, Bonferroni-corrected) higher ratings for the principle of *memory* ($M = 6.00$, $SE = 0.08$) compared with Eastern participants ($M = 5.41$, $SE = 0.17$). According to Eastern participants, the most frequent emotion evoked in response to sad music was peacefulness (117 of 219 nominations) followed by nostalgia (115 nominations). By contrast, the ranking of these two emotions for the Western participants was reversed, with nostalgia being the most frequent emotion (451 of 530 nominations) followed by peacefulness as the second most reported emotion (316 nominations).

5.4.7 Is "self-identified sad music" consistent with the cultural standards of representing sadness in music?

We made use of the tagging system supported by the online music database www.last.fm to verify that the music pieces named by the respondents can be considered culturally valid examples of sad music. Tags are keywords or labels that listeners can use to classify music. Music platforms, such as last.fm, are used by millions of listeners and thus offer behavioral ratings from a sufficiently large sample of user tags. We examined the tags provided for the music examples nominated by participants in the survey. First, we inspected all music pieces nominated more than once and second, all pieces nominated only one time.

Participants reported 52 music pieces (26 with lyrics and 26 instrumental) more than once, in a total of 165 nominations (see Appendix, Table S.7). Among these 52 pieces, 36 were tagged "sad" or "sadness" by last.fm users, and nine were assigned a "sadness-related" tag (e.g., "melancholic"). Three pieces received either very few or no tags and two were not found in the last.fm database. Only two music pieces were not labeled "sad" or with a "sadness-related" tag.

A total of 380 music pieces (233 with lyrics and 147 instrumental) were mentioned only once by the participants. Forty pieces were not considered in the analysis because the title provided was too general (i.e., it referred to an album rather than a song or to a symphony rather than a movement). Moreover, 71 pieces received either very few or no tags and 18 were not found in the last.fm database. Among the remaining 251 music examples, 168 were tagged "sad" or "sadness", and 53 were labeled with a "sadness-related" tag. Only 30 music pieces were not assigned either a "sad" or a "sadness-related" tag.

Furthermore, through a large database of more than 30 million songs (the.echonest.com) we retrieved a number of acoustic and musical features of the instrumental pieces named by the participants, including tempo, loudness, mode, energy, dance ability, and "valence" (note that the term valence is used here to refer exclusively to the database's musical attribute, which is derived from acoustic-driven information, not user tags; as indicated by the present data sad music can have a positive valence for listeners in certain circumstances). This was done in order to determine whether the example pieces contain musical parameters that have been consistently linked with sadness in Western music (e.g., slow tempo, low sound level, minor mode, low pitch, small intervals, legato, micro-structural irregularity, etc.; see Juslin & Laukka, 2003). Nominated songs with lyrics were excluded because lyrics may differ semantically from music-perceived emotion and may play a crucial role in evoking sadness (Brattico et al., 2011). Out of 142 instrumental pieces, 124 were retrievable in the database. Table 5.5 reports the descriptive statistics for the overall estimated tempo in BPM (M = 86.92, SD = 21.05), loudness in dB (M = -20.92, SD = 7.18), energy (M = 0.16, SD = 0.17), dance ability (M = 0.26, SD = 0.14), and valence (M = 0.13, SD = 0.14). Moreover, 52.41% of the music pieces were written in a major mode and 47.58% in a minor mode. In addition, the energy and valence values of each piece were plotted onto a two-dimensional plane, according to the affective circumplex model of emotion (Russell, 1980). Figure S.1 (Appendix) shows that a large majority of the retrieved instrumental pieces nominated by our respondents (113 out of 124) fell into the low energy/negative valence quadrant.

Table 5.5. *Descriptive statistics for the acoustic and musical features of the music pieces nominated by the participants (N = 124).*

	Minimum	Maximum	Mean	SD
Energy	0.00	0.84	0.16	0.17
Tempo (BPM)	48.21	138.35	86.92	21.05
Valence	0.00	0.67	0.13	0.14
Loudness (dB)	-39.34	-6.98	-20.92	7.18
Dance ability	0.06	0.66	0.26	0.14

Note. Energy measures the intensity and the powerful activity released throughout the piece. Dance ability describes whether a piece is suitable for dancing, and it combines musical elements such as tempo, rhythm stability, beat strength, and overall regularity. Valence takes into account acoustic information such as pitch, timbre, and mode. Energy, dance ability, and valence values range between 0 and 1. A value close to one indicates high energy or arousal, high dance ability, and positive valence, while a value close to zero corresponds to low energy or arousal, low dance ability, and negative valence. BPM = beats per minute; dB = decibel.

5.4.8 Which uses and rewards are specific to sad music?

A number of the identified uses and rewards of sad music, such as the use of music to retrieve autobiographical memories, overlap with uses and rewards of music listening in general, irrespective of the specific type of emotional experience evoked by the music (Chamorro-Premuzic & Furnham, 2007; Chin & Rickard, 2012; Laukka, 2007; Mas-Herrero, Marco-Pallares, Lorenzo-Seva, Zatorre, & Rodriguez-Fornells, 2013; Schäfer et al., 2013). To further evaluate which uses and rewards are specific to sad music, we distributed a survey on happy music to another sample of 212 participants aged 19–75 (M = 33.12, SD = 10.29; detailed demographics are reported in the Appendix, Table S.6). The survey was a shorter version of the original one, featuring the same 25 items as used in the previous survey, divided into five sections: *core details*, *musical training*, *happy music*, *rewarding aspects of music-evoked happiness*, and *favorite happy music*. The sections *musical engagement*, *principles underlying the evocation of happiness by music,* and *personality questionnaires* were omitted to focus this survey on the question of uses and rewards of happy music and to maintain the completion time below five minutes. The survey was distributed between the 22nd of

June and the 25th of July 2014.

Participants were first asked to report in which situations they commonly engage with happy music and why. A content analysis of the free responses revealed the following situation-related categories (Table 5.6): *entertainment*; *background*; *motor*; *arousal*; *mood maintenance*; *celebration*; *mood regulation*; *after work*; *motivation*; *distraction*; *avoiding happy music*; *memory*; *musical features*. The category *entertainment* includes situations such as a gathering with friends or a social occasion, in which happy music is used to entertain and to create a pleasant atmosphere. The category *background* refers to situations such as traveling, driving, housekeeping, and working, in which happy music provides an optimal auditory background to a primary activity. The category *motor* represents situations such as running, dancing or working out, in which the beat is used to enhance a particular motor response. The category *arousal* includes a number of situations in which happy music is used as a tool to regulate arousal, such as energizing in the morning, releasing energy or simply relaxing. The categories *mood maintenance*, *mood regulation*, and *distraction* represent situations in which happy music is selected to achieve various emotion regulation goals, such as maintaining a positive mood or emotional state, improving a negative mood or emotional state, and distracting oneself from worries and unwanted thoughts. The category *celebration* refers to situations such as a birthday, a graduation party, or a wedding. The category *after work* includes situations in which listeners engage with happy music after a busy day at work to celebrate or to relax. The category *motivation* includes situations in which listeners engage with happy music to improve achievement and motivation while coping with a challenging activity such as a job-related task. The category *avoiding happy music* comprises all answers of those participants who reported not to actively select happy music. The category *memory* refers to situations in which happy music is chosen to retrieve autobiographical memories of valued past events or people. The category *musical features* indicates an aesthetic appreciation of happy music focused on the formal properties of the music, rather than on perceptions of emotional content. The number of nominations for the different situational factors is provided in Figure 5.5. The categories *entertainment*, *celebration*, *background*, and *mood maintenance* received a total of 196 out of 353 nominations, indicating that participants are especially likely to engage with happy music when with friends or at social occasions, to experience pleasure and enjoyment, and to maintain a positive mood or emotional state. Interestingly, the categories *arousal* and *motor* received a total of 102 out of 353 nominations, indicating that another important use of happy music is to raise or synchronize energy levels, for example, during a morning routine or while physically exercising.

Participants were then asked to rate to what extent they agreed/disagreed with two items, in their ability to describe the liking of happy music: 1) mood-congruent, and 2) mood-incongruent conditions. These questions aimed to explore whether the liking of happy music follows a mood-congruent fashion, as found in the case of sad music. 73.6% of participants (156 out of 212) provided ratings ≥ 5 on a 7-point Likert scale (1 = "never", 7 = "always") in response to the statement "When I am in a positive mood I like to listen to happy music" (M = 5.30, SD = 1.29). On the other hand, only 20.8% of participants (44 out of 212) provided ratings ≥ 5 on a 7-point Likert scale (1 = "never", 7 = "always") in response to the statement "When I am in a negative mood I like to listen to happy music" (M = 3.17, SD = 1.61). A paired-samples t-test revealed a significant difference between the ratings for the two items, $t(211) = 15.161$, $p < .0001$, $r = .72$.

Table 5.6. *Summary of the situations in which participants engage with happy music and functions of listening to happy music in those circumstances.*

Situation Category	Situation Description	Function
Entertainment	Gathering with friends, social occasions	Social and emotional: use of happy music to entertain, to create a nice atmosphere, and to experience enjoyment
Background	Traveling or while doing a parallel activity such as housekeeping, working, driving	Happy music provides a pleasant background
Motor	Running, dancing, working out	Happy music helps to raise energy level and motivation
Arousal	Energizing in the morning, releasing energy, relaxing	Emotional: arousal and mood regulation
Mood maintenance	Listening to happy music when being in a positive mood or emotional state	Emotional: to maintain a positive mood and to experience enjoyment and pleasure
Celebration	To celebrate (birthday, graduation, wedding, new year)	Social and emotional: use of happy music to create a nice atmosphere, and to experience enjoyment and pleasure
Mood regulation	Listening to happy music when being in a negative mood or emotional state	Emotional: mood enhancement
After work	After a busy day at work	Happy music is used to relax, celebrate, entertain
Motivation	When copying with a challenging activity	Happy music is used to improve achievement and motivation
Distraction	Listening to happy music to forget about worries and unwanted thoughts	Emotional: diversion or distraction
Avoiding happy music	Preference for other types of music	-
Memory	Retrieving memories of valued past events	Happy music as a memory trigger
Musical features	Engaging with happy music not because of its emotional content but rather for the musical features of the piece	Aesthetic

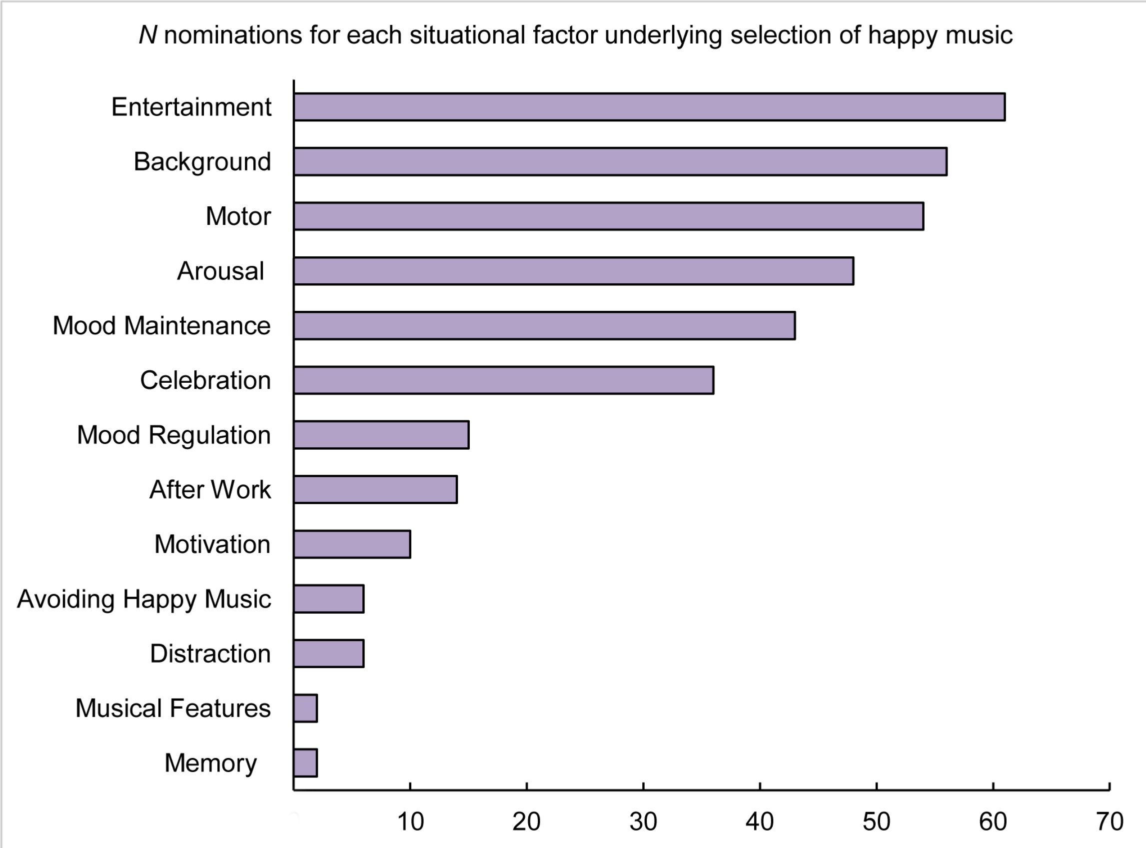

Figure 5.5. *The amount of nominations for each situation-related factor underlying listening to happy music.*

Participants were also asked to complete a questionnaire on the rewarding aspects of music-evoked happiness. The items were the same as those used in the survey on sad music, altered accordingly for happy music. To investigate whether the identified rewards are specific to sad music or also apply to happy music we computed four independent-samples *t*-tests (one for each reward dimension). This analysis revealed two significant differences. With regard to the *reward of no "real-life" implications*, participants provided higher ratings for sad music (M = 4.89, SD = 1.27) than for happy music (M = 4.16, SD = 1.19), with this difference being significant, $t(982) = 7.476$, $p < .0001$, $r = .23$ (Bonferroni-corrected). With regard to the *reward of empathy*, participants provided higher ratings for sad music (M = 4.27, SD = 1.65) than for happy music (M = 3.52, SD = 1.54), with this difference being significant, $t(982) = 5.911$, $p < .0001$, $r = .19$ (Bonferroni-corrected). On the other hand, the *reward of imagination* and the *reward of emotion regulation* did not significantly differ between sad and happy music. Figure 5.6 shows the mean ratings given to each reward dimension for sad and happy music.

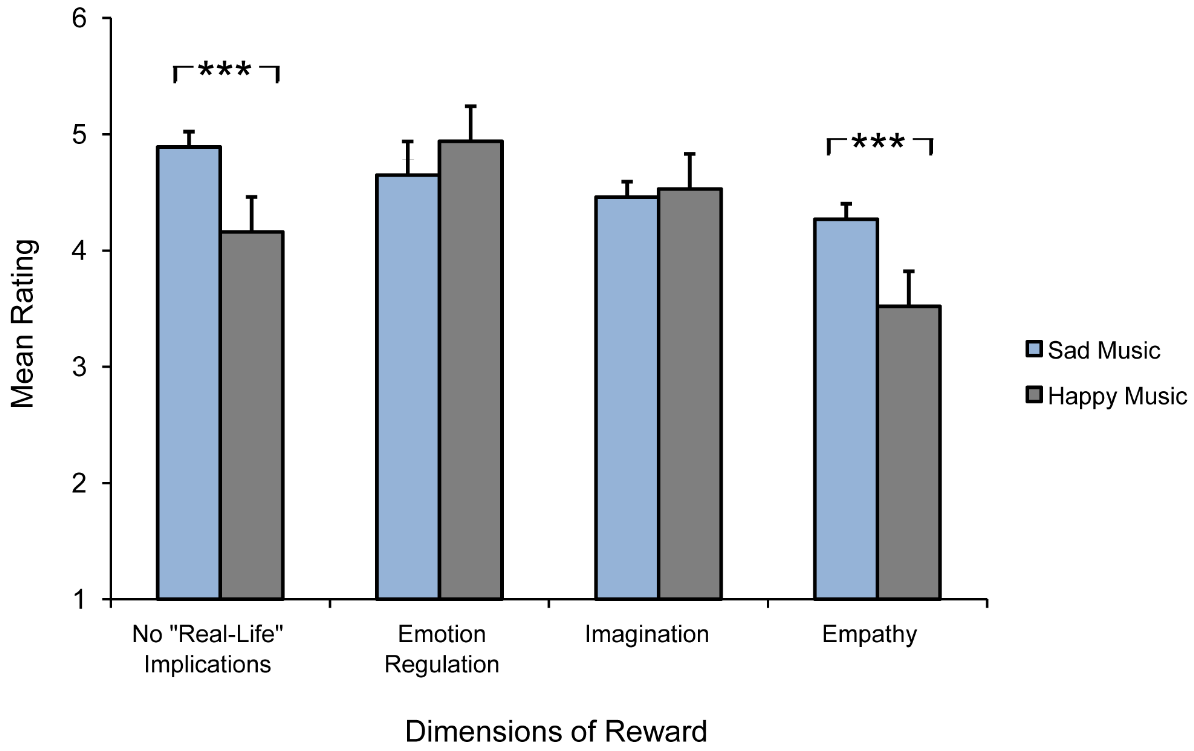

Figure 5.6. *Mean ratings for each of the four dimensions of reward identified for sad and happy music.* Error bars indicate SEM, *** indicates a p-level of $< .001$.

5.5 Discussion

This study dealt with the supposed paradox of why people engage with sad music if sadness is inherently a negative emotion. Using an online survey, we obtained comprehensive responses from a large internet sample. Results point out an extensive confluence between the uses of sad music in everyday life and experiences of reward derived from music-evoked sadness. For example, the use of sad music to regulate negative emotions and moods corresponds to the reward dimension of *emotion regulation*, while the consolatory use is related to the *reward of empathy*. Our findings, which were corroborated by a follow-up survey, are also consistent with previous research suggesting that the principal motivation for listening to sad music is to evoke and influence emotions and moods (Juslin & Laukka, 2004; Salimpoor, Benovoy, Longo, Cooperstock, & Zatorre, 2009).

5.5.1 Rewards of music-evoked sadness

With regard to the rewards of music-evoked sadness, the PCA suggests four dimensions, consistent with the possible existence of multiple sources of pleasure, as previously suggested by Huron (2009). Dimension 1 is interpreted as the *reward of imagination* - a dimension that is positively correlated with the pleasure derived from engaging imaginative processes (e.g., imagining to have the same richness and spontaneity of the music). Dimension 2 is interpreted as the *reward of emotion regulation* - a dimension that is positively correlated with the pleasurable outcome derived from the achievement of different self-regulatory goals, such as mood enhancement and venting. Dimension 3 is interpreted as the *reward of empathy* - a dimension that is positively correlated with the pleasurable effects associated with sharing the sadness portrayed by the music as an expression of another's emotion, such as the composer. This type of pleasure is presumed to relate to social function, even in the absence of other individuals. Dimension 4 is interpreted as the *reward of no "real-life" implications* - a dimension that is positively correlated with a reported pleasure that lacks any extra-musical or contextual implications. In other words, individuals can feel sad in response to sad music even in the absence of extra-musical circumstances that evoke sadness, such as, for example, a lost love (note that this does not necessarily mean that music is not associated with a sad "real-life" situation). Because of this contextual freedom, listeners can take pleasure in music-evoked sadness, by savoring and better understanding its emotional aspects *per se*, without necessarily experiencing negative "real-life" consequences.

5.5.2 Situational factors and listener characteristics contributing to the appreciation of sad music

The analysis of the situations in which people engage with sad music underlines the importance of the emotional use of sad music (e.g., to regulate negative mood and emotion as well as to take comfort) in everyday life, which is in line with two previous studies investigating the motivations underlying listening to sad music (Garrido & Schubert, 2011b; Van den Tol & Edwards, 2011). For instance, our data suggest that people choose to listen to sad music especially when experiencing emotional distress (in most of the cases due to a lost relationship) or when feeling lonely. Correspondingly, participants reported that the liking of sad music is significantly greater when they are sad compared with when they are in a positive emotional state, which is in line with behavioral studies reporting mood-congruent effects on sad music liking (Hunter et al., 2011; Schellenberg et al., 2008). Taken together, these results strongly highlight that, for most of the people, the engagement with sad music in everyday life is correlated with its potential to regulate negative moods and emotions as well as to provide consolation.

The results regarding the contribution of personality traits to individual differences in the appreciation of sad music corroborate findings from previous studies and point out the role of empathy (Garrido & Schubert, 2011a; Vuoskoski & Eerola, 2012; Vuoskoski et al., 2012): Liking of sad music (for both mood-congruent and mood-incongruent conditions) was indeed positively correlated with global *empathy* and its subscale *fantasy*. In addition, we found a negative association between the liking of sad music (when being sad) and the personality trait of *emotional stability*. That is, individuals with high *emotional stability* are less likely to prefer sad music when they are sad. Moreover, the trait *neuroticism* has been linked to the use of music for emotion regulation (Chamorro-Premuzic & Furnham, 2007; Chamorro-Premuzic, Fagan, & Furnham, 2010). Consistent with this, our findings suggest that individuals with low emotional stability prefer to listen to sad music when already in a sad state, presumably because this activity can help to regulate their current emotional state. In addition, it could be speculated that individuals with high *emotional stability* are more likely to use happy music to regulate their moods and emotions. If this is indeed the case (our data fall short for a comparison in this regard, since we did not investigate the relationship between personality traits and the appreciation of happy music), the present finding opens an intriguing direction for future work.

5.5.3 Emotions evoked by sad music

With regard to the emotions evoked in response to sad music, our results revealed that sad music evokes not only sadness, but also a wide range of complex and partially positive emotions, such as nostalgia, peacefulness, tenderness, transcendence, and wonder, in line with a previous study (Vuoskoski et al., 2012). According to the GEMS model, these emotions belong to the factor of *sublimity*, whereas sadness corresponds to *unease* (Zentner et al., 2008). In this respect, the present study indicates that the paradox of sad music has largely been discussed in an oversimplified form, based exclusively on the happy-sad dichotomy (Hunter, Schellenberg, & Schimmack, 2010; Ladinig & Schellenberg, 2012; Larsen & Stastny, 2011). Rather than happiness, sad music elicits an entire range of "sublime" emotions (Zentner et al., 2008). Moreover, our study supports the observation that music-evoked sadness often occurs in a blended fashion (Zentner et al., 2008). For instance, the average number of emotions that participants reported to have experienced in response to sad music was above three. Interestingly, the number of emotions evoked by sad music was positively associated with participants' liking of sad music. This suggests that a multifaceted emotional experience elicited by sad music enhances its aesthetic appeal.

Among the emotions evoked in response to sad music, nostalgia is the one listeners most frequently experience (note that for Eastern participants peacefulness is the most frequent emotion followed by nostalgia). Nostalgia has been characterized as a "bittersweet" emotion because it includes both positive and negative facets simultaneously, such as joy and sadness (Barrett et al., 2010). A number of studies have stressed the prominence of nostalgia among music-evoked emotions (Janata, Tomic, & Rakowski, 2007; Zentner et al., 2008), and the present study reinforces the importance of nostalgia in the domain of sad music. The experience of nostalgia also indicates the important role that memory processes play while listening to sad music.

Nostalgia is closely linked to the retrieval of autobiographical memories (Batcho, 2007; Sedikides, Wildschut, Arndt, & Routledge, 2008). Barrett and colleagues (2010) found that the autobiographical salience of a particular song was the strongest predictor of the intensity of music-evoked nostalgia. In line with this, our analysis of the situations in which participants engage with sad music shows that a motivation to evoke memories of valued past events often underlies the selection of sad music (Davies, 1978; Van Goethem & Sloboda, 2011).

5.5.4 Principles underlying music-evoked sadness

Our analysis of the principles underlying emotion evocation points out that *memory* is the most important principle for eliciting sadness. Therefore, the present findings highlight the mediating role of *memory* in the evocation of sadness via music. These results have relevant implications for the experimental design of studies on music-evoked sadness. For example, future experiments could use music-related memory tasks to manipulate sadness in participants. *Contagion* was rated the second most relevant principle after *memory*, and thus also plays an important role in music-evoked sadness. *Emotional contagion* refers to processes where the listener internally mimics the emotional expression of a musical passage (Juslin & Västfjäll, 2008) in terms of motor expression (Lundqvist et al., 2009), which is assumed to evoke an emotion due to emotion-specific peripheral physiological feedback. Interestingly, *contagion* was positively correlated with global *empathy* and its subscales, and negatively correlated with *emotional stability*. Studies have shown (Hatfield, Rapson, & Le, 2009; Singer & Lamm, 2009) that emotional contagion is a precursor to empathy, which may explain the positive association between the trait *empathy* and *contagion*. The negative correlation with *emotional stability* suggests that people who are prone to emotional contagion through sad music are also those who have low scores on *emotional stability*. It is noteworthy that global *empathy* correlated with all principles of evocation of sadness, pointing to a strong link between music-evoked sadness and empathy, regardless of the mechanism through which sadness is evoked.

