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Title of the publication-based thesis

Music engagement as a resource for health and well-being: an investigation of psychological and psychobiological correlates in clinical and non-clinical samples

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Acknowledgments

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Abstract

To maintain and improve health and well-being, human beings have naturally turned to music for thousands of years. Nowadays, music is an essential part of everyday life, though the engagement with music can occur in a multitude of ways and contexts. Correspondingly, researchers have become increasingly interested in exploring the health and well-being benefits of music engagement in the domains of music therapy and music medicine, music education, community music, and everyday uses of music. Since the findings from these different domains are rarely integrated, the aim of the present thesis was to investigate the impact of music engagement on psychological and psychobiological aspects of health and well-being in clinical settings (music therapy) and non-clinical settings (everyday music engagement) and to discuss their potential similarities and differences. Therefore, a daily diary study, a meta-analysis, and a randomized controlled trial in different settings of music engagement were conducted. In a non-clinical setting, the daily diary study with hobby musicians (Manuscript 1) showed that autonomous motivation to engage in music making predicted higher affective well-being and life satisfaction. Further, results suggested flow experiences as a mediating mechanism. Regarding a clinical setting, the aim of the systematic review and meta-analysis in Manuscript 2 was to gain a comprehensive overview of the impact of music therapy in oncology on health and well-being. Findings revealed beneficial effects on psychological well-being, quality of life, and physical symptom distress, while the frequency and type of music therapy moderated the effect on psychological well-being. To gain more thorough insights into the palliative care setting, a randomized controlled trial was conducted to evaluate a newly developed biographical music therapy showing beneficial effects on psychospiritual outcomes and treatment satisfaction compared to a relaxation intervention (Manuscript 3). Though there were no treatment effects on psychobiological outcomes, both the experimental and control group showed a significant reduction of cortisol and mean heart rate over time (Manuscript 4). As one of the few works combining research and theories of music psychology and music therapy, the discussion of these exemplary findings outlined similarities of music engagement in clinical and non-clinical settings in terms of health and well-being related study outcomes as well as possible underlying mechanisms such as flow experiences and psychobiological stress reduction. Further, findings also indicated differences in terms of the motivation to engage with music, the type of music engagement, and the presence of a therapeutic relationship. Nonetheless, a joint agenda of these disciplines may have highly relevant implications for both research and practice in prevention and health care with regard to improving the quality of studies and consolidating the role of music engagement as a resource for health and well-being in communities and public systems.

List of Publications of the Publication-Based Dissertation

Manuscript 1

Koehler, F., Warth, M., Ditzen, B., & Neubauer, A. B. (in press). Motivation to make music matters: Daily autonomous motivation, flow and well-being. *Psychology of Aesthetics, Creativity, and the Arts*. doi: 10.1037/aca0000409

Manuscript 2

Koehler, F., Martin, Z. S., Hertrampf, R. S., Gäbel, C., Kessler, J., Ditzen, B., & Warth, M. (2020). Music therapy in the psychosocial treatment of adult cancer patients: A systematic review and meta-analysis. *Frontiers in Psychology*, *11*, 651. doi:10.3389/fpsyg.2020.00651

Manuscript 3

Warth, M.*, **Koehler, F.*,** Brehmen, M., Weber, M., Bardenheuer, H. J., Ditzen, B., & Kessler, J. (in press). 'Song of Life': Results of a multicenter randomized trial on the effects of biographical music therapy in palliative care. *BMC Palliative Medicine.* doi: 10.1177/02692163211010394
* shared first authors

Manuscript 4

Koehler, F., Kessler, J., Stoffel, M., Weber, M., Bardenheuer, H. J., Ditzen, B., & Warth, M. (under revision). Psychoneuroendocrinological effects of music therapy versus mindfulness in palliative care: Results from the 'Song of Life' randomized controlled trial. *Supportive Care in Cancer*.

1 Introduction

As human beings, we spend a considerable amount of our daily life concerned with ensuring, maintaining, and improving our health and well-being. Expanding on traditional views separating health and disease, contemporary salutogenetic approaches assume a continuum of health and disease (Antonovsky, 1987) with a focus on resources rather than on factors causing disease. In other words, it may not only be relevant what makes us feel poorly, but also what makes us feel well. While health and well-being research mainly revolves around nutrition, physical activities, and environmental conditions, the value of cultural and arts activities has been significantly underrated (MacDonald, Kreutz, & Mitchell, 2012b). However, the discussion about feasible, non-invasive, and economically viable interventions often includes arts interventions, particularly with regard to music (MacDonald, 2013).

Correspondingly, the empirical investigation of music engagement has gained rapid momentum in the past decades (MacDonald, Kreutz, & Mitchell, 2012a). Evidence demonstrates that music and sounds are inherent components of human development and may therefore be a universal resource with significant implications for health and well-being (MacDonald et al., 2012b). While the beneficial effects of music engagement have been supported by a great amount of studies, comparatively less is known with regard to the specific correlates in different settings of music engagement (Mantie & Smith, 2017). One of the main reasons is the lack of collaboration and integration of findings in research and practice between the disciplines music psychology and music therapy (Vink, 2001).

Therefore, the general aim of the present thesis is to investigate the usefulness of music engagement as a resource for health and well-being and its implications for prevention and health care. Its major contribution to the current field can be seen as an attempt to build bridges between different domains of music research for an expanded understanding of the relationship of music engagement with health and well-being. More precisely, I will integrate theories and research from both clinical settings (music therapy) and non-clinical settings (everyday music engagement) to explore psychological and psychobiological correlates of music engagement. The focus of the thesis will thus lie on examining potential similarities and differences between music research in clinical and non-clinical settings as well as pointing out joint possibilities to enhance future research and practice in prevention and health care.

In the first section of the thesis, I will discuss why music engagement might be relevant for health and well-being and introduce a theoretical framework for research on this association. Next, I will outline the specific characteristics of music making in everyday life and present findings from a daily diary study with hobby musicians to gain insights into determinants, mechanisms, and outcomes in a non-clinical setting (Manuscript 1). Following this section, I will introduce the field of music therapy and summarize results from a systematic

review and meta-analysis on the health and well-being related effects of music therapy in psycho-oncology to investigate features of music engagement in a clinical setting (Manuscript 2). After that, I will describe the use of music in palliative care and present a clinical study on the effects of biographical music therapy with terminally ill patients on psychospiritual and psychobiological well-being (Manuscripts 3 and 4) to further differentiate specific correlates in a palliative care setting. Next, I will discuss similarities and differences between everyday music engagement and music therapy based on the manuscripts' findings including their strengths and limitations. Finally, I will conclude by presenting a possible synthesis and implications for both research and practice in the field of music, health, and well-being.

2 A Theoretical Framework for Music, Health, and Well-Being

Music can be considered one of the most common ways for human beings to express and communicate across all ages and cultures (Welch, Biasutti, MacRitchie, McPherson, & Himonides, 2020). Based on the strong human orientation to music, anthropologists suggest that musicality has been a collective trait for thousands of years (Cross, 2016) though its realization is diversely shaped by the individual environment and attributes (North & Hargreaves, 2006). While music engagement is commonly perceived as an enjoyable activity in and of itself and not primarily used for health reasons, its impact goes far beyond mere pleasure. Throughout ancient history up to today, human beings have attributed significant curative, therapeutic, and other medical value to the art of music and continuously utilized music for the maintenance and improvement of people's health and well-being (MacDonald et al., 2012a).

Therefore, it is not surprising that the impact of music engagement on health and well-being has gained considerable academic interest as well (MacDonald et al., 2012a). Regarding a variety of settings, empirical studies have provided substantial evidence that music engagement can positively influence numerous health and well-being outcomes (Västfjäll, Juslin, & Hartig, 2012). While the optimal flourishing of an individual can be conceptualized and assessed in a multitude of ways, one of the most discussed definitions of health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (World Health Organization, 1946) emphasizes the essential role of various domains of well-being in overall health. In positive psychology, subjective well-being has been commonly outlined as a two-dimensional construct consisting of an emotional component (emotions and moods) and a cognitive component evaluating the quality of life (life satisfaction; Diener, 1984).

While there is a plethora of factors influencing health and well-being ranging from genetic and socio-demographic conditions to life experiences and lifestyle choices, intentional

activities are considered to provide the greatest potential for sustainable maintenance and improvement of well-being (Lyubomirsky, Sheldon, & Schkade, 2005). These health and well-being promoting practices are often rooted in everyday activities, with several of those related to arts and culture (MacDonald et al., 2012b). A recent theoretical review postulates that for a lot of people music engagement may be such an activity supporting optimal health and well-being, as it both helps to alleviate maladaptive states (e.g., in music therapy) and to promote adaptive states as well (e.g., in hobby music making) (Croom, 2014).

With regard to the question how music impacts well-being and health, there is general consensus in literature and research that music mainly affects well-being through the emotions and changes in arousals it can evoke (Hallam, Creech, & Varvarigou, 2017). Depending on the nature of the music, it can be described as a catalyst for a wide variety of emotional experiences which are of high significance for individuals to lead fulfilling, harmonious, and spiritual lives (Hallam et al., 2017) and to increase well-being (Lamont, 2012). Indeed, recent research provides evidence that emotion regulation may mediate the relationship between music engagement and well-being (Chin & Rickard, 2013). The most comprehensive approach to outline the processes underlying the association between music and emotion postulates eight mechanisms including brain stem reflexes, rhythmic entrainment, evaluative conditioning, contagion, visual imagery, episodic memory, musical expectancy, and aesthetic judgment (Juslin, Liljeström, Västfjäll, & Lundqvist, 2010), which occur in a complex interplay between the individual, the music, and the context. Further, Västfjäll et al. (2012) postulate that music-evoked emotions may not only affect the subjective well-being of individuals, but also include bodily responses which influence physical health (e.g., changes in dopamine, cortisol and oxytocin levels, or alterations in brain functions). Further, music-evoked emotions may not only directly affect health, but may also indirectly motivate several health-related behaviors (Västfjäll et al., 2012). Therefore, the effects of music engagement are not only limited to emotions, but expand to a modulation of physiology, attention, cognition, perception, behavior, and communication enhancing well-being and health (Koelsch, 2009).

In investigating the relationship between music, health, and well-being, MacDonald's (2013) conceptual framework depicts four discrete but related main areas of research and practice: music therapy and music medicine, music education, community music, and everyday uses of music (Figure 1a). With the most explicit assignment relating to health and well-being, music therapy emphasizes the therapeutic relationship between the client and the therapist, and the use of music as a primary means of creating health and well-being benefits for the client (MacDonald et al., 2012a). Its related discipline music medicine also encompasses music interventions but without the requirement of a therapeutic relationship, such as listening to a CD during surgery (Gold et al., 2011).

Figure 1a

Areas of Research on Music, Health, and Well-Being (Adapted from MacDonald, 2013)
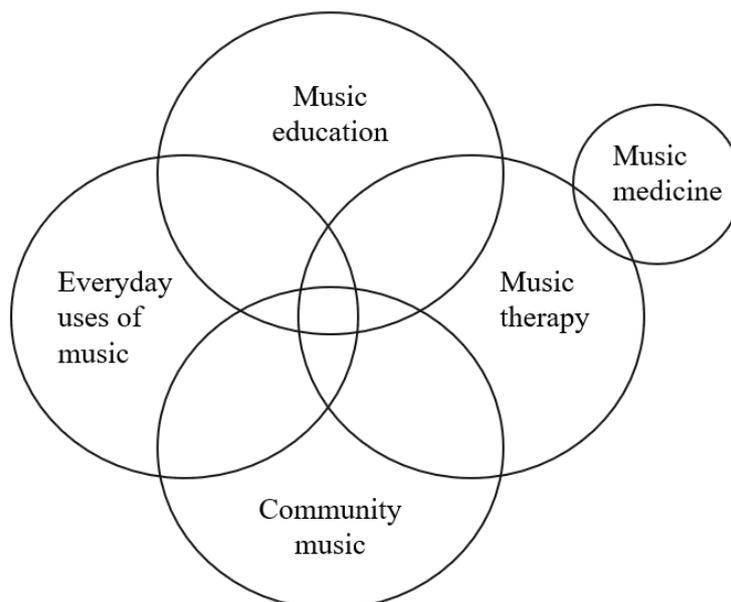
The second subsection refers to music education, that is, teaching and learning music in contexts such as schools, conservatoires, or universities. Although music education does not primarily aim at wider psychological or health benefits, music students might enjoy secondary benefits as indirect pathways to health and well-being, such as enhanced cognitive capacities or improved self-efficacy (MacDonald et al., 2012a). Community music can be specified as culturally organized music interventions outside of formal education contexts, such as music lessons with youth pop music groups in community centers. The fourth subsection describes everyday uses of music which include activities such as listening to music or hobby music making. Though not explicitly therapeutic, these everyday activities provide several emotional, cognitive, and social benefits and thus can contribute to general health and well-being as well (MacDonald et al., 2012a).

The model proposes both unique features as well as important overlaps among all areas and thus demands a multidisciplinary dialogue and research agenda across all professions involved (MacDonald, 2013). A conceptual review proposes that especially the two overarching domains of this model (music psychology and music therapy) could benefit essentially from a living-apart-together relationship (Vink, 2001), especially with regard to everyday music engagement and music therapy (Ansdell, 2013). However, findings from these areas are rarely shared and integrated, although they could benefit substantially from a more thorough exchange (Vink, 2001). For instance, music therapy might derive specific interventions from findings in everyday life, while research on music in everyday life might

build on the specific mechanisms and interindividual variation in responsiveness reported in music therapy.

Therefore, the essential intersection of everyday music engagement and music therapy will be addressed in the present thesis (Figure 1b) incorporating theories and empirical research from both non-clinical settings (Manuscript 1: everyday music engagement) and clinical settings (Manuscripts 2 to 4: music therapy). The aims of the manuscripts thus were to examine the impact of music engagement on health and well-being in terms of psychological indicators (Manuscripts 1 to 4: several domains of well-being) and psychobiological parameters (Manuscript 2: physical symptom distress; Manuscript 4: stress biomarkers). Additionally, the investigation also included potential underlying mechanisms and moderators (Manuscript 1: flow experiences; Manuscript 2: type of music engagement; Manuscripts 3 and 4: psychobiological stress reduction) to provide answers to the question *how* music engagement in clinical and non-clinical settings might affect health and well-being. Overall, the pluralistic approach of the thesis will contribute to an increased collaboration between two research disciplines expanding the understanding of the relationship of music engagement with health and well-being.

Figure 1b

Placement of Dissertation Within the Areas of Research on Music, Health, and Well-Being (Adapted from MacDonald, 2013)
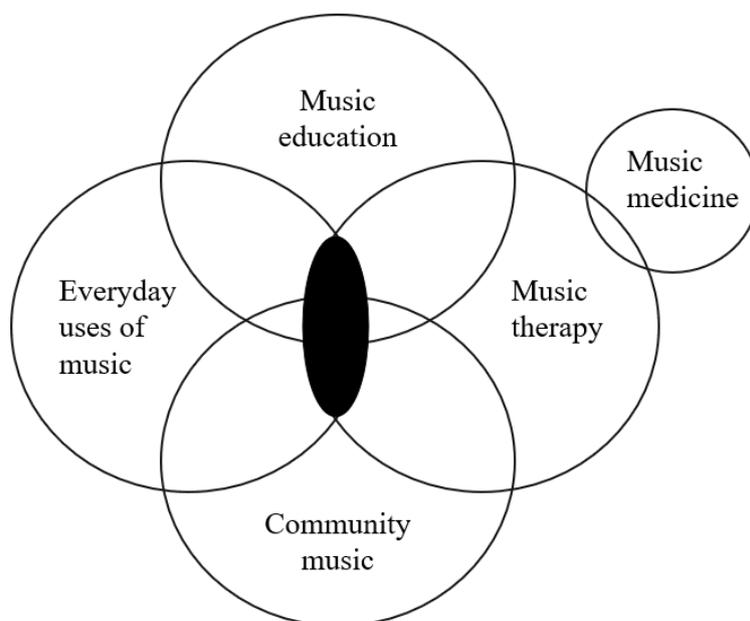
3 Music in Non-Clinical Settings: The Role of Motivation and Flow Experiences in Everyday Music Engagement (Manuscript 1)

As music plays an essential role in people's leisure time, one of the main areas of music psychology involves research on the everyday uses of music to investigate the various ways in which people experience and use music in their daily lives. Most commonly, music engagement in everyday life is categorized into passive forms, such as listening to music, and active forms, such as composing or making music (Weinberg & Joseph, 2016). Due to the technological advances and easy accessibility of music nowadays, most of past research has focused on music listening. The majority of people listen to music to regulate arousal and mood, to achieve self-awareness, and as an expression of social relatedness, contributing to a general sense of well-being (Schäfer, Sedlmeier, Städtler, & Huron, 2013). Further, research also frequently finds positive associations with well-being among people who sing (Sanal & Gorsev, 2013), attend a live musical event (Packer & Ballantyne, 2010), compose music (Habron, Butterly, Gordon, & Roebuck, 2013), or play an instrument (Perkins & Williamon, 2013). A recent systematic review categorized the effects of music engagement in everyday life into emotional, cognitive, social, physical, spiritual and life satisfaction aspects (Krause, Davidson, & North, 2018).

Although active forms of music engagement require greater commitment than music listening, they might have several additional benefits. In particular, Creech, Hallam, Varvarigou, McQueen, and Gaunt (2013) consider activities like making and composing music more helpful to support emotional expression, self-exploration, self-esteem and confidence than music listening. Further, active music engagement can provide a structure to life and offer opportunities to engage in social interaction, find relief from family and work chores, and support spiritual fulfillment and pleasure (Hallam et al., 2017). Indeed, a nationwide study in Denmark (Ekholm, Juel, & Bonde, 2016) found that people who engaged in singing or playing musical instruments at least one hour per day, reported better self-rated health than those who were not musically active. Further, hobby musicians in a daily diary study reported higher positive and lower negative affect on days they engaged in music making (Koehler & Neubauer, 2020).

Nevertheless, although active music making plays a major role in people's leisure time and has demonstrated beneficial health and well-being effects in initial studies, there is a remarkable lack of research replicating and expanding these findings (Mantie & Smith, 2017), in particular with regard to specific determinants and underlying mechanisms. Although hobby music making (i.e., singing or playing musical instruments as a leisure pursuit) partially intersects with music education (i.e., music students taking lessons and practicing specific skills), findings cannot unequivocally be transferred to the population of hobby musicians. Music making in leisure time possibly includes a much broader population concerning

variables such as age or socioeconomic status, as well as distinct features of a music setting outside a formal educational context, such as lack of pressure and competition. In particular, little is known with regard to the question *why* people choose to engage with music in leisure time, although the type of motivation for a certain behavior is a fundamental determinant for the impact of any activity on health and well-being (Deci & Ryan, 1985). In the first manuscript of the present thesis, we thus investigated the role of motivation to engage in music making for hobby musicians' subjective well-being.

Researchers especially in music education commonly examine the role of motivation to make music in the realm of Self-Determination Theory (SDT; Ryan & Deci, 2017) as a comprehensive framework for motivational processes. Emphasizing the quality rather than the quantity of motivation, SDT characterizes motivation as a relative continuum of self-determination ranging from least autonomous (extrinsic motivation) to most autonomous (intrinsic motivation) (Ryan & Deci, 2017). SDT research has increasingly shown that more autonomous forms of motivation for any behavior are related to positive health and well-being outcomes (Hagger et al., 2014). Indeed, with regard to music engagement, findings indicate associations of autonomous motivation with higher frequency and quality of music practice in music students (Evans & Bonneville-Roussy, 2016) and higher well-being in people participating in any musical activity (Krause, North, & Davidson, 2019).