5.5.5 Uses and rewards of sad music compared with happy music

The results from the follow-up survey on happy music provide some interesting insights into the unique uses and rewards of sad music compared with happy music, which we have summarized in the following three points. *First*, the use of music to regulate negative emotion and mood and to provide comfort is the most relevant use for sad music. This usage, however, appears to be marginal in the case of happy music. For instance, the category *emotion regulation* received only 7.1% of nominations, and the consolatory use of happy music was not mentioned by any participant in the survey on happy music. A number of functions of listening to sad music (i.e., *memory*, *background*, *arousal*) partially overlapped with the functions of happy music, however, the numbers of nominations they received indicate substantial differences in the significance they hold to listeners when engaging with sad versus happy music. For example, retrieving memories of valued past events is a frequent use of listening to sad music (13.5% of nominations), while it has only marginal relevance in the case of happy music (only 0.9% of nominations). In addition, sad music covers a range of various "inner" functions (directed to one's own conscious thoughts and feelings) linked to solitary settings (see, for example, the categories of *memory*, *introspection*, and *fantasy*), whereas happy music mainly covers "outer" functions (directed to the sociocultural network to which one belongs) linked to social settings (see, for example, the categories of *entertainment* and *celebration*). *Second*, the liking of happy music follows a mood-congruent pattern, as found for the liking of sad music. This is supported by results from the analysis of the situation-related factors, indicating that listeners frequently engage with happy music to maintain a positive mood or emotional state. Both findings suggest that regulation of negative emotion or mood is a key emotional process underlying the choice to listen to sad music, as is the case for happy music and the maintenance of positive emotion or mood. *Third*, our comparison between the reward questionnaires for sad and happy music indicates that two dimensions of reward, the *reward of no "real-life" implications* and the *reward of empathy*, are rated significantly higher in the case of sad music, suggesting that they represent unique rewarding aspects of music-evoked sadness, in comparison to music-evoked happiness. This appears to be particularly relevant with regard to the *reward of empathy*. For instance, this reward dimension is linked to the consolatory and comforting use of sad music, which was among the most frequently nominated functions of sad music. With regard to the *reward of no "real-life" implications*, our results are consistent with the fact that this type of reward, as conceived by Levinson, does not apply to positive emotions, such as happiness, but instead applies exclusively to negative emotions. On the other hand, no significant difference was found for the *reward of imagination* and the *reward of emotion regulation*, suggesting that these two dimensions of reward may be shared among happy and sad music.

5.5.6 Cross-cultural differences in the emotional experiences associated with sad music

The survey on sad music featured a large multi-ethnic sample of participants. Therefore, we additionally investigated whether cultural differences affect listeners' emotional experiences of sad music (i.e., rewarding experiences and principles through which sadness is evoked). We focused on broad cultural differences, namely Western versus Eastern, because a vast and well-established body of literature illustrates an array of West-East differences in psychological processes, including cognition and emotion (Kitayama, Markus, Matsumoto, & Norasakkunkit, 1997; Markus & Kitayama, 1991; Mesquita & Frijda, 1992; Murata, Moser, & Kitayama, 2013). In particular, more individualistic Western cultures are dominated by an independent construal of the self, while more collectivist Eastern cultures are dominated by an interdependent construal of the self (Markus & Kitayama, 1991). With regard to the principles underlying music-evoked sadness, our results suggest that Western participants experience sadness through memory-related processes more consistently than Eastern participants, in line with Juslin's (2013) theoretical prediction of a high cultural impact on *memory*. Indeed, nostalgia was reported as the most important music-evoked emotion in response to sad music according to Western participants. By contrast, peacefulness holds a parallel significance to nostalgia for Eastern participants. Juslin stated that "episodic memories require detached representations, as well as *self-consciousness* (i.e., perceptions of an inner world and a sense of self that is separate from the external world)" (Juslin, 2013, pp. 242–243), and "episodic memories may serve to confirm one's identity" (Juslin, 2012, p. 284). These statements provide a meaningful interpretation of our findings, suggesting that *memory* may serve to promote an independent construal of the self, and thus is more often experienced among individualistic Western cultures. Apart from *memory*, we did not detect any further significant differences, suggesting that the emotional as well as rewarding processes underlying listening to sad music might be largely shared across cultures.

5.5.7 Listeners' examples of sad music

Our analysis of the tags given for the respondents' examples of sad music indicates that a large majority (68.46%) of these music pieces are also considered sad by last.fm users (notice that among the remaining pieces, 20.80% were assigned a "sadness-related" tag and only 10.74% were not labeled sad). Thus, participants' view of sad music is consistent with the cultural representation of sadness in music. This finding was confirmed by the analysis of a number of acoustic and musical features, which influence music-perceived sadness in Western music (Juslin & Laukka, 2003). The average values of tempo, loudness, energy, dance ability, and valence (with the exception of mode) are consistent with the most well-established parameters attributed to Western sad music (in particular, energy, dance ability, and valence values were close to zero, and thus very low in the example pieces named by our sample). Considering the wide range of musical genres covered by the example pieces, the average tempo was relatively slow. Moreover, when energy and valence values for each nominated piece were combined, almost all of the retrievable pieces (113 out of 124) fell into the low energy/negative valence quadrant of the affective circumplex model (Russell, 1980). According to this dimensional approach, all emotions can be explained in terms of core affect dimensions such as valence and arousal, where sadness is an emotion with low arousal and negative valence (Posner et al., 2005; Russell, 1980). Furthermore, it is noteworthy to mention that our data are in line with the results from the BBC survey on the world's saddest music

(Anonymous, 2004). In particular, four out of the five most-nominated pieces of the BBC survey (i.e., *Dido's Lament*, *Barber's Adagio for Strings*, *Adagietto* from Mahler's *Symphony No.* 5, and *Gloomy Sunday*) were also present among the 26 most-rated instrumental pieces in the present study, suggesting that they represent the most popular of the saddest Western music pieces.

5.5.8 "Real" and music-evoked sadness

The paradox of the appreciation of music-evoked sadness is closely related to the question of how (and to what extent) music-evoked sadness relates to "everyday" sadness. The fact that sadness is experienced as a pleasant emotion mostly in aesthetic contexts (Garrido & Schubert, 2011a; Huron, 2011) has been used as an argument against the authenticity of music-evoked sadness. Along this line, some authors have argued that music-evoked emotions are not "real", but *aesthetic* emotions (Konečni, 2008; Noy, 1993), because they are not goal-oriented and do not have any material effect on the individual's well-being (Krumhansl, 1997; Scherer, 2004). The present study provides preliminary evidence against the last claim. For instance, two identified rewards (namely *reward of emotion regulation* and *empathy*) unveil two positive effects of music-evoked sadness on psychological health (i.e., regulation of negative emotion and mood, and consolation due to social contact and mood-sharing). This indicates that music-evoked sadness is not only experienced as an abstract aesthetic reward, but also as a means for improving well-being and engaging in social functions. For example, listeners frequently engage with sad music when experiencing emotional distress to facilitate venting of negative emotion or mood. On the other hand, our study also reveals that the lack of "real-life" implications is another reward dimension of music-evoked sadness. According to this reward dimension, music-evoked sadness is often not immediately linked to a sad extra-musical event, thus allowing the listener to take pleasure in so-called negative emotions. This component of music-evoked sadness (the lack of "real-life" implications) differentiates our experience of music-evoked sadness from "everyday" sadness.

5.5.9 Implications for music therapy

Our findings have important implications for music therapy. For instance, our study shows that music-evoked sadness is linked to four different dimensions of reward, and that sad music can evoke a wide range of positive "sublime" emotions in the listener (Zentner et al., 2008). Thus, the specific use of sad music in music therapy (preferably selected by the patient; Stratton & Zalanowski, 1984) might be particularly effective to promote music-induced reward, which in turn could improve health and well-being (through the engagement of neurochemical systems for reward, stress and arousal, as well as social affiliation; for a review, see Chanda & Levitin, 2013). This suggestion is supported by the evidence pointing to the efficacy of a form of music therapy called "Guided Imagery and Music" (GIM) in stress reduction (McKinney, Antoni, Kumar, Tims, & McCabe, 1997a; McKinney, Tims, Kumar, & Kumar, 1997b). In healthy subjects, GIM has been shown to reduce cortisol levels (McKinney et al., 1997a) as well as β-endorphins (McKinney et al., 1997b), which are two markers of hypothalamic-pituitary-adrenal (HPA) axis activations. GIM usually employs Western Classical music combined with conversation and relaxation to elicit imagery for accessing and working through emotional processes. The present study indicates that music-evoked sadness can enhance mental imagery (i.e., *reward of imagination*), thus suggesting that sad music is well suited as one therapeutic means in GIM.

Furthermore, our study reveals that people engage with sad music especially when feeling sad or lonely. Thus, from a therapeutic perspective, one could reasonably interpret a patient's decision to select sad music as, apart from an aesthetic preference, an indicator of emotional distress. This might be useful especially in children or adults with autism spectrum disorder or alexithymic individuals, who have a reduced ability to express their emotions verbally (Nemiah, Freyberger, & Sifneos, 1976). By "tuning" their emotions with the ones expressed by the music, patients may feel heard and understood (i.e., *reward of empathy*), even in the absence of a specific emotional vocabulary (Allen & Heaton, 2010). This empathic connection between the music and the patient may help to relieve distress and to progress in therapy. Furthermore, the beneficial emotional effects of sad music may be enhanced in emotionally unstable individuals, because our results suggest that they use sad music to regulate emotion. Thus, we also propose that the assessment of personality traits might be an important stage in estimating the successful use of sad music in music therapy.

5.5.10 Limitations of the study

The use of a retrospective survey may have limited the overall ecological validity of the study. Retrospective questionnaires can be inaccurate in the measurements of affective states (Randall & Rickard, 2013), because they are vulnerable to memory biases (Sloboda, O'Neill, & Ivaldi, 2001; Stone et al., 1998). Future research investigating everyday use of sad music could potentially benefit from the Experience Sampling Method (ESM; Csikszentmihalyi & LeFevre, 1989), a research procedure that asks individuals to provide systematic self-reports of their experience in real-time and at random occasions during the day. In particular, a recent development of ESM, consisting of a "smart-phone" application (Randall & Rickard, 2013), seems to be a promising solution because it maintains a natural listening experience for participants while collecting real-time data. In addition, further studies should validate the present findings with implicit measures to overcome the limitations of introspective survey methods, such as demand characteristics. This is important especially in regard to the rewards and principles underlying music-evoked sadness, which describe processes that may occur partly unconsciously, thereby proving more difficult for direct reporting by participants.

5.6 Conclusions

The fact that people seek and appreciate sadness in music may appear paradoxical, given the strong popular and scientific emphasis on happiness as a source of personal well-being (e.g., Lyubomirsky, King, & Diener, 2005; Seligman & Csikszentmihalyi, 2000). The present study demonstrates that for many individuals, listening to sad music can actually lead to beneficial emotional effects. Our findings are important for four reasons. *First*, the findings (using two large internet samples of participants) reveal sad music's potential for regulating negative moods and emotions as well as for providing consolation. In particular, the consolatory and comforting effects are likely to be unique features of sad music, as suggested by the comparison between the uses and functions of listening to sad versus happy music. *Second*, the results draw a comprehensive picture of situational factors of exposure and personality traits that contribute to the appreciation of sad music. In particular, the appreciation of sad music is enhanced when listeners are experiencing emotional distress, as well as among individuals with high *empathy* and low *emotional stability*. *Third*, our results unveil psychological mechanisms underlying the evocation of sadness by music, showing that memory-related processes are central in music-evoked sadness. *Fourth*, our findings contribute to the discussion surrounding the paradox of music-evoked sadness by providing the first empirical evidence that music-evoked sadness is related to a multidimensional experience of reward: Music-evoked sadness can be appreciated not only as an aesthetic abstract reward (due to the engagement of imaginative processes or the lack of "real-life" implications), but also plays a role in well-being, by providing consolation as well as by regulating negative moods and emotions. In particular, the results from the follow-up survey on happy music suggest that two out of the four identified rewards, the *reward of no "real-life" implications* and the *reward of empathy*, are rewarding experiences derived from listening to sad music, but not happy music (although rewarding experiences derived from listening to other types of music remain to be specified in future research). We hope that this study will lead to a deeper understanding of music-evoked sadness and will spur further research into the relationship between sadness and pleasure, particularly in the domain of music-therapeutic applications. Potential implications include the development of music interventions designed to improve health and well-being in healthy subjects as well as in the treatment of psychiatric disorders.

Chapter 6

Study 2 - Sad Music Engages Mind-Wandering and the Neural Default Mode Network[1]

> "I was a Flower of the mountains yes when I put the rose in my hair like the Andalusian girls used or shall I wear a red yes and how he kissed me under the Moorish wall and I thought well as well him as another and then I asked him with my eyes to ask again yes and then he asked me would I yes to say yes my mountain flower and first I put my arms around him yes and drew him down to me so he could feel my breasts all perfume yes and his heart was going like mad and yes I said yes I will Yes."
>
> — J. Joyce, *Ulysses*

6.1 Abstract

Sad music is a ubiquitous phenomenon in both Western and Eastern societies. Although sadness is usually experienced as unpleasant, it is nevertheless enjoyed through music as well as other art forms. Sad music is a powerful tool for the evocation and regulation of emotions and moods. However, its effects on cognition, and in particular on self-generated thought, are unknown. Here we use thought sampling and fMRI to investigate the influence of sad music on mind-wandering and its underlying neuronal mechanisms. In two experiments we found that sad music, compared with happy music, stimulates mind-wandering (Experiment 1) and that this is reflected in the brain by the increased centrality of the nodes of the default mode network (DMN) during sad music (Experiment 2). Thus, our results demonstrate that, when listening to sad music, people withdraw their attention inwards and engage in

1 This chapter is currently under revision: Taruffi, L., Pehrs, C., Skouras, S., & Koelsch, S. Sad music engages mind-wandering and the neural default mode network.

spontaneous, self-referential cognitive processes that are supported by the DMN. Importantly, our findings reveal that music triggers specific mental processes as a function of the emotion evoked by music. These findings call for a systematic investigation of the relation between music-evoked emotions and thought, having broad implications for the use of music in education, clinical settings and marketing/advertising.

6.2 Introduction

Most human cultures have sad and happy music (Bowling, Sundararajan, Han, & Purves, 2012). Sad and happy music exist at least since antiquity, as witnessed for example from the Greek music system (6th century BC), which ascribed certain emotional qualities, including sadness and happiness, to the unique sound of musical modes. The reason why people choose to listen to sad music, given that sadness is generally experienced as unpleasant, has piqued the curiosity of scholars across millennia (e.g., Aristotle, 1986). The appeal of sad music across the world reflects the special character of music-evoked sadness, which – in contrast to "real" sadness – represents a rather pleasurable affective state (Taruffi & Koelsch, 2014).

Although over the last decade neuroscience has provided numerous insights into how sad and happy music modulate activity in brain structures involved in emotion (Koelsch, 2014), the effects of music-evoked emotions on cognition remain elusive. In a previous study we found that a common use of sad (but not happy) music is to enhance self-reflection (Taruffi & Koelsch, 2014). Since the ability for self-reflection crucially requires internally-directed cognition, which is typical of mind-wandering (Dixon, Fox, & Christoff, 2014), we sought to investigate the influence of sad and happy music on mind-wandering in two separate experiments. Mind-wandering is a form of self-generated thought which involves overcoming the constraints of the "here and now" by immersing in one's own stream of consciousness (James, 1890). Humans spend a substantial amount of time mind-wandering (Killingsworth & Gilbert, 2010), predominantly about matters of self-importance (Smallwood et al., 2011), social relationships (Mar, Mason, & Litvack, 2012), future planning (Baird, Smallwood, & Schooler, 2011), and autobiographical memories (Smallwood & O'Connor, 2011). Mind-wandering is associated with benefits such as facilitating creative problem solving (Baird et al., 2012) and delaying gratification (Smallwood, Ruby, & Singer, 2013), but also with costs such as negative changes in mood and affect (Killingsworth & Gilbert, 2010), especially when the thoughts' content is retrospective and related to other people (Ruby, Smallwood, Engen, & Singer, 2013). Mind-wandering is supported by a set of brain regions typically active during rest periods, also referred to as the default mode network (DMN; Andrews-Hanna et al., 2010a; Andrews-Hanna et al., 2010b; Christoff et al., 2009; Kucyi, Salomons, & Davis, 2013; Mason et al., 2007; Mittner et al., 2014). The DMN comprises most notably the medial prefrontal cortex (dorsomedial prefrontal cortex [dmPFC] and ventromedial prefrontal cortex [vmPFC]), the medial parietal cortex (posterior cingulate cortex [PCC] and precuneus [PCu]), and the lateral parietal cortex (posterior inferior parietal lobule [pIPL]). Despite a remarkable increase of research on mind-wandering as well as music-evoked emotions in recent years (e.g., Juslin & Västfjäll, 2008; Killingsworth & Gilbert, 2010; Kucyi et al., 2013; Salimpoor et al., 2013), it is unknown whether music modulates mind-wandering.

In Experiment 1, we tested the hypothesis that sad music, compared with happy music, stimulates mind-wandering. Additionally, we explored whether the qualitative content and the form of mind-wandering vary according to the emotions expressed by the music (sadness and happiness). We analyzed a sample of 216 participants (132 female), who took part in an online thought sampling experiment (i.e., intermittently probing individuals about their current mental state while listening to music), which combined a self-report measure of mind-wandering (Christoff et al., 2009) with an assessment of the qualitative elements and the form of self-generated thought (Andrews-Hanna et al., 2013; Gorgolewski et al., 2014; O'Callaghan et al., 2015). Participants were asked to listen to music previously shown to evoke emotions of sadness and happiness, while keeping their eyes closed. Furthermore, they had to report their mental experience as occurring immediately before the music stopped.

In Experiment 2, we tested the hypothesis that increased mind-wandering in response to sad music is associated with increased DMN activity during listening to sad compared with happy music. From a sample of 24 right-handed healthy participants (12 female), we obtained whole-brain fMRI data while they listened to 4 min blocks of sad and happy music with their eyes closed. After each block, participants provided valence, arousal, sadness, and happiness ratings of their emotional state during the music. We used eigenvector centrality mapping (ECM; Lohmann et al., 2010) to investigate whether sad music (compared with happy music) engages the "computational hubs" of the DMN.

6.3 Method

6.3.1 Experiment 1

Participants. A total of 224 participants (137 female, mean age = 33.2, age range 18-55) were recruited through electronic mailing lists of students. 79% of the participants were European, 8.9% North American, 8.5% Asian, 2.7% Australian, and 0.9% South American. 46% of the participants reported to be non-musicians (never played an instrument), 33.9% amateur musicians (never received musical training), 11.2% semi-professional musicians (received musical training, but music is not main profession), and 8.9% professional musicians (playing music as main profession). Participants were not compensated for their participation. They completed the experiment online through a web survey platform (www.unipark.com). All participants gave informed consent according to the procedures approved by the ethics committee of the Psychology Department of the Freie Universität Berlin. Eight participants were discarded from the analysis due to low accuracy rates (≤ 4, see *Task design and procedure*) to follow the instructions of the experiment.

Music stimuli. The stimulus material consisted of four sad and four happy music pieces. Stimuli were instrumental excerpts from different genres (e.g., film soundtracks and classical music; for details see Appendix, Table S.9). There were four "short" (1.20-1.50 min) and four "long" (1.50-2.30 min) excerpts[2], counterbalanced

2 "Short" and "long" music stimuli were used to assess mind-wandering at different points in time

across conditions. All stimuli were edited to have 1.5 s fade in/out ramps and were RMS-normalized (root mean square) to have the same loudness.

In the present chapter (both Experiments 1 and 2), we refer to sad and happy music as music capable of evoking emotions of sadness and happiness, respectively. To this purpose, we carefully selected the music stimuli to ensure their capability to elicit sadness and happiness, while avoiding familiar pieces to reduce potential biases due to memory effects (Pereira et al., 2011). This was proven by the successful use of the stimuli in a previous study (Pehrs et al., 2014) and a behavioral pilot experiment. In the pilot experiment, 30 volunteers (17 female, mean age = 32.1, age range 18-53) listened to 12 sad and 12 happy pieces, presented in a counterbalanced order, and were then asked to rate their emotional state during the music as well as their familiarity with each piece on five scales (valence, arousal, sadness, and happiness [7-point scales]; familiarity [4-point scale]). Based on the pilot ratings, we chose the most homogeneous set of sad and happy stimuli, with the highest significant differences to the opposite affective tone, in order to assure orthogonality of emotional experimental conditions (p-values for all emotion dimensions $< .001$ except for valence, Bonferroni-corrected). Thus, for the sad condition, the selected set of stimuli was rated as highly pleasant [5.07 ± 1.23 ($M \pm SD$)], slightly arousing (2.40 ± 0.91), clearly sad (4.40 ± 1.39), not very happy (2.33 ± 0.79), and unfamiliar (1.29 ± 0.52). For the happy condition, the selected set of stimuli was rated as highly pleasant (5.23 ± 1.12), very arousing (4.92 ± 1.26), clearly happy (5.17 ± 1.26), not sad at all (1.34 ± 0.46), and unfamiliar (1.36 ± 0.45).

Task design and procedure. The task was designed to parallel a natural everyday setting of exposure to music, by employing unconstrained listening and use of relatively long music pieces. Participants were told that the experiment was about music, emotion, and relaxation. They were instructed to relax, close their eyes and listen to the music without any interruption. Moreover, they were asked to listen to the music through headphones.

The sad and happy music pieces were presented in a counterbalanced order.

after the onset of the emotion-eliciting stimulus.

After each music trial, thought probes were presented. For these thought probes, participants were instructed to focus on the thoughts they had just before the music ended. Two initial items measured mind-wandering. The first item ("Where was your attention just before the music stopped?") was used as a direct self-report measure of the amount of mind-wandering (participants answered on a scale from 1 = "completely on the music" to 7 = "completely on something else"). The second item ("How aware were you of where your attention was focused?") assessed meta-awareness as an orthogonal measure of mind-wandering (participants answered on a scale from 1 = "completely unaware" to 7 = "completely aware"). Only if mind-wandering was detected (first item > 1), participants were asked to provide further details about the content and the form of their thoughts, beginning with an open-ended question ("What were you thinking about, just before the music stopped?"). Moreover, based on previous research (Andrews-Hanna et al., 2013; Gorgolewski et al., 2014), we developed eight items to assess an array of phenomenological dimensions of thought (see Appendix, Table S.8 for precise questions and answer scales), including (*i*) valence, (*ii*) temporal orientation (past and future), (*iii*) self-referentiality, (*iv*) social aspects (familiar and unknown people), (*v*) movements, (*vi*) bodily sensations, (*vii*) music (thinking about the musical structure and evaluating the music), and (*viii*) experiment (thinking about the experiment). After these items, participants were asked whether their thoughts were based on images ("similar to a film or a painting") or words ("similar to a dialogue or an audio-book") to assess the form of mental activity. At the end of the task, participants answered to an item measuring the accuracy to follow the instructions of the experiment ("How accurately did you follow the instructions of this experiment?") on a scale from 1 ("not at all") to 7 ("very much so").

Participants completed a practice trial to familiarize with the task and to adjust the volume of their computer to a comfortable level. The total length of the experiment was about 20 min.

Analysis of thought-reports. In response to the open-ended item (see Appendix, Table S.8), participants provided 257 reports of their thoughts for the sad music condition and 242 for the happy music condition. We examined these thought-reports in two separate analyses.

First, we looked at the most frequent words used by participants to describe their thoughts during sad and happy music to gain an insight about the content of their thoughts. We used the web application Wordle (www.wordle.net) to generate a word cloud summarizing our results. The word cloud was prepared in four steps. First, we excluded all the words with an overall frequency of occurrence below a cut-off score of 10 as well as pronouns, adverbs, articles, and prepositions (regardless of their frequency). Words such as "music" and "thought" were also excluded from the word cloud, because they were not representative of the actual content of thoughts, but were rather biases due to the question used to inquire about participants' mental activity ("What were you thinking about just before the music stopped?"). Second, we grouped together words with similar semantic content (e.g., happy, happiness, joyful, joy). Third, we scaled word size by their overall frequency of occurrence within reports (i.e., referring to both sad and happy conditions). Fourth, we used color to represent words' overall frequency of occurrence over the sad and happy condition separately.

Second, we examined participants' reports of their thoughts using the Linguistic Inquiry and Word Count (LIWC) software (liwc.wpengine.com) to find out whether the use of positive and negative emotion words differs between thoughts that occurred during sad and happy music. LIWC identifies pre-chosen categories of language (such as positive and negative emotion) in a given text and calculates the percentage of total words that match such categories.

6.3.2 Experiment 2

Participants. 24 right-handed healthy participants (12 female, mean age = 25.3, age range 21-34) took part in Experiment 2 (none of the subjects participated in Experiment 1). Participants were screened for depressive symptoms, alexithymia, and sensitivity to music reward, using respectively the Quick Inventory of Depressive Symptomatology (QIDS-SR; Rush et al., 2003), the Toronto Alexithymia Scale (TAS-

20; Bagby, Parker, & Taylor, 1994), and the Barcelona Music Reward Questionnaire (BMRQ; Mas-Herrero et al., 2013). All participants scored below 6 on the QIDS-SR and 52 on the TAS-20 (thus, none of the participants were depressive or alexithymic). With regard to the BMRQ, all participants scored between 40 and 60 on the two factors of *emotion evocation* and *mood regulation*, indicating an average sensitivity to reward derived from music-evoked emotional experiences. All participants were native German speakers. None of the participants were professional musicians. 58.3% of the participants were non-musicians, 29.2% amateur musicians, and 12.5% semi-professional musicians. Exclusion criteria were prior history of major neurological or psychiatric disorder, alcohol and other drug abuse, and excessive consumption of alcohol or caffeine as well as poor sleep during the 24 hours before the experimental session. Participants either received course credit or 10€/h for participation. All participants gave written informed consent. The study was approved by the ethics committee of the Freie Universität Berlin.