From literature, several theories about the mechanisms underlying this association can be alienated. As music has been thoroughly linked to emotional processes (Juslin & Sloboda, 2010), the investigation of the emotional experience during music making offers a promising potential. Indeed, music making is considered one of the most convenient activities to facilitate flow experiences (Manzano, Theorell, Harmat, & Ullén, 2010), that is, a pleasurable state of complete absorption and deep concentration (Csikszentmihalyi, 1993). Correspondingly, an initial study found trait flow of elite musicians to be associated with higher life satisfaction (Habe, Biasutti, & Kajtna, 2019). Still, research has not addressed autonomous motivation to make music, flow experiences and well-being in hobby musicians' everyday life yet which we aimed to examine in the first manuscript. We hypothesized that autonomous reasons to make music in daily life would be associated with subjective well-being in terms of higher life satisfaction, higher positive affect, and lower negative affect, and that this association would be mediated via flow experiences during music making.

To this end, we conducted an online daily diary study for ten consecutive days with 975 hobby musicians who daily assessed their autonomous motivation to make music, flow experiences during music making (two subscales: fluency of performance and absorption) as well as their subjective well-being in terms of life satisfaction, positive and negative affect. Based on the hierarchical data structure, daily observations on Level 1 (i.e., within-person

level) were nested in individuals on Level 2 (i.e., between-person level) which allowed the investigation of both the associations in an individual over time (within-person variability) as well as between individuals (between-person variability). To avoid the confounding of the two sources of variance, multilevel modeling is commonly employed which separates the effects on different levels. Additionally, when variables cannot be measured perfectly (e.g., through several items assessing a theoretical construct), structural equation models enable the estimation of observed and latent variables. Combining the advantages of both approaches, we therefore employed multilevel structural equation modeling for data analysis.

Results showed a positive effect of autonomous motivation on life satisfaction that was mediated by flow, with fluency at the within-person level ($\beta = .038$, $p = .011$) and between-person level ($\beta = .059$, $p = .018$), and absorption at the within-person level ($\beta = .040$, $p = .012$). Similarly, there was a positive effect of autonomous motivation on positive affect which was also mediated by flow, with fluency at the within-person level ($\beta = .057$, $p = .003$) and between-person level ($\beta = .142$, $p = .001$), and absorption at the within-person level ($\beta = .057$, $p = .006$). We also found a negative indirect effect on negative affect via fluency on the within-person level ($\beta = -.080$, $p < .001$).

Our findings therefore contribute to an enhanced understanding of the importance of the quality of motivation as a determinant in the effects of music engagement in non-clinical settings like everyday life. Corresponding to theorems of SDT (Ryan & Deci, 2017), it may therefore not merely be the act of music making which contributes to well-being, but also the perceived autonomy in motivation to make music. Further, the study helps to gain insight into the processes how music engagement can affect well-being in non-clinical settings. In line with research on music-evoked emotional states (Juslin & Sloboda, 2010), our findings propose the experiences of flow during music making as a mechanism. Findings also emphasize the significance of using multidimensional constructs, both in flow experiences and well-being indicators, to specify differential effects. Further research might employ experimental designs, such as randomized controlled trials, to gain more insights into the causal direction of the effects of music engagement.

While the findings of Manuscript 1 contain great relevance inside the area of everyday uses of music, based on the model by MacDonald et al. (2012a, Figure 1a), its implications extend to and overlap with research of the other areas concerning music, health, and well-being as well. For instance, a conceptual review on the effects of music therapy on well-being recently introduced flow experiences as a potential mechanism (Silverman & Baker, 2018). Further, as music therapy naturally involves music interventions, research on music therapy frequently employs experimental studies to investigate its efficacy and thus might be able to

expand findings from Manuscript 1 to provide further information on causal effects of music engagement on health and well-being.

4 Music in Clinical Settings: Music Therapy in Psycho-Oncology (Manuscript 2)

In addition to music engagement in leisure time, music has been used as a tool to heal disease and ill-being for thousands of years. However, music therapy unfolded its identity as an established profession and academic discipline as late as the early twentieth century (Mastnak, 2015). In its beginnings, the empirical foundation of music therapy was rather speculative with mostly anecdotal reports and few poorly designed studies, but over the past decades, a growing body of evidence has accumulated evidence for its beneficial effects on health and well-being (Thompson, 2009). The most commonly cited definition depicts music therapy as a reflexive process to support the client's health and well-being with the use of the musical experience and the therapeutic relationship (Bruscia, 2014). In contrast to the effects of music engagement in everyday life, the effects of music therapy therefore not only involve music as a primarily nonverbal medium of expression and communication, but also entails the therapeutic relationship as well. With regard to the underlying processes of music therapeutic work, Hillecke and Wilker (2007) postulate five factors including modulation of attention, emotion, cognition, behavior, and communication. Corresponding to music psychology research on music-evoked emotions, the interconnection between sonic characteristics of the music and the client's emotional and communicative responses is considered one of the main features of music therapy (Preti & Welch, 2004).

Similar to the categorization of music engagement in everyday life, active forms of music therapy involve the client's intentional participation in singing, performing, improvising, or composing music, while in receptive forms, the therapist guides the client to listen to recorded or live music (Thompson, 2009). Music therapists typically ascertain a client's unique needs and customize their treatment and techniques accordingly (Koehler et al., 2019). Nowadays, music therapy is firmly implemented in many fields of medicine, pedagogies, and rehabilitation, while one of the most important clinical application of music therapy is in the field of oncology. For instance, in the United States, the majority of music therapists work with cancer patients (Stanczyk, 2011), since the diagnosis and course of a life-threatening illness like cancer is considered one of the most distressing life events disrupting all aspects of life (Holland, 2015).

Due to the disease and its treatment, the oncological patients' and their relatives' quality of life is often highly impaired on a physical, psychological, social, and spiritual level which requires the support of an interdisciplinary treatment team (Warth et al., 2019). Based on this holistic approach, music therapy is an explicitly recommended psycho-oncological treatment

option in national guidelines of Germany (Deutsche Krebsgesellschaft, Deutsche Krebshilfe, AWMF [Leitlinienprogramm Onkologie], 2014). Music therapy serves as a non-invasive and cost-effective modality to address the variety of a patient's psychosocial and physiological needs arising from the disease and the side-effects of its treatment. In particular, music therapy can help the patient to perceive, regulate, and express feelings related to the disease, like anger, sadness, or despair, without the requirement of explicit verbal communication (Bradt & Dileo, 2010). In oncological settings, music therapists commonly use relaxation and imagery, song and improvisation techniques tailored to the individual patient's needs (Koehler et al., 2019).

The main outcomes affected by music interventions in cancer care have been observed as pain, anxiety, mood, fatigue, and quality of life as well as several physiological parameters (e.g., Bradt, Dileo, Magill, & Teague, 2016). Corresponding to findings on affective well-being in non-clinical settings (Manuscript 1), Fredenburg and Silverman (2014) found that cancer patients receiving music therapy reported higher positive and lower negative affect than the waitlist control group. However, studies and systematic reviews on the effects of music therapy in psycho-oncology show various methodological challenges (Warth, Kessler et al., 2015), such as non-randomized study designs, lack of blinding, or heterogeneity of populations and interventions, which lead to a high risk of bias and limited validity. Therefore, we conducted a systematic review and meta-analysis in terms of a narrative and quantitative synthesis to provide an overview of the effects of music therapy in adult cancer patients in all stages of the disease (Manuscript 2).

We followed common guidelines for reporting reviews (Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PRISMA). In our literature search, randomized or non-randomized controlled clinical trials were included that investigated music therapy provided by a trained therapist in an oncological setting. After removing results that did not match eligibility criteria, 30 studies remained for a narrative synthesis, while 21 studies were included in a quantitative analysis. The narrative synthesis indicated mixed, but overall positive effects of music therapy on a wide range of outcomes, though effects and techniques were heterogeneous among different stages of treatment. Music therapy during curative treatment, which included chemotherapy and radiation as well as surgery and transplantation, was mostly associated with a reduction of pain, anxiety, negative mood, and fatigue. Techniques encompassed music listening, relaxation, improvisation, and song writing. In palliative care, findings mainly indicated beneficial effects of music therapy on well-being, quality of life, and anxiety. Most music therapeutic treatment in these studies focused on relaxation and individually tailored sessions.

Results of the meta-analysis showed that music therapy had significant beneficial effects on psychological well-being ($d = 0.35$, $p < .001$), physical symptom distress ($d = -0.26$,

$p = .017$), and quality of life ($d = 0.36$, $p = .023$), with small to medium heterogeneity between effect sizes. While no moderating variables were found for physical symptom distress and quality of life, the type of music therapy moderated the effect on psychological well-being with stronger effects of receptive techniques ($d = 0.33$) compared to active techniques ($d = 0.19$). Further, music therapy interventions with a single session were more beneficial for psychological well-being ($d = 0.47$) compared to interventions with a higher number of sessions ($d = 0.18$).

Our review provides a comprehensive overview of the impact of music therapy in adult cancer care and shows evidence for overall small but beneficial effects in this specific clinical setting. Results also point to possible moderating variables, that is, the number of sessions and the type of music therapy technique, which provide more detailed insights into the processes of music engagement in an oncological setting. Building on the determinants and mechanisms derived from Manuscript 1 with a non-clinical sample (motivation and flow experiences), Manuscript 2 with a clinical sample adds the frequency and the type of music engagement as potential modulating factors to the association between music, health, and well-being. In addition, Manuscript 2 extends the effects on well-being outcomes used in Manuscript 1 (positive and negative affect, life satisfaction) to general psychological well-being, quality of life, and physical symptom distress, broadening the understanding of the multidimensional impact of music engagement and emphasizing the use of clinically relevant outcomes in clinical settings. Further, the distinct findings among the stages of treatment outline the specific needs of cancer patients during the disease progression pointing to the state of health as a possible determinant in the effects of music engagement. While Manuscript 2 underlines the unique potential of music therapy in different phases, especially the palliative care context was identified as a particularly promising field characterized by distinct features and requirements.

5 Music Therapy in Palliative Care

In palliative care, patients faced with a terminal diagnosis often experience exceptional physical, psychological, social, and spiritual challenges, such as weakness, depression, or loss of meaning in life (Rodin, 2013). Similar to general psycho-oncological treatment, a multi-professional team therefore aims to provide holistic support for meeting the variety of needs of the patients and their relatives. For this purpose, pharmacological interventions often treat patients with a biomedical focus. Psychosocial interventions, such as mindfulness, psychotherapy, or music therapy, however, specifically address the patients' psychological, spiritual, and social concerns (Warth et al., 2019). Indeed, since the beginnings of palliative care in Canada in the 1970s, music therapy has been an essential part of the psychosocial treatment of patients with a terminal disease (Munro & Mount, 1978).

Corresponding to findings from Manuscript 2, the specific conditions of terminally ill patients, such as physical decline, limited life expectancy, and existential fear of death, require music therapy in palliative care to flexibly adapt to the patient's state of physical and mental health. According to McConnell and Porter's (2017) framework of music therapy in palliative care (Table 1), its purpose is to maintain or improve quality of life through offering assistance on a physical and psychological level as well as on an emotional, existential, and social level. Depending on the level, different music therapy interventions with specific underlying mechanisms can be employed affecting different outcomes, such as improved emotional or spiritual well-being. Therefore, determined by the patient's needs, music therapy in palliative care is not only able to provide simple relaxation and pleasure, but it can also facilitate a psychospiritual process transforming suffering into meaning (Salmon, 2001).

Table 1

Palliative Care Model for Music Therapy (Adapted from McConnell & Porter, 2017)

Domain	Typical music therapy intervention	Mechanism	Outcomes
Supportive (physical and psychological level)	Song choice, lyric analysis, entrainment; music and imagery (GIM), toning, singing, playing instruments, music listening, music with movement	Gate control theory of pain: music therapy acts as a distraction and influences affective and cognitive factors	Decreased levels of depression, anxiety, and pain
Communicative /expressive (emotional level)	Life review and musical life review, musical autobiographies, song dedications, music/song legacies, improvisation, music and art, songwriting, song choice, lyric analysis, GIM	Catharsis (relief from repressed emotions); music as a channel for emotional expression/ allows safe expression of emotions either verbally or nonverbally	Improved emotional well-being
Transformative (existential level)	Songwriting, musical improvisation, song dedications, music legacies, GIM	Cognitive reframing; music as transformative (from suffering to meaning)	Improved spiritual well-being
Social level	Music legacies, musical improvisation	Relationship completion, sense of community, "humanized" ward	lower levels of bereavement, improved staff mood and patient care

Despite its value in clinical practice, Manuscript 2 found that empirical studies on music therapy in palliative care have been scarce and infused with a high risk of bias and low level of evidence. Most of them found improvements in quality of life (Hilliard, 2003) and well-being (Warth, Keßler, Hillecke, & Bardenheuer, 2015), as well as reductions in anxiety (Horne-Thompson & Grocke, 2008) and pain (Gutgsell et al., 2013). Due to a lack of methodologically rigorous studies with standardized intervention protocols, our aim was to develop and empirically evaluate an innovative music therapy intervention ("Song of Life") to improve psychological and spiritual well-being for terminally ill patients in palliative care (Manuscript 3).

5.1 "Song of Life": Effects on Psychospiritual Well-Being (Manuscript 3)

According to Erikson's psychosocial stages of development (Erikson, 1982), the main tasks at the end of life involve generativity (i.e., helping and guiding next generations with a sense of usefulness) and ego-integrity (i.e., accepting one's own life course with a sense of meaning and peace). To address these themes, psychosocial interventions using life review techniques contain a reflection on the patient's biography and sometimes the creation of a legacy (e.g., the transcription of a biographical interview in Dignity Therapy; Chochinov et al., 2005). Single experience-based case studies combining life review techniques with music therapy (e.g., Sato, 2011) have described the supportive role of music especially in its ability to bring out unconscious material to consciousness.

However, no experimental study has examined the efficacy of a standardized biographical music therapy with palliative care patients yet. Integrating elements from (musical) life reviews and the creation of a legacy, we therefore developed and evaluated the new pilot-tested (Warth, Kessler, van Kampen, Ditzen, & Bardenheuer, 2018) music therapy intervention "Song of Life" (SOL) based on a biographically meaningful song. The SOL could be any song that evokes memories and emotions of the patient connected to significant events, people, or situations during their life (e.g., the song of the wedding dance, or a lullaby). In a parallel study design, 104 patients from two palliative care units in Germany were randomly assigned either to SOL in the experimental group or to a relaxation/mindfulness intervention in the control group, both carried out by two trained music therapists. SOL consisted of three 20 minute-sessions of music therapy (exploration and identification of the patient's SOL; live performance by music therapist and audio recording of SOL; handing over of audio recording and reflection). The control group received three 20-minute sessions of standardized relaxation techniques (muscle relaxation; focus on breath; imagery).

Building on the health and well-being parameters of Manuscript 1 in a non-clinical sample (positive and negative affect, life satisfaction) and Manuscript 2 in cancer patient

samples (psychological well-being, quality of life, physical symptom distress), we adjusted the study variables to clinically relevant outcomes of palliative care patients at the end of life. In the palliative care model for music therapy (McConnell & Porter, 2017; Table 1), the SOL intervention may primarily function on the emotional and existential level, since its aim is a musical life review and creating a music legacy. Therefore, the primary outcome included the pre-to-post-change in the psychological domain of quality of life, while secondary outcomes encompassed spiritual well-being, ego-integrity, global quality of life, and distress. Additionally, treatment satisfaction was assessed in a feedback questionnaire by both patients and family members.

To minimize the risk of bias, we analyzed the data in an intention-to-treat approach which implies the analysis of all randomized participants according to the group they were initially assigned to, regardless of whether they received or completed the treatment. In the primary analysis, we computed an analysis of covariance using multiple imputation to handle missing data. Results showed no significant differences regarding psychological and global quality of life. However, SOL participants described significantly higher spiritual well-being ($d = 0.52$, $p = .04$) and ego-integrity ($d = 0.72$, $p < .01$), as well as lower distress ($d = -0.51$, $p = .05$) than patients receiving relaxation exercises. To test the robustness of findings, we then conducted a sensitivity analysis based on multilevel modeling using all data that was available which yielded identical patterns of effects. Higher treatment satisfaction of both patients and family members was observed for SOL with large between-group effect sizes on items addressing meaningfulness ($d = 0.96$, $p < .001$) and importance ($d = 1.00$, $p < .001$).

Findings of this study suggest that biographical music therapy may be beneficial for health and well-being in palliative care patients, especially regarding psychospiritual outcomes relevant at the end of life, which corresponds to predictions of the palliative care model for music therapy (Table 1). Results therefore extend findings from Manuscripts 1 and 2 highlighting the importance of determining health and well-being parameters that are congruent with the specific characteristics of the sample. Corresponding to findings from Manuscript 2, Manuscript 3 emphasizes the tole of the type of music engagement in the effects on health and well-being. While for terminally ill patients biographical work with music may be favorable (Manuscript 3), Manuscript 2 demonstrates other useful techniques with general cancer patients (e.g., imagery, song writing) and Manuscript 1 shows beneficial effects for hobby music making (e.g., practicing, playing in an ensemble). Building on the call for high-quality experimental trials on music engagement and well-being (Manuscripts 1 and 2), the randomized controlled study design in Manuscript 3 provides further evidence on the causal direction of the effects of music engagement.

5.2 "Song of Life": Effects on Psychobiological Stress Markers (Manuscript 4)

In Manuscripts 1 to 3, the effects of music engagement were mainly assessed regarding several self-reported domains of psychological well-being, quality of life, or physical symptoms. However, studies on the effects of music engagement on health and well-being have recently joined the increasing trend in biobehavioral research toward complementing psychological with biological assessment for a more comprehensive understanding of underlying processes. Past research on music engagement mostly focused on the effects of music listening on psychobiological stress parameters indicating a decrease of physiological arousal in terms of reduced cortisol levels, lowered heart rate, and decreases in mean arterial pressure (e.g., Linnemann, Ditzen, Strahler, Doerr, & Nater, 2015; Witte et al., 2020).

In presence of a stressor, the human stress response includes the activation of two key pathways, the hypothalamic-pituitary adrenal (HPA) axis and the sympathetic branch of the autonomic nervous system (ANS). While the ANS rapidly prepares the body for active coping with the stressor through effects on the cardiovascular and metabolic systems, the HPA axis enables a slower cascade of secretory signals peaking in the release of the hormone cortisol from the adrenal gland (Laurent, Powers, & Granger, 2013). Common psychobiological markers of stress therefore include cortisol mirroring HPA axis activity, as well as heart rate or heart rate variability, and the enzyme alpha-amylase, mirroring activity of the ANS (Sittler, Worschech, Wilz, Fellgiebel, & Wuttke-Linnemann, 2021). While an acute stress response is highly adaptive, especially clinical samples show impaired psychobiological stress markers on account of chronic stress (Cohen et al., 2012). Due to the severity of the diagnosis and treatment of a life-limiting disease, particularly oncological patients show significant alterations of levels and diurnal patterns of cortisol and alpha-amylase in comparison to healthy controls or other diseases (e.g., Bernabé et al., 2012).

Based on the encompassing impact of music, music therapy as a cost-effective intervention without side effects provides promising potential to offer support to cancer patients impacting not only the psychosocial but the biological level as well. Therefore, research on music therapy has also begun to incorporate psychobiological assessment to investigate its impact on health and well-being (e.g., Ribeiro et al., 2018). Even though some reviews on psychosocial interventions and general music interventions with cancer patients have shown decreased cortisol, blood pressure, and heart rate (e.g., Tang, Liu, Wu, & Shi, 2020; Wang, Zhang, Fan, Tan, & Lei, 2018), further studies specifically on the psychobiological effects of music therapy have been scarce. Particularly in the field of palliative care, to date there are few and inconsistent findings on the effects of music therapy on biomarkers of stress (Allmendinger, 2016; Nakayama, Kikuta, & Takeda, 2009).

Due to the lack of research and high relevance of integrating psychobiological assessment, we investigated several psychobiological markers of stress in the SOL study with 104 palliative care patients regarding the effects of music therapy compared to a mindfulness intervention (Manuscript 4). To minimize patient burden, we complemented only the second session of both interventions with psychobiological assessment as this session contained live music by the therapist. Before and after the session, the patients rated their momentary subjective distress. Further, the patients were asked to deliver three saliva samples by chewing on a cotton swab for measurement of salivary cortisol and alpha-amylase (immediately before and after the session, as well as 20 minutes later as follow-up). Correspondingly, photoplethysmography was used for a continuous recording of the patients' autonomic cardiac response during the whole session by means of a finger sensor to analyze heart rate variability and mean heart rate. Parallel to the third saliva sample, 20 minutes later, a 5-minute recording served as a follow-up. Data analysis included multilevel modeling of all available data and sensitivity analysis with multiply imputed data to test the robustness of findings.

The primary analyses of psychobiological parameters contained between 67% and 75% of the maximally available measurement points. Multilevel models using all available data revealed a significant time*treatment effect on distress ($b = -0.83$, $p = .02$) pointing to a larger decrease in the music therapy group. Regarding psychobiological outcomes, no interaction effects were observed (all $p > .05$). However, there were significant main effects on cortisol ($b = -0.06$, $p = .01$) and mean heart rate ($b = -7.89$, $p = .05$) indicating a reduction over time in both intervention groups. The sensitivity analysis including multiply imputed data produced the same pattern of effects.

While the findings suggest a beneficial effect of music therapy on distress, we did not find a superiority of either intervention regarding the effects on stress marker trajectories. One explanation might be the similarity of underlying mechanisms between both interventions, such as attention, empathy, and care, highlighting the importance of aspects of the therapeutic relationship. Another reason for the present findings might involve the enormous challenges in psychobiological data collection in palliative care due to the patients' deteriorating state of health (Allmendinger, 2016). However, despite the lack of interaction effects in objective psychobiological assessments, the results of Manuscript 4 also show a beneficial effect on subjective self-reports of distress corresponding to previous findings in psycho-oncology (Manuscript 2) and other clinical settings (Witte et al., 2020). Overall, Manuscript 4 contributes to an integral investigation of the effects of music engagement on health and well-being emphasizing the promising potential of psychobiological stress reduction as an underlying mechanism.

6 General Discussion

The present thesis aimed to investigate the usefulness of music engagement as a resource for health and well-being by exploring psychological and psychobiological correlates in clinical and non-clinical samples. While a considerable amount of reviews on music engagement across various settings has shown numerous health and well-being benefits (e.g., Krause et al., 2018), hardly any work has combined research from everyday music engagement and music therapy to discuss possible similarities and differences. Although the thesis does not claim to be able to provide an all-encompassing overview on music research in clinical and non-clinical settings, the manuscripts offer valuable concepts, results, and suggestions for a potential synthesis. In the following section, I will therefore discuss the contributions of each manuscript within the current state of literature regarding similarities and differences of research on music engagement in clinical and non-clinical settings. Additionally, I will examine the thesis' strengths and limitations and conclude with a synthesis and possible implications for research and practice.

6.1 Music Research in Clinical versus Non-Clinical Settings

To briefly summarize the results of each manuscript, Manuscript 1 showed positive effects of autonomous motivation to engage in hobby music making on subjective well-being which were partially mediated by flow experiences. The meta-analysis in Manuscript 2 demonstrated beneficial effects of music therapy with cancer patients on psychological well-being, quality of life and symptom distress. The SOL study on biographical music therapy in palliative care revealed beneficial effects on psychospiritual well-being (Manuscript 3) as well as on psychobiological parameters and distress (Manuscript 4). In the following, I will discuss their potential similarities and differences regarding several selected issues that deemed meaningful. These topics included health and well-being related study outcomes, flow experiences and psychobiological stress reduction as underlying mechanisms, as well as the motivation and type of music engagement, and the presence of a therapeutic relationship.

6.1.1 Health and well-being related study outcomes

In line with the variety of definitions, domains, and measurements of health and well-being (e.g., Diener, 1984; World Health Organization, 1946), each manuscript contains specific health and well-being outcomes relevant in the perspective of each area of research. For instance, in Manuscript 1 as the representative for a music psychological approach in a non-clinical setting, we found beneficial effects of autonomous motivation to engage in hobby music making on subjective well-being (positive and negative affect, life satisfaction), which is a common conceptualization in psychology research and covers basic human flourishing.

Especially in public health and national surveys as non-clinical settings, the construct of subjective well-being is used as an acknowledged outcome to inform cultural program and policy development (Daykin et al., 2018).

With regard to clinical settings, the meta-analysis in Manuscript 2 showed effects of music therapy in oncology on clinically relevant outcomes regarding quality of life, psychological well-being (e.g., mood, anxiety, depression), and physical symptom distress (e.g., pain, generic physical symptom scales, and fatigue). Clinical settings therefore might require the specific inquiry of common symptoms or comorbidities as they become more acute and relevant in the evaluation of health and well-being when diagnosed with a severe disease (Manuscript 2). The outcomes measured in clinical settings therefore need to be considered meaningful and pertinent by patients and clinicians (Ramsey, Eckert, Hutchinson, Marker, & Corsini, 2020). Similarly, in palliative care, according to its model for music therapy (McConnell & Porter, 2017), the outcomes affected by music therapy can vary depending on the level (physical/psychological, emotional, existential, or social) which the specific music therapy technique addresses (Table 1). As the SOL technique investigated in Manuscripts 3 and 4 works with a biographically meaningful song addressing the existential level, the model's assumptions would mainly predict beneficial effects on spiritual well-being. Indeed, medical literature places great importance to the spiritual and religious domain of health (Koenig, King, & Carson, 2012), which includes a sense of purpose, meaning, and connectedness to what is personally important or sacred. Correspondingly, in the SOL study (Manuscripts 3 and 4), we found statistically significant effects on those domains of well-being (i.e., spiritual well-being, ego-integrity) which become increasingly relevant at the end of life.

Concerning psychobiological and physical parameters of health and well-being, Manuscript 2 and Manuscript 4 both found beneficial effects of music therapy on subjective self-reported physical symptoms and distress in oncological and palliative care settings respectively, which is congruent with a great amount of studies on music therapy in other clinical settings as well (Witte et al., 2020). In contrast, we did not find any interaction effects of the intervention with objective biomarkers of stress corresponding to previous inconsistent findings partially due to difficult data collection in palliative care settings (Allmendinger, 2016; Nakayama et al., 2009). However, in other clinical settings such as neonatology or geriatrics, several studies and systematic reviews have provided evidence for beneficial effects of music therapy on psychobiological parameters such as heart rate, blood pressure, or cortisol (La Rubia Ortí et al., 2018; Yue, Han, Luo, Zeng, & Yang, 2021). Regarding non-clinical settings, no study has investigated psychobiological stress parameters in relation to hobby music engagement yet, even though these findings point to the huge potential of psychobiological outcomes in research on active music making in everyday life as well. For instance, research

showed that other forms of everyday music engagement, i.e., music listening, with the aim of relaxation was associated with lower cortisol, while alpha-amylase varied with the arousal of the music showing energizing music to increase and relaxing music to decrease alpha-amylase activity (Linnemann et al., 2015).

6.1.2 Flow experiences and psychobiological stress reduction as underlying mechanisms

Since past research on music engagement as a resource for health and well-being has mainly focused on the effects on outcomes, comparatively few studies have investigated the question *why* music engagement might be beneficial for health and well-being in terms of underlying mechanisms and moderators. Based on past research highlighting the emotional processes during music engagement (Swaminathan & Schellenberg, 2015), we investigated flow experiences as a mediator in the association between autonomous motivation to engage in hobby music making and subjective well-being, and found significant positive indirect effects on life satisfaction and positive affect as well as negative indirect effects on negative affect (Manuscript 1). In music research in non-clinical settings, a growing body of studies has examined flow in the context of music performance, music teaching, and music consumption (Tan & Sin, 2019). Nonetheless, our findings suggest that hobby music engagement may also provide beneficial conditions to induce a state of flow, such as a sense of autonomy and agency (e.g., choosing the time and space for music making, or selecting a specific music piece), lack of pressure and competition, and heightened intrinsic motivation in a voluntary leisure pursuit.

In clinical settings, flow experiences have been proposed as a mediating mechanism in music therapy as well (Silverman & Baker, 2018). The authors postulate that especially the all-encompassing attention during a highly focused and intrinsically motivating activity, such as music engagement, may provide temporary relief of negative emotional states and problem-focused mindsets (Silverman & Baker, 2018). Indeed, a clinical trial on songwriting interventions (Silverman, Baker, & MacDonald, 2016) showed that flow but not meaningfulness predicted therapeutic outcomes such as hope. Although in the SOL study (Manuscripts 3 and 4) we did not directly assess flow experiences, the interviews with the patients in the third music therapy session suggest similar emotional states as well. Several patients reported that during listening to their song they were completely absorbed in the music and memories forgetting the here and now for a moment. These comments might especially refer to the flow subscale absorption as the subscale fluency of performance may not be as relevant due to the patients' lack of active engagement in the music therapy protocol.

Apart from flow experiences, Manuscript 4 also points to the importance of psychobiological mechanisms in research on music engagement on health and well-being, especially regarding stress reduction. From a neuroendocrine and neurophysiological point of

view, a recent review on the psychobiological mechanisms of music suggests that the processing of music activates brain regions which partially overlap with projections of the two main stress systems, the HPA axis and the ANS (Sittler et al., 2021). In particular, listening to music mobilizes limbic and paralimbic regions of the brain including the hippocampus and the amygdala which modulate the autonomic, hormonal, and immune system (Koelsch, 2014). Therefore, it is hypothesized that the health and well-being benefits of music engagement may manifest through these shared neural circuits in terms of psychobiological stress reduction (Sittler et al., 2021). Correspondingly, the beneficial effects of hobby music making on subjective well-being in everyday life (Manuscript 1) might be a function of stress reduction through the musical activity. Similarly, music therapy in clinical settings such as psycho-oncology (Manuscript 2) may also work through reducing stress on both the psychological and biological level. Indeed, the SOL study in palliative care showed beneficial effects on not only psychospiritual well-being, but momentary distress and cortisol as well (Manuscripts 3 and 4), highlighting psychobiological stress reduction as a potential mechanism.

6.1.3 Motivation and type of music engagement

Another fundamental topic that can be derived from the present manuscripts is the motivation to engage with music which might be considerably different among clinical and non-clinical settings. While hobby music engagement may be accompanied by an intentional choice and autonomous motivation (Manuscript 1), the palliative care patients in the SOL study (Manuscript 3) frequently reported other reasons to participate, such as convenience, enjoyment of attention and care, or supporting research. While music research in non-clinical settings often involves observing naturally occurring musical activities (Manuscript 1), research on music therapy in clinical settings commonly investigates interventions that are assigned by the investigators (Manuscripts 2 to 4). Therefore, the study design in each setting might reflect and affect the motivation to engage with music as well. Nonetheless, the most frequently reported function of everyday uses of music, that is, emotion regulation (Schäfer et al., 2013), might be a great motivator for people in clinical settings to engage with music as well. Indeed, hospitalized patients commonly report increased emotional disturbances which music therapy might be able to address through facilitating emotional expression or relaxation (Rafieyan & Ries, 2007).

Therefore, due to the different states of mental or physical health in clinical compared to non-clinical settings, the type of music engagement might play an important role as well. Indeed, findings from Manuscript 2 revealed the type of music therapy in psycho-oncology as a moderating variable. The stronger effects of receptive compared to active music therapy techniques may reflect the highly impaired state of health of oncological patients,

corresponding to previous meta-analytical findings of music therapy in people diagnosed with dementia (Tsoi et al., 2018). Active music therapy might require too much physical or mental fitness which may not be available to the patients in this situation. Similarly, as extreme fatigue is observed as one of the most common symptoms in palliative care patients (Radbruch et al., 2008), receptive music therapy techniques might also be more helpful with patients at the end of life. Correspondingly, the SOL music therapy intervention (Manuscripts 3 and 4) required no active participation which was positively mentioned by the patients in the interviews. However, in contrast to the oncological setting, healthy people in non-clinical settings might benefit more from active forms of music engagement in everyday life (Manuscript 1). For instance, Creech et al. (2013) postulate that active forms of music engagement may produce greater health and well-being benefits than passive engagement because they can enhance emotional expression, self-exploration, self-esteem and confidence. In both clinical and non-clinical settings, the effects of music engagement might therefore depend on the state of mental and physical health and the resulting type of music engagement that is doable in the current conditions.

6.1.4 Presence of a therapeutic relationship

However, the most protruding difference of everyday music engagement to music therapy might be the presence of a trained music therapist and a systematic therapeutic process (Bruscia, 2014). Indeed, literature on psychotherapy in general emphasizes the quality and strength of the relationship between the person receiving therapy and the person providing it as fundamental for improved outcomes (Lambert & Barley, 2001). Correspondingly, although in the SOL study (Manuscripts 3 and 4) the biographically meaningful song was the focus of the music therapy, several patients reported the attention and care of the therapist to be immensely valuable and supportive as well. According to the palliative care model for music therapy (McConnell & Porter, 2017), SOL may mainly function on the communicative/expressive and transformative level (Table 1) both of which may be hugely impacted and enhanced by the presence of a therapist. Although the meta-analysis in psycho-oncology (Manuscript 2) deliberately only included music therapy studies, a recent study on cancer patients (Bradt et al., 2015) compared the impact of music therapy with music medicine (i.e., music interventions in clinical settings without a therapist). Results showed both to be equally effective in enhancing mood and anxiety, though three quarters of the patients reported a preference for music therapy.

The therapeutic component of music therapy in clinical settings thus might be a major difference to hobby music engagement in non-clinical settings. In the daily diary study on hobby musicians (Manuscript 1), the participants mainly reported solitary musical activities

suggesting the existence of other factors contributing to the effects on well-being in everyday life. Although past research on community music, such as choir singing (Sanal & Gorsev, 2013), showed health and well-being benefits, these findings may not be directly transferrable to general hobby music engagement covering a wide range of daily musical activities other than orchestra or choir rehearsals. However, due to the social function of other forms of everyday music engagement (i.e., music listening, Boer & Abubakar, 2014), the presence of other musicians during hobby music making might still influence the effects on well-being in terms of enhancing a sense of social connectedness and belonging. Nonetheless, the relational component of everyday music engagement may operate on another level (e.g., through a shared focus on the music itself) compared to music therapy with an explicit therapeutic focus corresponding to different motivations in each setting.

Overall, the integration and discussion of the thesis' manuscripts revealed several potential similarities between music engagement in clinical and non-clinical settings regarding health and well-being related study outcomes, flow experiences and psychobiological stress reduction as underlying mechanisms, as well as differences regarding the motivation and type of music engagement, and the presence of a therapeutic relationship.

6.2 Strengths, Limitations and Future Research

As the strengths and limitations specific to each manuscript were discussed in the respective discussion section of the manuscripts, the aim of this section is to identify the overarching strengths and weaknesses of the whole thesis and to alienate recommendations for future research.

The fundamental strength of the present work is the high quality of the combined research regarding study design, sample, operationalization, and statistical analysis, which will be discussed in the following. First, the study designs have been carefully selected to allow valid conclusions in their respective fields of research and to enhance internal validity. In Manuscript 1, the ambulatory assessment in the daily diary study over the course of ten days allowed for repeated measurements providing a large data base. Further, it reduced retrospective biases in collecting data from peoples' daily lives in real time or near real time with a high ecological validity (Trull & Ebner-Priemer, 2013). The systematic review and meta-analysis in Manuscript 2 enable a more accurate conclusion on the effects in the population than single studies and help to resolve inconsistencies in research including publication bias (Stone & Rosopa, 2017). In Manuscripts 3 and 4, the conduction of a randomized controlled trial as the gold standard for effectiveness research overcomes the selection bias in treatment assignment and thus offers a rigorous tool to investigate cause-effect relationships (Hariton & Locascio, 2018).

Second, given that the samples investigated in the manuscripts may represent only a portion of the target populations, the samples can be considered appropriate to the respective manuscripts' objectives contributing to a high internal validity. In Manuscript 1 focusing on hobby musicians, the sample was recruited through contacting hobby orchestras, choirs, and ensembles via e-mail, and posting in musicians' forums. Although a priori sample size calculation was not possible due to a lack of accurate level-specific estimates (Bolger, Stadler, & Laurenceau, 2012), the sample of 975 participants with 4,382 observations provided sufficient statistical power for valid inferences. The sample selection of Manuscript 2 as a systematic review followed a database search with specific inclusion and exclusion criteria to adhere to the Manuscript's focus on adult cancer patients in all stages of the disease. Despite the rather homogenous sample, data of 21 studies with 1,380 participants were available which provided enough information for a meta-analysis generating more heterogeneity within the target population. The sample of the SOL study (Manuscripts 3 and 4) was recruited on palliative care units based on specific eligibility criteria which mirrors the general aim of clinical trials to select participants who are most likely to benefit from the intervention. To counteract the limited generalizability and homogeneity of the population, we conducted a multicenter trial as recommended in literature (Martínez-Mesa, González-Chica, Duquia, Bonamigo, & Bastos, 2016). Further, the a priori sample size calculation and actually recruited sample of 104 patients minimized the risk of underpowered results.

Third, the operationalization of outcomes in all manuscripts included validated and widely used scales with good psychometric qualities contributing to a high reliability of the studies. For instance, Manuscript 1 on research in a non-clinical setting used a version of the Positive and Negative Affect Schedule (Thompson, 2007) which is broadly employed in general research on well-being. Although the measure of life satisfaction consisted only of one item as commonly used in large-scale public health surveys, reviews have shown that single-item life satisfaction measures perform nearly identically to a multiple-item measure (Cheung & Lucas, 2014). Similarly, in Manuscripts 3 and 4 reporting findings in palliative care, we only employed scales which have shown adequate psychometric properties as well as high perceived content validity and acceptability for people at the end of life, such as the McGill Quality of Life Questionnaire-Revised (Cohen et al., 2019). While in the meta-analysis of Manuscript 2 we did not articulate any exclusion criteria regarding the scales used in the selected studies, most of them employed widely established scales of clinically relevant outcomes as well.

Fourth, the conclusions of the present work were drawn based on advanced statistical analyses in each manuscript. In Manuscript 1, we employed multilevel structural equation modeling to provide the most accurate answers with regard to mediating mechanisms, as it allows modeling the measurement error and examining the relationships between latent

variables simultaneously on different levels. Further, the meta-analysis of Manuscript 2 adhered to statistical recommendations of the most recent methodological review on meta-analyses in clinical psychology (Rubio-Aparicio, Marín-Martínez, Sánchez-Meca, & López-López, 2018) in terms of considering baseline differences between groups in the estimation of effect sizes and therefore taking most advantage of the given data. Finally, data of the randomized controlled trial in Manuscripts 3 and 4 were analyzed in an intention-to-treat approach based on analyses with all available data and sensitivity analyses with multiply imputed data. This approach addresses the two major challenges of randomized controlled trials, noncompliance and missing data, and preserves the prognostic balance produced by the initial random treatment assignment avoiding overestimated effects (Gupta, 2011).

Despite the mentioned strengths, the thesis also faces several limitations, which need to be considered in the interpretation of conclusions and will therefore be discussed in the following. Since these limitations can form key starting points for future research, an outlook for future research will be provided. First, the combination of different illustrative studies to draw conclusions about similarities and differences in research on music engagement in clinical and non-clinical settings may be a major limitation. While theoretical and conceptual statements might be alienated, the comparison does not rely on direct statistical inferences. Though each manuscript contains a high-quality study design and data analysis in and of itself, large-scale studies directly comparing semi-standardized music engagement in clinical and non-clinical settings with joint measurements of health and well-being are necessary to statistically affirm valid conclusions about the comparison of effects.