Music stimuli. We initially selected a large number of instrumental excerpts of sad and happy film soundtracks, avoiding popular music themes to control for memory effects (similarly as in Experiment 1). Importantly, because the tempo, measured in BPM, is usually faster for happy than sad music, and because music beats also evoke vestibular responses (potentially leading to the activation of vestibular cortical areas, which overlap in part with areas implicated in emotional processing; Koelsch, 2014), we ensured that both sad and happy excerpts had the same tempo. To achieve this, we compiled sad and happy pairs of excerpts that could be musically combined with an isochronous sequenced electronic beat (Pehrs et al., 2014), containing sounds of drum kits or percussions. We added such electronic beat to each pair of excerpts using the software FL Studio 6.0 (www.image-line.com). Different types of beats were used, following the rule of applying the same beat to each pair (sad, happy) of excerpts. The volume of the beats was set to 6 dB below the volume of the original music excerpts during the rendering of the music stimuli. Thus, all sad-happy stimulus pairs featured an acoustically identical beat track, leading to the same perceived tempo and similar vestibular responses for sad and happy music. All excerpts were edited to have 1.5 s fade in/out ramps and were RMS-normalized to have the same loudness.

A behavioral pilot study was performed to determine the best pairs (sad, happy) of stimuli capable of evoking emotions of sadness and happiness. 42 volunteers (24 female, mean age = 28.1, age range 18-38) listened to 15 sad and 15 happy pieces, presented in a counterbalanced order, and were then asked to rate their emotional state during the music on four scales (valence, arousal, sadness, and happiness [7-point scales]). Based on the emotion ratings, we selected the four "sad-happy" pairs of excerpts that were most consistently identified as belonging to their respective emotion category. Thus, the stimulus material for Experiment 2 included eight excerpts of sad and happy music (for details see Appendix, Table S.10). There were four "short" (36 s) and four "long" (1.18-1.30 min) excerpts, counterbalanced across conditions. Stimuli of the same emotion category were concatenated into blocks of 4 min duration (no stimulus was repeated), resulting in one 4 min stimulus block per experimental condition. The use of only one 4 min block of music per condition ensured optimal data for the application of the fMRI data analysis, in which we adopted ECM (Lohmann et al., 2010). ECM requires relatively long trial periods, but has the advantage that only one trial per condition is sufficient per subject.

Task design and procedure. Prior to the fMRI measurements, the participants were tested on their familiarity with the selected music pieces. Participants listened to short excerpts (15 s) of the sad and happy stimuli and indicated their familiarity with each excerpt on a scale ranging from 1 ("I have never heard this piece before") to 5 ("I know this piece"). Participants were not included in the fMRI session if they were familiar with any of the music pieces. A paired *t*-test showed that there was no significant difference in familiarity between the happy (1.62 ± 0.57) and the sad pieces (1.57 ± 0.63), $p > .05$. A minimum of 14 days passed between this behavioral session and the fMRI experiment to avoid memory effects (Pereira et al., 2011).

In the scanner participants were presented with the sad and happy excerpts. We also presented blocks with dissonant sad and dissonant happy music, as well as with neutral music, but for the sake of brevity the results about these blocks will be reported elsewhere. The order of blocks was pseudo-randomized across subjects. Stimuli were presented via MRI-compatible headphones (under which participants wore earplugs) at a comfortable volume level, using Presentation (www.neurobs.com). Participants were instructed to close their eyes and relax during the music listening. Each block of music stimuli was followed by a 2 s signal tone, signaling to participants to open their eyes, and then by a 16 s evaluation period, during which participants were asked to indicate their overall emotional state during the music listening, using a response pad they held in their right hand. Ratings about felt emotions were obtained on four scales (valence, arousal, sadness, and happiness [6-point scales]; these behavioral results are reported in Chapter 8, see Fig. 8.1 on p. 120). The rating period was followed by a silence period of 10 s to avoid emotional blending between different blocks of stimuli. The total length of the experiment was about 27 min.

fMRI acquisition. MRI data were acquired using a 3.0 T MRI scanner (Magnetom TIM Trio, Siemens, Erlangen, Germany) at the Dahlem Institute for Neuroimaging of Emotion (D.I.N.E.). Prior to functional scanning, a high-resolution (1x1x1 mm) T1-weighted anatomical reference image was obtained from each participant using a rapid acquisition gradient echo (MP-RAGE) sequence. For the functional session, a continuous echo planar imaging (EPI) sequence was used (37 slices interleaved; slice thickness = 3 mm; interslice gap = 0.6 mm; TE = 30 ms; TR = 2,250 ms; flip angle = 70°; matrix = 64x64; FOV = 192x192 mm). To minimize susceptibility artifacts in areas such as the orbitofrontal cortex and the temporal lobes, the acquisition window was tilted at an angle of 30° to the intercommissural (AC-PC) plane (Deichmann, Gottfried, Hutton, & Turner, 2003; Weiskopf, Hutton, Josephs, Turner, & Deichmann, 2007).

fMRI data analysis/preprocessing. Functional MRI data were processed using the software LIPSIA 2.1 (Lohmann et al., 2001). Prior to statistical analysis, functional images were corrected for slicetime acquisition and normalized into MNI-space-registered images with isotropic voxels of 3 mm^3. Low frequency drifts in the fMRI time-series were removed using a high-pass filter with a cutoff frequency of 1/90 Hz and functional images were spatially smoothed using a Gaussian kernel of 6 mm full-width at half-maximum (FWHM). Furthermore, the mean signal value per scanned volume was computed and regressed out of each participant's data. The movement parameters of each participant were also regressed out of the respective fMRI time-series to control for motion artifacts.

ECM analysis. ECM is a graph-based network analysis technique, which measures the importance, or influence, of network nodes. ECM assigns a centrality value to each voxel (3x3x3 mm) in the brain such that a voxel receives a larger value if its time-series is strongly correlated with the time-series of many other voxels that are themselves central within the network (Lohmann et al., 2010). Thus, voxels receive high eigenvector centrality values if they show functional connectivity with many other voxels that have high centrality values themselves. Furthermore, ECM has the advantage of being a data-driven model-free method that is observer-independent. ECM was used similarly in a previous study (Koelsch & Skouras, 2014) to assess “computational hubs” within brain networks underlying music-evoked joy and fear.

ECM analysis was carried out in two steps. On the first level, whole-brain eigenvector centrality maps (ECMs) were computed separately for each participant during each 4 min experimental condition. On the second level, ECMs were compared between the two experimental conditions using voxel-wise paired *t*-tests. Results were corrected for multiple comparisons using cluster-size and cluster-value thresholds obtained by Monte Carlo simulations with a significance level of $p < .05$ (Lohmann, Neumann, Müller, Lepsien, & Turner, 2008).

6.4 Results

6.4.1 Experiment 1

Comparisons using paired *t*-tests (all *p*-values reported are Bonferroni-corrected) revealed that sad music [3.71 ± 1.83] evoked significantly more mind-wandering than happy music (3.28 ± 1.51), $t(215) = 2.979$, $p = .003$ (Fig. 6.1A). This was confirmed by the fact that meta-awareness, which involves one's explicit knowledge of the current content of thoughts (Schooler et al., 2011), was significantly stronger during happy (5.25 ± 1.63) than sad music (4.86 ± 1.79), $t(215) = 3.354$, $p = .001$

(Fig. 6.1A). Thoughts were significantly more self-referential during sad (3.80 ± 2.03) than happy music (3.17 ± 1.77), $t(163) = 3.306$, $p = .001$ (Fig. 6.1B). Conversely, thoughts were significantly more focused on movements as well as unknown people during happy [movements (3.95 ± 2.25); unknown people (3.17 ± 2.03)] than sad music [movements (1.87 ± 1.44), $t(163) = 11.309$, $p < .001$; unknown people (2.38 ± 1.89), $t(163) = 4.075$, $p < .001$; Fig. 6.1B], which may be due to the strong association between happy music and imagining people dancing (see also Fig. 6.2). Overall, participants attended significantly more to happy [thinking about the music (4.40 ± 1.87); evaluating the music (3.89 ± 2.02)] than sad music [thinking about the music (3.64 ± 1.97), $t(163) = 4.718$, $p < .001$; evaluating the music (3.28 ± 1.97), $t(163) = 4.171$, $p < .001$; Fig. 6.1B]. The diminished attention to the musical structure during the sad condition is in line with the decoupling of attention from external stimuli, which is typical of mind-wandering (Schooler et al., 2011). Furthermore, thoughts were significantly more focused on the experiment during happy (3.20 ± 2.07) than sad music (2.34 ± 1.79), $t(163) = 5.708$, $p < .001$ (Fig. 6.1B). The form of mental activity (visual imagery or inner language) did not differ significantly between the two experimental conditions, and visual mental imagery was the predominant modality for both sad (4.90 ± 1.82) and happy music (5.05 ± 1.74) compared with inner language [sad music (2.90 ± 1.70), $t(179) = 9.049$, $p < .001$; happy music (2.70 ± 1.69), $t(186) = 11.304$, $p < .001$; Fig. 6.1C]. Thoughts were significantly more positive during happy (5.08 ± 1.31) than sad music (3.89 ± 1.36), $t(163) = 7.819$, $p < .001$ (Fig. 6.1B). Nevertheless, the analysis of the thought-reports revealed that thoughts occurring during sad music were characterized by both negative (e.g., sorrow) and positive (e.g., love) emotion words, indicating a mixed affective tone (Fig. 6.2 and Appendix, Table S.11).

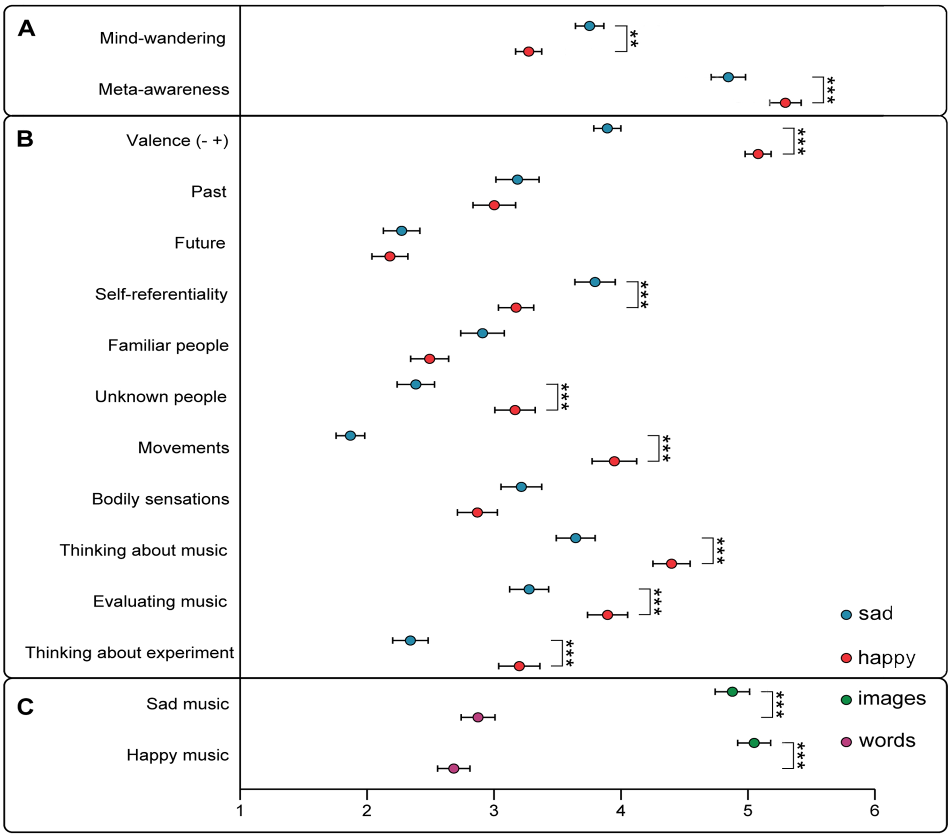

Figure 6.1. *Differences in the amount of mind-wandering and its phenomenological dimensions between experimental conditions (sad and happy music)*. Mean ratings (± SEM) of each item featured in the thought probes are shown (answer scales 1-7; see Appendix, Table S.8 for precise questions). (*A*) Significantly more mind-wandering and less meta-awareness were observed during sad (compared with happy) music. (*B*) During sad (compared with happy) music, thoughts were significantly more self-referential. By contrast, during happy (compared with sad) music, thoughts were significantly more focused on positive content, movements, unknown people, music, and experiment. (*C*) During both sad and happy music, thoughts occurred significantly more in the form of images compared with words. ** $p < .005$, *** $p \leq .001$.

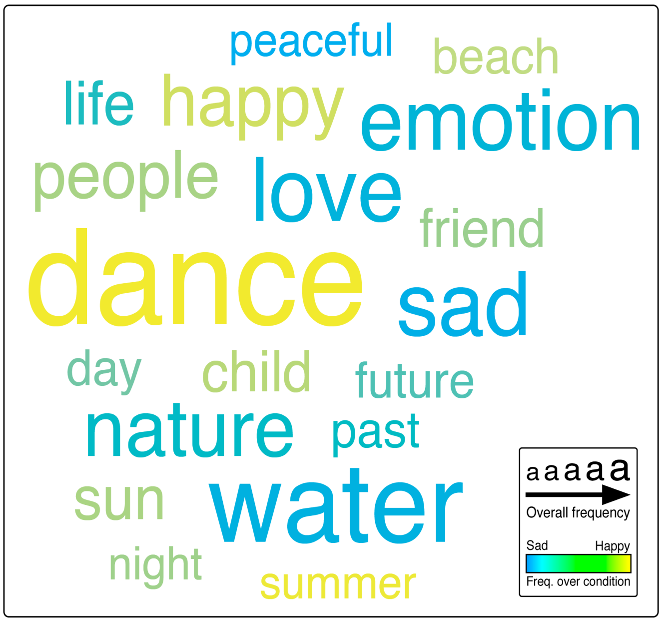

Figure 6.2. *Word cloud of thought content during sad and happy music.* Word size is scaled according to the overall word frequency (larger words indicate more frequent thought content over both experimental conditions). Blue color indicates thought content more frequently reported during sad music and yellow color indicates thought content more frequently reported during happy music. Thought content during sad music mainly referred to emotions and natural elements. By contrast, thought content during happy music was predominantly characterized by dance imagery.

6.4.2 Experiment 2

Comparing ECMs between the sad and the happy condition (*sad* > *happy* contrast, Fig. 6.3 and Table 6.1; for the results of the *happy* > *sad* contrast, see Appendix, Fig. S.2 and Table 6.1) revealed a midline four-cluster pattern of significantly higher centrality values, including vmPFC (Brodmann area [BA] 32), dmPFC (BA 9), PCC (BA 23), and PCC/PCu (BAs 31 and 7). Two additional clusters were found in the pIPL bilaterally (BA 39). All of these clusters were on average within a distance of only 5 brain voxels (max. distance 6 voxels) from the brain regions of the DMN as reported in a meta-analysis on default-mode processing (Spreng, Mar, & Kim, 2009). Thus, in accord with the hypothesis motivated by Experiment 1, sad music, compared with happy music, engaged the core nodes of the DMN.

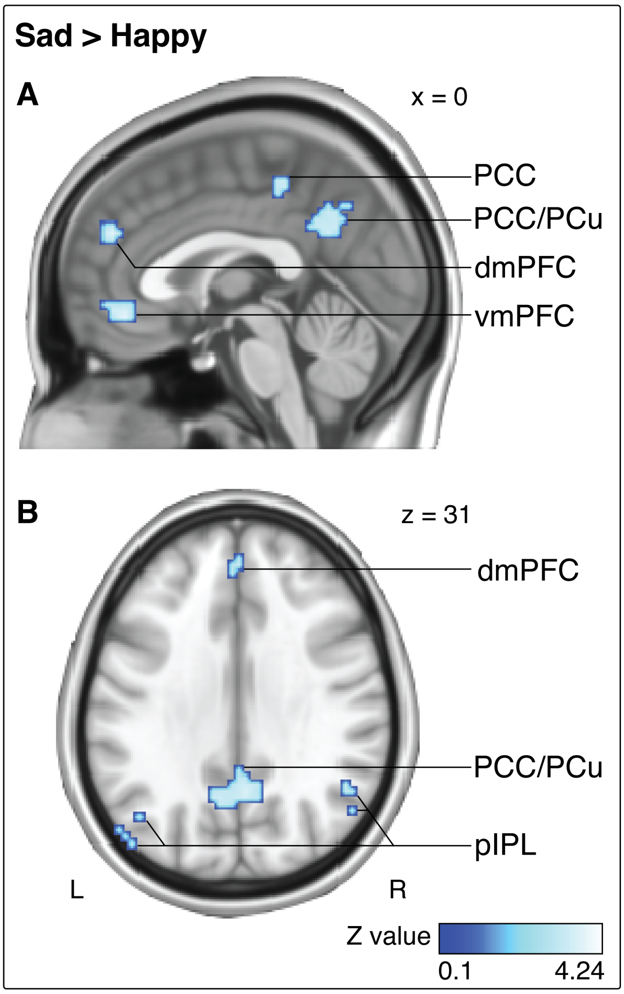

Figure 6.3. *Increased centrality of the DMN nodes during listening to sad music.* (*A*) Sagittal and (*B*) axial views show ECMs obtained from voxel-wise paired *t*-tests comparing sad and happy music. Sad and happy stimuli had identical loudness and number of BPM. Results were corrected for multiple comparisons ($p < .05$). Clusters of significantly higher centrality values were observed in the main nodes of the DMN: ventromedial prefrontal cortex (vmPFC), dorsomedial prefrontal cortex (dmPFC), posterior cingulate cortex (PCC), posterior cingulate cortex/precuneus (PCC/PCu), and posterior inferior parietal lobule bilaterally (pIPL). Coordinates refer to MNI space.

Table 6.1. *Results of the ECM contrasts sad > happy and happy > sad, corrected for multiple comparisons (p < .05).*

anatomical location	MNI coordinates	cluster size (mm³)	*z*-value: max
sad > happy			
vmPFC	-6 39 -8	1,755	4.24 (3.22)
r cingulate gyrus/vPFC	15 39 -2	810	4.04 (3.03)
dmPFC	0 45 31	864	3.70 (3.13)
PCC	0 -36 52	378	3.22 (3.00)
PCC/PCu	21 -51 16	3,699	4.18 (3.12)
l pIPL	-48 -69 43	864	3.31 (2.97)
r pIPL	54 -63 28	729	3.42 (3.01)
happy > sad			
r IFG (pars opercularis)	48 12 25	486	3.68 (3.21)

Note. The outermost right column shows the maximal z-value within a cluster (with the mean z-value of all voxels within a cluster in parentheses). Abbreviations: dmPFC = dorsomedial prefrontal cortex; IFG = inferior frontal gyrus; PCC = posterior cingulate cortex; PCu = precuneus; pIPL = posterior inferior parietal lobule; vmPFC = ventromedial prefrontal cortex; vPFC = ventral prefrontal cortex.

6.5 Discussion

In this study, we examined music-dependent thought as a function of the emotion evoked by music. Our findings reveal that sad music, compared with happy music, increased the propensity to mind-wander. Importantly, very little is known about which external cues trigger mind-wandering, as mind-wandering is traditionally considered to be stimulus-independent (Teasdale et al., 1995). The fact that mind-wandering can be externally modulated by means of music is in line with previous evidence of mind-wandering elicited during task such as reading aloud (Franklin, Mooneyham, Baird, & Schooler, 2014), and flags the importance of external emotional cues in eliciting mind-wandering episodes. The enhanced mind-wandering during sad music as observed in Experiment 1 is consistent with the stronger centrality of the DMN nodes in Experiment 2, since the DMN has been indicated as the principal contributor to mind-wandering (Andrews-Hanna et al., 2010a; Andrews-Hanna et al., 2010b; Christoff et al., 2009; Kucyi et al., 2013; Mason et al., 2007;

Mittner et al., 2014). Although in previous studies DMN nodes were among numerous regions activated in response to music (e.g., Janata et al., 2002), this was never attributed to self-generated thought. By contrast, the present study links activity within this large-scale brain network to mind-wandering triggered by sad music. In addition, our results reveal that participants' mental activity while listening to sad music was self-referential, in line with (*i*) individuals reporting to mind-wander about personally significant matters (Smallwood et al., 2011) and (*ii*) evidence of a putative role of the DMN's midline core in self-referential processing (Andrews-Hanna et al., 2010a).

Contrary to previous findings, our results do not corroborate that sad mood always enhances mind-wandering in a past-oriented way (Smallwood & O'Connor, 2011). In fact, music-evoked sadness, and art-evoked sadness in general, differs in valence from “real” sadness or negative mood (Taruffi & Koelsch, 2014; see also Fig. 8.1 on p. 120 for valence ratings obtained in Experiment 2). Thus, our study suggests that the multi-faceted emotional experience underlying sad music, often described by listeners as melancholic yet pleasurable (Taruffi & Koelsch, 2014), shapes mind-wandering in a unique way, qualitatively non-identical to mind-wandering triggered by “everyday” negative mood. This points to a fascinating relationship between emotions evoked by artworks and thought. Likewise, we did not observe any significant difference in past-oriented thought between sad and happy music, and the analysis of participants' reports of thoughts occurring during sad music reflects the mixed emotions evoked by sad music.

An additional interesting result was about the form of mental experiences during sad and happy music. In particular, images (compared with words) were clearly the dominant modality for both sad and happy music, pointing to a strong link between visual mental imagery and music processing. Notably, this finding is consistent with previous studies reporting activations in the primary visual cortex during music listening (Koelsch & Skouras, 2014; Trost et al., 2012) and with the predominance of visual mental imagery during resting state (Andrews-Hanna et al., 2013; Delamillieure et al., 2010). Moreover, visual imagery has been proposed as a core mechanism underlying the evocation of emotion through music (Juslin & Västfjäll, 2008).

In conclusion, listening to sad (compared with happy) music engages mind-wandering associated with increased centrality of the DMN nodes. We demonstrate that sad music modulates self-generated thought: Listeners direct their attention inwards, engaging in spontaneous thoughts related to the self and emotional aspects of life. Thus, our findings highlight the capability of music to trigger specific mental processes as a function of the emotion evoked by music, opening a novel line of future research elucidating the impact of music-evoked emotions on cognition. This has crucial implications for the application of music in a variety of domains including education, psychotherapy and marketing/advertising. The stimulating effect of sad music on mind-wandering could be harnessed to improve creativity (Baird et al., 2012), social cognition (Tamir, Bricker, Dodell-Feder, & Mitchell, 2016), and decision-making (Reniers et al., 2012). The diminishing effect of happy music on mind-wandering, by contrast, may be beneficial for sustained attention during task performance (Cheyne, Solman, Carriere, & Smilek, 2009), and reduce rumination as a repetitive style of thinking associated with depression (Nolen-Hoeksema, 2000). Our study also shows modulation of the DMN by music. The DMN was initially introduced as resting state phenomenon (Raichle et al., 2001) and subsequent studies revealed that its engagement reflects mind-wandering (Andrews-Hanna et al., 2010a; Andrews-Hanna et al., 2010b; Christoff et al., 2009; Kucyi et al., 2013; Mason et al., 2007; Mittner et al., 2014). Our results reveal that the DMN is highly sensitive to external emotional cues, indicating that the DMN is more strongly associated with affective processing than previously believed. Furthermore, given that aberrant DMN activity has been linked to mental disorders such as schizophrenia (Garrity et al., 2007), depression (Sheline et al., 2009), autism spectrum disorder (Kennedy, Redcay, & Courchesne, 2006), and Alzheimer's disease (Greicius, Srivastava, Reiss, & Menon, 2004), our findings provide new perspectives for the investigation of the efficacy of music therapy in the treatment of such disorders.

Chapter 7

Study 3 - Individual Differences in Music-Perceived Emotions: The Influence of Externally-Oriented Thinking[1]

> "I haven't understood a bar of music in my life, but I have felt it."
>
> — I. Stravinsky

7.1 Abstract

Previous music and emotion research suggests that individual differences in empathy, alexithymia, personality traits, and musical expertise may play a role in music-perceived emotions. In this study, we investigated the relationship between these individual characteristics and the ability of participants to recognize 5 basic emotions (happiness, sadness, tenderness, fear, and anger) conveyed by validated excerpts of film music. One hundred and twenty participants were recruited through an online platform and completed an emotion recognition task as well as the IRI (Interpersonal Reactivity Index), TAS-20 (Toronto Alexithymia Scale), BFI (Big Five Inventory), and Gold-MSI (Goldsmiths Musical Sophistication Index). While participants recognized the emotions depicted by the music at levels that were better than chance, their performance accuracy was negatively associated with the *externally-oriented thinking* subscale from the TAS-20. Our results suggest that alexithymia, previously linked to a deficit in perception of facial and vocal expressions of emotion, is also associated with difficulties in perception of emotions conveyed by music.

7.2 Introduction

It has long been debated whether, and to what extent, music expresses emotions which are effectively understood across cultures (e.g., Balkwill & Thompson, 1999;

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Thompson & Balkwill, 2010). In 2009, a landmark study by Fritz and colleagues showed that people from a native African population called Mafa, naive to Western music, were able to recognize the three “basic” emotions of happiness, sadness, and fear conveyed by Western music. Their findings strongly suggest that music-perceived emotions (i.e., the emotions depicted by the music) are not culturally determined, but universal across human cultures. This idea is supported by a number of studies which showed that even young children are able to recognize basic emotions represented by music, including happiness and sadness (Cunningham & Sterling, 1988; Dalla Bella, Peretz, Rousseau, & Gosselin, 2001; Kastner & Crowder, 1990; Nawrot, 2003), anger (Cunningham & Sterling, 1988; Heaton, Allen, Williams, Cummins, & Happé, 2008; Kastner & Crowder, 1990; Nawrot, 2003), and fear (Cunningham & Sterling, 1988; Heaton et al., 2008; Nawrot, 2003). However, questions remain about the extent that this ability is influenced by listener characteristics. If such individual differences exist across the typical population (meaning that we are not all the same at recognizing emotions in music), it follows that the “universal” tendency to perceive musical emotions can be modulated by individual factors.

Preliminary evidence for individual differences in music-perceived emotions comes from research on facial and verbal expressions of basic emotions. Although healthy individuals generally perform well in recognizing basic emotion expressed in faces and voices, it has also been shown that there are considerable and stable individual differences in the accuracy of people's judgments (e.g., Bowles et al., 2009; Ekman & Oster, 1979; Matthews et al., 2015; Miura, 1993; Palermo, O'Connor, Davis, Irons, & McKone, 2013). With regard to facial expression, the perception of emotional faces and pictures can be altered by temporary moods in an affect-congruent fashion (Bouhuys, Bloem, & Groothuis, 1995; Isen & Shalker, 1982). For example, Bouhuys and colleagues (1995) demonstrated that induced sad mood leads to an increased perception of sadness in ambiguous emotional expressions. Furthermore, there is some evidence for sex differences, with female children and adults being more sensitive to non-verbal emotion cues than male children and adults (e.g., Allgood & Heaton, 2015; Briton & Hall, 1995). With regard to verbal expression, research suggests that younger participants are more sensitive to emotional voices than older participants (Allen & Brosgole, 1993; Brosgole & Weisman, 1995; Kiss & Ennis, 2001; Orbelo, Grim, Talbott, & Ross, 2005; Paulmann, Pell, & Kotz, 2008).

Further preliminary proof that individual differences can influence perception of musically expressed emotions arises from music research investigating felt emotions (i.e., emotions evoked in response to the music). A few studies have shown that listener characteristics consistently influence the individual's personal emotional experience and enjoyment of sad music. For instance, trait empathy (Taruffi & Koelsch, 2014; Vuoskoski & Eerola, 2012; Vuoskoski et al., 2012) and the personality trait of *openness to experience* (Vuoskoski et al., 2012) are associated with the enjoyment of sad music and the susceptibility to music-evoked sadness. Similarly, the enjoyment of sad music is positively associated with individual differences in *musical empathy* and *absorption* (Garrido & Schubert, 2011a, 2013), and is negatively associated with *emotional stability* (Taruffi & Koelsch, 2014). As perceived and felt emotions are intrinsically connected (Gabrielsson, 2002), it is likely that such individual factors may impact both types of musical responses. Moreover, the so-called "paradox of sad music" perfectly illustrates the existence of individual differences in the perception of sad music (Garrido & Schubert, 2011a, 2013; Huron, 2011; Taruffi & Koelsch, 2014). Many listeners describe the sadness conveyed by music as pleasant (positive emotions associated with sad music include nostalgia, peacefulness, wonder and tenderness; Taruffi & Koelsch, 2014), while others perceive it as negatively valenced.

To sum up, although previous studies have provided substantial evidence for the role of individual differences in music-evoked emotions, research has yet to identify the individual characteristics influencing the perception of emotional expressions in music. Importantly, emotion perception may draw on more general mechanisms of emotional sensitivity, which are necessary for adequate social functioning. For instance, alexithymia – a personality trait characterized by a reduced ability to translate internal emotional experiences into precise, explicit verbal form and common in autism spectrum disorder (Allen & Heaton, 2010; Nemiah et al., 1976) - is linked to deficits in perception of facial and vocal expressions of emotions

(Heaton et al., 2012; Jessimer & Markham, 1997; Lane et al., 1996; Parker, Bagby, Taylor, Endler, & Schmitz, 1993; Prkachin, Casey, & Prkachin, 2009). Thus, investigating whether also the perception of musical emotions is altered in alexithymia can shed light on the nature of the mechanisms involved in emotion perception. Furthermore, the ability to correctly identify and communicate emotions depicted by music is a relevant aspect of music performance (Juslin & Laukka, 2003), and, for the listener, emotion recognition may lead to deeper understanding as well as greater aesthetic appreciation of the music (Goodman, 1968). Therefore, it is important to understand how emotions are decoded through music and to identify which factors influence this decoding process. As a contribution to this field of research, we examined the relationship between the perception of musical emotions and individual differences in empathy, alexithymia, personality traits, and musical expertise. Such characteristics were chosen over other plausible candidates, like mood, because they are strongly implicated in the recognition of musical emotions, as the following review illustrates.

Empathy is defined as an individual affective response to the observed, imagined or inferred experiences of others, involving both perspective-taking capabilities or tendencies, and emotional reactivity (Singer & Lamm, 2009). Apart from the literature on negative music-evoked emotions, to date only one study has directly examined the relationship between trait empathy and music-perceived emotions (Wöllner, 2012). In this study, a string quartet performance was video recorded, and the members of the quartet were asked to rate their expressive musical intentions during the performance. Independent observers were asked to evaluate the musicians' expressive intentions, and observers with higher affective and overall empathy scores performed better than observers with lower scores on these measures. In line with this finding, Resnicow and colleagues (2004) found a significant positive correlation between emotional intelligence (a construct involving empathy) and correct identification of emotions in music, suggesting that the correct decoding of emotions in music is an important aspect of emotional intelligence.

Several studies have highlighted an association between empathic deficits and alexithymia (Guttman & Laporte, 2000; Jonason & Krause, 2013; Moriguchi et al., 2007; Silani et al., 2008). Conscious understanding of one's own emotions is linked to the understanding of another individual's feelings (Singer et al., 2004), and it is unsurprising that alexithymia correlates with empathic deficits. Alexithymia is found not only in psychiatric and psychosomatic patients but also among general healthy people (Taylor & Bagby, 2004). In the general population, alexithymia is associated with a broad range of sociodemographic variables such as poor education (Kokkonen et al., 2001), low income level (Kokkonen et al., 2001), increasing age (Mattila, Salminen, Nummi, & Joukamaa, 2006), and low health-related quality of life. Moreover, alexithymia is usually higher in men than in women (Kokkonen et al., 2001; Mattila et al., 2006; Salminen, Saarijärvi, Äärelä, Toikka, & Kauhanen, 1999). As mentioned above, several studies have shown that individuals with high levels of alexithymia are significantly less able to recognize facial expressions of emotions (Jessimer & Markham, 1997; Lane et al., 1996; Parker et al., 1993; Prkachin et al., 2009) and vocal expressions of emotion (Heaton et al., 2012) than those with low levels of alexithymia. This suggests that alexithymia involves a deficit in interpreting external as well as internal emotion cues. In addition, this deficit appears to be linked specifically to negative emotions (Parker et al., 1993; Parker, Prkachin, & Prkachin, 2005). For example, Prkachin and colleagues (2009) found that students with high alexithymia scores experienced difficulties in detecting facial expressions of sadness, anger, and fear. With regard to the music domain, Allen, Davis and Hill (2013) compared a group of high-functioning adults on the autism spectrum with a group of matched controls on verbal and physiological measures of musical responsiveness. Following exposure to music excerpts, the participants were presented with a check-list of words related to emotions, feelings and sensations, and were asked to tick words that described the way the music made them feel. Individuals with autism obtained significantly lower scores than typical individuals. However, when the participants' alexithymia scores were included as a mediator variable the group difference was no longer significant. On the measure of physiological responsiveness to music, the groups did not significantly differ, indicating that the visceral impact of the music was similar. Nevertheless, the results from the study clearly indicate that alexithymia was responsible for the autistic participants' relative inability to articulate the emotional experience induced by the music.

Individual differences in the ability to perceive musical expressions of emotions may also depend on personality traits. In particular, personality traits can lead to emotion-specific biases. For instance, Vuoskoski and Eerola (2011) found a positive association between trait *neuroticism* and sadness ratings (given after the exposure to music stimuli depicting basic emotions) as well as a negative association between trait *extraversion* and sadness ratings, thus suggesting that personality traits modulate perceived emotions in a trait-congruent fashion (see also Rusting, 1998). In other terms, *neuroticism* would lead to a general scale-use bias towards negative emotions, while *extraversion* would lead to a positive emotion bias. However, the sample size was relatively small in the study (N = 67), and further research should try to replicate the findings with a larger population.

Because perception of emotion in music partly relies on the processing of musical and acoustic features (Juslin & Västfjäll, 2008), musical expertise may influence performance accuracy in the recognition of musical emotions. For instance, musical abilities (e.g., tonal encoding of pitch) may constitute an advantage in a musical emotion recognition task. However, conflicting findings emerge from research on music and emotion. While some studies have provided evidence for a role of musical expertise in emotion perception (Bigand et al., 2005), several studies have failed to reveal a difference in the way musicians and non-musicians process musical structure (for a review, see Bigand & Poulin-Charronnat, 2006). Given these conflicting results, more research is needed to clarify whether musical expertise can contribute to the recognition of emotions in music.

The aim of the current study was to test whether individual differences in empathy, alexithymia, personality traits, and musical expertise influence the listeners' sensitivity to music-perceived emotions. To address this question we measured short-term emotion perception of validated music stimuli conveying happiness, sadness, tenderness, fear, and anger. While studies of music and emotion often use Western classical music (e.g., Krumhansl, 1997; Mitterschiffthaler et al., 2007), we aimed to increase ecological validity by employing film music as our stimulus material. To measure individual differences we administered the Interpersonal Reactivity Index (IRI; Davis, 1980), the Toronto Alexithymia Scale (TAS-20; Bagby et al., 1994), the Big Five Inventory (BFI; John & Srivastava, 1999), and the Goldsmiths Musical Sophistication Index (Gold-MSI; Müllensiefen, Gingras, Musil, & Stewart, 2014).

We tested two experimental hypotheses. First, we expected that participants who obtained high scores on empathy and musical expertise and low scores on alexithymia would perform at high levels on the musical emotion recognition (MER) task. Second, we expected that personality traits would modulate perceived emotions in a trait-congruent fashion. Our aim in testing the second hypothesis was to extend the findings of Vuoskoski and Eerola (2011), by investigating the influence of personality traits in the recognition of musical emotions in a larger multi-ethnic sample of participants.

7.3 Method

7.3.1 Participants

120 (73 female) subjects, aged 19-72 (M = 30.37, SD = 9.49), took part in the study. The sample was composed mainly of students (49.3%). Around half of the participants had obtained post-graduate degrees (46.7%). The majority of the participants were Italian (45.8%), followed by English (20.8%). Among the remaining participants, 21% grew up in Europe, 5% in US, 2.5% in Australia, 2.5% in South America, and 2.4% in Asia. The participants' favorite musical genres fell into the following categories: 65% rock and pop, 20.8% classical music, 8.4% folk and ethnic music, and 5.8% jazz. 26.7% of the participants could not play any musical instrument and did not sing.

Participants were recruited through fliers posted around the University campus as well as through advertisements on student mailing lists. Participation was voluntary and completely anonymous, all participants provided informed consent, and no financial compensation was offered. The study was conducted according to the Declaration of Helsinki and approved by the ethics committee of Goldsmiths Department of Psychology. The privacy of participants was ensured and their data were anonymized.

7.3.2 Materials

The test battery included a MER task plus the following four questionnaires: IRI, TAS-20, BFI, and Gold-MSI. Descriptive statistics for each of the used instruments are displayed in the Appendix, Table S.12.

The IRI comprises 28 items divided in four subscales, which measure the following related aspects of empathy: *perspective-taking*; *fantasy*; *empathic concern*; and *personal distress*. The items were scored on a 5-point Likert scale (from 1 = "strongly disagree" to 5 = "strongly agree").

The TAS-20 comprises 20 items and yields a general score plus three subscores corresponding to three factors, labeled respectively as: *difficulty in identifying feelings*; *difficulty in describing feelings*; and *externally-oriented thinking*. The items were scored on a 5-point Likert scale (from 1 = "strongly disagree" to 5 = "strongly agree").

The BFI comprises 44 items, scored on a 5-point Likert scale (from 1 = "strongly disagree" to 5 = "strongly agree"). The questionnaire assesses the following five personality dimensions: *extraversion*; *agreeableness*; *conscientiousness*; *neuroticism*; and *openness to experience*.

The Gold-MSI measures individual differences in musical sophistication. It includes the following five factors: *active engagement*; *perceptual abilities*; *musical training*; *singing abilities*; and *emotion*. For the scope of the present study, we assessed only the factor of *musical training* (i.e., the amount of formal musical training received), which comprises seven items, scored on a 7-point Likert scale (from 1 = "completely disagree" to 7 = "completely agree").

The music stimuli used in the MER task aimed to convey the five basic emotions of happiness, sadness, tenderness, fear, and anger. These emotions were selected because they represent common emotional responses to music and have been widely investigated in previous studies of musical emotion recognition (Juslin & Sloboda, 2010; Juslin & Västfjäll, 2008). The stimulus material was created and validated by Eerola and Vuoskoski (2011). In the present study, 50 music excerpts from film soundtracks (10 for each emotion) were randomly allocated to five audio blocks of 10 excerpts. Each stimulus was approximately 15 s long. The 10 music excerpts for each emotion comprised five "high" and five "moderate" examples of that specific emotion. The "high emotion" excerpts were clearer and easier to interpreter, while the "moderate emotion" ones were more ambiguous and difficult to identify.

7.3.3 Procedure

A website containing the questionnaires and the MER task was set up. A description of the study and its aims was presented in the home page of the website. Participants were instructed to complete the experiment individually and in a quiet environment. They were instructed to begin by providing general information (i.e., age, gender, occupation, education, nationality, and favorite musical genre), before completing the questionnaires and the music task. Presentation of each questionnaire was followed by an audio block (in total five blocks presented in a random order). After listening to each music excerpt, participants were asked to select one of the five emotions shown on the screen (i.e., happiness, sadness, tenderness, fear, and anger). The instructions made a clear distinction between felt and perceived emotions and participants were explicitly asked to report the latter ("You are now going to listen to a group of 10 music excerpts. After listening to each excerpt, please match it to one of the five emotions shown on the screen, according to which emotion you think the music aimed to convey rather than how the music made you feel"). Following the completion of each audio block and questionnaire, the participants had the option of taking a break and completing the rest of the experiment later. However, they were not allowed to access and change responses that they had already submitted. This procedure aimed to guard against fatigue effects, potentially resulting from the design (repeated measures) and the length of the experiment (between 35 and 45 minutes, depending on the participant's speed). A menu displayed on the right side of the screen recorded the individual progress through the experiment.

7.4 Results

7.4.1 MER task

We measured the performance accuracy on the MER task by calculating the sum of the correct answers across the entire stimuli set for each participant ("MER total score") as well as within the subset of stimuli corresponding to each specific emotion. The MER total score ranged from 28 to 45 (out of 50), with *M* of 35.78 and *SD* of 3.95.

First, we conducted a single sample *t*-test to verify that the MER total score was significantly greater than chance level, $t(119) = 71.36$, $p < .001$. Then, we compared the numbers of correct answers given for the "high emotion" ($M = 19.97$, $SD = 2.33$) with the "moderate emotion" excerpts ($M = 15.81$, $SD = 2.49$) in a paired samples *t*-test. As expected, participants recognized the "high emotion" excerpts better than the "moderate emotion" ones with this difference being significant, $t(119) = 16.50$, $p < .001$.

Second, we carried out five repeated-measures ANOVAs (one for each target emotion) with emotion category (five levels) as within-subjects factor, to investigate whether there was any significant difference between the numbers of correct answers given for each emotion category. As the Kolmogorov-Smirnov test revealed that scores deviated from a normal distribution, we transformed the data with reverse score followed by log transformations. The results revealed significant main effects for all target emotion categories: happiness, $F(1.97, 234) = 1437.30$, $p < .001$; sadness, $F(1.78, 211) = 661$, $p < .001$; tenderness, $F(1.79, 213.45) = 599.33$, $p < .001$; fear, $F(2.17, 257) = 864.19$, $p < .001$; and anger, $F(1.19, 142.63) = 529.67$, $p < .001$ (all reported degrees of freedom were Greenhouse-Geisser adjusted for deviance from sphericity). Bonferroni pairwise comparisons showed that the mean correct ratings for the target emotions were significantly greater than the mean correct ratings for other emotions. Figure 7.1 illustrates this pattern and shows the mean correct ratings for each target emotion.

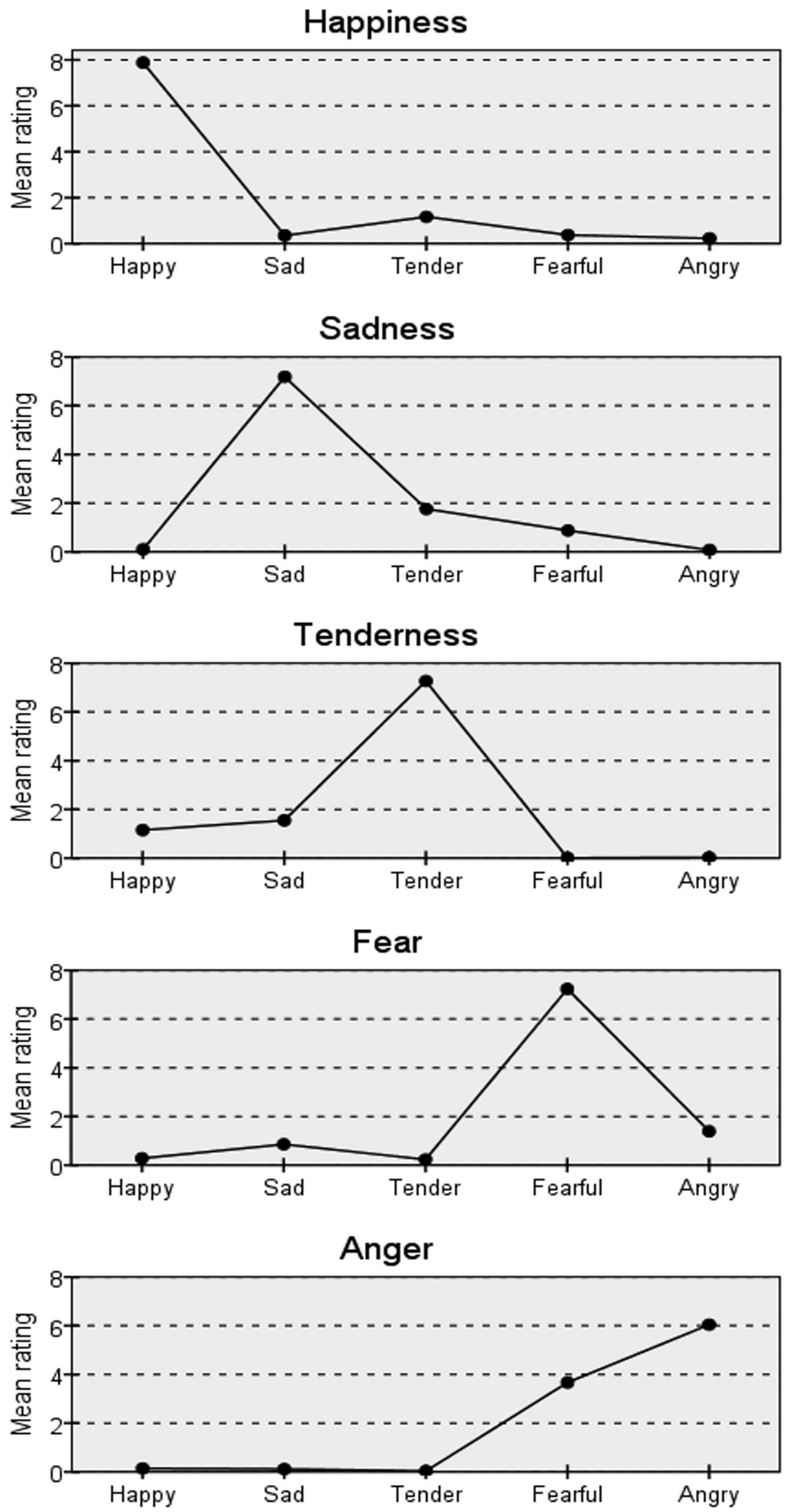

Figure 7.1. *Mean correct ratings of five basic emotions and music excerpts representing these target emotions.*

Third, a confusion matrix (Table 7.1) was computed to summarize the amount of error and the confusion patterns emerging from the MER task. Overall, the error rate was low (0.29, 29% of all predictions). Table 7.1 shows that the highest amount of total error per emotion category occurred in the case of anger (see also Fig. 7.1). In particular, angry music was mistaken for fearful music (440 out of 475 total incorrect predictions). Moreover, the category (target emotion) with the lowest amount of total error was happiness (254 total incorrect predictions). By contrast, listeners frequently confused sadness with tenderness (211 predictions) and vice versa (187 predictions).

Table 7.1. *Error analysis: Confusion matrix for the MER task.*

	Target Emotion				
Emotion	Happiness	Sadness	Tenderness	Fear	Anger
Happiness	**946 (15.77)**	12 (0.2)	137 (2.28)	34 (0.57)	17 (0.28)
Sadness	42 (0.7)	**862 (14.37)**	187 (3.12)	103 (1.72)	14 (0.23)
Tenderness	140 (2.33)	211 (3.52)	**872 (14.53)**	28 (0.47)	4 (0.07)
Fear	45 (0.75)	105 (1.75)	2 (0.03)	**868 (14.47)**	440 (7.33)
Anger	27 (0.45)	9 (0.15)	3 (0.05)	167 (2.78)	**725 (12.08)**
Total Error	254 (4.23)	337 (5.62)	329 (5.48)	332 (5.54)	475 (7.91)

Note. Values are numbers of errors (with % in brackets). Correct predictions are in bold. Target emotions denote the 5 emotion conditions employed in this study. The matrix shows a total of 1727 errors and 4273 correct predictions.

7.4.2 Individual characteristics influencing performance on the MER task

Data were further analyzed in two ways to investigate the main hypotheses that individual characteristics influence the perception of musical emotions. First, an exploratory correlation analysis of the subscale scores with the correct answers given for the "high emotion" and the "moderate emotion" excerpts was conducted to see if overall patterns could be identified. Second, a regression model based on the identified patterns was performed.

Table 7.2. *Pearson correlations between individual characteristics and performance accuracy in the MER task.*

	MER CORRECT SCORE						
Factor	Happiness	Sadness	Tenderness	Fear	Anger	HE ex.	ME ex.
C	.03	.06	.21*	.13	.05	.26**	.00
EOT	-.02	-.25**	-.19*	-.04	-.17	-.28**	-.08
MT	-.09	-.05	.13	.03	.25**	.19*	.02

Note. * $p < .05$, ** $p < .01$. C = *conscientiousness*; EOT = *externally-oriented thinking*; HE ex. = “high emotion” excerpts; MT = *musical training*; ME ex. = “moderate emotion” excerpts.

After correcting for multiple tests using the False Discovery Rate (FDR; Benjamini & Hochberg, 1995), only two significant correlations emerged. The subscale of alexithymia named *externally-oriented thinking* correlated negatively with the correct score for the “high emotion” excerpts (r = -.28, p = .002), and among the BFI factors, trait *conscientiousness* correlated positively with the correct score for the “high emotion” excerpts (r = .26, p = .004). Consequently, the *p*-values relative to the correlations between *externally-oriented thinking*, as well as *conscientiousness,* and MER score for individual emotions were explored, giving an alpha value with FDR correction of .05/5 = .01. *Externally-oriented thinking* was significantly associated, in a negative fashion, with correct ratings for sadness (r = -.25, p = .006). Furthermore, we detected a significant positive correlation between *musical training* and correct ratings for anger (r = .25, p = .006). Table 7.2 reports the results of this correlation analysis (the complete correlation matrix is available in the Appendix, Table S.13). Consequently, *externally-oriented thinking, conscientiousness,* and *musical training* were used as predictors in a standard multiple regression analysis with MER total score as dependent variable. As shown in Table 7.3, only *externally-oriented thinking* made a significant contribution to MER total score (β = .21, $p < .05$), accounting for 8.2% of the variance (R^2).

Table 7.3. *Predictors for standard multiple regression model of the MER total score.*

	B	SE	β	T	*p*
Constant	34.98	2.63		13.30	< 0.001
C	0.89	0.57	0.14	1.55	0.12
EOT*	-0.21	0.09	0.21	2.34	0.02
MT	0.03	0.02	0.12	1.36	0.18

Note. R^2 = .08. *B* denotes unstandardised regression coefficient. SE denotes standard error of *B*. β denotes the standardised regression coefficient. * denotes significant predictor. C = *conscientiousness*; EOT = *externally-oriented thinking*; MT = *musical training*.

As an alternative approach, we examined the relationship between individual characteristics and emotion ratings for groups of extreme scorers. The extreme scorers method can be used to increase the statistical power to detect an effect by focusing exclusively at those participants who are highly representative of a specific trait (Preacher, Rucker, MacCallum, & Nicewander, 2005). Extreme scorers on each scale were those individuals scoring in the upper tertiles. We calculated the percentage of extreme scorers exhibiting high accuracy rates (> 5 correct answers out of 10) in the recognition of the five basic emotions presented in the experimental task. Results are shown in Table 7.4. First of all, the average highest and lowest percentages of extreme scorers with high accuracy rates belong respectively to the categories of happiness and anger, in line with the error analysis, indicating that happiness was the easiest emotion to detect while anger the most difficult one. Furthermore, the percentage of extreme scorers on *externally-oriented thinking* with high accuracy rates for sad stimuli (78%) was lower compared with the percentages of extreme scorers on other scales. Moreover, 80.5% of extreme scorers on *musical training* provided high accuracy rates for stimuli conveying anger. This percentage was the highest for anger stimuli among the other groups of extreme scorers. Both these results corroborate the findings of the correlation and regression analyses. Interestingly, a relatively low percentage of extreme scorers on *musical training* (78%) exhibited high accuracy rates for sad stimuli, suggesting that this was the most difficult emotion category to detect for this group of listeners. Also, extreme scorers on *personal distress* (78.6%) showed the same trend in regard to sadness, while a high percentage of extreme scorers on *fantasy* (95.3%) provided high accuracy rates for this emotion category. Finally, the percentage of extreme scorers on *neuroticism* (94.9%) with high accuracy rates for sad stimuli was also relatively high.