Second, as the manuscripts were used as examples for music engagement in clinical settings (psycho-oncology and palliative care; Manuscripts 2 to 4) and non-clinical settings (hobby music engagement; Manuscript 1), the generalizability of the results may be limited regarding other non-clinical settings (e.g., music listening or music engagement as a profession) and clinical settings (e.g., psychiatry or pediatrics). To enhance external validity, future research may thus transfer the findings of the present work to other non-clinical samples (e.g., professional musicians) and other clinical samples (e.g., patients diagnosed with a depression). Additionally, to increase clarity on differential effects, research may consider a careful selection of (other) control groups in clinical settings (e.g., spiritual care or psychotherapy) and non-clinical settings (e.g., passive music listening or ensemble music making). Further, the findings may not be representative for each target population due to the convenience sample of hobby musicians (Manuscript 1) or specific eligibility criteria of oncological or palliative care patients (Manuscripts 2 to 4). As most participants were Germans belonging to the middle class, the results of the manuscripts need to be replicated with larger

and more diverse samples regarding demographic variables such as sex, ethnicity, or socioeconomic status.

Third, all manuscripts focused on relatively short-term effects of music engagement on health and well-being and thus cannot make conclusions about long-term effects. However, long-term effects of music engagement might play an important role in both clinical settings (e.g., affecting progress of the disease) and non-clinical settings (e.g., developing resilience in everyday life). Additionally, knowledge about longer-term effects might help to further implement music therapy into health care and promote music education in communities. Therefore, longitudinal studies and ambulatory assessment studies over a longer time period may be able to provide insights into long-term effects of both music therapy and music engagement in everyday life. These might also include common epidemiological measures such as longevity, morbidity, and mortality to enable comparisons with other health promoting factors and activities.

Fourth, although the thesis provides initial essential observations and proposals for exploring health and well-being outcomes as well as underlying mechanisms, it may be limited to the specific frameworks used in the manuscripts (e.g., SDT; Manuscript 1). Other conceptualizations might contribute valuable suggestions for the measurement of outcomes and mechanisms as well. For instance, studies might actively manipulate other postulated emotional mechanisms in music engagement (e.g., rhythmic entrainment, visual imagery, or episodic memory; Juslin et al., 2010) for achieving predictable effects. Further, although we controlled for a considerable number of confounding variables and employed parallel randomization in the experimental trial, we cannot rule out the influence of other factors. Future studies might additionally explore other moderating variables such as the individual musical appraisal (e.g., musical experience, or preference), musical factors (e.g., musical style, or tempo), and the social aspect of music engagement (e.g., the presence of the therapist or other musicians).

6.3 Synthesis and Implications: A United Agenda to Promote Music Engagement?

Through investigating the psychological and psychobiological correlates of music engagement in clinical and non-clinical settings and discussing their similarities and differences, valuable suggestions might be derived for a synthesis of the different domains of music research and for implications in practice. As discussed in chapter 6.1, everyday music engagement and music therapy share the focus on health and well-being related outcomes as well as possible underlying mechanisms, such as flow experiences and psychobiological stress reduction. However, both settings may differ regarding the motivation to engage with music, the type of music engagement, and the presence of a therapeutic relationship. The challenge

for a synthesis therefore consists of maintaining the own distinctiveness of each research area and simultaneously including mutual suggestions for a joint collaboration (i.e., living-apart-together relationship; Vink, 2001). For instance, on a conceptual level, research on everyday music engagement might complement music therapy research with constructs such as flow experiences or motivation, while music research in clinical settings might generate ideas about working mechanisms to be further explored in a healthy population engaging in music. On a methodological level, research on non-clinical music engagement could benefit from experimental trials inspired by clinical research to investigate the causality of effects, while studies in clinical settings might integrate experiencing sampling methods as commonly used in research on everyday uses of music to capture momentary effects repeatedly.

While a living-apart-together relationship of everyday music engagement and music therapy might manifest as doing separate research complemented by conceptual and methodological suggestions from each discipline, it may also consist of joint studies directly comparing the impact of music engagement in clinical and non-clinical settings. Due to its objectiveness and standardization, the psychobiological assessment of health and well-being benefits might constitute a common ground for both areas of research, since subjective self-report scales might need to be adapted to relevant domains of well-being in each field. Such a joint study may include a standardized set of psychobiological stress assessment during music engagement of the same participants in both a clinical and non-clinical setting.

The findings of the present work and their synthesis also entail implications for practice, especially regarding prevention and health care. Manuscript 1 highlights the importance of autonomous motivation to engage in hobby music making with several implications for music education (e.g., creating autonomous-supportive teaching environments), community music (e.g., offering accessible musical activities for communal participation), as well as program and policy development (e.g., emphasizing the value of music and culture for people's health and wellbeing and increasing the financial promotion of music programs). As music engagement in non-clinical settings may be considered a resource contributing to people's health and well-being in everyday life, prevention strategies for mental or physical disease might include creating and facilitating opportunities for music engagement in daily life, such as openly accessible "music libraries" for playing and practicing instruments or listening to music, or public spaces for encounters specifically designed to meet with people for music making.

Further, Manuscripts 2 to 4 underline essential implications for health care as well. Though the findings indicate beneficial but small effects of music therapy on health and well-being outcomes in cancer and palliative care patients, even slight improvements in the hugely distressing situation of dealing with a life-threatening disease might make a difference for this

sensitive sample. Therefore, the ongoing development of national guidelines on cancer treatment (e.g., Deutsche Krebsgesellschaft, Deutsche Krebshilfe, AWMF, 2014) may be encouraged to further strengthen the role of music therapy as an effective complementary therapy and support studies contributing to the evidence base. In addition, not only do the present findings underline a strengthened implementation of music therapy in oncological and palliative care settings, but also point to the huge potential for the expansion of music therapy in other clinical settings.

Finally, the findings of the thesis might inspire an ongoing exchange of experiences between practitioners engaged with music in both clinical settings (e.g., music therapists) and non-clinical settings (e.g., hobby musicians or professional musicians). For example, music therapists might offer their knowledge about specific techniques helping hobby musicians to consciously use their music engagement to foster their own self-care and well-being. On the other side, hobby musicians might describe important motivating factors to engage with music, which music therapist can implement in their work with patients. Overall, research on music engagement in clinical and non-clinical settings may benefit from each other in theoretical and methodological propositions as well as in practical implications, while maintaining the specific features relevant to each field. In a living-apart-together relationship, the two music research disciplines might be able to contribute to a close collaboration for a joint approach to promote music engagement as a resource for health and well-being in prevention and health care.

6.4 Conclusion

The present thesis aimed to investigate the impact of music engagement on psychological and psychobiological aspects of health and well-being in clinical and non-clinical samples and to discuss the similarities and differences of everyday music engagement and music therapy. While findings from a daily diary study, a meta-analysis, and a randomized controlled trial in general indicate beneficial effects of music engagement, their synthesis and discussion revealed specific clinical and non-clinical characteristics in terms of similarities (health and well-being related study outcomes, possible underlying mechanisms such as flow experiences and psychobiological stress reduction) as well as differences (motivation and type of music engagement, the presence of a therapeutic relationship). Nonetheless, suggestions for a synthesis of everyday music engagement and music therapy offer promising potential for research and practice, such as designing high-quality studies and strengthening the role of music engagement as a resource for health and well-being in prevention and health care.

References

Allen, L., O'Connell, A., & Kiermer, V. (2019). How can we ensure visibility and diversity in research contributions? How the Contributor Role Taxonomy (CRediT) is helping the shift from authorship to contributorship. *Learned Publishing*, *32*, 71‑74. https://doi.org/10.1002/leap.1210

Allmendinger, I. D. C. (2016). *Randomisierte kontrollierte klinische Studie zur Überprüfung der Wirksamkeit von Musiktherapie zur Reduktion von Stress sowie deren Einfluss auf die Lebensqualität bei Palliativpatienten [Randomized controlled clinical trial on the effects of music therapy in palliative care on stress and quality of life]* (Dissertation). Saarländische Universitäts- und Landesbibliothek, Saarbrücken. Retrieved from http://scidok.sulb.uni-saarland.de/volltexte/2016/6627

Ansdell, G. (2013). Foreword: To music's health. In L. O. Bonde, E. Ruud, M. S. Skånland, & G. Trondalen (Eds.), *Centre for Music and Health publication series: vol. 6. Musical life stories: Narratives on health musicking* (pp. 3–12). Oslo: Norwegian Academy of Music.

Antonovsky, A. (1987). *Unraveling the mystery of health*. San Francisco: Jossey-Bass.

Bernabé, D. G., Tamae, A. C., Miyahara, G. I., Sundefeld, M. L. M., Oliveira, S. P., & Biasoli, É. R. (2012). Increased plasma and salivary cortisol levels in patients with oral cancer and their association with clinical stage. *Journal of Clinical Pathology*, *65*(10), 934–939. https://doi.org/10.1136/jclinpath-2012-200695

Boer, D., & Abubakar, A. (2014). Music listening in families and peer groups: Benefits for young people's social cohesion and emotional well-being across four cultures. *Frontiers in Psychology*, *5*, 392. https://doi.org/10.3389/fpsyg.2014.00392

Bolger, N., Stadler, G., & Laurenceau, J.-P. (2012). Power analysis for intensive longitudinal studies. In M. R. Mehl & T. S. Conner (Eds.), *Handbook of research methods for studying daily life* (pp. 285–301). New York: Guilford Press.

Bradt, J., & Dileo, C. (2010). Music therapy for end-of-life care. *The Cochrane Database of Systematic Reviews*. (1), CD007169. https://doi.org/10.1002/14651858.CD007169.pub2

Bradt, J., Dileo, C., Magill, L., & Teague, A. (2016). Music interventions for improving psychological and physical outcomes in cancer patients. *The Cochrane Database of Systematic Reviews*. (8), CD006911. https://doi.org/10.1002/14651858.CD006911.pub3

Bradt, J., Potvin, N., Kesslick, A., Shim, M., Radl, D., Schriver, E., . . . Komarnicky-Kocher, L. T. (2015). The impact of music therapy versus music medicine on psychological outcomes and pain in cancer patients: A mixed methods study. *Supportive Care in Cancer : Official Journal of the Multinational Association of Supportive Care in Cancer*, *23*(5), 1261–1271. https://doi.org/10.1007/s00520-014-2478-7.

Bruscia, K. E. (2014). *Defining music therapy* (3rd ed.). Gilsum, NH: Barcelona Publishers.

Cheung, F., & Lucas, R. E. (2014). Assessing the validity of single-item life satisfaction measures: Results from three large samples. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*, *23*(10), 2809–2818. https://doi.org/10.1007/s11136-014-0726-4

Chin, T., & Rickard, N. S. (2013). Emotion regulation strategy mediates both positive and negative relationships between music uses and well-being. *Psychology of Music*, *42*(5), 692–713. https://doi.org/10.1177/0305735613489916

Chochinov, H. M., Hack, T., Hassard, T., Kristjanson, L. J., McClement, S., & Harlos, M. (2005). Dignity therapy: A novel psychotherapeutic intervention for patients near the end of life. *Journal of Clinical Oncology: Official Journal of the American Society of Clinical Oncology*, *23*(24), 5520–5525. https://doi.org/10.1200/JCO.2005.08.391

Cohen, S. R., Russell, L. B., Leis, A., Shahidi, J., Porterfield, P., Kuhl, D. R., . . . Sawatzky, R. (2019). More comprehensively measuring quality of life in life-threatening illness: The McGill Quality of Life Questionnaire - Expanded. *BMC Palliative Care*, *18*(1), 92. https://doi.org/10.1186/s12904-019-0473-y

Cohen, S., Janicki-Deverts, D., Doyle, W. J., Miller, G. E., Frank, E., Rabin, B. S., & Turner, R. B. (2012). Chronic stress, glucocorticoid receptor resistance, inflammation, and disease risk. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(16), 5995–5999. https://doi.org/10.1073/pnas.1118355109

Creech, A., Hallam, S., Varvarigou, M., McQueen, H., & Gaunt, H. (2013). Active music making: A route to enhanced subjective well-being among older people. *Perspectives in Public Health*, *133*(1), 36–43. https://doi.org/10.1177/1757913912466950

Croom, A. M. (2014). Music practice and participation for psychological well-being: A review of how music influences positive emotion, engagement, relationships, meaning, and accomplishment. *Musicae Scientiae*, *19*(1), 44–64. https://doi.org/10.1177/1029864914561709

Cross, I. (2016). The nature of music and its evolution. In S. Hallam, I. Cross, & M. Thaut (Eds.), *The Oxford handbook of music psychology* (2nd ed., pp. 3–13). Oxford: Oxford University Press.

Csikszentmihalyi, M. (1993). Activity and happiness: Towards a science of occupation. *Journal of Occupational Science*, *1*(1), 38–42. https://doi.org/10.1080/14427591.1993.9686377

Daykin, N., Mansfield, L., Meads, C., Julier, G., Tomlinson, A., Payne, A., . . . Victor, C. (2018). What works for wellbeing? A systematic review of wellbeing outcomes for music and singing in adults. *Perspectives in Public Health*, *138*(1), 39–46. https://doi.org/10.1177/1757913917740391

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Press.

Deutsche Krebsgesellschaft, Deutsche Krebshilfe, AWMF (2014). Psychoonkologische Diagnostik, Beratung und Behandlung von erwachsenen Krebspatienten, Langversion 1.1, 2014, AWMF-Registernummer: 032/051OL. Retrieved from http://leitlinienprogramm-onkologie.de/Leitlinien.7.0.html

Diener, E. (1984). Subjective well-being. *Psychological Bulletin*, *95*(3), 542–575. https://doi.org/10.1037/0033-2909.95.3.542

Ekholm, O., Juel, K., & Bonde, L. O. (2016). Associations between daily musicking and health: Results from a nationwide survey in Denmark. *Scandinavian Journal of Public Health*, *44*(7), 726–732. https://doi.org/10.1177/1403494816664252

Erikson, E. H. (1982). *The life cycle completed*. New York: W.W. Norton & Company.

Evans, P., & Bonneville-Roussy, A. (2016). Self-determined motivation for practice in university music students. *Psychology of Music*, *44*(5), 1095–1110. https://doi.org/10.1177/0305735615610926

Fredenburg, H. A., & Silverman, M. J. (2014). Effects of music therapy on positive and negative affect and pain with hospitalized patients recovering from a blood and marrow transplant: A randomized effectiveness study. *The Arts in Psychotherapy*, *41*(2), 174–180. https://doi.org/10.1016/j.aip.2014.01.007

Gold, C., Erkkilä, J., Bonde, L. O., Trondalen, G., Maratos, A., & Crawford, M. J. (2011). Music therapy or music medicine? *Psychotherapy and Psychosomatics*, *80*(5). https://doi.org/10.1159/000323166

Gupta, S. K. (2011). Intention-to-treat concept: A review. *Perspectives in Clinical Research*, *2*(3), 109–112. https://doi.org/10.4103/2229-3485.83221

Gutgsell, K. J., Schluchter, M., Margevicius, S., DeGolia, P. A., McLaughlin, B., Harris, M., . . . Wiencek, C. (2013). Music therapy reduces pain in palliative care patients: A randomized controlled trial. *Journal of Pain and Symptom Management*, *45*(5), 822–831. https://doi.org/10.1016/j.jpainsymman.2012.05.008

Habe, K., Biasutti, M., & Kajtna, T. (2019). Flow and satisfaction with life in elite musicians and top athletes. *Frontiers in Psychology*, *10*, 698. https://doi.org/10.3389/fpsyg.2019.00698

Habron, J., Butterly, F., Gordon, I., & Roebuck, A. (2013). Being well, being musical: Music composition as a resource and occupation for older people. *British Journal of Occupational Therapy*, *76*(7), 308–316. https://doi.org/10.4276/030802213X13729279114933

Hagger, M. S., Hardcastle, S. J., Chater, A., Mallett, C., Pal, S., & Chatzisarantis, N. L. D. (2014). Autonomous and controlled motivational regulations for multiple health-related

behaviors: Between- and within-participants analyses. *Health Psychology and Behavioral Medicine*, *2*(1), 565–601. https://doi.org/10.1080/21642850.2014.912945

Hallam, S., Creech, A., & Varvarigou, M. (2017). Well-being and music leisure activities through the life span: A psychological perspective. In R. Mantie & G. D. Smith (Eds.), *[Oxford handbooks]. The Oxford handbook of music making and leisure* (pp. 31–60). New York, NY: Oxford University Press.

Hariton, E., & Locascio, J. J. (2018). Randomised controlled trials - the gold standard for effectiveness research: Study design: Randomised controlled trials. *BJOG: An International Journal of Obstetrics and Gynaecology*, *125*(13), 1716. https://doi.org/10.1111/1471-0528.15199

Hillecke, T. K., & Wilker, F.-W. (2007). Ein heuristisches Wirkfaktorenmodell der Musiktherapie. *Verhaltenstherapie Und Verhaltensmedizin*. (28), 62–85.

Hilliard, R. E. (2003). The effects of music therapy on the quality and length of life of people diagnosed with terminal cancer. *Journal of Music Therapy*, *40*(2), 113–137. https://doi.org/10.1093/jmt/40.2.113

Holland, J. C. (Ed.) (2015). *Psycho-oncology* (Third edition). Oxford, New York: Oxford University Press.

Horne-Thompson, A., & Grocke, D. (2008). The effect of music therapy on anxiety in patients who are terminally ill. *Journal of Palliative Medicine*, *11*(4), 582–590. https://doi.org/10.1089/jpm.2007.0193

Juslin, P. N., Liljeström, S., Västfjäll, D., & Lundqvist, L.-O. (2010). How does music evoke emotions? Exploring the underlying mechanisms. In P. N. Juslin & J. Sloboda (Eds.), *Handbook of music and emotion: Theory, research, applications* (pp. 605–642). Oxford: Oxford University Press.

Juslin, P. N., & Sloboda, J. (Eds.) (2010). *Handbook of music and emotion: Theory, research, applications*. Oxford: Oxford University Press.

Koehler, F., Martin, Z., Hertrampf, R., Gäbel, C., Keßler, J., Ditzen, B., & Warth, M. (2019). Musiktherapeutische Ansätze in der Psychoonkologie. *Der Onkologe*, *25*(12), 1103–1109. https://doi.org/10.1007/s00761-019-0646-6

Koehler, F., & Neubauer, A. B. (2020). From music making to affective well-being in everyday life: The mediating role of need satisfaction. *Psychology of Aesthetics, Creativity, and the Arts*, *14*(4), 493–505. https://doi.org/10.1037/aca0000261

Koelsch, S. (2009). A neuroscientific perspective on music therapy. *Annals of the New York Academy of Sciences*, *1169*, 374–384. https://doi.org/10.1111/j.1749-6632.2009.04592.x

Koelsch, S. (2014). Brain correlates of music-evoked emotions. *Nature Reviews. Neuroscience*, *15*(3), 170–180. https://doi.org/10.1038/nrn3666.

Koenig, H., King, D., & Carson, V. B. (2012). *Handbook of religion and health* (2nd ed.). s.l.: Oxford University Press USA. Retrieved from http://gbv.eblib.com/patron/FullRecord.aspx?p=931219

Krause, A. E., Davidson, J. W., & North, A. C. (2018). Musical activity and well-being. *Music Perception: An Interdisciplinary Journal*, *35*(4), 454–474. https://doi.org/10.1525/mp.2018.35.4.454

Krause, A. E., North, A. C., & Davidson, J. W. (2019). Using self-determination theory to examine musical participation and well-being. *Frontiers in Psychology*, *10*, 405. https://doi.org/10.3389/fpsyg.2019.00405

La Rubia Ortí, J. E. de, García-Pardo, M. P., Iranzo, C. C., Madrigal, J. J. C., Castillo, S. S., Rochina, M. J., & Gascó, V. J. P. (2018). Does music therapy improve anxiety and depression in Alzheimer's patients? *Journal of Alternative and Complementary Medicine (New York, N.Y.)*, *24*(1), 33–36. https://doi.org/10.1089/acm.2016.0346

Lambert, M. J., & Barley, D. E. (2001). Research summary on the therapeutic relationship and psychotherapy outcome. *Psychotherapy: Theory, Research, Practice, Training*, *38*(4), 357–361. https://doi.org/10.1037/0033-3204.38.4.357

Lamont, A. (2012). Emotion, engagement and meaning in strong experiences of music performance. *Psychology of Music*, *40*(5), 574–594. https://doi.org/10.1177/0305735612448510

Laurent, H. K., Powers, S. I., & Granger, D. A. (2013). Refining the multisystem view of the stress response: Coordination among cortisol, alpha-amylase, and subjective stress in response to relationship conflict. *Physiology & Behavior*, *119*, 52–60. https://doi.org/10.1016/j.physbeh.2013.05.019

Linnemann, A., Ditzen, B., Strahler, J., Doerr, J. M., & Nater, U. M. (2015). Music listening as a means of stress reduction in daily life. *Psychoneuroendocrinology*, *60*, 82–90. https://doi.org/10.1016/j.psyneuen.2015.06.008

Lyubomirsky, S., Sheldon, K. M., & Schkade, D. (2005). Pursuing happiness: The architecture of sustainable change. *Review of General Psychology*, *9*(2), 111–131. https://doi.org/10.1037/1089-2680.9.2.111

MacDonald, R., Kreutz, G., & Mitchell, L. (Eds.) (2012a). *Music, health, and wellbeing*: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199586974.001.0001

MacDonald, R., Kreutz, G., & Mitchell, L. (2012b). What is music, health, and wellbeing and why is it Important? In R. MacDonald, G. Kreutz, & L. Mitchell (Eds.), *Music, health, and wellbeing* (pp. 3–11). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199586974.003.0001

MacDonald, R. A. R. (2013). Music, health, and well-being: A review. *International Journal of Qualitative Studies on Health and Well-Being*, *8*, 20635. https://doi.org/10.3402/qhw.v8i0.20635

Mantie, R., & Smith, G. D. (Eds.) (2017). *[Oxford handbooks]. The Oxford handbook of music making and leisure*. New York, NY: Oxford University Press.

Manzano, O. de, Theorell, T., Harmat, L., & Ullén, F. (2010). The psychophysiology of flow during piano playing. *Emotion (Washington, D.C.)*, *10*(3), 301–311. https://doi.org/10.1037/a0018432

Martínez-Mesa, J., González-Chica, D. A., Duquia, R. P., Bonamigo, R. R., & Bastos, J. L. (2016). Sampling: How to select participants in my research study? *Anais Brasileiros De Dermatologia*, *91*(3), 326–330. https://doi.org/10.1590/abd1806-4841.20165254

Mastnak, W. (2015). The evolution of music therapy. *Musik-, Tanz- Und Kunsttherapie*, *26*(4), 207–221. https://doi.org/10.1026/0933-6885/a000221

McConnell, T., & Porter, S. (2017). Music therapy for palliative care: A realist review. *Palliative & Supportive Care*, *15*(4), 454–464. https://doi.org/10.1017/S1478951516000663

Munro, S., & Mount, B. (1978). Music therapy in palliative care. *Canadian Medical Association Journal*, *119*(9), 1029–1034.

Nakayama, H., Kikuta, F., & Takeda, H. (2009). A pilot study on effectiveness of music therapy in hospice in Japan. *Journal of Music Therapy*, *46*(2), 160–172. https://doi.org/10.1093/jmt/46.2.160

North, A. C., & Hargreaves, D. J. (2006). Music and adolescent identity. *Music Education Research*, *1*(1), 75–92. https://doi.org/10.1080/1461380990010107

Packer, J., & Ballantyne, J. (2010). The impact of music festival attendance on young people's psychological and social well-being. *Psychology of Music*, *39*(2), 164–181. https://doi.org/10.1177/0305735610372611

Perkins, R., & Williamon, A. (2013). Learning to make music in older adulthood: A mixed-methods exploration of impacts on wellbeing. *Psychology of Music*, *42*(4), 550–567. https://doi.org/10.1177/0305735613483668

Preti, C., & Welch, G. F. (2004). Music in a hospital setting: a multifaceted experience. *British Journal of Music Education*, *21*(3), 329–345. https://doi.org/10.1017/S0265051704005893

Radbruch, L., Strasser, F., Elsner, F., Gonçalves, J. F., Løge, J., Kaasa, S., . . . Stone, P. (2008). Fatigue in palliative care patients - an EAPC approach. *Palliative Medicine*, *22*(1), 13–32. https://doi.org/10.1177/0269216307085183

Rafieyan, R., & Ries, R. (2007). A description of the use of music therapy in consultation-liaison psychiatry. *Psychiatry (Edgmont)*, *4*(1), 47–52.

Ramsey, I., Eckert, M., Hutchinson, A. D., Marker, J., & Corsini, N. (2020). Core outcome sets in cancer and their approaches to identifying and selecting patient-reported outcome measures: A systematic review. *Journal of Patient-Reported Outcomes*, *4*(1), 77. https://doi.org/10.1186/s41687-020-00244-3

Ribeiro, M. K. A., Alcântara-Silva, T. R. M., Oliveira, J. C. M., Paula, T. C., Dutra, J. B. R., Pedrino, G. R., . . . Rebelo, A. C. S. (2018). Music therapy intervention in cardiac autonomic modulation, anxiety, and depression in mothers of preterms: Randomized controlled trial. *BMC Psychology*, *6*(1), 57. https://doi.org/10.1186/s40359-018-0271-y

Rodin, G. (2013). Research on psychological and social factors in palliative care: An invited commentary. *Palliative Medicine*, *27*(10), 925–931. https://doi.org/10.1177/0269216313499961

Rubio-Aparicio, M., Marín-Martínez, F., Sánchez-Meca, J., & López-López, J. A. (2018). A methodological review of meta-analyses of the effectiveness of clinical psychology treatments. *Behavior Research Methods*, *50*(5), 2057–2073. https://doi.org/10.3758/s13428-017-0973-8

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. New York: Guilford Press.

Salmon, D. (2001). Music therapy as psychospiritual process in palliative care. *Journal of Palliative Care*, *17*(3), 142–146.

Sanal, A. M., & Gorsev, S. (2013). Psychological and physiological effects of singing in a choir. *Psychology of Music*, *42*(3), 420–429. https://doi.org/10.1177/0305735613477181

Sato, Y. (2011). Musical life review in hospice. *Music Therapy Perspectives*, *29*(1), 31–38. https://doi.org/10.1093/mtp/29.1.31

Schäfer, T., Sedlmeier, P., Städtler, C., & Huron, D. (2013). The psychological functions of music listening. *Frontiers in Psychology*, *4*, 511. https://doi.org/10.3389/fpsyg.2013.00511

Silverman, M. J., & Baker, F. A. (2018). Flow as a mechanism of change in music therapy: Applications to clinical practice. *Approaches: An Interdisciplinary Journal of Music Therapy*, *10*(1), 43–51.

Silverman, M. J., Baker, F. A., & MacDonald, R. A. R. (2016). Flow and meaningfulness as predictors of therapeutic outcome within songwriting interventions. *Psychology of Music*, *44*(6), 1331–1345. https://doi.org/10.1177/0305735615627505

Sittler, M. C., Worschech, F., Wilz, G., Fellgiebel, A., & Wuttke-Linnemann, A. (2021). Psychobiological mechanisms underlying the health-beneficial effects of music in people living with dementia: A systematic review of the literature. *Physiology & Behavior*, *233*, 113338. https://doi.org/10.1016/j.physbeh.2021.113338

Stanczyk, M. M. (2011). Music therapy in supportive cancer care. *Reports of Practical Oncology and Radiotherapy: Journal of Greatpoland Cancer Center in Poznan and Polish Society of Radiation Oncology*, *16*(5), 170–172. https://doi.org/10.1016/j.rpor.2011.04.005

Stone, D. L., & Rosopa, P. J. (2017). The advantages and limitations of using meta-analysis in human resource management research. *Human Resource Management Review*, *27*(1), 1–7. https://doi.org/10.1016/j.hrmr.2016.09.001

Swaminathan, S., & Schellenberg, E. G. (2015). Current emotion research in music psychology. *Emotion Review*, *7*(2), 189–197. https://doi.org/10.1177/1754073914558282

Tan, L., & Sin, H. X. (2019). Flow research in music contexts: A systematic literature review. *Musicae Scientiae*, *6*(14), 102986491987756. https://doi.org/10.1177/1029864919877564

Tang, M., Liu, X., Wu, Q., & Shi, Y. (2020). The effects of cognitive-behavioral stress management for breast cancer patients: A systematic review and meta-analysis of randomized controlled trials. *Cancer Nursing*, *43*(3), 222–237. https://doi.org/10.1097/NCC.0000000000000804

Thompson, E. R. (2007). Development and validation of an internationally reliable short-form of the Positive and Negative Affect Schedule (PANAS). *Journal of Cross-Cultural Psychology*, *38*(2), 227–242. https://doi.org/10.1177/0022022106297301

Thompson, W. F. (2009). *Music, thought, and feeling: Understanding the psychology of music*. New York, Oxford: Oxford University Press.

Trull, T. J., & Ebner-Priemer, U. (2013). Ambulatory assessment. *Annual Review of Clinical Psychology*, *9*, 151–176. https://doi.org/10.1146/annurev-clinpsy-050212-185510

Tsoi, K. K. F., Chan, J. Y. C., Ng, Y.-M., Lee, M. M. Y., Kwok, T. C. Y., & Wong, S. Y. S. (2018). Receptive music therapy is more effective than interactive music therapy to relieve behavioral and psychological symptoms of dementia: A systematic review and meta-analysis. *Journal of the American Medical Directors Association*, *19*(7), 568-576. https://doi.org/10.1016/j.jamda.2017.12.009

Västfjäll, D., Juslin, P. N., & Hartig, T. (2012). Music, subjective wellbeing, and health: The role of everyday emotions. In R. MacDonald, G. Kreutz, & L. Mitchell (Eds.), *Music, health, and wellbeing* (pp. 405–423). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199586974.003.0027

Vink, A. (2001). Music and emotion: Living apart together: a relationship between music psychology and music therapy. *Nordic Journal of Music Therapy*, *10*(2), 144–158. https://doi.org/10.1080/08098130109478028

Wang, X., Zhang, Y., Fan, Y., Tan, X.-S., & Lei, X. (2018). Effects of music intervention on the physical and mental status of patients with breast cancer: A systematic review and meta-analysis. *Breast Care (Basel, Switzerland)*, *13*(3), 183–190. https://doi.org/10.1159/000487073

Warth, M., Keßler, J., Hillecke, T. K., & Bardenheuer, H. J. (2015). Music therapy in palliative care. *Deutsches Arzteblatt International*, *112*(46), 788–794. https://doi.org/10.3238/arztebl.2015.0788

Warth, M., Kessler, J., Koenig, J., Hillecke, T. K., Wormit, A. F., & Bardenheuer, H. J. (2015). Methodological challenges for music therapy controlled clinical trials in palliative care. *Nordic Journal of Music Therapy*, *24*(4), 344–371. https://doi.org/10.1080/08098131.2014.987803

Warth, M., Kessler, J., van Kampen, J., Ditzen, B., & Bardenheuer, H. J. (2018). Song of life: Music therapy in terminally ill patients with cancer. *BMJ Supportive & Palliative Care*, *8*(2), 167–170. https://doi.org/10.1136/bmjspcare-2017-001475

Warth, M., Koehler, F., Weber, M., Bardenheuer, H. J., Ditzen, B., & Kessler, J. (2019). "Song of Life (SOL)" study protocol: A multicenter, randomized trial on the emotional, spiritual, and psychobiological effects of music therapy in palliative care. *BMC Palliative Care*, *18*(1), 14. https://doi.org/10.1186/s12904-019-0397-6

Weinberg, M. K., & Joseph, D. (2016). If you're happy and you know it: Music engagement and subjective wellbeing. *Psychology of Music*, *45*(2), 257–267. https://doi.org/10.1177/0305735616659552

Welch, G. F., Biasutti, M., MacRitchie, J., McPherson, G. E., & Himonides, E. (2020). Editorial: The impact of music on human development and well-being. *Frontiers in Psychology*, *11*, 1246. https://doi.org/10.3389/fpsyg.2020.01246

Witte, M. de, Pinho, A. d. S., Stams, G.-J., Moonen, X., Bos, A. E. R., & van Hooren, S. (2020). Music therapy for stress reduction: A systematic review and meta-analysis. *Health Psychology Review*, 1–26. https://doi.org/10.1080/17437199.2020.1846580

World Health Organization (1946). Constitution of the World Health Organization. *American Journal of Public Health and the Nations Health*, *36*(11), 1315–1323. https://doi.org/10.2105/AJPH.36.11.1315

Yue, W., Han, X., Luo, J., Zeng, Z., & Yang, M. (2021). Effects of music therapy on preterm infants in neonatal intensive care unit: Systematic review and meta-analysis of randomized controlled trials. *Journal of Advanced Nursing*, *77*(2), 635–652. https://doi.org/10.1111/jan.14630

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Koehler, F., Warth, M., Ditzen, B., & Neubauer, A. B. (2021). Motivation to make music matters: Daily autonomous motivation, flow and well-being. *Psychology of Aesthetics, Creativity, and the Arts*. Advance online publication. Copyright © 2021. Reproduced with permission.
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Motivation to Make Music Matters: Daily Autonomous Motivation, Flow and Well-Being in

Hobby Musicians

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Abstract

Music engagement is an essential part in many people's everyday life. A large body of research has provided evidence for the beneficial effects of music engagement on health and well-being although studies on underlying mechanisms (e.g., flow experiences) have been scarce. Therefore, we examined in the present study the potential effects of the quality of motivation (autonomous vs. controlled) to engage in active hobby music making on flow and well-being. We tested the prediction by Self-Determination Theory that autonomous forms of motivation are related to higher well-being. Furthermore, we examined if flow experiences during music making might account for this association in an online daily diary study with 975 hobby musicians. Daily autonomous motivation to make music, flow (two subscales: fluency and absorption), and subjective well-being (life satisfaction, positive and negative affect) were assessed each day for ten consecutive days. Multilevel structural equation models indicated that there was a positive effect of autonomous motivation on life satisfaction and positive affect that was mediated by both subscales of flow, with fluency of performance at both the within- and between person level and absorption only at the within-person level. Further, there was a negative indirect effect on negative affect via fluency on the within-person level. This study provides evidence for the importance of autonomous motivation in hobby music making with regard to subjective well-being and highlights investigating the effects on a within-person level. Results further suggest the experience of flow as a potential mediating mechanism.

Keywords: music, life satisfaction, affect, self-determination, daily diary

Motivation to Make Music Matters: Daily Autonomous Motivation, Flow and Well-Being in Hobby Musicians

Throughout time and culture, music has been one of the most pleasurable everyday activities people choose to engage with (Mas-Herrero, Marco-Pallares, Lorenzo-Seva, Zatorre, & Rodriguez-Fornells, 2013). One of the manifold reasons to make music may be its positive impact on health and well-being which has been largely demonstrated on a psychological, social and biological level (MacDonald, Kreutz, & Mitchell, 2012). With regard to particular determinants and mechanisms contributing to the affective consequences of music making, past research has mainly focused on music listening, music therapy, music as a profession or music education (e.g., Freer & Evans, 2019). Still, although music making is an integral leisure activity for a large part of the population (Weinberg & Joseph, 2016), studies on the motivation of hobby musicians and its correlates have been scarce.

The present study therefore investigates music engagement as a serious leisure activity which describes a systematic amateur pursuit requiring a specific set of skills and experience, and providing fulfillment (Stebbins, 2017). Specifically, we examine the role of autonomous motivation to engage in music making for hobby musicians' subjective well-being. Specifically, we propose that autonomous reasons to engage in music making will be associated with higher life satisfaction, higher positive affect, and lower negative affect, and that this association will be mediated via flow experiences during music making. For this purpose, we begin by outlining relevant literature and research on autonomous motivation, in particular with regard to Self-Determination Theory (SDT; Ryan & Deci, 2000b, 2017), and its association with music making. Next, we explore flow as a potential mediating mechanism underlying the positive effect of autonomous motivation to make music with well-being. We then proceed by showing results of a daily diary study assessing autonomous motivation to make music, flow, and well-being in 975 hobby musicians for 10 consecutive days.

Motivation for music making

Especially researchers in music education aim to explore motivation for music making. Based on attribution theory (Weiner, 1972), Asmus (1986) postulated that music students attribute success and failure to eight factors specific to the musical setting: effort, background, class environment, musical ability, affect for music, personal commitment, school music, and music compared to other activities. Similar to other academic achievement settings, Schmidt (2005) found three factors of motivation to practice music (Learning/Task Orientation, Ego/Performance Orientation, Individual orientation). Recently, researchers have increasingly turned to SDT (Ryan & Deci, 2000b, 2017) as a comprehensive theory of motivational processes at large (Evans, 2015). As an organismic dialectical approach, SDT proposes an innate human propensity toward integrity and growth (Deci & Ryan, 2000). According to SDT, motivation is not only characterized by the amount of motivation an individual has for a specific behavior (e.g., music making), but also by the quality of motivation (the "why" of goal pursuit; Deci & Ryan, 2000).

The distinction between intrinsic motivation (i.e., doing an activity for its own sake and because it is inherently enjoyable) and extrinsic motivation (i.e., doing an activity for any other reason than the activity itself) (Deci & Ryan, 1985) has been largely agreed upon in the study of motivation and has been further differentiated on a continuum of self-determination in SDT research. In terms of SDT, the quality of the motivation for a certain behavior can be aligned on a relative continuum of autonomy ranging from most controlled / least autonomous (external motivation) to least controlled / most autonomous (intrinsic motivation) with the intermediate steps of introjected motivation, identified motivation, and integrated motivation (Ryan & Deci, 2017). Relatively external regulations are considered to be associated with less self-determined behavior and negative outcomes, while relatively internal regulations are attributed to more self-determined behavior and positive outcomes

(Ryan & Deci, 2000b). According to SDT, autonomous motivation is followed by fulfillment

of the basic psychological needs for autonomy, competence and relatedness, which in turn

leads to positive outcomes such as higher well-being (Ryan & Deci, 2000a).

When it comes to the motivation to pursue an activity such as music making,

individuals generally choose to do so based on a complex motivational system of both

external reasons, such as rewards or pressure by parents, teachers and orchestra peers, and

internal reasons, such as joy for the instrument or a musical piece itself (MacIntyre, Schnare,

& Ross, 2018). Most of SDT music research has been conducted with students of classical

music at universities, conservatoires or middle-schools (e.g., Evans & Bonneville-Roussy,

2016; Schatt, 2018; Valenzuela, Codina, & Pestana, 2018). In music lessons, parents and

teachers commonly use external motivators, though music education researchers recommend

providing opportunities for need fulfillment in order to internalize motivation (Evans, 2015;

Kingsford-Smith & Evans, 2019). For instance, findings point to positive associations of

fulfillment of psychological needs and autonomous motivation with the frequency and quality

of music practice (Evans & Bonneville-Roussy, 2016). Further, MacIntyre et al. (2018) found

that outcomes such as the desire to continue playing, motivational intensity, willingness to

play music, and global self-esteem were more strongly linked to internal than external

motivational regulations in both classical pianists and rock guitarists.

With regard to music making as a leisure activity (which does not necessarily include

frequent music lessons), motivation might be more autonomous as it may be less attached to

external motivators, such as teachers or parents. Especially over the life span and in everyday

life, the persistence in such a hobby may be fueled by an inherent enjoyment and the

rewarding experience of music making itself. Nevertheless, external motivators may also play

a role here. For instance, upcoming concerts of one's hobby orchestra may lead to an external

demand to rehearse a piece that one is not particularly fond of, which likely changes the

quality of motivation from more autonomous to more controlled. Therefore, as both intrinsic and extrinsic motivation might be important for hobby musicians, the present study investigated both types of motivation in hobby musicians in their daily music making.