Table 7.4. *Percentages of extreme scorers with high accuracy rates in the recognition of basic emotions.*

		Emotion Category					
Factor	N	Happy	Sad	Tender	Fearful	Angry	Mean
TAS-20							
DIF	41	**95.1%**	**90.2%**	**95.1%**	85.4%	61%	85.36%
DDF	41	**97.6%**	85.4%	**92.7%**	**92.7%**	63.4%	86.36%
EOT	41	**95.1%**	78%	82.9%	80.5%	63.4%	79.98%
Gold-MSI							
MT	41	90.2%	78%	**87.8%**	87.8%	**80.5%**	84.86%
IRI							
PT	36	**97.2%**	**88.9%**	86.1%	**94.4%**	**69.4%**	87.2%
EC	37	**94.6%**	**89.2%**	83.8%	**97.3%**	**78.4%**	88.66%
FT	43	93%	**95.3%**	**88.4%**	88.4%	**74.4%**	87.9%
PD	42	90.5%	78.6%	**88.1%**	**95.2%**	66.7%	83.82%
BIG-5							
E	40	**95%**	**92.5%**	80%	87.5%	60%	83%
A	39	92.3%	79.9%	76.9%	87.2%	66.7%	80.6%
C	40	92.5%	82.5%	**90%**	**92.5%**	65%	84.5%
N	39	**94.9%**	**94.9%**	**89.7%**	79.5%	**69.2%**	85.64%
O	41	85.4%	82.9%	85.4%	85.4%	**70.7%**	81.96%
Mean		93.34%	85.87%	86.68%	88.75%	68.37%	

Note. Percentages above the average per emotion category are in bold. The last row shows average per emotion category and the last column average per individual factor. A = *agreeableness*; C = *conscientiousness*; DDF = *difficulty in describing feelings*; DIF = *difficulty in identifying feelings*; E = *extraversion*; EC = *empathic concern*; EOT = *externally-oriented thinking*; FT = *fantasy*; MT = *musical training*; N = *neuroticism*; O = *openness to experience*; PD = *personal distress;* PT = *perspective-taking.*

7.5 Discussion

The aim of the present study was to examine the relationship between individual differences and perception of musical emotions. Through an online interface, a sample of 120 participants completed an emotion recognition task as well as four questionnaires assessing empathy, alexithymia, personality, and musical expertise.

Participants successfully recognized the emotions conveyed by the music well above chance level, although the emotion categories of fear and anger were frequently confused especially when anger was the target emotion. This pattern of confusion has been identified by previous research (Eerola & Vuoskoski, 2011) and indicates that these two emotion categories cannot be easily disentangled in the music domain. According to Russell's two-dimensional model of emotion (1980), arousal and valence often overlap in expressions of anger and fear (however, please notice that in three-dimensional models of emotion anger and fear are distinguished by tension and energy; see Schimmack & Grob, 2000) and future studies should evaluate differences and similarities in the acoustic and musical features of angry and fearful music. Moreover, it would be valuable for future studies to examine whether the confusion of anger with fear occurs across different musical genres. For example, it is possible that heavy metal music communicates the emotion of anger more clearly than other musical genres, and consequently the confusion of anger with fear might be minimal. In the present study, a secondary source of error was reported for the emotion categories of sadness and tenderness. Both sadness and tenderness are characterized by low arousal and share a number of important acoustic features such as slow tempo, low pitch, legato articulation, and slow tone attacks (Juslin & Laukka, 2004; Juslin, 2001). Furthermore, in everyday life sadness is experienced as a negatively valenced emotion, while tenderness has a positive valence. In the music domain however, sadness, as well as tenderness, is often perceived and experienced as a pleasant emotion (Kawakami et al., 2013; Taruffi & Koelsch, 2014; Vuoskoski et al., 2012). Interestingly, the recognition of anger was less successful in comparison to the other emotion categories. This finding is consistent across the error analysis for the MER task, the ANOVAs, and the extreme scorers analysis. Compared with other basic emotions (e.g., happiness or sadness), anger is less commonly evoked by music (Juslin & Laukka, 2004; Zentner et al., 2008). While anger may be expressed in heavy-metal or punk music, none of the participants in the current study expressed a liking for these types of music. Moreover, the analysis of the data from the extreme scorers showed that individuals with high levels of *musical training* were the most accurate in identifying angry excerpts. This may then suggest that relatively poor recognition of angry music, observed in the majority of participants, results from a lack of exposure to this emotion in music and can be counterbalanced by musical expertise.

Our first experimental hypothesis stated that participants with high scores on empathy and musical expertise and low scores on alexithymia would perform at high levels on the MER task. The results of the exploratory correlation analysis revealed a negative association between the MER total score and *externally-oriented thinking* as well as a positive association between the correct ratings for anger and *musical training.* These findings are consistent with our predictions about musical expertise and alexithymia (*externally-oriented thinking* is a primary factor of alexithymia). Furthermore, the correlation analysis pointed to a diminished ability to detect sadness in participants who score high on *externally-oriented thinking*. This finding, which was confirmed by the extreme scorers analysis, is in line with the results from a previous study showing an association between *externally-oriented thinking* and difficulties in identifying facial expressions of anger, sadness and fear in a sample of students (Prkachin et al., 2009).

The results of the regression analysis indicated that *externally-oriented thinking* was the only individual characteristic significantly influencing performance on the MER task, accounting for 8.2% of the variance. Moreover, the relationship between the recognition of musical emotions and *externally-oriented thinking* was negative, meaning that *externally-oriented thinking* is a negative predictor of the overall MER correct score. *Externally-oriented thinking* describes a cognitive style that is concrete, utilitarian, and focused on external details of everyday life, rather than personal thoughts and feelings or other aspects of a person's inner experience (Parker et al., 1993). *Externally-oriented thinking* is positively associated with primary psychopathy, emotional detachment, low tenderness, and lack of empathy (Lander, Lutz-Zois, Rye, & Goodnight, 2012). Unlike the other two factors of alexithymia, high scorers on *externally-oriented thinking* show reduced physiological reactivity in response to sad movies (Davydov, Luminet, & Zech, 2013). Results from the present study highlight that *externally-oriented thinking* leads to a perceptual negative bias towards music stimuli depicting sadness. Experimental stimuli conveying sadness, such as film clips or music excerpts, can trigger rumination and/or spontaneous cognition, which are characterized by a shift of attention from the external environment to “internal” thoughts (Luminet, Bouts, Delie, Manstead, & Rimé, 2000; Luminet, Rimé, Bagby, & Taylor, 2004; Lumley & Bazydlo, 2000; see also Study 2, Chapter 6); in this sense, *externally-oriented thinking* may distract attention from “internal” thoughts by inhibiting arousal changes associated with inwardly-directed cognition (Davydov et al., 2013). Thus, on the one hand an *externally-oriented* cognitive style can protect against experiencing negative feelings by avoiding unpleasant stimuli, while on the other hand it may favor long-term dysfunctional psychosomatic outcomes by depriving individuals from positive stress experiences (i.e., stress that enhances one's functioning and is resolved through coping; Davydov et al., 2013).

With regard to trait empathy, we initially detected two positive correlations between the MER score and the subscales of *empathic concern* and *fantasy*. This finding is consistent with previous studies of music-evoked emotions revealing a positive correlation between sadness ratings and *fantasy* (Taruffi & Koelsch, 2014; Vuoskoski et al., 2012). However, after correcting for multiple tests, the correlations were no longer significant. Therefore, in contrast to the results of Wöllner (2012), neither empathy nor any of its subscales was associated with better recognition of emotion in music. This discrepancy is probably due to the fact that Wöllner's experimental paradigm differed from the one employed in the current study. Wöllner (2012) made use of audio and video recordings of a performance from a string quartet, in which musical intentions were also expressed through facial and bodily expressions and movements. Moreover, empathy was not assessed by the IRI, but by the Questionnaire of Cognitive and Affective Empathy (QCAE; Reniers, Corcoran, Drake, Shryane, & Völlm, 2011), which yields a different structure of factors to the measure used in the present study. Importantly, significant results were only related to empathy's affective factor and to the part of the music composition “characterized by a high degree of expressiveness, which was also present in the musicians actions” (Wöllner, 2012, p. 220). It is therefore plausible to suggest that differences in affective empathy may play a decisive role in the perception of musical emotions, when the emotional information is delivered by both visual and auditory modalities (for example, in the settings of a live performance). Empathic skills are indeed a crucial factor in the ability to correctly perceive changes in emotional states depicted by facial expressions and bodily gestures (Hooker, Verosky, Germine, Knight, & D'Esposito, 2010). According to embodied simulation theories, the perception of a facial emotional expression triggers the simulation of a corresponding affective state in the observer, and favors access to specific emotional concepts (Gallese, 2005; Goldman & Sripada, 2005; Niedenthal, 2007).

Our second hypothesis, stating that personality traits would modulate perceived emotions in a trait-congruent fashion, was not fully supported by the study, despite the results of the extreme scorers analysis are consistent with previous work suggesting that *neuroticism*, but not *extraversion*, is associated with sadness ratings (Vuoskoski & Eerola, 2011). Although we used the same stimulus materials as those employed by Vuoskoski and Eerola (2011), we opted for a forced-choice measure of perceived emotions rather than ratings on continuous scales (as in Vuoskoski & Eerola, 2011), and this choice might have led to the inconsistency of results with regard to *extraversion*. Interestingly, the present study also points to a novel finding: *conscientiousness* correlated with the correct score for the “high emotion” excerpts, in a trait-congruent fashion. *Conscientiousness* is a personality trait characterized by a tendency to be organized, careful, and efficient. This trait may therefore have favored good performance on the MER task.

Our results showed that a tendency towards externally-oriented cognition, which is a feature of alexithymia, can predict low performance on a MER task. The present study therefore provides preliminary evidence suggesting that alexithymic difficulties in recognition of emotional expressions in the visual and language domains (Heaton et al., 2012; Lane et al., 1996; Parker et al., 1993; Prkachin et al., 2009) generalize to music. It is important for further research to verify this suggestion by testing directly the perception of emotions represented by music in an alexithymic sample.

Nevertheless, on the basis of our data we cannot exclude the following alternative interpretation: the results from the correlation and regression analyses, rather than pointing to a perceptual deficit in emotional processing of music stimuli in individuals with tendencies to alexithymia, might instead suggest that *externally-oriented thinking* involves a conscious decision not to explore one's own emotions and those of others, and may be an autonomous factor, independent from alexithymia (Meins, Harris-Waller, & Lloyd, 2008). According to this interpretation, participants with high scores on *externally-oriented thinking* performed worse on the MER task because of their tendency to avoid processing of emotional information. Future studies could test whether *externally-oriented thinking* is an independent construct from alexithymia, for example, by taking into consideration the other factors of the TAS-20 (i.e., *difficulty in identifying feelings* and *difficulty in describing feelings*).

Although the results of the correlation and regression analyses were corroborated by the extreme scorers analysis, the overall magnitude of the correlation coefficients and the explained variance were small ($r < .3$ and $R^2 = .082$). Thus, our findings require independent replication to evaluate their robustness. On the other hand, it should be noted that the problem of weak associations is rather common in correlational studies of music and personality traits, which usually report smaller correlations when compared with the standards used in other psychological research (e.g., Ladinig & Schellenberg, 2012; Vuoskoski & Eerola, 2011). This may be due to a wide variety of factors that play a confounding role. For example, mood and musical preference can interact with personality traits, and in turn affect recognition of musical emotions (Vuoskoski & Eerola, 2011). Furthermore, self-reported *externally-oriented thinking* scores were slightly lower in the current study than have been previously reported for the general population (see Appendix, Table S.12), and consequently may have impacted our results.

Another limitation of the present study lies in the measure used for the assessment of alexithymia, the TAS-20. Although the TAS-20 is the most common and reliable self-report measure to assess alexithymia in the general population, it has also been subject to criticism (Kooiman, Spinhoven, & Trijsburg, 2002; Leising, Grande, & Faber, 2009; Lumley, 2000). Thus, it is important for further studies to replicate our results using other self-report questionnaires, for example the more elaborated 40-item Bermond-Vorst Alexithymia Questionnaire (BVAQ; Vorst & Bermond, 2001). This scale is known to provide a comprehensive operationalization of alexithymia. Furthermore, alexithymia can be subdivided into two subsidiary concepts, namely type I and II (Berthoz & Hill, 2005). Type I is associated with the phenomenon of individuals who do not experience strong emotions at any conscious level (Berthoz & Hill, 2005). Type II describes people who are aware of their emotional experience but do not have the corresponding cognitions (Berthoz & Hill, 2005). The factor structure of the BVAQ (five factors) enables researchers to distinguish the presence (or the absence) of type I alexithymia (i.e., the “affective” dimension), while the TAS-20 simply measures the strength of type II alexithymia (i.e., the “cognitive” dimension).

Despite the methodological limitations highlighted above, our study provides the first empirical evidence showing that *externally-oriented thinking*, a characteristic of alexithymia, significantly influences the recognition of musical emotions. Importantly, our results suggest that the impact of alexithymia is not restricted to the processing of emotion-laden information in the visual and language domains, but also extends to music. The findings further highlight the importance of collecting alexithymia data for future studies of music-perceived emotions.

Chapter 8

Study 4 - Mapping a Brain Network Underlying Empathic Responses to Sad Music

> "music heard so deeply / That it is not heard at all, but you are the music / While the music lasts."
>
> — T. S. Eliot, *The Dry Salvages*

8.1 Abstract

The capacity to experience and understand someone else's feelings as one's own is not only critical for social interaction, prosocial behavior and morality, but also for appreciation of art. For instance, sharing the feelings of a movie character can lead to a greater enjoyment while watching a movie. Although empathy has become an increasingly popular subject in neuroscience, little is known about the neural processes underlying empathic responses to aesthetic stimuli, such as music. In this study, we examined empathy-related neural activity in response to sad music, using eigenvector centrality mapping (ECM) and functional connectivity. 24 subjects underwent fMRI while listening to 4 min blocks of sad and happy music and completed a self-report measure of empathy afterward. ECM results showed that high levels of empathy were associated with high centrality values in the ventromedial prefrontal cortex (vmPFC) during listening to sad compared with happy music. Furthermore, the vmPFC was functionally connected to the dorsomedial prefrontal cortex, primary visual cortex, bilateral claustrum, and cerebellum during sad music. Together, these data highlight that empathic responses to music are supported by affective sharing, mentalizing, and visual imagery, and provide novel evidence for a role of the claustrum in music-empathy.

8.2 Introduction

Empathy is one of the most remarkable human abilities that allow, for instance, to understand what it feels like to experience someone else's joy or sadness, and that ultimately promote successful social interaction (Singer et al., 2004). Empathic behaviors rely on the ability to resonate with others' emotions (affective empathy or experience sharing) and the ability to comprehend others' mental and affective states (cognitive empathy or mentalizing) (Davis, 1996; Goubert, Craig, & Buysse, 2009; Hodges & Wegner, 1997; Walter, 2012; Zaki & Ochsner, 2012)[1]. Although empathy often occurs in interpersonal contexts where a target's affect is observed and vicariously shared, empathic responses extend beyond the immediate social environment to imagined or inferred affective experiences of human, non-human as well as fictional targets (Singer & Lamm, 2009). While empathy can be directed towards both positive and negative emotions, most of the neuroscientific research on empathy has predominantly focused on empathy for physical pain. These studies revealed that the medial/anterior cingulate cortex and the anterior insula are consistently activated during first-hand experience of pain as well as while observing another person in pain (e.g., Jackson, Meltzoff, & Decety, 2005; Lamm, Batson, & Decety; 2007; Lamm, Meltzoff, & Decety, 2010; Singer et al., 2004; for a meta-analysis see Lamm, Decety, & Singer, 2011). The neural correlates of empathy for pain generalize to affective empathy (for a meta-analysis see Fan, Duncan, de Greck, & Northoff, 2011), which also engages amygdala, secondary somatosensory cortex, and inferior frontal gyrus (Walter, 2012). However, it was also demonstrated that empathy for positive emotions activates the ventromedial prefrontal cortex (vmPFC) (Mobbs et al., 2009; Morelli, Rameson, & Lieberman, 2014), indicating multiple pathways to sharing others' emotions. With regard to mentalizing, the dorsomedial prefrontal cortex, the superior temporal sulcus/temporo-parietal junction, the posterior cingulate cortex and the temporal poles are reliably engaged when participants are asked to make judgments about targets' beliefs, thoughts, intentions, and emotions (Amodio & Frith, 2006; Denny, Kober, Wager, & Ochsner, 2012; Frith & Frith, 2003;

1 Zaki & Ochsner (2012) also suggested a third component, which consists of the prosocial motivation to help the target (i.e., the individual towards whom empathy is directed).

Gallagher & Frith, 2003; Gallagher, Jack, Roepstorff, & Frith, 2002; Mar, 2011; Mitchell, 2009; Mitchell, Macrae, & Banaji, 2005; Van Overwalle, 2009; Van Overwalle & Baetens, 2009).

Although this literature has been invaluable for the understanding of the neural substrate of human empathy, it remains unknown whether the above-mentioned brain regions are also implicated in empathic responses to artworks. Empathic responses to artworks have been largely overlooked by neuroscientific research, even though they are considered a crucial aspect of aesthetic appreciation[2] (Crozier & Greenhalgh, 1992; D'Aloia, 2012; Levinson, 1997; Livingstone & Thompson, 2009; Zillmann, 1991). Artworks are the products of, and are expressive of, human feelings, beliefs and intentions. Depending on the artwork's expressive capabilities as well as on the individual's ability to empathize[3], people may experience empathy for the object represented by the artwork (for example, the protagonist of a movie or a landscape portrayed in a painting). In addition, empathy can also be directed towards the artist, for example by taking his/her perspective. Empathy evoked in response to artworks features affective and cognitive sub-processes. In literature and cinema, experience sharing and mentalizing are often involved when readers or viewers follow the stories of fictional characters (Altmann, Bohrn, Lubrich, Menninghaus, & Jacobs, 2012; de Wied et al., 1995; Gallese & Guerra, 2012; Hsu, Conrad, & Jacobs, 2014; Lüdtke, Meyer-Sickendieck, & Jacobs, 2014). While contemplating a painting, beholders can respond empathetically, by understanding the emotions represented or, most strikingly, by simulating the gestures/actions represented in the painting (i.e., embodied simulation supported by the mirror neuron system; Freedberg & Gallese, 2007). Although at a first glance empathy for music seems less apparent given music's abstract nature compared with other art forms, listeners often experience emotion by internally mimicking the emotional

2 The etymology of the English word *empathy* already illustrates a great deal about the importance of empathic processes in aesthetic experiences. The term *empathy* was translated from the German *Einfühlung* (literally *feeling in*), which was coined by the philosophers Robert Vischer (1873) and Theodor Lipps (1903) to describe how appreciation of art draws on the beholders' ability to resonate with the piece of art.

3 Contextual and interindividual variance modulate empathic processes evoked by artworks. For instance, some artworks are more likely to elicit empathy than others, and some individuals are more likely to deploy experience sharing and mentalizing than others.

expression of the music (by means of physiological feedback of muscular and autonomic activity triggered by the music) (Juslin & Västfjäll, 2008; Lundqvist et al., 2009). This process is referred to as emotional contagion and is an early form of affective empathy (Hatfield, Cacioppo, & Rapson, 1993). Interestingly, recent studies have shown a close relation between empathy disposition[4] and enjoyment as well as sensitivity to sad music (Garrido & Schubert, 2011a; Kawakami & Katahira, 2015; Taruffi & Koelsch, 2014; Vuoskoski & Eerola, 2012; Vuoskoski et al., 2012). Individuals who score high on self-report questionnaires of empathy experience more intense and pleasurable emotions while listening to sad music compared with individuals who score low, suggesting that dispositional empathy may facilitate experience sharing of music-evoked sadness. Moreover, the association between empathy and sad music draws also on cognitive aspects of empathy, as indicated by the positive correlation between the empathy subscale *fantasy*[5] and the liking of sad music (Taruffi & Koelsch, 2014; Vuoskoski et al., 2012). Overall, these findings underline that sad music engages empathic listeners to affectively resonate with the emotions conveyed by the music and to fantasize/simulate mental images related to the music, pointing to sad music as an ideal empathy-eliciting stimulus to investigate the neural correlates of empathy evoked in aesthetic contexts.

The present study sought to investigate whether dispositional empathy is linked to stronger activity in empathy-related brain regions in response to sad music. Participants were scanned while listening to 4 min blocks of sad and happy music, and subsequently completed a psychological measure of empathy including both affective and cognitive aspects (Interpersonal Reactivity Index; Davis 1980). Functional data were analyzed using eigenvector centrality mapping (ECM; Lohmann et al., 2010) and functional connectivity (FC) (as in a previous study investigating "small-world" networks underlying music-evoked joy; Koelsch & Skouras, 2014). First, eigenvector centrality maps (ECMs) were correlated with the empathy scores,

4 The personality trait empathy characterizes individuals with a tendency to experience empathy more readily than others across different situations.

5 The *fantasy* subscale of the Interpersonal Reactivity Index assesses people's tendency to transpose themselves imaginatively into the feelings and actions of fictitious characters in books, movies, and plays (Davis, 1980).

and then FC analysis (with the "computational hub" identified by the ECM used as seed region) was performed to identify a network of brain regions underlying empathic responses evoked by sad compared with happy music. Although sadness may be conceived as a form of emotional pain (distinguished from physical pain), music-evoked sadness and "everyday" sadness actually differ to a certain extent. While "everyday" sadness is typically considered an undesirable affective state, music-evoked sadness is deprived of the aversive aspects of "everyday" sadness and involves subjective pleasurable feelings (Taruffi & Koelsch, 2014; Zentner et al., 2008). Therefore, we did not expect that empathy in response to sad music would engage the same brain network involved in empathy for pain (e.g., Jackson et al., 2005; Lamm et al., 2011; Singer et al., 2004, 2006). Instead, we expected that neural regions activated during empathy for positive emotions (vmPFC; Morelli et al., 2014) would also be associated with empathy in response to sad music. In addition, we also expected the recruitment of regions implicated in mentalizing, since sad music appears to trigger cognitive aspects of empathy such as imaging or mentally simulating the self or others to experience the emotions expressed by the music (Taruffi & Koelsch, 2014; see also Chapter 6).

8.3 Method

8.3.1 Participants

24 (12 female) right-handed, native German speakers with no history of neurological problems participated in this study (mean age = 25.3, age range 21-34). All participants provided informed consent in a manner approved by the ethics committee of the Freie Universität Berlin. None of the participants were depressive or alexithymic. Participants either received course credit or 10€/h for participation.

8.3.2 Music stimuli

The stimulus set consisted of four pairs of sad-happy excerpts of film soundtracks (Appendix, Table S.10), capable of evoking sad and happy feelings, respectively (as demonstrated by a pilot study, see subsection 6.3.2 - *Music stimuli*). All excerpts were edited to have 1.5 s fade in/out ramps and were RMS-normalized to have the same loudness. Each pair featured an acoustically identical beat track, leading to the same perceived tempo and similar vestibular responses for sad and happy music (for further information about the preparation of the music stimuli see subsection 6.3.2 - *Music stimuli*). Stimuli of the same emotion category were concatenated into blocks of 4 min duration (no stimulus was repeated) to ensure optimal data for the application of ECM analysis.

8.3.3 Self-report measure of trait empathy

Individual differences in trait empathy were measured through the validated German version (Paulus, 2009) of the Interpersonal Reactivity Index (IRI; Davis 1980). The IRI is one of the most commonly used self-report questionnaires of dispositional empathy, which builds on a multidimensional conceptualization of empathy including cognitive and affective aspects, and has been consistently used in previous studies examining the relationship between sad music and empathy (Kawakami & Katahira, 2015; Taruffi & Koelsch, 2014; Vuoskoski & Eerola, 2012; Vuoskoski et al., 2012). The IRI yields a global score and four subscores corresponding to the following factors: *perspective taking*, *fantasy*, *empathic concern*, and *personal distress* (the first two factors measure affective empathy, while the others measure cognitive empathy). For this study, we focused on the global empathy score because we expected both affective and cognitive aspects of empathy to be implicated in the experience of listening to sad music. Global empathy scores showed a *M* of 15.4 and a *SD* of 1.37 (corresponding *M* of German population norms = 14.49, and *SD* = 3.17; Paulus, 2009).

8.3.4 Procedure

Around two weeks before the scanning session, the participants were tested on their familiarity with the music stimuli (familiarity can strongly affect music-evoked emotions; Pereira et al., 2011). Participants were not included in the fMRI session if they were familiar with any of the music pieces. Importantly, there was no significant difference in levels of familiarity between the happy and the sad pieces (for further information about this behavioral session see subsection 6.3.2 - *Task design and procedure*). In the fMRI session, participants listened to the 4 min sad and happy music blocks presented in a pseudo-randomized order[6]. Stimuli were presented via MRI-compatible headphones at a comfortable volume level and participants were instructed to close their eyes and relax during the music listening. Each music block was followed by: (*i*) a 2 s signal tone signaling to participants to open their eyes, (*ii*) a 16 s evaluation period during which participants were asked to indicate their overall emotional state during the music listening (ratings of valence, arousal, sadness, and happiness obtained on four 6-point scales), and (*iii*) a 10 s silence period to avoid emotional blending between different blocks of stimuli. The total length of the fMRI session was about 27 min. All 24 subjects completed the IRI after the scanning session.