Autonomously motivated behavior and need fulfillment are considered essential for well-being, health and optimal functioning (Deci & Ryan, 2000), which has been supported by a vast amount of studies, including research on leisure pursuits (e.g., Coleman & Iso-Ahola, 1993). Prior work showed that music making of classical and rock/pop hobby musicians was associated with higher affective well-being in everyday life, and that this association was mediated by the satisfaction of basic psychological needs (Koehler & Neubauer, 2020). In this study, researchers have, however, not examined if well-being outcomes depend not only on whether or not people make music, but also as a function of why they make music. Regarding the effects of autonomous motivation, cross-sectional findings from Krause, North, and Davidson (2019) indicate that autonomous motivation for music participation in domestic, community, and educational settings is positively associated with both need fulfillment and well-being. Still, the psychological process underlying the potential effect of autonomous motivation to make music on hobby musicians' well-being in everyday life has not been thoroughly investigated yet and will thus be addressed in the present daily diary study. With regard to the underlying mechanism, various constructs can be derived from literature and research as potential mediators, including need fulfillment, artistic expression or social bonding (e.g., Boer & Abubakar, 2014). However, since autonomous motivation for an activity has been frequently linked to flow experiences (Fong, Zaleski, & Leach, 2015; Kowal & Fortier, 1999), the investigation of flow in music making with regard to well-being might be particularly promising (Fritz & Avsec, 2007; Habe, Biasutti, & Kajtna, 2019).

Flow in music making

Individuals who engage in hobby music making might experience an inherent enjoyment of and absorption in the activity, namely the repeated experience of flow (Araújo & Hein, 2019). When the pioneer Csikszentmihalyi (1975) first investigated the concept of enjoyment through questionnaires and interviews, he discovered that almost any activity can induce some level of flow (Csikszentmihalyi, 1993). The state of flow can be characterized as a mental condition in which an individual is fully absorbed in an activity without reflective self-awareness but with a deep sense of control and focus (Araújo & Hein, 2019). The main condition for flow that has been postulated and thoroughly empirically investigated is a perceived balance of challenge and skills in the activity (Nakamura & Csikszentmihalyi, 2002). Although research can approach flow as a trait, that is, with regard to individual differences in proneness to flow, flow as a state is prominently studied with regard to specific activities and external factors (Chirico, Serino, Cipresso, Gaggioli, & Riva, 2015).

Since the first introduction of this concept (Csikszentmihalyi, 1975) many researchers have investigated the state of flow in various activities demonstrating a huge set of situational, psychological and social correlates. Most importantly, research consistently provides evidence that frequent flow experiences can contribute to greater health and well-being (e.g., Croom, 2014; Csikszentmihalyi, 1975, 1990; Ericsson, Krampe, & Tesch-Römer, 1993; Seligman, 2011). Apart from direct effects, flow further is commonly investigated as a mechanism on the pathway to well-being. For instance, findings from Rivkin, Diestel, and Schmidt's (2018) daily diary study on employees provide initial support for the hypothesis that day-specific flow experiences mediate the beneficial effects of affective commitment on day-specific well-being.

One antecedent of flow that has emerged from research is autonomous motivation (Fong et al., 2015; Kowal & Fortier, 1999), suggesting that an intrinsic willingness to invest personal energetic resources might facilitate experiences of flow (Rivkin et al., 2018). In the

SDT framework, flow is considered an intrinsically motivated state and experiential signature of self-determination (Fullagar, Knight, & Sovern, 2013; Koole, Schlinkert, Maldei, & Baumann, 2019) and a manifested peak of autonomous motivation (Rivkin et al., 2018). Therefore, activities with high intrinsic motivating potential, in particular music making, are considered to provide the greatest potentials to induce flow (Lowis, 2002). Indeed, Baker and MacDonald (2013) found that creating lyrics during a songwriting intervention with university students and retirees elicited flow, but it was stronger when music was created, too. Hence, flow research in music contexts has been gathering momentum in the past decades, largely in the field of music education (Tan & Sin, 2019). Similar to evidence from sports settings, music students report frequent experiences of flow in music making (Araujo & Andraude, 2013; Sinnamon, Moran, & O'Connell, 2012). Music-specific proneness to flow also was the strongest predictor of music practice frequency in a large twin cohort study (Butkovic, Ullén, & Mosing, 2015).

Especially music education studies with a focus on SDT consistently suggest that music making may be an autonomously motivated and flow facilitating activity (Bonneville-Roussy & Bouffard, 2015; Evans & Bonneville-Roussy, 2016; Valenzuela et al., 2018). Research on students in music conservatoires showed a direct association of autonomous motivation on flow (Valenzuela et al., 2018). If an individual is more intrinsically motivated to make music, the inherent joy for music might enable conditions for the experience of flow to occur. For example, a cellist may make music because of the beautiful sound of the instrument and thus be more open for becoming fully immersed in the musical experience than when she chooses to make music because of an upcoming orchestra concert. In particular, extrinsically motivated practice often requires a narrow attentional focus and more intentional effort which possibly hinder the occurrence of an absorbing flow experience as an all-encompassing attention allocation (Csikszentmihalyi, 2000). Similarly, a conceptual

review on the effects of music therapy on well-being proposes that the all-encompassing attention of flow experiences in intrinsically motivated activities like music making may even offer individuals a more positive focus in life (Silverman & Baker, 2018).

Correspondingly, Csikszentmihalyi (1993) hypothesizes that flow experiences in any activity fostering both immense pleasure and self-actualization should lead to well-being and personal growth. Apart from several cross-sectional findings supporting this assumption (e.g., Briki & Dagot, 2020), there is some initial evidence from a randomized controlled study which induced either high flow activities or low flow activities in college students (Rogatko, 2009). The author found that participants in the high flow condition reported higher increases in affective well-being than those in the low flow condition (Rogatko, 2009). Although music making is considered a flow facilitating activity (Lowis, 2002), few research has addressed the association between flow experiences in music making and well-being. Habe et al. (2019) examined classical elite musicians and found life satisfaction to be positively associated with trait musical experience of flow. Fritz and Avsec (2007) reported similar results in classical music students in terms of positive associations of dispositional flow with both life satisfaction and affective well-being. Further, a randomized controlled trial on a music therapeutic songwriting intervention showed that flow positively predicted therapeutic outcomes such as hope (Silverman, Baker, & MacDonald, 2016), introducing flow as a mechanism in a conceptual framework on the effects of music therapy on well-being (Silverman & Baker, 2018).

Although previous studies have been conducted with music students, professional musicians, or music therapy patients, the circumstances for flow might be especially beneficial in music making as a hobby due to the relative lack of limiting factors in other areas, such as pressure, anxiety, mental or physical illness. Especially leisure music making might be characterized by favorable conditions for flow experiences, such as a familiar

environment, a sense of safety and autonomous choices of time and space to make music.

Therefore, hobby music making might contain enough challenge to stimulate the individual

but not so much as to create anxiety (Csikszentmihalyi, 1990). How the daily experience of

flow during music making is associated with well-being has, however, not been investigated

so far.

Taken together, two central propositions from literature and research support the

postulation that flow experiences might mediate the association between autonomous

motivation to make music and well-being. First, autonomous motivation to make music might

enable specific conditions for flow experiences to manifest (e.g., Keller & Bless, 2008;

Rivkin et al., 2018; Valenzuela et al., 2018), such as an intrinsic willingness to invest

personal energetic resources (Nakamura & Csikszentmihalyi, 2002). Second, due to both the

immense enjoyment and possible self-actualization, flow experiences in music making seem

to be positively linked to well-being (e.g., Fritz & Avsec, 2007; Habe et al., 2019; Silverman

et al., 2016).

The Present Study

The present study aimed to investigate whether autonomous motivation for music

making in hobby musicians' everyday lives would be associated with well-being, in terms of

higher life satisfaction as well as higher positive and lower negative affect. We examined this

research question both on the between-person ("Do hobby musicians who on average have

higher autonomous motivation for music making report higher average well-being?") and the

within-person level of analysis ("Do hobby musicians report higher well-being on days on

which they have higher-than-usual autonomous motivation for music making?"). With this

work, we addressed several limitations of past research. First, few studies have considered

SDT and motivation within a music context, and even less work has investigated the well-

being benefits of autonomously motivated music making in everyday life. Second, we aimed

to shed light on the question why autonomous motivation in music making might be associated with higher well-being and propose the experience of flow as a mediating mechanism. Third, expanding past research which targeted a tightly defined sample of participants such as professional musicians or music students, the present study considered music participation more broadly as it widened the focus to hobby musicians. In line with literature and past research, we hypothesized a positive effect of autonomous motivation in hobby music making on life satisfaction and positive affect as well as a negative effect on negative affect on both the within-person and between-person level. We further hypothesized that these relationships would be mediated by flow experiences during music making.

Methods

Participants and Procedure

Study invitations were posted in online musician forums and sent via e-mail to hobby and university orchestras, choirs and bands in Germany asking to pass them on to their members. The invitation specified the prerequisite that participants should be actively engaged in music making at least once a week. Interested musicians sent an e-mail to the corresponding author to receive confirmation of participation. Participants were asked via e-mail to fill in an online baseline questionnaire (the duration to fill in this questionnaire was approximately 25 minutes). Daily assessments over a period of 10 consecutive days started one week after the last participant had completed the baseline questionnaire. Beginning on a Friday, the assessments reached an approximately balanced number of weekdays (6) and weekend days (4). Every evening at 7 pm, an e-mail containing the link to a 5- to 10-minute survey was sent to the participants to fill in before going to bed. The link was deactivated at 6 am the following morning to avoid completions the next day. Since power analysis in a daily diary design presupposes realistic estimates for a multitude of (co-)variances on both the

within-and the between-person level (Bolger, Stadler, & Laurenceau, 2012), and these were difficult to derive from prior research, no a priori sample size calculation was conducted. Overall, 1,205 participants (65.2% female), aged 10 to 82 ($M = 39.7$, $SD = 17.7$), completed at least one questionnaire, while 351 (29.1%) filled in all 11 questionnaires. Participants who had participated at least in 80% of the daily questionnaires received individual feedback on their personal association between music making and well-being as incentive. No financial incentives were offered for participation.

  Sample for analysis. 79 of the initial 1,205 participants did not fill in at least one of the daily questionnaires and were therefore discarded from further analyses. All participants characterized their musical activity as (a) "earning one's living exclusively or mainly by music making", (b) "partially earning money by music making, but mainly employed elsewhere", or (c) "making music without intention to earn money". We categorized the 84 participants selecting option (a) as professional musicians and thus excluded them from all analyses. Therefore, we initially included 1,042 self-identified hobby musicians (65.3% female), aged 13 to 82 ($M = 39.9$, $SD = 17.6$) in the analyses. During the daily assessments, participants showed an average compliance of 77.2 % (8,045 of potentially 10,420 observations were available). Most of the participants were German (94.9%) and were married or in a relationship (62.5%). Further, 57.1% had a college degree and nearly half of the sample reported being currently in employment (47%). With respect to the musical background, participants on average had played their instrument for 22.1 years ($SD = 15.42$, *median* = 17, IQR = 23.7) with 5.5 years of music training ($SD = 4.6$, *median* = 5, IQR = 5.8). On a 5-point scale (1 = *less than 2 times a month*, 2 = *once a week*, 3 = *every 2-3 days*, 4 = *daily*, 5 = *several times daily*), they reported making music on average between one and three times a week ($M = 2.73$, $SD = 0.8$, *median* = 2.67, IQR = 1), with a mean duration of a musical activity of 71.4 minutes ($SD = 44$, *median* = 60, IQR = 50; *min* = 0; *max* = 540).

During the daily assessment phase, participants reported music making on average on 5.4 out of 10 days (*SD* = 2.8, *median* = 5, IQR = 4). Participants mainly practiced music alone (58.8%), though rehearsals in music groups also were a common setting (22%). They mostly played the violin (15.8%), piano (13%) or they sang (11.1%). The most frequently reported genre was Classical music (50.4%), followed by Rock/Pop (12.1%). The musical activity endured for 85.6 minutes on average (*SD* = 76.4, *median* = 60, IQR = 90; *min* = 1; *max* = 606) with a modal value of 30 minutes. Since autonomous motivation and flow were only assessed on days on which participants reported engaging in music making, the final sample for the analyses comprises data from 975 participants who engaged in musical activities at least once during the ten-day observation period (4,382 data points).

Measurements

Autonomous motivation. On each day, participants were asked why they had made music on that day. In order to maintain participant compliance over the study course, we aimed to keep the daily assessments as short as possible. In line with the conceptualization of motivation on a continuum in SDT, we designed two items measuring the poles intrinsic and extrinsic motivation which we adapted from the Self-Regulation Questionnaire version for music research (Brown, Miller, & Lawendowski, 1999; MacIntyre et al., 2018). Intrinsic motivation was assessed with the item "I made music for the joy of music". Extrinsic motivation was assessed as response to the item "I made music because of external pressure, such as parents, teachers, ensembles". For both items, participants were asked to indicate to what extent they agree with the statements, ranging from 1 ("not at all") to 5 ("completely"). In line with previous work (Sheldon, Osin, Gordeeva, Suchkov, & Sychev, 2017; Yang, Zhang, & Sheldon, 2018), autonomous motivation was computed as the difference between intrinsic motivation and extrinsic motivation.

Flow. Flow during music making was measured via 10 items of the Flow State Scale Short Form (Rheinberg, Vollmeyer, & Engeser, 2003) which has been successfully used in a previous study using experience-sampling methodology (Rheinberg, Manig, Kliegl, Engeser, & Vollmeyer, 2007). Participants rated on a 7-point Likert scale to what degree each statement applied to their experience while they engaged in music making (ranging from *not at all* to *completely*). Example items are "I was totally absorbed in what I was doing" or "The right thoughts/movements occurred of their own accord". Prior factor analytical results provided evidence for the two subscales fluency of performance and absorption (Rheinberg et al., 2003). We calculated internal consistencies as multilevel coefficient alphas according to Geldhof, Preacher, and Zyphur's (2014) approach. Estimates for fluency of performance showed good consistencies ($\alpha_{within} = .82$, $\alpha_{between} = .94$), while alphas for absorption were lower ($\alpha_{within} = .72$, $\alpha_{between} = .79$).

Life satisfaction. Life satisfaction was assessed daily via the single item of the Short Scale of Life Satisfaction (L-1) (Beierlein, Kovaleva, Lászlo, Kemper, & Rammstedt, 2014). Participants were asked on a 10-point Likert scale how satisfied they were all in all with their life on the present day (ranging from *not at all* to *completely*).

Positive and negative affect. Positive and negative affect were measured by the German version (Krohne, Egloff, Kohlmann, & Tausch, 1996) of the Short Form of the Positive and Negative Affect Schedule (I-PANAS-SF; Thompson, 2007) with five items each. Participants evaluated how often they experienced a specific affect during the day, for example, "anxious" or "inspired", on a 5-point Likert scale from *very slightly* to *extremely*. At the between-person level, internal consistencies were good (α from .90 to .92) and lower at the within-person level (α from .61 to .78).

Covariates. Covariates on the between-person level encompassed *age*, *gender* (coded 0 for male and 1 for female), and *relationship status* (single, in a relationship, married,

separated/divorced, widowed) as well as the Big Five personality traits *openness*,

conscientiousness, *extraversion*, *agreeableness* and *neuroticism* from the Short Form of the

Big Five Inventory (Rammstedt & John, 2005). The estimated reliabilities of the Big Five

scales in the present study were $\alpha = .68$ (openness), $\alpha = .72$ (conscientiousness), $\alpha = .83$

(extraversion), $\alpha = .64$ (agreeableness), and $\alpha = .73$ (neuroticism). Additionally, *stress* was

included as a covariate which was assessed daily with the question "How stressed did you

feel today?" on a 5-point Likert scale from *very slightly* to *extremely*. All covariates have

shown associations with life satisfaction, flow or motivation in previous studies

(Csikszentmihalyi, 1993; Fritz & Avsec, 2007; Seligman, 2011; Tang, Wang, & Guerrien,

2020). The covariates are the same as the ones we had included in our prior work with this

data set in which we targeted the association between music making, need fulfillment, and

affective well-being (Koehler & Neubauer, 2020).

Data Analysis

Multilevel models (MLM) are commonly used when data is hierarchical, e.g., when

daily observations (Level 1) are nested within individuals (Level 2) as in the present study.

Structural equation models (SEM) generally are recommended when variables cannot be

measured impeccably, either through items assessing a hypothetical construct or through

fallible measurements (Rabe-Hesketh, Skrondal, & Zheng, 2007). The advantages of both

approaches can be combined in multilevel structural equation modeling (ML-SEM) which

allows simultaneous estimation of regression coefficients at both the within- and between-

person level of analysis to prevent conflation of level-specific effects (Preacher, Zyphur, &

Zhang, 2010).

In the first set of analyses, we tested two competing measurement models for the

assessment of flow: A one-factor model (all items load on one common flow factor on both

the between-person and the within-person level), and a two factor model separating fluency

and absorption (Rheinberg et al., 2003). These two models are nested, since the one factor

model is equivalent to a restricted version of the two-factor model in which the factor

correlation is fixed to one on both levels. We further tested a common measurement model

for all latent variables (flow, positive and negative affect).

Next, we tested the hypothesized mediation model. Following the suggestion by

Preacher, Zhang, and Zyphur (2011), we used ML-SEM for this purpose. Corresponding to

Model I in the terminology by Preacher et al. (2010), we computed a 1-1-1 mediation model

(all variables measured at Level 1) with random intercepts and fixed slopes on each within-

and between-person level. With regard to covariates on the between-person level, we added

age, gender, relationship status (entered as four dummy variables with "single" as the

reference category), the Big Five, and stress. On the within-person level, we included stress

and day of week (coded 0 for weekday and 1 for weekend). The relevant regression path

coefficients for the study hypotheses are shown in Figure 1. Analyses were conducted with

Mplus 6.11 (Muthén & Muthén, 1998-2011) and parameters were obtained via robust

maximum likelihood estimation (MLR). Model fit was assessed via the root mean square

error of approximation (RMSEA), the comparative fit index (CFI), and the standardized root

mean square residual (SRMR). Mediation hypotheses were tested via inspection of the

statistical significance of the indirect effects. Data and analysis scripts are available on

https://osf.io/4yh6r/?view_only=ad735f7084cb40029f9241c3fee4f449.

Results

Descriptive statistics on the within- and between-person level as well as correlations

of relevant variables can be seen in Table 1; correlations with covariates are reported in

Appendix A in the Supplementary Online Material. On average, participants reported similar

scores on both flow subscales, relatively high life satisfaction, medium positive affect, and

relatively low negative affect. As expected, on both the within- and between-person level,

autonomous motivation, the flow scales, life satisfaction and positive affect were positively

correlated with each other, while they all showed negative correlations with negative affect.

Intra-class correlations indicate that inter-individual differences accounted for more than 41%

of variance in the respective variables, necessitating multilevel modeling to account for the

dependency among observations within individuals.

Factor Analysis

Comparing the two flow models (one factor on both levels vs. two factors on both

levels) showed that the fit of the two-factor model was statistically significantly better than

the fit of the one-factor model, $\chi^2(2) = 16260.11$, $p < .001$. In line with Rheinberg et al.

(2003), we therefore considered two separate flow factors for further analyses. Absolute fit

indices of the two-factor model were, however, below conventionally acceptable levels (CFI

= .87, RMSEA = .06, $SRMR_{within}$ = .06, $SRMR_{between}$ = .11). After inspecting modification

indices we included a covariance between the residuals for item 8 ("I knew what I had to do

each step of the way") and item 9 ("I felt that I had everything under control") as well as for

item 4 ("I had no difficulty concentrating") and item 5 ("My mind was completely clear").

All of these items belonged to the fluency factor. Allowing these covariances to be freely

estimated improved model fit, $\chi^2(4) = 1477.78$, $p < .001$, and yielded acceptable absolute fit

(CFI = .94, RMSEA = .05, $SRMR_{within}$ = .04, $SRMR_{between}$ = .07). Therefore, both residual

covariances were freely estimated in the mediation analysis. Overall, the measurement model

of the latent variables (both flow factors as well as positive and negative affect) showed

adequate model fit (CFI = .94, RMSEA = .03, $SRMR_{within}$ = .04, $SRMR_{between}$ = .09) and all

loadings of items on their determined factors were statistically significant. Note that for

reasons of consistency with our prior work with this data set (Koehler & Neubauer, 2020),

the Level-1 residual covariance between the two negative affect indicators "hostile" and

"annoyed" was freely estimated in this and all following models. Results of the measurement model are reported in the Supplementary Online Material Appendix B.

Mediation Analysis

The mediation model yielded adequate model fit (CFI = .92, RMSEA = .03, $SRMR_{within}$ = .02, $SRMR_{between}$ = .06). Table 2 contains all estimates of path coefficients analogous to Figure 1; results from covariates are reported in the Supplementary Online Material in Appendix C. Residual covariances between the two flow factors (fluency, absorption) and among the three well-being indicators (life satisfaction, positive affect, negative affect) were freely estimated on both levels. After controlling for the covariates, autonomous motivation positively predicted both subscales of flow on the within- and between-person level (p < .001, see paths *a*). When controlling for flow and covariates, there were no significant direct effects of motivation on either life satisfaction or positive affect (see path *c'*); the negative direct effect on negative affect was only statistically significant on the within-person level.

Table 3 depicts estimates of total and specific indirect effects. The positive indirect effects of autonomous motivation on life satisfaction and positive affect via fluency of performance were statistically significant at both the within- and between person level, whereas the indirect effect via absorption was statistically significant at the within-person level only. For negative affect, the total indirect effect of autonomous motivation was not statistically significant on either the between-person level or the within-person level. Notably, on the within-person level, the two specific indirect effects were statistically significant, but in opposite directions. This pattern was driven by an unexpected positive effect of absorption on negative affect on the within-person level (see Table 2). To investigate the robustness of this unexpected finding, we re-estimated the model without the residual covariance of the two negative affect items on the within-person level. In this model, the within-person effect of

absorption on negative affect was no longer statistically significant, b = .047, *p* = .487, as was

the indirect effect of autonomous motivation on negative affect via absorption, a x b = .014 [-

.025; .053]. The total indirect effect on negative affect was now statistically significant, a x b

= -.028 [-.045; -.012]. The pattern of the remaining effects remained unchanged: On the

within-person level, there were statistically significant indirect effects on all three outcomes

via fluency, and statistically meaningful indirect effects via absorption for life satisfaction

and positive affect. On the between-person level, only the indirect effects on life satisfaction

and positive affect via fluency were statistically significant.

Discussion

Music making might be a leisure activity that individuals choose with high

autonomous motivation, and according to SDT, autonomous reasons to engage in this activity

might positively impact well-being. The present study examined the effect of autonomous

reasons to engage in music making on subjective well-being in hobby musicians' everyday

life. We further investigated flow experiences in music making as a potentially mediating

mechanism.

In line with studies with music students (Araujo & Andraude, 2013; Sinnamon et al.,

2012), descriptive statistics in our study indicate that hobby musicians frequently experience

flow during music making as well. In line with our hypotheses, multilevel structural equation

models showed positive associations of autonomous motivation with both subscales of flow

on the within- and between-person level of analysis. This is in line with findings from a

cross-sectional study by Valenzuela et al. (2018) who found a direct effect of autonomous

motivation on flow experiences in music students. It further extends findings on positive

associations of flow with autonomously motivating activities, such as work (Demerouti,

Bakker, Sonnentag, & Fullagar, 2012) or athletic performance (Kowal & Fortier, 1999), to

music making as a leisure activity. It may be that an intrinsic willingness to invest personal

energetic resources in an activity like hobby music making might enable experiences of flow more than extrinsic motivators (Rivkin et al., 2018). One reason from a perceptional perspective might be the lack of a narrow attentional focus enabling an all-encompassing attention allocation (Silverman & Baker, 2018) contributing to the effortless state of attention during flow experiences (Manzano, Theorell, Harmat, & Ullén, 2010). Further, the daily diary study design also allowed us to examine within-person associations among these constructs, adding a new layer of understanding of flow experiences during hobby music making: On days on which individuals report higher-than-usual autonomous motivation for music making they also report higher-than-usual flow experiences. This finding implies that autonomous motivation may be relevant for flow experiences not only in explaining differences between persons, but also in individual processes in everyday life.

Correlates of Flow Experiences During Hobby Music Making

Corroborating literature linking flow experiences with well-being (Croom, 2014; Csikszentmihalyi, 1993; Seligman, 2011), with regard to both life satisfaction and positive affect, our results showed positive associations of the flow subscale fluency of performance on both levels of analysis, whereas the unique effect of the subscale absorption was only statistically significant on the within-person level of analysis. From a theoretical perspective, the results are in line with Csikszentmihalyi's assumption (1993) that flow experiences during everyday activities contribute to greater well-being. Expanding cross-sectional studies with elite musicians and music students connecting dispositional flow with well-being (Fritz & Avsec, 2007; Habe et al., 2019), our study suggests that flow experiences during music making might have positive consequences in hobby musicians' everyday life in terms of higher life satisfaction and higher positive affect. In the realm of positive psychology, the results highlight the importance for individuals to create the conditions for flow experiences in everyday life to foster their flourishing (Seligman, 2011).

Contrasting our expectations, while the effect of the subscale fluency on negative affect was negative, absorption had a positive within-person effect on negative affect in our main analyses. A possible explanation may be that the two flow subscales might address different experiential qualities of the participants' flow experience. While the items of the subscale fluency of performance might measure a rather cognitive and focused concentration during flow (e.g., "My thoughts/activities ran fluidly and smoothly" or "I had no difficulties concentrating"), the items of the absorption subscale might assess a higher (emotional) intensity of flow (e.g., "I was totally absorbed in what I was doing" or "I did not notice time passing"). The concentration aspect of flow experiences might provide individuals with more supportive experiences to enhance pleasure and well-being in everyday life than the emotional intensity aspect of flow. It may be that the intensity of a trance-like state losing awareness of time and surroundings (absorption) facilitates access to a wide range of emotions, including both positive and negative feelings. We note, however, that this unexpected positive effect of absorption on negative affect was not robust in our analyses, and was no longer statistically significant, when the residual covariance of two negative affect items was set to zero. We therefore consider it more likely that this unexpected positive effect of absorption on negative affect is a statistical artifact created by the two highly correlated mediators (fluency and absorption).

Further, the subscale absorption was not significantly related to either life satisfaction, positive or negative affect on the between-person level of analysis. Hence, participants who report higher average absorption when engaging in music making do not report higher levels of well-being on average – but days with higher absorption in music making are also days with somewhat higher life satisfaction and positive affect. This pattern emphasizes the importance of investigating the effect of flow experiences on the within-person level as relatively to one's own average level of flow. It suggests that potentially beneficial effects of

absorption on well-being (life satisfaction and positive affect) might be more short-lived and

do not translate into stable, and more enduring between-person differences in well-being.

Indirect Effects of Motivation

We further aimed to gain deeper insights into the mechanisms underlying the effect of

autonomous motivation to make music on well-being and investigated flow experiences

during music making as a mediating factor. On the within-person level, results from the

mediation analysis showed significant indirect effects via both flow subscales on both life

satisfaction and positive affect as well as significant total effects which is in line with the

assumption of a mediation. The findings suggest that on days on which individuals report

higher-than-usual autonomous motivation to make music they also report higher life

satisfaction and positive affect because they experienced more flow during music making

(fluency of performance and absorption). The indirect within-person effect on negative affect

via fluency was significant and negative, suggesting that fluency accounts not only for the

effects of autonomous motivation on positive outcomes (life satisfaction and positive affect),

but also on negative emotional states.

In our main analyses, there was also an unexpected positive indirect effect of

autonomous motivation on negative affect via absorption on the within-person level. As

noted above, this may indicate that the concentration aspect of flow might be a more

pleasurable state for individuals contributing to well-being, while the emotional intensity

aspect of flow may enable access to all kinds of emotions, including negative emotions. We

would like to add, however, that this effect, too, was not robust, and should therefore be

interpreted very cautiously. Again, we consider it more likely that this unexpected finding is a

statistical artefact created by the high correlation between the two flow subscales. On the

between-person level, although the indirect effects via fluency on both life satisfaction and

positive affect were statistically significant, the total effect of motivation was statistically

significant only for life satisfaction, pointing to a possible mediating effect only for this component of subjective well-being: Participants who, on average engage in their music making for more autonomous reasons, report slightly higher life satisfaction because they experiences more fluency in their music making on average.

The Importance of Within- versus Between-Person Analyses

The differences between the two levels of analysis suggest that the quality of motivation and flow experiences during music making have a stronger impact on short-term variation in well-being than on stable interindividual differences. Our study emphasizes the possible function of autonomous motivation and flow in leisure music making as a supply for positive daily experiences (Seligman, 2011). The hedonic adaptation principle postulates that people ultimately adapt to the positive effects of an event or activity so it loses its potency (Brickman & Campbell, 1971). Therefore, intentional activities that are pursued on a day-to-day basis are important to sustain high well-being. Specifically, research suggests that not life circumstances but intentional activities and practices, preferably matching individual interests and values, offer the most promising potential for sustaining and increasing one's own happiness level (Lyubomirsky, Sheldon, & Schkade, 2005). Further, one potential mediator from successful volitional activity to enhanced well-being might be the accumulation of positive daily experiences along the way (Sheldon & Elliot, 1999). Correspondingly, our findings indicate that an intentional and possibly self-concordant activity like hobby music making mainly affects individual temporary fluctuations in daily well-being rather than stable differences between persons. With regard to SDT (Deci & Ryan, 2017), findings are in line with the assumption of the beneficial effects of autonomously regulated motivation on well-being. Our study underlines the importance of the quality of motivation for a behavior such as music making with regard to intense experiences (flow) and well-being (life satisfaction, positive and negative affect).

Limitations

The findings of the present study should be considered in light of several limitations. First, the causal direction of associations between the study variables cannot be impeccably ensured by a mediation analysis. We delineated our hypothesis that autonomous motivation for music making is associated with flow experiences which in turn contribute to higher well-being from previous studies and theoretical implications of SDT, but other causal directions cannot be excluded with the present study. It is also possible that individuals who are overall happier tend to have more autonomous motivation to engage in music making. Further, flow experiences might both emerge from and lead to more dynamic processes in positive and negative affect (Koole et al., 2019). To gain insights into the causal directions between autonomous motivation, flow and well-being, future research should consider experimental trials to eliminate the potential impact of confounding factors and uncontrolled third variables. For instance, studies with a randomized design might induce either flow facilitating activities, such as music making, or a neutral control activity and investigate their effects on well-being.

Second, the present study's underlying theoretical framework of SDT and flow theory has been critically discussed in previous work (Chemolli & Gagné, 2014; Swann, Piggott, Schweickle, & Vella, 2018). While flow theory has been targeted because of its unclear dimensionality and untestable predictions (Swann et al., 2018), SDT has received criticism on their assumption of a motivational continuum with two opposing poles (Chemolli & Gagné, 2014). One possible consequence of these theoretical challenges is that the conceptualization of autonomous motivation and flow might partially overlap. Although empirical research found evidence of flow in extrinsically motivated or amotivated activities as well (e.g., Kowal & Fortier, 1999), both autonomous motivation and flow include an inherent enjoyment of the activity itself. One distinction might be that autonomous motivation is

fueled by the *anticipated* enjoyment, while flow may be the *actual* experience of enjoying the

activity (Koole et al., 2019). It might be worthwhile for future studies to approach the present

research question based on other theoretical frameworks for motivation to make music (e.g.,

Asmus, 1986; Schmidt, 2005) and flow to replicate our findings.

Still, the measurement and operationalization of the constructs may therefore include

limitations as well. For instance, many operationalizations of flow have been criticized for

the conflation of the conditions and the experience of flow (e.g., Swann et al., 2018). Future

research should employ progressive research designs in terms of event-focused interview

studies exploring the experience and occurrence of flow as well as studies seeking to collect

real-time data on flow during activities (Swann et al., 2018). Further, as the daily diary design

of the present study required relatively short and feasible daily assessments to maintain

participants' compliance, the measurement of life satisfaction included only a single item

which may have limited reliability. Single items are contaminated with an unknown amount

of measurement error. Not unlike short scales consisting of only 2-3 items, their relative lack

of measurement reliability might lead to attenuated and less precise effect size estimates.

Additionally, autonomous motivation in the present study was defined as the difference

between two items on extrinsic and intrinsic motivation. Still, to meet the complex

motivational processes underlying hobby music making, it would be interesting to employ

instruments covering the different motivational regulations in more detail, such as the

Situational Motivation Scale (SIMS) (Guay, Vallerand, & Blanchard, 2000) or the Self-

Regulation Questionnaire (SRQ) (Ryan & Connell, 1989), adopted to music making, and to

further include aspects of introjected, identified, and integrated motivation,.

Third, daily assessments in the study design were conducted for ten days which

provides first important insights into the daily processes of hobby music making.

Nevertheless, to maximize power of statistical analyses and gain more in-depth knowledge

about hobby musicians' everyday life, studies might employ longer periods of ambulatory assessment and longitudinal designs.

Fourth, our sample exclusively consisted of hobby musicians, we thus can only make possible conclusions about individuals who practice an instrument or sing as a leisure activity. Future research topics might include within-person comparisons of activities with more autonomous vs. more controlled motivation or between-person comparisons of hobby musicians with professional musicians or individuals engaging in other hobbies.

Conclusion

Autonomous motivation to engage in hobby music making was positively associated with flow, life satisfaction and positive affect, and negatively associated with negative affect. Results from the present daily diary study showed that days on which individuals engaged in music making for more autonomous (vs. more controlled) reasons were days with more flow experiences and days with higher well-being. Furthermore, findings were consistent with the assumption of a mediation of autonomous motivation on well-being via flow (primarily via the subscale fluency). Our results emphasize the importance (a) to target the interplay of motivation, flow and well-being on both the within-person level and the between-person level, (b) to consider multiple dimensions of flow (here: fluency and absorption) since they might differ in their association with well-being, and (c) to investigate multiple dimensions of well-being.

Table 1

Summary of Within- and Between-Person Correlations and Descriptive Statistics

	Autonomous motivation	Flow: Fluency of performance	Flow: Absorption	Life satisfaction	Positive Affect	Negative Affect	*M*	*SD*
Autonomous motivation	-	.26	.30	.17	.09	-.22	2.94	0.99
Flow: Fluency of performance	.25	-	.69	.43	.52	-.30	5.31	0.74
Flow: Absorption	.29	.62	-	.34	.36	-.12	5.01	0.81
Life satisfaction	.15	.28	.28	-	.56	-.53	7.89	1.33
Positive Affect	.13	.33	.32	.44	-	-.33	3.64	0.47
Negative Affect	-.13	-.19	-.13	-.34	-.11	-	1.46	0.36
SD	1.05	0.80	0.92	1.22	0.56	0.42	-	-
ICC	.47	.46	.44	.54	.42	.42	-	-

Note. Table depicts within- and between-person correlation coefficients as well as between-person means and within- and between-person standard deviations. Values in the upper diagonal refer to the between-level, values in the lower diagonal to the within-level. ICC = Intra-class correlation.

Table 2

Path Coefficients of the Mediation Model (ML-SEM) of the Effect of Autonomous Motivation on Life Satisfaction, Positive and Negative Affect

via Flow

		a: X→M	b: M→Y			c': X→Y	c
X: Autonomous motivation			**Y_1: Life satisfaction**	**Y_2: Positive Affect**	**Y_3: Negative Affect**		
	(R^{2a})						
M: Flow	Fluency of performance	**.258*** [.215; .302]	**.146** [.039; .253]	**.221** [.084; .359]	**-.309* [-.444; -.174]**	-	-
		.228* [.130 .327]	**.259** [.094; .424]	**.620*** [.428; .812]	-.017 [-.292; .258]	-	-
	Absorption	**.298*** [.252; .344]	**.133** [.032; .234]	**.192** [.059; .324]	**.200** [.063; .338]	-	-
		.266* [.171; .361]	.084 [-.062; .231]	-.047 [-.202; .107]	.072 [-.057; .201]	-	-
Y_1: Life satisfaction	within (.155)	-	-	-	-	.037 [-.002; .077]	**.115*** [.075; .155]
	between (.358)	-	-	-	-	.007 [-.077; .091]	**.089*** [.002; .176]
Y_2: Positive Affect	within (.167)	-	-	-	-	.028 [-.018; .073]	**.142*** [.098; .185]
	between (.483)	-	-	-	-	-.063 [-.162; .036]	.067 [-.074; .207]
Y_3: Negative Affect	within (.326)	-	-	-	-	**-.059* [-.109; -.010]**	**-.079*** [-.127; -.032]

Note: In the "M: Flow" section, the first row for each of "Fluency of performance" and "Absorption" is labeled "within" and the second row "between", with R^{2a} values: within (.111), between (.212) for Fluency of performance; within (.120), between (.185) for Absorption.

between	-	-	-	-	-.052	-.037
(.670)					[-.135; .030]	[-.192; .081]

Note. Path coefficients are standardized. 95% confidence intervals are reported in parentheses. a represents the effects of autonomous motivation on flow; b represents the effects of flow on life satisfaction, positive and negative affect; c' represents the direct effect of autonomous motivation on life satisfaction, positive and negative affect after controlling for flow; c represents the total effect of autonomous motivation on life satisfaction, positive and negative affect (a x b + c'). Between-covariates include age, gender, relationship, extraversion, agreeableness, conscientiousness, neuroticism, openness, and stress. Within-covariates include stress and day of the week (weekday vs. weekend). Results of covariates are not listed here (see Supplementary Online Material Appendix C for results of the covariates).

[a]R^2 values include the proportion of variance accounted for by the covariates.

p < .05. **p* < .01. ***p* < .001.

Table 3

Indirect Effects From Autonomous Motivation on Life Satisfaction, Positive and Negative Affect

		Within			Between		
		Estimate	95% CI	Total indirect effect	Estimate	95% CI	Total indirect effect
Outcome: Life Satisfaction				.077***			.082***
				[.058; .096]			[.037; .126]
Mediators							
Flow	Fluency	**.038***	[.009; .067]		**.059***	[.010; .108]	
	Absorption	**.040***	[.009; .070]		.022	[-.018; .063]	
Outcome: Positive Affect				.114***			.130***
				[.086; .142]			[.050; .210]
Mediators							
Flow	Fluency	**.057****	[.019; .095]		**.142***	[.057; .228]	
	Absorption	**.057****	[.016; .098]		-.013	[-.054; .028]	
Outcome: Negative Affect				-.020			.015
				[-.043; .003]			[-.049; .079]
Mediators							
Flow	Fluency	**-.080***	[-.118; -.041]		-.004	[-.066; .059]	
	Absorption	**.060****	[.018; .102]		.019	[-.017; .055]	

Note. Table depicts standardized indirect effects and 95% confidence intervals at the within- and between-person level.