8.3.5 fMRI data acquisition and data analysis

Functional data were acquired on a 3T Siemens Trio using a continuous echo planar imaging (EPI) sequence (37 slices interleaved; slice thickness = 3 mm; interslice gap = 0.6 mm; TE = 30 ms; TR = 2,250 ms; flip angle = 70°; matrix = 64x64; FOV = 192x192 mm). To minimize susceptibility artifacts in areas such as the orbitofrontal cortex and the temporal lobes, the acquisition window was tilted at an angle of 30° to the intercommissural (AC-PC) plane (Deichmann et al., 2003; Weiskopf et al., 2007).

Functional images were preprocessed and analyzed using LIPSIA 2.1 (Lohmann et al., 2001). Data were corrected for slicetime acquisition and normalized into MNI-space-registered images with isotropic voxels of 3 mm^3. A high-pass filter with a cutoff frequency of 1/90 Hz was used to remove low frequency drifts in the fMRI time-series, and a spatial smoothing was performed using a Gaussian kernel of 6 mm FWHM. The mean signal value per scanned volume was computed and regressed out of each participant's data. To control for motion artifacts, the movement parameters of each participant were also regressed out of the respective fMRI time-series.

Whole-brain ECMs were computed separately for each participant during each

6 We also presented blocks with happy and sad dissonant music and neutral music for data collecting purposes.

4 min experimental condition (for more information see subsection 6.3.2 - *ECM analysis*). Global empathy scores were used as regressor of interest, with age and gender as covariates of no interest (as in Koelsch, Skouras, & Jentschke, 2013), in a second level design matrix comparing ECMs between the two experimental conditions (contrast *sad* > *happy*) using voxel-wise paired sample *t*-tests. Regression was used because empathy scores fell into a normal distribution, as shown by K-S test of normality, $D(24) = 0.16$, $p > .05$. Results of this analysis were corrected for multiple comparisons using cluster-size and cluster-value thresholds obtained by Monte Carlo simulations with a significance level of $p < .05$ (Lohmann et al., 2008).

FC analysis was conducted using as seed region the cluster identified by the above-described voxel-wise regression analysis between ECMs and empathy scores. The average time-course of activity within the seed region was extracted and correlated with the activity in the rest of the brain, separately for the sad and happy music conditions. FC maps were first computed separately for each participants and later normalized across the whole sample. Then, FC maps were compared between the two experimental conditions using paired sample *t*-tests corrected for multiple comparisons (using cluster-size and cluster-value thresholds obtained by Monte Carlo simulations with a significance level of $p < .05$).

8.4 Results

8.4.1 Behavioral results

Paired *t*-tests (using a Bonferroni adjusted alpha level of .012) showed that valence ratings did not significantly differ between sad [4.29 ± 1.46 ($M \pm SD$)] and happy music (5.21 ± 0.88), $p > .012$ (Fig. 8.1A), indicating that both types of music evoked a highly pleasurable emotional experience. Similarly, arousal ratings did not significantly differ between sad (3.21 ± 1.18) and happy music (3.75 ± 0.9), $p > .012$ (Fig. 8.1B), in accordance with the use of music stimuli controlled for tempo characteristics. Furthermore, sadness ratings were significantly higher during sad (4.54 ± 0.83) compared with happy music (1.5 ± 0.83), $t(23) = 10.90$, $p < .001$

(Fig. 8.1C). Inversely, happiness ratings were significantly higher during happy (5.42 ± 0.72) compared with sad music (2.71 ± 1.27), $t(23) = 8.74$, $p < .001$ (Fig. 8.1D).

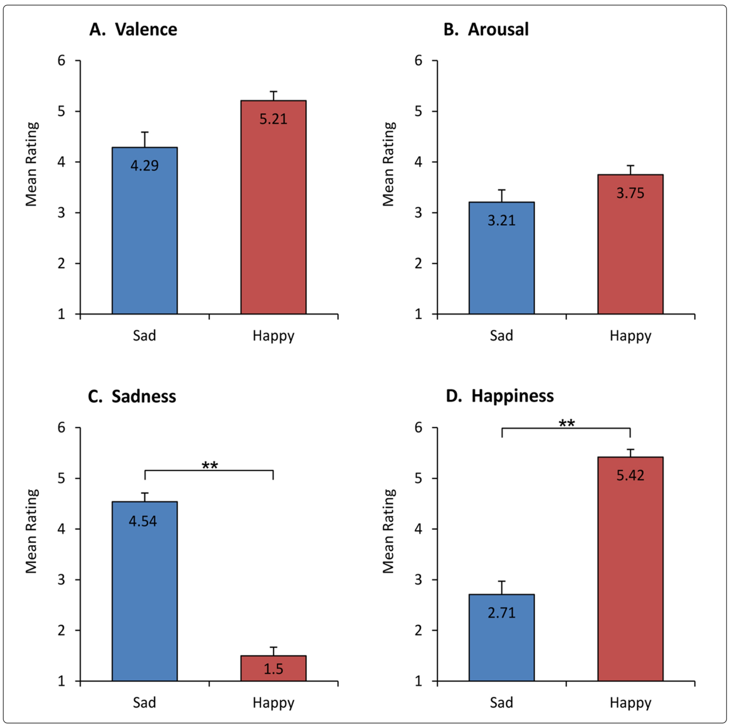

Figure 8.1. *Emotions evoked by sad and happy music during the fMRI experiment.* Participants rated their emotional state on four scales: valence, arousal, sadness, and happiness. Scales ranged from 1 ("very unpleasant", "very calm", "not at all") to 6 ("very pleasant", "very aroused", "very much so"). ** $p < .001$. Results are Bonferroni-corrected. Error bars indicate 1 SEM. (*A*) Valence ratings did not significantly differ between sad and happy music. (*B*) Arousal ratings did not significantly differ between sad and happy music. (*C*) Sadness ratings were significantly higher during sad than happy music. (*D*) Happiness ratings were significantly higher during happy than sad music.

8.4.2 fMRI results

Significant positive correlations between ECMs computed for the *sad* > *happy* contrast and the total empathy scores were observed in a cluster located in the vmPFC extending inferiorly into the orbital part of the mPFC (Fig. 8.2 and Table 8.1).

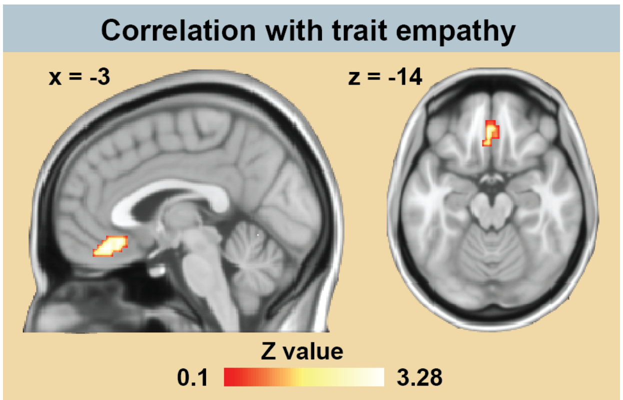

Figure 8.2. *Results of the correlation analysis between eigenvector centrality maps and empathy scores.* Positive correlations (shown in red-yellow colors) were found in a cluster located in the ventromedial prefrontal cortex extending inferiorly into the orbital part of the medial prefrontal cortex. Results were controlled for age and gender, and corrected for multiple comparisons ($p < .05$). Coordinates refer to MNI space.

This ECM cluster (vmPFC) exhibited significantly stronger functional connectivity during sad than during happy music with the dorsomedial prefrontal cortex (dmPFC), primary visual cortex (V1), bilateral claustrum (CL), and cerebellum (CB) (Fig. 8.3 and Table 8.1). The V1 was by far the largest target region identified (15,255 mm^3). Conversely, no region was found to show significantly stronger functional connectivity with the vmPFC during happy than during sad music.

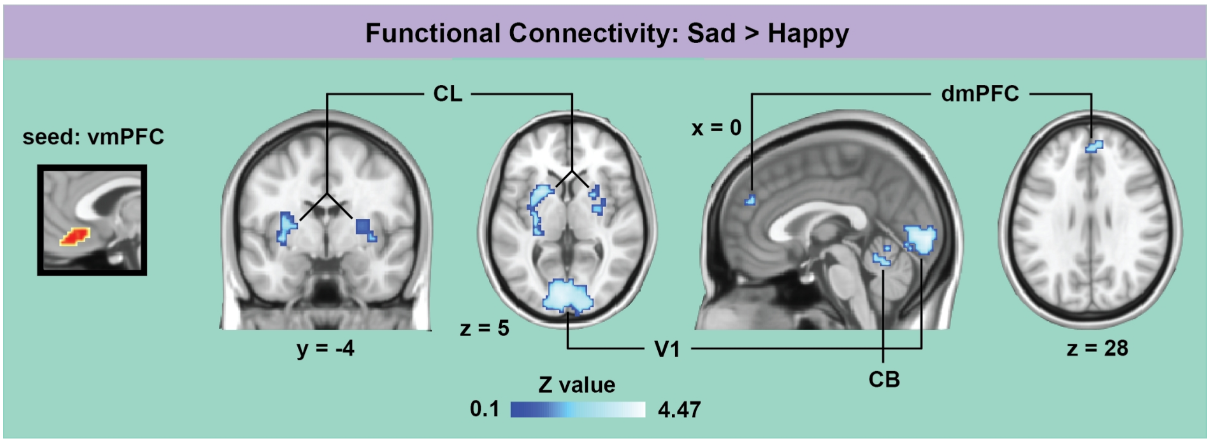

Figure 8.3. *Results of the comparison of functional connectivity maps between the sad and happy condition (sad > happy).* The ventromedial prefrontal cortex (vmPFC) showed stronger functional connectivity with the dorsomedial prefrontal cortex (dmPFC), primary visual cortex (V1), bilateral claustrum (CL), and cerebellum (CB). Results were corrected for multiple comparisons ($p < .05$). Coordinates refer to MNI space.

Table 8.1. *Results of empathy correlation and functional connectivity analyses for the contrast sad > happy, corrected for multiple comparisons (p < .05).*

anatomical location	MNI coordinates	cluster size (mm³)	*z*-value: max
empathy correlation			
vmPFC	-3 36 -14	1,053	3.28 (2.75)
FC (seed region: vmPFC)			
dmPFC	9 48 37	972	3.09 (2.78)
L. claustrum/putamen	-24 12 10	5,238	3.77 (2.93)
R. claustrum/putamen	27 -6 10	1,404	3.35 (2.79)
cerebellum (lobule V, 70%)	-3 -60 -5	1,026	3.46 (2.84)
calcarine sulcus (V1, 90%)	-6 -90 1	15,255	4.47 (3.11)

Note. The outermost right column shows the maximal *z*-value within a cluster (with the mean *z*-value of all voxels within a cluster in parentheses). Percentage in parentheses indicates the anatomical probability according to the SPM Anatomy Toolbox (Eickhoff et al., 2005). Abbreviations: dmPFC = dorsomedial prefrontal cortex; V1 = primary visual cortex; vmPFC = ventromedial prefrontal cortex.

8.5 Discussion

This study used ECM in combination with FC to investigate neural networks underlying empathic responses to sad music. Our findings provide the first evidence that individual differences in trait empathy track with high centrality within a distributed network of brain areas that are spontaneously recruited during listening to sad music. This network encompasses vmPFC, dmPFC, V1, CL, and CB: the vmPFC acts as “computational hub” and the remaining brain areas as functionally connected nodes.

The ECM data revealed a significant positive correlation between participants' self-reported empathy and high centrality values in the vmPFC during sad compared with happy music. Activations of the vmPFC have been previously related to affective empathy (Hynes, Baird, & Grafton, 2006; Mobbs et al., 2009; Saxe, 2006; Völlm et al., 2006) and in particular to empathy for positive emotions (Morelli et al., 2014). Consistently, lesion studies have shown that damages within the ventral and orbital PFC are linked to deficits in affective empathy (e.g., Shamay-Tsoory & Aharon-Peretz, 2007; Shamay-Tsoory, Tomer, Goldsher, Berger, & Aharon-Peretz, 2004). In line with this literature, our findings underscore a relation between empathy disposition and processing of pleasurable (as indicated by the valence ratings) sad music in the vmPFC. Moreover, the relation between vmPFC and trait empathy is of particular interest because it supports the view that empathy is a motivated phenomenon (i.e., different types of motivations drive people to avoid or approach empathy; Zaki, 2014). The vmPFC is well-known to play an important role in computation of positive affect and reward (Bartra, McGuire, & Kable, 2013; Berridge & Kringelbach, 2008; Kringelbach, 2005; Morelli, Sacchet, & Zaki, 2015; O'Doherty, 2004), suggesting that, in listeners with a predisposition to empathize, the coding of the reward value of the music may strongly motivate empathic responses to sad music.

The vmPFC exhibited functional connectivity with the dmPFC during sad compared with happy music. The dmPFC plays a pivotal role in mentalizing (e.g., Amodio & Frith, 2006), and specifically in the attribution of enduring traits and qualities about others (Van Overwalle, 2009). Interestingly, activity in the dmPFC predicts altruistic behavior (Moll et al., 2006; Waytz, Zaki, & Mitchell, 2012), consistent with the view that prosocial tendencies rely on the capacity to understand the minds of others. In our study, the functional connection between the vmPFC and the dmPFC was probably due to the integration of affective and cognitive aspects of empathy for sad music[7]. In particular, our results suggest that participants not only shared the emotions conveyed by the music (as illustrated by the behavioral ratings and the high centrality values in the vmPFC), but also engaged with mentalizing-related computations[8] (e.g., thinking about themselves or other people to undergo the same emotions as the ones conveyed by the music).

The functional connection between vmPFC and V1 during sad music is likely to be due to visual imagery processes. Neural activity in the visual cortex (primarily V1)

7 This is in line with Walter's proposal (2012) that the vmPFC is an important rely station between affective and cognitive empathy.

8 A previous study has already shown that music recruits brain areas, such as the anterior medial frontal cortex, superior temporal sulcus and temporal poles, involved in the attribution of mental states (Steinbeis & Koelsch, 2009). In this study, neural activations in the above-mentioned areas were reported when contrasting man-made music against music that was supposed to be generated by a computer.

can occur also with eyes closed, and this activity mediates the experience of visual imagery (Kosslyn, Ganis, & Thompson, 2001; Kosslyn, Thompson, Kim, & Alpern, 1995; Kosslyn et al., 1999; Le Bihan et al., 1993). Furthermore, music can trigger mental images to unfold. Notably, Study 2 of this dissertation project highlights the occurrence of mind-wandering in the form of vivid visual imagery during sad music. Moreover, previous fMRI studies of music and emotion reported the engagement of the visual cortex during music listening (Koelsch & Skouras, 2014; Trost et al., 2012), consistent with the theory that visual imagery can lead to emotion evocation (Juslin & Västfjäll, 2008). Therefore, the present data suggest that visual imagery might have facilitated empathic participants to transpose themselves into the feelings and thoughts of their imagined characters during the music. Of the observed functionally connected structures, V1 exhibited the highest centrality values and was by far the largest region, suggesting that visual imagery is a central mechanism underlying empathic responses to sad music.

Of particular interest is the functional connection between the vmPFC and bilateral CL during sad compared with happy music. The CL - whose function has remained rather obscure - is a thin, irregular sheet of gray matter that lies below the general region of the insular cortex and above the putamen (Crick & Koch, 2005). The CL has extensive reciprocal connections to almost all cortical areas and also to a number of subcortical areas, including lateral amygdala, caudate, putamen, and globus pallidus (Crick & Koch, 2005; Fernandez-Miranda, Rhoton, Kakizawa, Choi, & Alvarez-Linera, 2008; LeVay & Sherk, 1981a; Park, Tyszka, & Allman, 2012; Pearson, Brodal, Gatter, & Powell, 1982; Sherk, 1986; Sherk & LeVay, 1981; Smythies, Edelstein, & Ramachandran, 2012). Due to these widespread connections, Crick and Koch (2005) proposed that the CL synchronizes and binds separate multi-sensory information, including perceptual, cognitive, motor and emotional content, to form a unitary, single object, thus serving as a consciousness center for the brain. This proposal is consistent with a number of neuroimaging studies showing the involvement of the CL in tasks in which integration of multi-modal information is required (e.g., Banati, Goerres, Tjoa, Aggleton, & Grasby, 2000; Baugh, Lawrence, & Marotta, 2011; Hadjikhani & Roland, 1998). Changes in claustral activity in neuroimaging studies of music and emotion are rather uncommon; however, this may be due to the small size of the CL and its proximity to the insula (that is instead more commonly engaged during music listening; see, for example, Caria et al., 2011), which make challenging to discriminate between claustral and insular activity. The functional connectivity between vmPFC and CL observed in the present study is consistent with anatomical bidirectional projections from the CL to the PFC (Park et al., 2012; Tanné-Gariépy, Boussaoud, & Rouiller, 2002) and suggests a role of the CL in the integration of the different sub-processes involved in empathic responses to sad music. Specifically, the CL may synchronize music processing, experience sharing, mentalizing, and visual imagery (note that the CL has reciprocal anatomical projections to primary visual as well as auditory cortices; Beneyto & Prieto, 2001; LeVay & Sherk, 1981b; Neal, Pearson, & Powell, 1986; Smythies et al., 2012), binding these processes together in a unitary construct that is experienced while the music unfolds.

The functional connection between vmPFC and CB might be due to the subjective emotional experience elicited by the music (Fusar-Poli, Placentino, Carletti, Landi, & Abbamonte, 2009; Stoodley & Schmahmann, 2009). Importantly, changes in cerebellar activity have been previously observed in empathy tasks (Jackson et al., 2005; Lamm, Nusbaum, Meltzoff, & Decety, 2007; Moriguchi et al., 2007; Singer et al., 2004). In particular, in the study by Singer et al. (2004), individuals scoring higher on empathy (as measured by the *empathic concern* subscale of the IRI and the Balanced Emotional Empathy Scale from Mehrabian & Epstein, 1972) showed higher pain-related activity in ACC, left AI, and also lateral right cerebellum.

The present results are limited by the use of "reverse inference" (Poldrack, 2006). Although empathic responses to sad music are well supported by the observed patterns of neural activity and by previous studies (Garrido & Schubert, 2011a; Kawakami & Katahira, 2015; Taruffi & Koelsch, 2014; Vuoskoski & Eerola, 2012; Vuoskoski et al., 2012), it is necessary for future research to directly assess affective and cognitive empathic sub-processes during music listening. Nevertheless, these findings provide a good framework that can guide prospective research on music-empathy.

In sum, this study identified a brain network associated with individual differences in trait empathy and spontaneously recruited during listening to sad music. This music-empathy network comprises brain regions sub-serving affective as well as cognitive empathy, and visual imagery. In addition, a novel site of activation was found in the CL, showing for the first time its involvement in empathic responses to music. Our findings show that, when listening to instrumental sad music, individuals with a predisposition to empathize resonate with the affective tone of the music and engage in highly dense fantasies and mental simulations. These empathic responses to sad music may largely draw on the tendency to attribute anthropomorphic qualities to music (Stern, 2010) and/or to view music as a product of the expressed intentions of the artist (Steinbeis & Koelsch, 2009). Clearly, a question arises about the extent to which empathic responses to artworks are modulated by aesthetic evaluation. This issue should be addressed by future research. Further, one might assume that the artist's skills in evoking an empathic response have a directly impact in the aesthetic value of the work (Freedberg & Gallese, 2007). Importantly, the unique human capability to empathize with artworks could be utilized to train empathic abilities. Our findings show that listening to sad music engages of a neural network encompassing regions involved in both affective and cognitive empathy. In this sense, sad music may improve empathic skills to the extent that it encourages listeners to mentally simulate and affectively share the emotions conveyed by the music.

III

General Discussion

Chapter 9

General Discussion and Outlook

The main goal of the current work was to investigate emotional and cognitive experiences in response to sad music from empirical and theoretical perspectives. To gain a comprehensive insight into listeners' responses to sad music, the dissertation projects employed a large variety of methodologies including self-reports of felt and perceived emotions, thought sampling, fMRI, survey sampling, and psychometric measures. Study 1 made use of an internet survey to capture the prime motives to listen to sad music in a large sample of participants of different ages and nationalities. Study 2 investigated the effects of sad music on mind-wandering and its underlying neural mechanisms. For this aim, a stimulus set of not well-known excerpts of film soundtracks and classical music capable of evoking sad and happy emotions was prepared and validated; subsequently, a thought sampling and an fMRI experiments were conducted. Study 3 explored the role of individual differences in the perception of sadness, using a musical emotion recognition task and validated excerpts of film music conveying five basic emotions. Study 4 made use of fMRI to investigate whether dispositional empathy is associated with neural activity in brain regions involved in empathy in response to sad music. Finally, the theoretical article brought together findings from philosophy, psychology and neuroscience in an attempt to elucidate why sadness through music is experienced as a pleasurable affective state. Figure 9.1 shows a summary of the dissertation's main findings, which are discussed in detail in the next paragraphs.

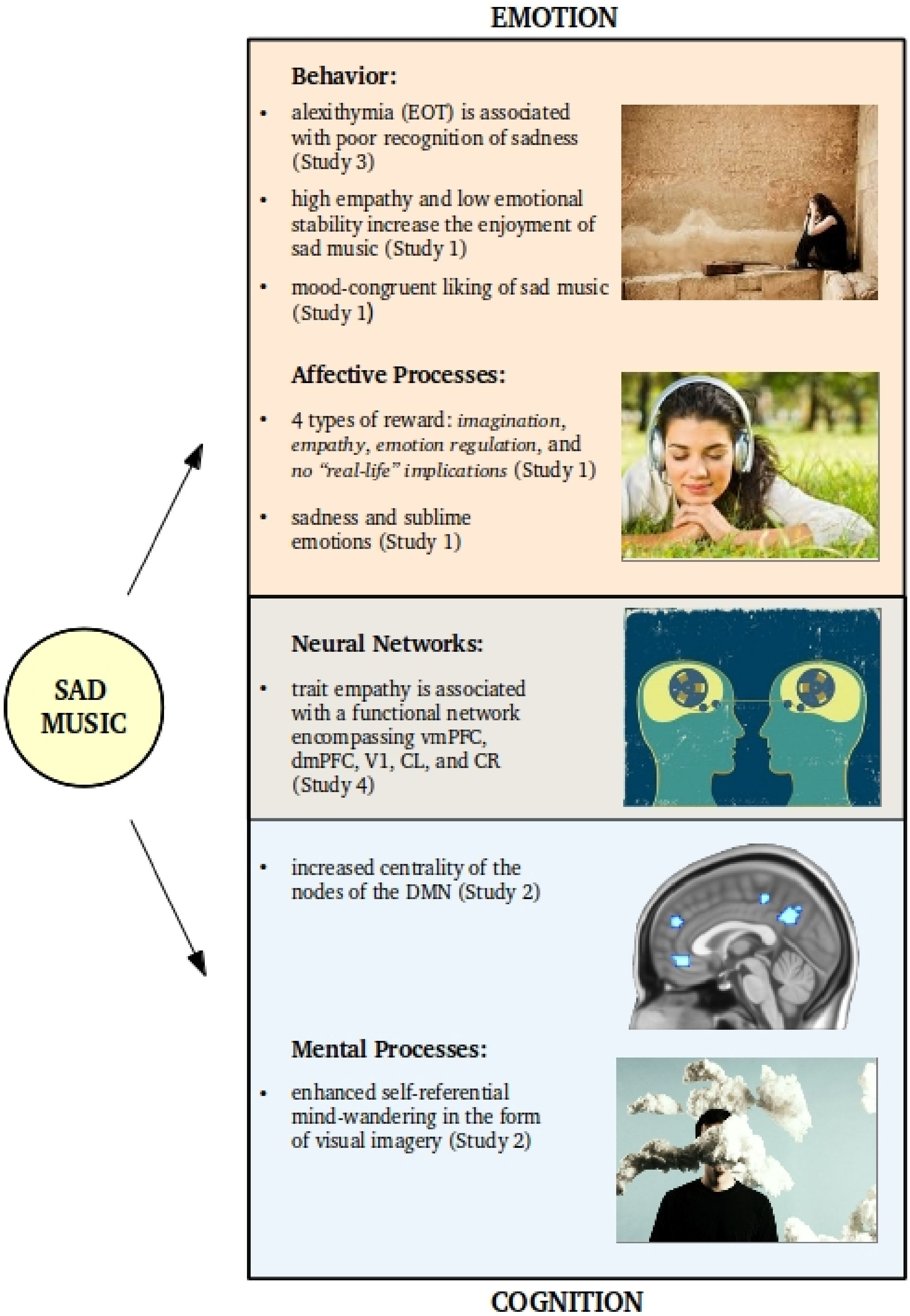

Figure 9.1. *Effects of sad music on emotion and cognition: Summary of the main findings.* CL = claustrum; CR = cerebellum; DMN = default mode network; dmPFC = dorsomedial prefrontal cortex; EOT = externally-oriented thinking; vmPFC = ventromedial prefrontal cortex; V1 = primary visual cortex.

9.1 Effects of Sad Music on Emotion

Study 1 constitutes the first comprehensive survey of sad music, which provides a thorough insight into the different ways through which sad music can have beneficial emotional effects for both hedonic and eudaimonic well-being. The study also includes an empirical test of Levinson's theory on music and negative emotion (1997). In particular, sad music was reliably associated with four types of pleasurable experiences such as regulating or purging negative emotions (*reward of emotion regulation*), inducing feelings of comfort and connectedness (*reward of empathy*), engaging in imaginative processes (*reward of imagination*), and experiencing intense emotions without "real-life" implications (*reward of no "real-life" implications*). Moreover, the comparison between the rewards resulting from listening to sad and happy music suggests that the *rewards of empathy* and *no "real-life" implications* are specific to sad music. Notably, the *reward of empathy* speaks of how critically sad music taps into human social nature. In this regard, our results are in line with the previous studies of sad music and "chills" conducted by Panksepp (1995). Interestingly, Panksepp (1995) showed that sad music evokes more pleasurable responses or "chills" than happy music, suggesting that sad music (including sad songs of love and loss) is desirable because it reminds us of our social relationships. The comforting effects of sad music reported by our participants suggest a "healing" power of sad music that is particularly effective when listeners feel lonely or experience emotional distress. Such capacity of sad music to induce feelings of comfort and connectedness appears to rely on sad music acting as a surrogate for social interaction and shared experiences, as if sad music had human-like properties (Davies, 2001) leading to similar effects as interpersonal interaction. In this regard, future studies of the neurochemical effects of music will be crucial to the understanding of these consolatory effects. For instance, the feelings of comfort evoked by sad music might derive from the release of endogenous opioids, which have been suggested to play a fundamental role in sociality, especially in primates (Machin & Dunbar, 2011). Moreover, the *reward of no "real-life" implications*, which flags an intrinsic characteristic of aesthetic experiences in general, may serve again a social "tuning" function coupled with a profound personal affective experience. In other words, the fact that sad music is a vicarious stimulus with no "real-life" implications allows individuals imaginatively to "try on" different emotional states, leading to the exploration and the practice of human social and emotional capabilities.

The findings about the rewards elicited by sad music parallel the analysis of the situational factors motivating the engagement with sad music in everyday life. Specifically, participants reported to engage with sad music more often when they are alone, when they are in emotional distress or feeling lonely, when they are in reflective or introspective moods, when they think about the past, when they want to relax, or when they are in contact with nature. Some individuals also reported to listen to sad music according to the time of day (i.e., evening) or of the year (i.e., winter). Although all together these findings are consistent with previous results pointing to an emotional use of sad music (Garrido & Schubert, 2011b; Van den Tol & Edwards, 2011), they are – to the best knowledge of the author – the first to reveal that listening to sad music can lead to beneficial emotional effects such as regulation of negative emotion and mood as well as consolation, which in turn constitute the prime motivations for engaging with sad music.

While sad music is associated with various psychological benefits that are inherently pleasurable, not all listeners enjoy sad music all the time. Besides the rewards and the situational factors described above, Study 1 highlights that personality and mood are other two crucial factors in the enjoyment of sad music. For instance, the liking of sad music is greater when listeners are in a negative mood compared with a positive mood. Furthermore, the study demonstrates that – in addition to such mood-congruent effects – the traits *empathy* and *emotional stability* also influence the enjoyment of sad music: Individuals with high *empathy* and low *emotional stability* tend to enjoy more sad music compared with individuals with low *empathy* and high *emotional stability*. Interestingly, the present findings also suggest that mood and personality interact, as individuals with high *empathy* generally enjoy sad music regardless of their mood, while individuals with low *emotional stability* enjoy sad music especially when they are in a sad mood (presumably because sad music facilitates regulation of negative affect)[1]. Taken together, these findings contribute to explain why certain people like sad music while others do not, and why the same individual enjoys a certain piece of sad music more on one day than on another one.

Study 1 also aimed to classify the various types of emotions that people generally experience when listening to sad music. Although anecdotal evidence and theoretical positions are in accordance with the view that sad music is linked to pleasurable feelings with strong aesthetic connotations (Gabrielsson & Lindström, 1993; Kivy, 1989), the previous literature mainly focused on the sad-happy dichotomy (Hunter et al., 2010; Ladinig & Schellenberg, 2012; Larsen & Stastny, 2011). Thus, it has remained unclear so far whether the emotions evoked by sad music can be exclusively represented by sadness, since they appear to involve also positive affect. By employing a music-specific and more nuanced measure of emotions such as the GEMS (Zentner et al., 2008), Study 1 illustrates that sad music evokes not only sadness, but also a wide range of complex and partially positive emotions, such as nostalgia, peacefulness, tenderness, transcendence, and wonder (i.e., "sublime" emotions; Zentner et al., 2008). This indicates that the emotional experience underlying listening to sad music is not monochromatic but rather strongly multifaceted, and contributes to further explain the phenomenon of enjoyment of sad music. Furthermore, the results reveal that nostalgia is the most frequent emotion evoked in response to sad music among Western participants. Nostalgia is a complex emotion often triggered by music and has been characterized as "bittersweet", because it includes both positive and negative facets, such as joy and sadness. Interestingly, many listeners report experiencing sadness-related feelings by listening to music that is linked to personal memories (the so-called "Love, they are playing our tune" phenomenon; see Davies, 1978). Study 1 corroborates such findings, as participants reported that *memory* was the most important principle for eliciting sadness. Thus, Study 1 strongly underlines that autobiographical memory and

1 Nevertheless, future studies should rule out the possibility of a maladaptive attraction to sad music in individuals with low *emotional stability* (e.g., listening to sad music to prolong negative affect).

nostalgia are intrinsic components of the experience underlying listening to familiar sad music. While Study 1 shows that positive pleasurable emotions have a prominent position within the emotional experiences evoked while listening to sad music, further research should clarify the role of unpleasant emotions, such as grief. Although painful feelings and grief are almost never reported in musical contexts (Juslin et al., 2008; Zentner et al., 2008), it is nevertheless possible that they might be experienced in response to sad music. In this regard, contextual aspects (e.g., listening situation, type of music, etc.) and listener features (e.g., depressive traits) might play a decisive role in mediating such negative emotional experiences.

9.2 Effects of Sad Music on Cognition

Another important merit of this dissertation project is the discovery that music has a modulatory impact on spontaneous thoughts and their neural correlates by the emotional tone of the music. The thought sampling experiment (Experiment 1, Study 2, Chapter 6) demonstrates that listening to sad music unfolds spontaneous, internally-directed, self-referential cognition mostly associated with visual mental imagery. In line with these results, the fMRI experiment (Experiment 2, Study 2, Chapter 6) shows that sad music modulates activity within the DMN, which has been consistently indicated as the principal neural contributor to mind-wandering (Andrews-Hanna et al., 2010a; Andrews-Hanna et al., 2010b; Christoff et al., 2009; Kucyi et al., 2013; Mason et al., 2007; Mittner et al., 2014). Taken together, these findings show for the first time effects of music-evoked emotions on a ubiquitous mental phenomenon such as mind-wandering, therewith advancing the scientific understanding of how music, and art in general, can shape mental processes.

Music listening can trigger memories, awaken and regulate emotions, and induce reward (Blood, Zatorre, Bermudez, & Evans, 1999; Janata, 2009; Juslin & Västfjäll, 2008; Salimpoor et al., 2011). Music making/playing engages a wide range of processes including perception, action, social cognition, emotion, learning, and memory (Koelsch, 2009a, 2012). During the past decade, neuroscientific research on the neural underpinnings of music processing has massively increased, and has provided invaluable knowledge to the understanding of the human brain. For instance, findings reveal that music recruits motor, memory, limbic, and reward brain circuitries (Chen, Penhune, & Zatorre, 2008; Janata, 2009; Salimpoor et al., 2011; Trost et al., 2012). In this framework, the results from Study 2 add new important evidence: Music also engages the brain's DMN, reflecting a major role of music in the modulation of spontaneous cognition. The analysis of previous neuroimaging research employing sad music as stimulus material (see Chapter 4) showed that only a few studies reported activity within brain regions belonging to the DMN (Brattico et al., 2011; Green et al., 2008; Khalfa et al., 2005). However, such activations were not related to mentation modes (i.e., whether they reflect an “internal” or “external” mode of cognition, see section 4.2). Through the combination of a thought sampling and an fMRI experiments as well as the use a more ecological paradigm (i.e., uninterrupted music listening), the present work was able to link mind-wandering/DMN to music-evoked emotions. Notably these results demonstrate a good applicability of naturalistic approaches to the investigation of the neural networks involved in the processing of music with different emotional qualities.

Importantly, these findings underline that spontaneous thoughts are strongly related to the context in which they occur, and can be influenced by manipulations of external emotional cues. So far, variations of task context and external cues for mind-wandering have remained under-investigated, most likely because mind-wandering is still traditionally regarded as a self-generated and stimulus-independent mental phenomenon (Teasdale et al., 1995), despite evidence of mind-wandering evoked during task such as, for example, reading aloud (Franklin et al., 2014) and encoding of information into long-term memory (Smallwood, Baracaia, Lowe, & Obonsawin, 2003). However, the spontaneous thoughts that people experience are not independent of the context in which they occur. For instance, systematic manipulations of connotations of external cues (e.g., emotional qualities) may have a strong impact especially on the functional outcome of mind-wandering (whether it is beneficial or detrimental for well-being; Smallwood & Andrews-Hanna, 2013), as Study 2 suggests. Also the content of thoughts during mind-wandering episodes may play a crucial role in determining costs and/or benefits of mind-wandering in healthy and clinical populations (see Box 3 on p. 145). In fact, the results of the analysis of the thought-reports (Experiment 1) show that, while listening to sad music, participants did not particularly engage in a retrospective style[2] of mind-wandering as well as negatively hued spontaneous thoughts, which are typical of depressed patients (see *Implications for Therapy*). Instead, listeners' thoughts predominantly referred to emotions and natural elements and were characterized by a mixed affective tone, suggesting that mind-wandering evoked by sad music may not have detrimental effects, at least in healthy individuals.

Astonishingly, the relation between music, emotion and thought was a fundamental aspect of ancient Western and Eastern civilizations (Ghosh, 2002; Plato, 2003). In classical Greece, for example, the effects of music were believed to go beyond short-term emotional responses, encompassing also long-term behavioral and cognitive changes necessary for the formation of ethical capabilities or *ethos* (Plato, 2003), thus postulating an intrinsic capability of music to influence human psychology in its different facets. The present findings provide evidence that music can induce changes in specific mental processes, and that these changes are due to the emotional tone of the music, as Plato suggested more than two millenia ago. Therefore, the present findings open a vast novel field of empirical research about the connections between music, emotion and thought, which will certainly have crucial application for the use of music in different fields, and in particular music therapy (see section 9.6).

9.3 The SADMUS Model

Figure 9.2 shows a heuristic model of listener characteristics and contextual factors contributing to emotional responses and psychological effects of sad music based on the results of Studies 1 and 2. The SADMUS model can be used to orientate future research on sad music by providing a starting point from which experimental hypotheses can be derived.

2 In Study 2 (Chapter 6), sad compared with happy music was not associated with the retrieval of past memories as found in Study 1 (Chapter 5). This difference is explained by the use of sad and happy unfamiliar music in Study 2.

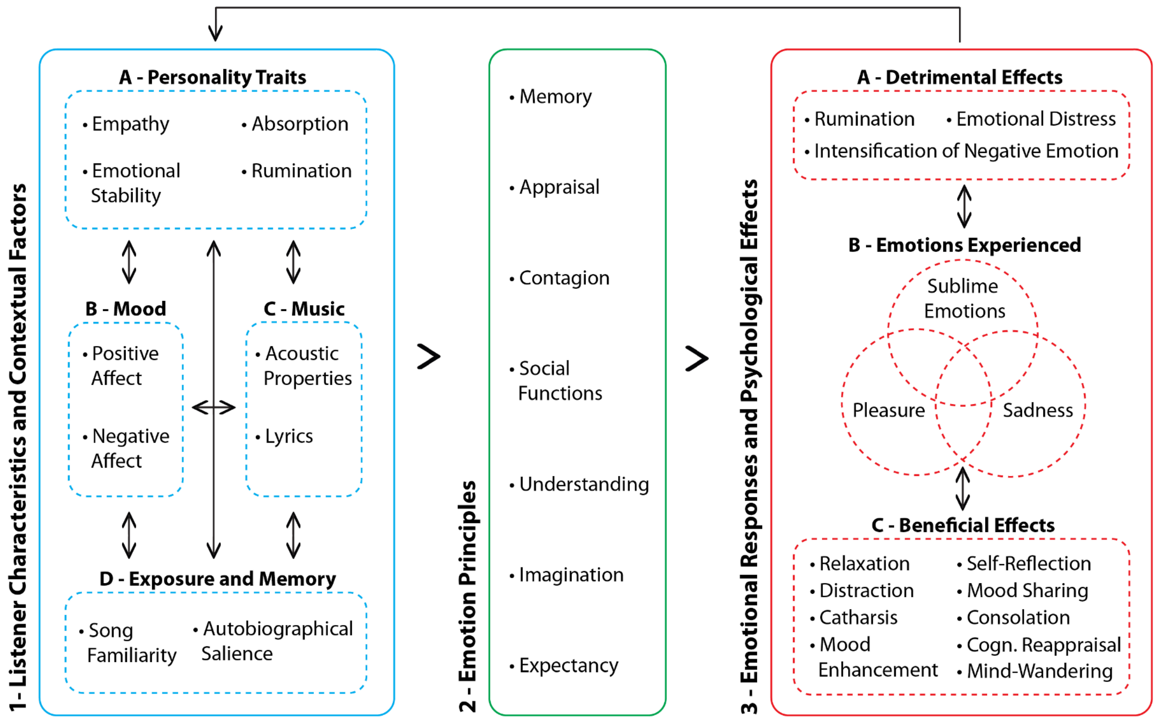

Figure 9.2. *The SADMUS model of listener characteristics and contextual factors contributing to emotional responses and psychological effects of sad music.* Constructs to the left include listener-level and context-level variables, while constructs to the right include emotions evoked by sad music and its psychological effects. Constructs in the middle represent the different principles through which emotions are evoked. Constructs presented in each of the three main boxes can interact with constructs belonging to the same box. The arrows between the three main boxes indicate temporality. Bi-directional arrows in the third box indicate a reciprocal relation between the emotions evoked and the positive or negative effects derived from music listening. Box 3 is also connected to box 1B (emotional responses to sad music influence subsequent mood). Future research should assess whether emotional responses to sad music can affect in the long-term personality dimensions (box 3 → box 1A).

According to the SADMUS model, sad music elicits a rich range of emotions, including sadness, feelings of pleasure, and sublime emotions such as nostalgia, peacefulness, transcendence, tenderness, and wonder (box 3B). More than one emotion can be evoked simultaneously (i.e., mixed emotions) and emotions are evoked through a number of principles that describe the different mechanisms through which listeners react affectively to sad music (box 2). Such principles encompass *memory*, *appraisal*, *contagion*, *social functions*, *understanding*, *imagination*, and *expectancy* (for a more detailed discussion of each principles see Chapter 3). Importantly, the model illustrates the listener characteristics (boxes 1A and 1B) and the contextual factors (boxes 1C and 1D) that contribute to the evocation of sadness, pleasure, and other emotions through sad music. Listener characteristics refer to individual differences in personality traits (i.e., *empathy*, *absorption*, *emotional stability*, and *rumination*; box 1A) and to the mood of the listener prior to music exposure (i.e., positive or negative; box 1B). Contextual factors include specific aspects of the unique relationship between a song and a listener (i.e., the degree of familiarity with a piece of music – which also encompasses familiarity with the musical genre of the piece as well as with the composer/band - and the extent to which the song is linked to an autobiographical memory of the listener; box 1D). For example, autobiographical salience is a contextual factor that is particularly relevant in the evocation of sadness and nostalgia through the *memory* principle. The SADMUS model also takes into account interactions between listener characteristics and contextual factors. For example, it is possible that the autobiographical salience of a song might contribute to stronger music-evoked sadness and/or nostalgia in individuals who are already in a sad mood. The model allows the distinction of emotional effects of sad music (box 1C) due to acoustic properties (e.g., instrumental music) or to lyrics (e.g., pop song). Furthermore, the model outlines the psychological benefits (i.e., *self-reflection*, *mood sharing*, *consolation, relaxation, mind-wandering, distraction, catharsis, cognitive reappraisal,* and *mood enhancement*) that can be obtained by listening to sad music (box 3C). On the other hand, the model also describes the possibility of a maladaptive outcome (box 3A) originating from listening to sad music (i.e., *rumination*, *emotional distress*, and *intensification of negative emotion*).

9.4 Individual Differences in Music-Perceived Emotions

Study 3 extends the results of Study 1 on listener's characteristics and music-evoked sadness by investigating individual differences in the perception of sadness as well as other four basic emotions (happiness, tenderness, anger, and fear) conveyed by film music. Previous research mainly focused on the relationship between individual characteristics and recognition of facial and verbal expressions of basic emotions (e.g., Bowles et al., 2009; Ekman & Oster, 1979; Matthews et al., 2015; Miura, 1993; Palermo et al., 2013; Paulmann et al., 2008), while music-perceived emotions received less attention. The results from Study 3 indicate that recognition of emotions conveyed by music, particularly sadness, is influenced by alexithymia's factor *externally-oriented thinking*. These findings suggest that alexithymia is linked to a perceptual deficit to detect musical expressions of emotions, similarly as in the visual (Jessimer & Markham, 1997; Lane et al., 1996; Parker et al., 1993; Prkachin et al., 2009) and language domains (Heaton et al., 2012). Because alexithymia is considered as a stable personality trait after a minimum of 5 years (e.g., Salminen et al., 2006), it is necessary for further research to directly investigate whether the perception of sadness, as well as other basic emotions, is altered in clinical populations, in which alexithymia is a prominent symptom. Nevertheless, the present results have implications for future studies of music-perceived emotions, flagging the importance of assessing alexithymia in their samples (for the fMRI experiments featured in this dissertation, all subjects were screened for alexithymia, and only non-alexithymic subjects were included in the experiments).

9.5 Brain Correlates of Empathic Responses to Sad Music

Study 4 shows that individual differences in trait empathy are related to high centrality values in the vmPFC in response to sad (compared with happy) music, and that the vmPFC is functionally connected to the dmPFC, V1, bilateral CL and CB during music-evoked sadness. While previous fMRI studies mainly focused on empathy for pain, Study 4 highlights the importance of examining empathy in aesthetic contexts. In line with previous accounts of empathic responses to music (e.g., Davies, 2011), our results suggest that sad music acts as a social signal, which engages empathic listeners to mentally simulate and vicariously share the emotions depicted by the music. In particular, the visual cortex showed the highest eigenvector centrality values and was the largest region identified by the FC, motivating the hypothesis that visual imagery is a prominent empathic sub-process while listening to music. The engagement with highly dense fantasies may indeed facilitate cognitive and affective empathy for the target. Interestingly, this interpretation is in line with Levinson's hypothesis of a “musical persona” (1997; see also section 2.3). Levinson argues that listeners respond empathetically to music by imaging it as a narrative about an indefinite persona they hear as inhabiting it (1997). In other words, listeners empathize with a “musical persona”, similarly as readers do with a novel's fictional character, but with the difference that they (the listeners) can imagine their own narrative unfolding on the basis of the musical events. Although previous accounts of music-empathy underlined emotional contagion as core empathic subprocess in response to music, Study 4 rather points to a strong involvement of imagery and mentalizing. This could be partly due to the musical genre participants were exposed to. Specifically, Study 4 made use of instrumental excerpts of soundtrack music, which is generally very suggestive and evocative, and can allow listeners to find their own inner images associated with the music.

The results of Study 4 inform current neural models of empathy as well as theories of aesthetic appreciation, by showing that empathic processes are core components of the enjoyment of sad music. Nevertheless, further studies directly assessing empathic responses to music are needed to substantiate the present results, which are based on the correlation between dispositional empathy and brain responses to sad music and did not directly assess empathic experience during the music. Moreover, because FC cannot infer causality, future work featuring different fMRI data analyses, such as dynamic causal modeling (DCM; Friston, Harisson, & Penny, 2003), should address the question about the directionality of the observed functional connections.

9.6 Implications for Therapy[3]

The present research has several key implications for the use of music in both healthy individuals and clinical populations. Because music can influence a large variety of processes including, for example, emotion (Koelsch, 2014), memory (Janata, 2009),

3 Music therapy can be receptive or active. Receptive music therapy involves music listening and aims to directly influence physical and emotional processes through music, movement, meditation, and relaxation. Active music therapy is based on playing, composing, and/or improvising in an individual or a group setting.

social cognition (Steinbeis & Koelsch, 2009), attention (Koelsch, 2009b), perception-action mediation (Callan et al., 2006), it is particularly suited to be employed as a therapeutic tool for psychological intervention and as a "safe"[4] means of enhancing and maintaining well-being. In recent years, music has been used in the treatment of a number of mental and physical conditions such as acute and chronic pain (Cepeda, Carr, Lau, & Alvarez, 2006; however, please note that the effect sizes for pain relief are relatively small compared to analgesic drugs), brain injury (Bradt, Magee, Dileo, Wheeler, & McGilloway, 2010), autism spectrum disorder (Gold, Wigram, & Elefant, 2006; Kaplan & Steele, 2005), dementia (Vink, Bruinsma, & Scholten, 2004), schizophrenia (Mössler, Chen, Heldal, & Gold, 2011), and mood and anxiety disorders (Maratos, Gold, Wang, & Crawford, 2008). Given the relevance of music's use in therapy, it is surprising that there has been no attempt to discuss and/or empirically test the effectiveness of specific types of music such as sad music[5]. In this framework, the findings that sad music triggers internally-oriented cognition and leads to various beneficial emotional responses should encourage a systematic investigation of the effects of sad music (but also of other types of music, e.g., happy) on the different facets of mental life and emotional well-being, which will be critical for defining *ad hoc* clinical applications of music.

9.6.1 Implications for healthy populations

Study 1 (Chapter 5) reveals that sad music is a powerful means for inducing positive "sublime" emotions as well as different psychological benefits, indicating that people do not exclusively listen to sad music for hedonic reasons, but also because it has an impact on their eudaimonic well-being. For example, sad music can provide solace and comfort in the absence of social support. Consequently, these findings underline that, for healthy individuals, listening to sad music is not detrimental but instead beneficial (with factors such as mood, context, and listener's characteristics further modulating such salutary effects). A number of these benefits, such as regulation or venting of negative emotions and experiencing feelings of connectedness and

4 Excessive music listening is not likely to generate side effects differently from drugs.
5 It is also important to notice that the number of high-quality empirical studies in the field of music therapy is rather limited.

comfort, could be harnessed to enhance health and well-being. For example, listening to sad music could function as an adaptive coping strategy[6] for many people. Especially those individuals who use music for reflecting purposes may particularly benefit from listening to sad music to help processing their negative emotions (Garrido & Schubert, 2013). Moreover, educational settings may implement music-focused training programs, where young students could explore the psychological functions of listening to sad music and learn beneficial listening strategies aimed to improve their emotional health. In addition, music- and/or art-based trainings aimed to improve empathic abilities may also be designed, since the results of Study 4 (Chapter 8) indicate that sad music encourages listeners to mentally simulate and affectively share the emotions conveyed by the music (in the same way as reading fiction can engage social-cognitive skills; see Tamir et al., 2016).

Similarly, the results of Study 2 (Chapter 6) suggest that, in healthy individuals, the enhanced mind-wandering in response to sad music may have beneficial outcomes such as favoring creativity (Baird et al., 2012) and self-reflection (Smallwood et al., 2011). This suggestion is supported by participants' reports showing that one of the motives to engage with sad music in everyday life is to improve creative thinking and introspection (Study 1). Furthermore, cognitive operations such as creative thinking and self-reflection are promoted by mind-wandering episodes (Baird et al., 2012; Smallwood et al., 2011). Likewise, DMN activity has been positively associated with creativity, particularly with spontaneous creative insight (i.e., the so-called “Eureka” experience; Jung et al., 2010).

9.6.2 Implications for clinical populations

Due to a lack of studies, the effects of sad music on clinical populations such as depressed patients remain rather obscure to date. Nevertheless, previous research in cognitive psychology established a positive association between mind-wandering and

6 A coping strategy is a technique or practice aiming at minimizing and tolerating stress and/or conflict (Labbé, Schmidt, Babin, & Pharr, 2007). Coping strategies can be appraisal-based (directed towards the modification of the individual's thoughts), problem-based (directed towards the modification of the cause of stress), and emotion-based (directed towards the modification of the individual's emotions).

depressive thinking (Smallwood, O'Connor, Sudbery, & Obonsawin, 2007). Specifically, dysphoric students show increased mind-wandering across a wide range of tasks, including signal detection (Smallwood et al., 2004), encoding (Smallwood, O'Connor, Sudberry, Haskell, & Ballantyne, 2004) and word fragment completion (Smallwood, O'Connor, & Heim, 2005). Furthermore, one of the main behaviors associated with depression is rumination[7] (Nolen-Hoeksema, 1991), and rumination is one of the strongest predictors of clinical depression (Calmes & Roberts, 2007; Nolen-Hoeksema & Morrow, 1993). Previous studies found that ruminators spend more time listening to negatively-valenced music than non-ruminators (Chen, Zhou, & Bryant, 2007) and that listening to sad music is a maladaptive mood regulation strategy in ruminators (Garrido & Schubert, 2015). Thus, the available evidence suggests that listening to sad music in everyday life may have detrimental effects on depressed individuals (but not on healthy subjects), such as favoring a ruminative style of mind-wandering. Hence, music interventions aimed at diminishing rumination as a symptom of depression may rely on happy music rather than sad music.

On the other hand, there are also a number of reasons why depressive patients may benefit from listening to sad music. For instance, research on mind-wandering has highlighted that unhealthy effects of mind-wandering such as rumination can be attenuated through mindfulness training (Schooler et al., 2014). In this way, exploring thoughts evoked by sad music in the safe context of music therapy could help depressed patients to practice how to steer their thoughts towards more positive directions and how to switch rumination with self-reflection[8] (Trapnell & Campbell, 1999). Moreover, experiencing spontaneous reactions to sad music under the guidance of the therapist could help patients better understand and manage their response to negative stimuli in general, providing them with new ways of coping with sadness and connecting with others (Sachs et al., 2015). So far, these suggestions are

7 Rumination involves repetitive thinking patterns with an involuntary focus on negative and pessimistic thoughts (Joormann, 2005) and is strongly associated with an attentional bias towards negative stimuli (Gotlib, Krasnoperova, Neubauer Yue, & Joormann, 2004).

8 *Self-reflection* is a psychologically healthy trait, distinct from *rumination* (Trapnell & Campbell, 1999). *Self-reflection* denotes a self-attentive type of personality motivated by curiosity and epistemic interest in the self, which is associated with the dimension *openness to experience*.

supported only by a few studies with depressed participants, which found that music listening and improvisation are capable to reduce depression symptoms severity (Brandes et al., 2010; Erkkilä et al., 2008; Erkkilä et al., 2011; Maratos et al., 2008). High-quality randomized controlled trials are essential to evaluate the effectiveness of music-based interventions, employing sad or happy music, on depression.

Other populations in which sad music could have therapeutic effects are autism spectrum disorder (ASD) and alexithymia. ASD is a neurodevelopmental disorder that impairs the ability to communicate and interact with others and that is characterized by repetitive and restricted behaviors (American Psychological Association, 2013). Although individuals with ASD exhibit strong deficits in socio-emotional functioning (including, for example, ToM, and difficulties in recognizing emotional cues in faces and speeches), they have relatively intact perception and processing of musical emotions (Allen & Heaton, 2010; Caria et al., 2011; Quintin, Bhatara, Poissant, Fombonne, & Levitin, 2011). Likewise, when listening to favorite sad music, individuals with ASD activated cortical and subcortical brain regions that are involved in emotion processing and reward (Caria et al., 2011). ASD often overlaps with alexithymia (Allen & Heaton, 2010). Alexithymic individuals exhibit low empathic abilities and reduced engagement of the insula and the mentalizing network including dorso- and ventromedial prefrontal cortex, temporo-parietal junction and posterior cingulate cortex[9] (Bird et al., 2010; Moriguchi et al., 2007; Silani et al., 2008). As shown by Study 1, sad music can evoke feelings of connectedness and empathy, as well as intense and pleasurable emotional states, enabling individuals to express their feelings without the need to find the correct words for them. Study 4 further reveals that listening to sad music spontaneously recruits brain regions implicated in both cognitive and affective aspects of empathy. Thus, using sad music in the context of music therapy could help patients with ASD and alexithymia to improve emotional expression and empathic abilities, and in the long-term to develop an emotion vocabulary, which they can apply also to non-

9 Notice that these brain regions overlap with the DMN. Interestingly, previous research has provided evidence of a convergence in the neural correlates of social and resting state cognition (e.g., Mars, Neubert, Noonan, Sallet, Toni, & Rushworth, 2012; Schilbach, Eickhoff, Rotarska-Jagiela, Fink, & Vogeley, 2008; Schilbach et al. 2012).

musical domains (Allen & Heaton, 2010). This could be done simply by establishing an associative link between music-evoked emotions and their cognitive correlates.

Finally, the findings from Study 2 show modulation of the DMN by music, indicating that the DMN is strongly sensitive to external emotional cues. The potential of music to influence activity in such large-scale brain network has important implications for the use of music in the treatment of a wide range of mental disorders. Specifically, schizophrenia (Garrity et al., 2007), depression (Sheline et al., 2009), ASD (Kennedy, Redcay, & Courchesne, 2006) and Alzheimer's disease (Greicius, Srivastava, Reiss, & Menon, 2004) have been consistently linked to aberrant DMN activity. Therefore, the present work offers novel possibilities for the investigation of the effectiveness of music therapy in the treatment of such disorders.

9.7 Conclusions

This dissertation, which was motivated by the long-lasting philosophical debate on the enjoyment of sad music, investigated psychological mechanisms and neural networks underlying listening to sad music. The empirical findings unveil a wide range of functions of listening to sad music in everyday life and a multifaceted emotional experience including sadness and more positive “sublime” emotions. The findings further illuminate that the “paradox of sad music” can be untangled by taking into account the four different rewards of sad music, which tap into different aspects of human psychology such as imagination, empathy, and emotion regulation. With regard to empathy, this work has identified a neural network associated with trait empathy and spontaneously engaged while subjects listened to sad music. The dissertation has also specified how personality traits modulate the enjoyment and perception of sadness in music. Importantly, the dissertation has investigated for the first time the relation between music-evoked emotions and spontaneous cognition, demonstrating that sad music enhances mind-wandering as reflected by both behavioral data and the engagement of the brain's DMN. In sum, the present work provides novel and intriguing evidence for the power of sad music not only to evoke nuanced and rewarding emotional experiences but also to stimulate internally-oriented, self-referential cognitive processes. These effects of sad music on emotion and cognition could be harnessed to improve emotional well-being in healthy individuals and to tailor novel intervention strategies in clinical populations.

Box 3. Outstanding Questions

- Which are the short- and long-term effects of listening to sad music?
- Which are the specific patterns of mixed emotions evoked by sad music?
- Do endogenous opioids modulate the comforting effects experienced while listening to sad music?
- Are effects of music-evoked emotions on mind-wandering mediated by differences in arousal?
- How does the task-context affect the functional outcome of mind-wandering? For example, does mind-wandering triggered by sad music have the same costs and benefits associated to mind-wandering elicited by other tasks?
- Is it possible to develop music-based techniques for maximizing the benefits (e.g., creativity, future planning) of spontaneous cognition while minimizing its costs (e.g., negative changes in mood)?
- How does music-evoked emotions relate to thought content in healthy and clinical populations?
- Is *externally-oriented thinking* an autonomous factor, independent from alexithymia?
- How does aesthetic judgment influence empathetic responses to artworks?
- What experiments can be devised to test the hypothesis that the CL synchronizes the different music-empathy sub-processes?

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Appendix

Supplementary Figures

Study 1

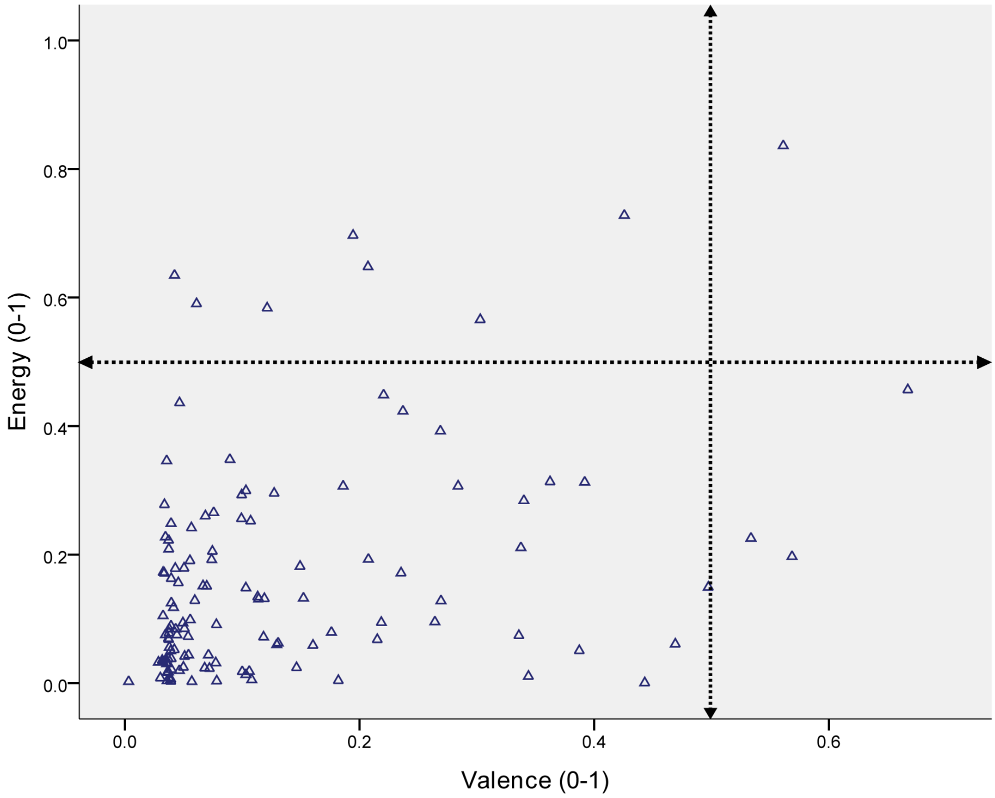

Figure S.1. *Scatter plot of valence and energy values of the retrieved instrumental music pieces.* Valence values ranged between 0 and 1. A value close to 1 indicates a positive emotion, while a value close to 0 is a negative emotion. Energy values ranges between 0 and 1. A value close to 1 indicates high energy or arousal, while a value close to 0 corresponds to low energy or arousal. The dotted lines divide the area into the 4 quadrants of the circumplex model of emotion: high energy/positive valence, high energy/negative valence, low energy/positive valence, and low energy/negative valence. According to this model, sadness corresponds to the low energy/negative valence quadrant.

Study 2

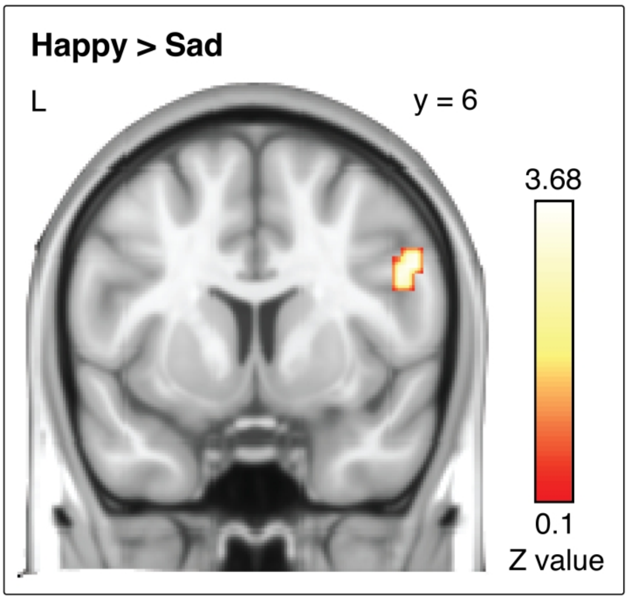

Figure S.2. *Increased centrality in the right inferior frontal gyrus (IFG) during listening to happy music.* Shown is a cluster of significantly higher centrality values located in the right IFG (pars opercularis) extending into the right precentral gyrus. The pars opercularis of the IFG (BA 44) is implicated in the processing of music syntax (Maess, Koelsch, Gunter, & Friederici, 2001), consistent with the results of Experiment 1, indicating more focus on the musical structure during happy (compared with sad) music (Fig. 6.1B).

Supplementary Tables

Study 1

Table S.1. *List of items of the questionnaire on sad music listening habits (third section of the survey).*

Item	**Item Text**
Frequency of listening to sad music	How often do you actively select sad music to listen to?
Importance of situation-related factors	How much do specific situations influence your choice to listen to sad music?
Example of situation-related factors	Could you write down one or more examples of situations in which you engage with sad music and why?
Mood-congruent liking of sad music	When I am in a sad mood I like to listen to sad music.
Mood-incongruent liking of sad music	When I am in a positive mood I like to listen to sad music.
Emotions evoked by sad music:	
Sadness	Sad music makes me feel sad or sorrowful.
Tenderness	Sad music makes me feel tender, affectionate or in love.
Nostalgia	Sad music makes me feel nostalgic, dreamy or melancholic.
Tension	Sad music makes me feel tense, agitated or nervous.
Peacefulness	Sad music makes me feel serene, calm or soothed.
Joyful Activation	Sad music makes me feel joyful, amused or bouncy.
Transcendence	Sad music makes me feel fascinated or overwhelmed and evokes in me feelings of transcendence or spirituality.
Wonder	Sad music makes me feel filled with wonder, dazzled or moved.
Power	Sad music makes me feel strong, triumphant or energetic.
Any emotion	Sad music does not evoke in me any particular emotion.

Table S.2. *List of items of the questionnaire on the principles underlying the evocation of sadness by music (fourth section of the survey).*

Principle	**Item Text**
Memory	Sad music makes me feel sad because it evokes memories of certain past events, people or places.
Contagion 1	I am affected by the expression of sadness in music to the point that I frown or even cry.
Contagion 2	Sad music makes me feel sad because its musical features (e.g., slow tempo, legato articulation, etc.) evoke a sad mood in myself.
Appraisal 1	Sad music helps me to be sad when I want to be sad.
Appraisal 2	Sad music can evoke sad mood when it is appropriate (e.g., funeral).
Imagination	Sad music makes me feel sad because I imagine sad objects/scenes.
Social Functions	Sad music makes me feel sad because I am touched by the sadness of others.

Table S.3. *List of items of the questionnaire on the rewarding aspects of music-evoked sadness (fifth section of the survey).*

Item Name	**Item Text** (I like to listen to sad music because...)
Understanding Feelings	... by contemplating this feeling in the music, I can get a better understanding of my own feelings, without negative life consequences.
Emotional Assurance	... I can reassure myself - in a non-destructive manner - of the depth of my ability to feel.
Savoring Feeling	... I can enjoy the pure feeling of sadness in a balanced fashion, neither too violent, nor as intense as in real-life.
Mood Enhancement	... sad music helps me to regulate my mood (e.g. feel better) when I am feeling sad.
Catharsis/Venting	... experiencing sadness through music makes me feel better after listening to it, and thus has a positive impact on my emotional well-being.
Expressive Potency 1	... I imagine I have the same RICH expressive ability as present in the music.
Expressive Potency 2	... I imagine I have the same POWERFUL expressive ability as present in the music.
Expressive Potency 3	... I imagine I have the same SPONTANEOUS expressive ability as present in the music.
Emotional Communion	... I imagine I share the same emotional experience of the composer and thus I do not feel alone anymore.
Empathic Responses	... I like to empathize with the sadness expressed in the music, as if it were another individual.
Emotional Resolution	… I can match my emotional state to the one that unfolds over the course of the music, maintaining at the same time a sense of control over it.
Realistic Thinking	… it makes me think more realistically about life.
Apprehending Expression	… it facilitates my grasp of the musical work.

Table S.4. *Free responses to the item asking which are the rewarding aspects of sadness evoked by music, with number of nominations for each answer (N = 31).*

Rewarding aspects of music-evoked sadness	N. Nominations
Sad music calms me down or relaxes me	10
Sad music helps me to release feelings of sadness or loss	9
Sad music evokes intense emotions or makes me feel alive	4
Sad music connects me to the suffering of others and makes me feel less alone	4
Sadness is expressed non-violently and it is enjoyable because music is a safe environment	2
Sad music helps me to maintain motivation during long working periods	2

Note. Similar answers are grouped together.

Table S.5. *Free responses to the item asking which are the most frequent emotions experienced in response to sad music, with number of nominations for each answer (N = 40).*

Emotions experienced in response to sad music	N. Nominations
Cathartic experience or feeling of relief	12
Feeling of being understood and connected with others	10
Feeling of being moved	8
Thoughtful or introspective	4
Hopeless or weak	2
Regretful	1
Creative	1
Romantic	1
Melodramatic	1

Note. Similar answers are grouped together.

Table S.6. *Respondents' demographics for the happy music survey (N = 212).*

	Number of respondents	Percentage of respondents
Gender		
Male	75	35.4
Female	137	64.6
Musical training		
professional musicians	22 (7 female)	10.4
semi-professional musicians	27 (11)	12.7
amateur musicians	76 (51)	35.8
non-musicians	87 (68)	41
Place of origin		
Africa	1 (1)	0.5
Asia	41 (26)	19.4
Australia	2 (1)	1
Europe	148 (98)	69.7
North America	12 (6)	5.6
South America	8 (5)	3.8

Table S.7. *Music pieces nominated more than one time.*

Title	Composer	Number of Nominations	Tags
Adagio for strings Op.11	Samuel Barber	9	sad
Adagio in G minor	Tomaso Albinoni	7	sad
Address in the stars	Caitlin & Will	2	not many tags
Air on the 4th string: Suite No. 3 in D major, BWV 1068	Johann Sebastian Bach	2	sad
Ashes in the snow	Mono	2	melancholic
Bedshaped	Keane	2	sad
Cello suite No. 1 (Prelude)	Johann Sebastian Bach	2	melancholic
Colorblind	Counting Crows	2	sad
Comfortably numb	Pink Floyd	2	sad
Dance with my father	Luther Vandross	2	sad
Dido's lament	Henry Purcell	3	dramatic, tragic
Exit music (for a film)	Radiohead	3	sad
Fade to black	Metallica	2	sad
Fix you	Coldplay	2	sad
Für Elise	Ludwig van Beethoven	2	sad
Gloomy Sunday	Rezso Seress	2	melancholic
Gnossienne No.1	Erik Satie	2	sad
Gymnopédie No. 1	Erik Satie	6	sad
Hallelujah	Jeff Buckley	2	sad
Hurt	Johnny Cash	6	sad
Il cantico dei drogati	Fabrizio De Andre'	2	not found
In a sentimental mood	Duke Ellington	2	sad
Kindertotenlieder	Gustav Mahler	2	sad
Kol Nidrei Op. 47	Max Bruch	2	rainy day, bittersweet
Lonely day	System of a Down	3	sad
Lux aeterna (Requiem for a dream OST)	Clint Mansell	2	sad
Mad world	Gary Jules	3	sad
Maggot brain	Funkadelic	2	sad
Mass in B minor BWV 232	Johann Sebastian Bach	2	not many tags
Moon reflected in the second spring	Ah Bing	8	not found

Moonlight sonata: Piano sonata No. 14 in C-sharp minor, Op. 27, No. 2	Ludwig van Beethoven	12	sad
My hearth will go on	Celine Dion	2	sad
Nocturnes	Frederic Chopin	3	melancholic
Pathétique: Symphony No. 6 in B minor, Op. 74	Pyotr Ilyich Tchaikovsky	2	classical, russian
Piano concerto No. 2 in C minor, Op. 18	Sergei Rachmaninoff	2	mellow
Requiem Mass in D minor (K. 626)	Wolfgang Amadeus Mozart	5	sad
River flows in you	Yiruma	3	sad
Skinny love	Bon Iver	2	sad
Someone like you	Adele	5	sad
Street spirit (fade out)	Radiohead	2	sad
Symphony No. 5 (Adagietto)	Gustav Mahler	3	sad
Symphony of sorrowful songs: No. 3, Op. 36	Henryk Górecki	3	sorrow
Symphony No. 7 in A major, Op. 92 (Allegretto)	Ludwig van Beethoven	3	sad
Tears in heaven	Eric Clapton	4	sad
The heart asks pleasure first (The piano OST)	Michael Nyman	5	melancholy
The Planets Op. 32: Jupiter	Gustav Holst	2	melancholic, more sad than jolly
The tourist	Radiohead	2	sad
Theme from Schindler's list	John Williams	5	sad
This woman's work	Kate Bush	2	sad
Tristan und Isolde (Prelude)	Richard Wagner	3	any tag
Yesterday	Beatles	3	sad
You are my sister	Antony and the Johnsons	2	sad

Study 2

Table S.8. *Items used in Experiment 1.*

Thought probe	Question
Mind-wandering	
Mind-wandering	Where was your attention just before the music stopped?
Meta-awareness	How aware were you of where your attention was focused?
Content of thought	
Open-ended format	What were you thinking about just before the music stopped?
Valence	Was the content of your thoughts positive or negative?
Past	Were you thinking about something from the past?
Future	Were you thinking about something from the future?
Self-referentiality	To what extent were these thoughts about yourself?
Familiar people	Please indicate the extent to which your thoughts were about … people you know (e.g., family, friends, partner)
Unknown people	… unknown people
Movements	… body movements or dancing
Bodily sensations	… bodily sensations (e.g., feeling hot/cold/tired/hungry, smiling/frowning)
Musical structure	… thinking about the music (e.g., its melody, beat, harmony)
Evaluating the music	… evaluating the music (e.g., I like it because..)
Experiment	… thinking about the experiment
Form of thought	
Visual imagery	Did you think in images?
Inner language	Did you think in words?

Note. Answers were given on scales from 1 (“not at all”) to 7 (“very much so”), except for mind-wandering (1 = “completely on the music” and 7 = “completely on something else”), meta-awareness (1 = “completely unaware” and 7 = “completely aware”), valence (1 = “very negative” and 7 = “very positive”), and the open-ended question.

Table S.9. *Music stimuli from Experiment 1.*

Title	Artist/Composer	Album	Year	Genre
Sad pieces				
Song for Bob	Nick Cave & Warren Ellis	The Assassination of Jesse James by the Coward Robert Ford	2007	soundtrack
Darcy's Letter	Dario Marianelli	Pride & Prejudice	2005	soundtrack, classical
Elo Hi	Goran Bregović	Queen Margot	1994	soundtrack
Xibalba	Clint Mansell	The Fountain	2006	soundtrack, contemporary classical
Happy pieces				
Papaya	Stelvio Cipriani	The Police Can't Move	1975	soundtrack
Grand Hotel Fox	Nicola Piovani	Life is Beautiful	1997	soundtrack
String Quartet in F major, Op. 77 No. 2 (Finale Vivace Assai)	Joseph Haydn	Haydn: String Quartets	1994	classical
What Players Are They	Patrick Doyle	Hamlet	1996	soundtrack, classical

Table S.10. *Music stimuli from Experiment 2.*

Title	Artist/Composer	Album	Year	Genre
Sad pieces				
Hamlet	Ennio Morricone	Hamlet	1990	soundtrack, classical
Sadness	Dirk Reichardt, Stefan Hansen, Max Berghaus	Barefoot	2005	soundtrack
The Imperfect Enjoyment	Michael Nyman	The Libertine	2005	soundtrack, contemporary classical
Death is The Road to Awe	Clint Mansell	The Fountain	2006	soundtrack, contemporary classical
Happy pieces				
À La Folie	Michael Nyman	6 Days, 6 Nights	1994	soundtrack, contemporary classical
Willoughby	Patrick Doyle	Sense and Sensibility	1995	soundtrack, classical
Meryton Townhall	Dario Marianelli	Pride & Prejudice	2005	soundtrack, classical
Two Hornpipes (Tortuga)	Hans Zimmer	Pirates of the Caribbean: Dead Man's Chest	2006	soundtrack, classical

Table S.11. *Percentage of total positive and negative emotion words across reports of thoughts' content during sad and happy music.*

	Emotion words	
	Positive	**Negative**
Sad music	2.64%	2.77%
Happy music	3.67%	0.82%

Note. Reports of participants' thoughts were analyzed with the LIWC software, which provided percentage of word usage over the pre-chosen categories of positive and negative emotion words.

Study 3

Table S.12. *Descriptive statistics.*

	Study Sample (*N* = 120)			Normative Data		
	Mean	SD	Range	Mean	SD	Range
TAS-20 Total	46.58	10.98	21-78	45.57	11.35	20-100
Difficulty in Identifying Feelings	17.97	6.27	7-34	14.38	5.21	7-35
Difficulty in Describing Feelings	12.93	4.93	5-23	12.50	4.20	5-25
Externally-Oriented Thinking	15.68	3.88	8-26	18.70	4.72	8-40
Musical Training	33.68	16.58	9-49	26.52	11.44	7-49
Perspective-taking	19.43	4.20	4-27	17.37	4.78	0-28
Fantasy	20.30	4.64	5-28	17.24	5.38	0-28
Empathic Concern	20.99	4.06	9-28	20.35	4.02	0-28
Personal Distress	12.73	5.23	0-27	10.87	4.78	0-28
Extraversion	3.43	0.75	1.13-5	3.28	0.90	1-5
Agreeableness	3.77	0.59	2-5	3.67	0.69	1-5
Conscientiousness	3.55	0.61	2.22-5	3.63	0.72	1-5
Neuroticism	3.06	0.77	1-4.88	3.22	0.84	1-5
Openness to Experience	4.12	0.53	2.2-5	3.94	0.67	1-5

Note. Normative data are from Parker, Taylor, and Bagby, 2003 (TAS-20); Müllensiefen et al., 2014 (Gold-MSI); Davis, 1980 (IRI); Srivastava, John, Gosling, and Potter, 2003 (BFI).

Table S.13. *Complete correlation matrix.*

Factor	Happy	Sad	Tender	Fearful	Angry	HE ex.	ME ex.	Tot. MER
TAS-20								
DIF	-.09	.13	.08	.02	-.02	-.02	.11	.06
DDF	.10	-.03	.12	.08	-.07	-.04	.17	.10
EOT	-.02	-.25**	-.19*	-.04	-.17	-.28**	-.08	-.21*
Gold-MSI								
MT	-.09	-.05	.13	.03	.25**	.19*	.02	.13
IRI								
PT	-.08	-.02	.06	.13	.11	.15	-.01	.08
EC	.00	.04	-.01	.04	.19*	.18*	.00	.11
FT	-.18	.20*	.12	-.03	.19*	.12	.02	.08
PD	-.04	.08	.11	.06	.02	.09	.08	.10
BIG-5								
E	-.08	.12	-.16	.00	.05	.06	-.15	-.06
A	.02	-.13	-.09	.14	-.01	.10	-.12	-.02
C	.03	.06	.21*	.13	.05	.26**	.00	.16
N	.03	.14	.02	-.13	.11	-.04	.17	.08
O	-.13	.17*	.04	.09	.16	.19*	-.01	.10

Note. * $p < .05$, ** $p < .01$. A = *agreeableness*; C = *conscientiousness*; DDF = *difficulty in describing feelings*; DIF = *difficulty in identifying feelings*; E = *extraversion*; EC = *empathic concern*; EOT = *externally-oriented thinking*; FT = *fantasy*; HE ex. = "high emotion" excerpts; ME ex. = "moderate emotion" excerpts; MT = *musical training*; N = *neuroticism*; O = *openness to experience*; PD = *personal distress;* PT = *perspective-taking;* Tot. MER = MER total score.