Between-person covariates include age, gender, relationship, extraversion, agreeableness, conscientiousness,

neuroticism, openness, and stress. Within-person covariates include stress and day of the week (weekday vs. weekend).

p < .05. **p* < .01. ***p* < .001.
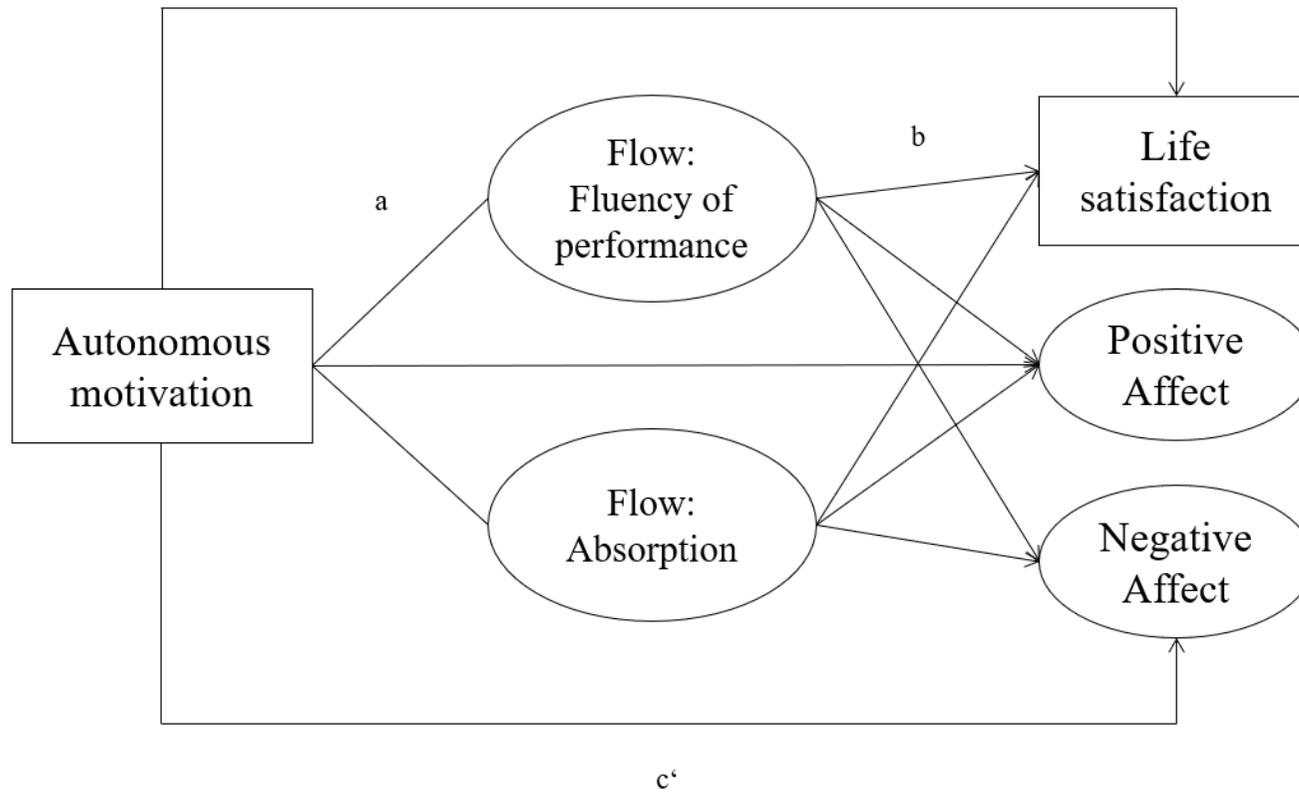
Figure 1. Postulated mediation model. a represents the effect of motivation on flow; b is the effect of flow on life satisfaction, positive and

negative affect. c' is the direct effect of autonomous motivation on life satisfaction, positive and negative affect after controlling for flow. a x b

then is the indirect effect of autonomous motivation via flow on life satisfaction, positive and negative affect. For better legibility, covariates and

covariances are not included in the Figure, but they were included in the model.

References

Araujo, R. C. de, & Andraude, M. A. de (2013). A study on teenagers' musical practice and

flow theory. *Musicworks: Journal of the Australian Council of Orff Schulwerk*. (18), 19–

25.

Araújo, M. V., & Hein, C. F. (2019). A survey to investigate advanced musicians' flow

disposition in individual music practice. *International Journal of Music Education*, *37*(1),

107–117. https://doi.org/10.1177/0255761418814563

Asmus, E. P. (1986). Student Beliefs about the Causes of Success and Failure in Music: A

Study of Achievement Motivation. *Journal of Research in Music Education*, *34*(4), 262.

https://doi.org/10.2307/3345260

Baker, F. A., & MacDonald, R. A. R. (2013). Flow, identity, achievement, satisfaction and

ownership during therapeutic songwriting experiences with university students and

retirees. *Musicae Scientiae*, *17*(2), 131–146. https://doi.org/10.1177/1029864913476287

Beierlein, C., Kovaleva, A., Lászlo, Z., Kemper, C. J., & Rammstedt, B. (2014). *Eine Single-*

Item-Skala zur Erfassung der Allgemeinen Lebenszufriedenheit: Die Kurzskala

Lebenszufriedenheit-1 (L-1) (GESIS-Working Papers No. 33). Mannheim. Retrieved from

http://nbn-resolving.de/urn:nbn:de:0168-ssoar-426681

Boer, D., & Abubakar, A. (2014). Music listening in families and peer groups: Benefits for

young people's social cohesion and emotional well-being across four cultures. *Frontiers in*

Psychology, *5*, 392. https://doi.org/10.3389/fpsyg.2014.00392

Bolger, N., Stadler, G., & Laurenceau, J.-P. (2012). Power analysis for intensive longitudinal

studies. In M. R. Mehl & T. S. Conner (Eds.), *Handbook of research methods for studying*

daily life (pp. 285–301). New York: Guilford Press.

Bonneville-Roussy, A., & Bouffard, T. (2015). When quantity is not enough: Disentangling

the roles of practice time, self-regulation and deliberate practice in musical achievement.

Psychology of Music, *43*(5), 686–704. https://doi.org/10.1177/0305735614534910

Brickman, P., & Campbell, D. T. (1971). Hedonic relativism and planning the good society.

In M. H. Appley (Ed.), *Adaption-level theory*. New York: Academic Press.

Briki, W., & Dagot, L. (2020). Conservatives Are Happier than Liberals: the Mediating Role

of Perceived Goal Progress and Flow Experience — a Pilot Study. *Current Psychology*,

6(1), 219. https://doi.org/10.1007/s12144-020-00652-0

Brown, J. M., Miller, W. R., & Lawendowski, L. A. (1999). The self-regulation

questionnaire. In *Innovations in clinical practice: A source book, Vol. 17* (pp. 281–292).

Sarasota, FL, US: Professional Resource Press/Professional Resource Exchange.

Butkovic, A., Ullén, F., & Mosing, M. A. (2015). Personality related traits as predictors of

music practice: Underlying environmental and genetic influences. *Personality and

Individual Differences*, *74*, 133–138. https://doi.org/10.1016/j.paid.2014.10.006

Chemolli, E., & Gagné, M. (2014). Evidence against the continuum structure underlying

motivation measures derived from self-determination theory. *Psychological Assessment*,

26(2), 575–585. https://doi.org/10.1037/a0036212

Chirico, A., Serino, S., Cipresso, P., Gaggioli, A., & Riva, G. (2015). When music "flows".

State and trait in musical performance, composition and listening: A systematic review.

Frontiers in Psychology, *6*, 906. https://doi.org/10.3389/fpsyg.2015.00906

Coleman, D., & Iso-Ahola, S. E. (1993). Leisure and Health: The Role of Social Support and

Self-Determination. *Journal of Leisure Research*, *25*(2), 111–128.

https://doi.org/10.1080/00222216.1993.11969913

Croom, A. M. (2014). Music practice and participation for psychological well-being: A

review of how music influences positive emotion, engagement, relationships, meaning,

and accomplishment. *Musicae Scientiae*, *19*(1), 44–64.

https://doi.org/10.1177/1029864914561709

Csikszentmihalyi, M. (Ed.) (2000). *Optimal experience: Psychological studies of flow in

consciousness* (Reprinted 2000). Cambridge: Cambridge University Press.

Csikszentmihalyi, M. (1975). *Beyond Boredom and Anxiety*. San Francisco: Jossey-Bass.

Csikszentmihalyi, M. (1990). *Flow: The Psychology of Optimal Performance*. New York:

Cambridge University Press.

Csikszentmihalyi, M. (1993). Activity and happiness: Towards a science of occupation.

Journal of Occupational Science, *1*(1), 38–42.

https://doi.org/10.1080/14427591.1993.9686377

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human

behavior*. New York: Plenum Press.

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and

the self-determination of behavior. *Psychological Inquiry*, *11*(4), 227–268.

https://doi.org/10.1207/S15327965PLI1104_01

Demerouti, E., Bakker, A. B., Sonnentag, S., & Fullagar, C. J. (2012). Work-related flow and

energy at work and at home: A study on the role of daily recovery. *Journal of

Organizational Behavior*, *33*(2), 276–295. https://doi.org/10.1002/job.760

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in

the acquisition of expert performance. *Psychological Review*, *100*(3), 363–406.

https://doi.org/10.1037//0033-295X.100.3.363

Evans, P. (2015). Self-determination theory: An approach to motivation in music education. *Musicae Scientiae*, *19*(1), 65–83. https://doi.org/10.1177/1029864914568044

Evans, P., & Bonneville-Roussy, A. (2016). Self-determined motivation for practice in university music students. *Psychology of Music*, *44*(5), 1095–1110. https://doi.org/10.1177/0305735615610926

Fong, C. J., Zaleski, D. J., & Leach, J. K. (2015). The challenge–skill balance and antecedents of flow: A meta-analytic investigation. *The Journal of Positive Psychology*, *10*(5), 425–446. https://doi.org/10.1080/17439760.2014.967799

Freer, E., & Evans, P. (2019). Choosing to study music in high school: Teacher support, psychological needs satisfaction, and elective music intentions. *Psychology of Music*, *47*(6), 781–799. https://doi.org/10.1177/0305735619864634

Fritz, B. S., & Avsec, A. (2007). The experience of flow and subjective well-being of music students. *Horizons of Psychology*, *16*(2), 5–17.

Fullagar, C. J., Knight, P. A., & Sovern, H. S. (2013). Challenge/Skill Balance, Flow, and Performance Anxiety. *Applied Psychology*, *62*(2), 236–259. https://doi.org/10.1111/j.1464-0597.2012.00494.x

Geldhof, G. J., Preacher, K. J., & Zyphur, M. J. (2014). Reliability estimation in a multilevel confirmatory factor analysis framework. *Psychological Methods*, *19*(1), 72–91. https://doi.org/10.1037/a0032138

Guay, F., Vallerand, R. J., & Blanchard, C. (2000). On the Assessment of Situational Intrinsic and Extrinsic Motivation: The Situational Motivation Scale (SIMS). *Motivation and Emotion*, *24*(3), 175–213. https://doi.org/10.1023/A:1005614228250

Habe, K., Biasutti, M., & Kajtna, T. (2019). Flow and Satisfaction With Life in Elite Musicians and Top Athletes. *Frontiers in Psychology*, *10*, 698. https://doi.org/10.3389/fpsyg.2019.00698

Keller, J., & Bless, H. (2008). Flow and regulatory compatibility: An experimental approach to the flow model of intrinsic motivation. *Personality and Social Psychology Bulletin*, *34*(2), 196–209. https://doi.org/10.1177/0146167207310026

Kingsford-Smith, A., & Evans, P. (2019). A longitudinal study of psychological needs satisfaction, value, achievement, and elective music intentions. *Psychology of Music*, *36*, 030573561986828. https://doi.org/10.1177/0305735619868285

Koehler, F., & Neubauer, A. B. (2020). From music making to affective well-being in everyday life: The mediating role of need satisfaction. *Psychology of Aesthetics, Creativity, and the Arts*, *14*(4), 493–505. https://doi.org/10.1037/aca0000261

Koole, S. L., Schlinkert, C., Maldei, T., & Baumann, N. (2019). Becoming who you are: An integrative review of self-determination theory and personality systems interactions theory. *Journal of Personality*, *87*(1), 15–36. https://doi.org/10.1111/jopy.12380

Kowal, J., & Fortier, M. S. (1999). Motivational Determinants of Flow: Contributions From Self-Determination Theory. *The Journal of Social Psychology*, *139*(3), 355–368. https://doi.org/10.1080/00224549909598391

Krause, A. E., North, A. C., & Davidson, J. W. (2019). Using Self-Determination Theory to Examine Musical Participation and Well-Being. *Frontiers in Psychology*, *10*, 405. https://doi.org/10.3389/fpsyg.2019.00405

Krohne, H. W., Egloff, B., Kohlmann, C.-W., & Tausch, A. (1996). Untersuchungen mit einer deutschen Version der "Positive and Negative Affect Schedule" (PANAS) [Investigations with a German version of the Positive and Negative Affect Schedule (PANAS)]. *Diagnostica*, *42*(2), 139–156.

Lowis, M. J. (2002). Music as a Trigger for Peak Experiences Among a College Staff

Population. *Creativity Research Journal*, *14*(3-4), 351–359.

https://doi.org/10.1207/S15326934CRJ1434_6

Lyubomirsky, S., Sheldon, K. M., & Schkade, D. (2005). Pursuing Happiness: The

Architecture of Sustainable Change. *Review of General Psychology*, *9*(2), 111–131.

https://doi.org/10.1037/1089-2680.9.2.111

MacDonald, R., Kreutz, G., & Mitchell, L. (Eds.) (2012). *Music, health, and wellbeing*:

Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199586974.001.0001

MacIntyre, P. D., Schnare, B., & Ross, J. (2018). Self-determination theory and motivation

for music. *Psychology of Music*, *46*(5), 699–715.

https://doi.org/10.1177/0305735617721637

Manzano, O. de, Theorell, T., Harmat, L., & Ullén, F. (2010). The psychophysiology of flow

during piano playing. *Emotion (Washington, D.C.)*, *10*(3), 301–311.

https://doi.org/10.1037/a0018432

Mas-Herrero, E., Marco-Pallares, J., Lorenzo-Seva, U., Zatorre, R. J., & Rodriguez-Fornells,

A. (2013). Individual differences in music reward experiences. *Music Perception: An

Interdisciplinary Journal*, *31*(2), 118–138. https://doi.org/10.1525/mp.2013.31.2.118

Muthén, L. K., & Muthén, B. O. (1998-2011). *Mplus user's guide* (6th ed.). Los Angeles:

Muthén & Muthén.

Nakamura, J., & Csikszentmihalyi, M. (2002). The Concept of Flow. In S. J. Lopez & C. R.

Snyder (Eds.), *Handbook of positive psychology* (pp. 89–105). New York: Oxford

University Press.

Preacher, K. J., Zhang, Z., & Zyphur, M. J. (2011). Alternative Methods for Assessing

Mediation in Multilevel Data: The Advantages of Multilevel SEM. *Structural Equation*

Modeling: A Multidisciplinary Journal, *18*(2), 161–182.

https://doi.org/10.1080/10705511.2011.557329

Preacher, K. J., Zyphur, M. J., & Zhang, Z. (2010). A general multilevel SEM framework for

assessing multilevel mediation. *Psychological Methods*, *15*(3), 209–233.

https://doi.org/10.1037/a0020141

Rabe-Hesketh, S., Skrondal, A., & Zheng, X. (2007). Multilevel Structural Equation

Modeling. In *Handbook of Computing and Statistics with Applications. Handbook of

latent variable and related models* (Vol. 1, pp. 209–227). Amsterdam: Elsevier.

https://doi.org/10.1016/S1871-0301(06)01010-9

Rammstedt, B., & John, O. P. (2005). Kurzversion des Big Five Inventory (BFI-K).

Diagnostica, *51*(4), 195–206. https://doi.org/10.1026/0012-1924.51.4.195

Rheinberg, F., Vollmeyer, R., & Engeser, S. (2003). Die Erfassung des Flow-Erlebens. In J.

Stiensmeier-Pelster & F. Rheinberg (Eds.), *Diagnostik von Motivation und Selbstkonzept

(Tests und Trends N.F. 2)* (pp. 261–279). Göttingen: Hogrefe.

Rheinberg, F., Manig, Y., Kliegl, R., Engeser, S., & Vollmeyer, R. (2007). Flow bei der

Arbeit, doch Glück in der Freizeit. *Zeitschrift Für Arbeits- Und Organisationspsychologie

A&O*, *51*(3), 105–115. https://doi.org/10.1026/0932-4089.51.3.105

Rivkin, W., Diestel, S., & Schmidt, K.-H. (2018). Which daily experiences can foster well-

being at work? A diary study on the interplay between flow experiences, affective

commitment, and self-control demands. *Journal of Occupational Health Psychology*,

23(1), 99–111. https://doi.org/10.1037/ocp0000039

Rogatko, T. P. (2009). The Influence of Flow on Positive Affect in College Students. *Journal

of Happiness Studies*, *10*(2), 133–148. https://doi.org/10.1007/s10902-007-9069-y

Ryan, R. M., & Deci, E. L. (2000a). The darker and brighter sides of human existence: Basic

psychological needs as a unifying concept. *Psychological Inquiry*, *11*(4), 319–338.

https://doi.org/10.1207/S15327965PLI1104_03

Ryan, R. M., & Deci, E. L. (2000b). Self-determination theory and the facilitation of intrinsic

motivation, social development, and well-being. *American Psychologist*, *55*(1), 68–78.

https://doi.org/10.1037/0003-066X.55.1.68

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in*

motivation, development, and wellness. New York: Guilford Press.

Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization:

Examining reasons for acting in two domains. *Journal of Personality and Social*

Psychology, *57*(5), 749–761. https://doi.org/10.1037//0022-3514.57.5.749

Schatt, M. D. (2018). Middle school band students' self-determination to practice.

Psychology of Music, *46*(2), 208–221. https://doi.org/10.1177/0305735617705008

Schmidt, C. P. (2005). Relations among Motivation, Performance Achievement, and Music

Experience Variables in Secondary Instrumental Music Students. *Journal of Research in*

Music Education, *53*(2), 134–147. https://doi.org/10.1177/002242940505300204

Seligman, M. E. P. (2011). *Flourish: A visionary new understanding of happiness and well-*

being (First Atria paperback edition). New York: Atria.

Sheldon, K. M., & Elliot, A. J. (1999). Goal striving, need satisfaction, and longitudinal well-

being: The self-concordance model. *Journal of Personality and Social Psychology*, *76*(3),

482–497. https://doi.org/10.1037//0022-3514.76.3.482

Sheldon, K. M., Osin, E. N., Gordeeva, T. O., Suchkov, D. D., & Sychev, O. A. (2017).

Evaluating the Dimensionality of Self-Determination Theory's Relative Autonomy

Continuum. *Personality & Social Psychology Bulletin*, *43*(9), 1215–1238.

https://doi.org/10.1177/0146167217711915

Silverman, M. J., & Baker, F. A. (2018). Flow as a mechanism of change in music

therapy: Applications to clinical practice. *Approaches: An Interdisciplinary Journal of*

Music Therapy, *10*(1), 43–51.

Silverman, M. J., Baker, F. A., & MacDonald, R. A. R. (2016). Flow and meaningfulness as

predictors of therapeutic outcome within songwriting interventions. *Psychology of Music*,

44(6), 1331–1345. https://doi.org/10.1177/0305735615627505

Sinnamon, S., Moran, A., & O'Connell, M. (2012). Flow Among Musicians. *Journal of*

Research in Music Education, *60*(1), 6–25. https://doi.org/10.1177/0022429411434931

Stebbins, R. (2017). Leisure Music Production: Its Spaces and Places. In R. Mantie & G. D.

Smith (Eds.), *[Oxford handbooks]. The Oxford handbook of music making and leisure*

(pp. 347–361). New York, NY: Oxford University Press.

Swann, C., Piggott, D., Schweickle, M., & Vella, S. A. (2018). A Review of Scientific

Progress in Flow in Sport and Exercise: Normal Science, Crisis, and a Progressive Shift.

Journal of Applied Sport Psychology, *30*(3), 249–271.

https://doi.org/10.1080/10413200.2018.1443525

Tan, L., & Sin, H. X. (2019). Flow Research in Music Contexts: A Systematic Literature

Review. *Musicae Scientiae*, *6*(14), 102986491987756.

https://doi.org/10.1177/1029864919877564

Tang, M., Wang, D., & Guerrien, A. (2020). A systematic review and meta-analysis on basic

psychological need satisfaction, motivation, and well-being in later life: Contributions of

self-determination theory. *PsyCh Journal*, *9*(1), 5–33. https://doi.org/10.1002/pchj.293

Thompson, E. R. (2007). Development and validation of an internationally reliable short-

form of the Positive and Negative Affect Schedule (PANAS). *Journal of Cross-Cultural

Psychology*, *38*(2), 227–242. https://doi.org/10.1177/0022022106297301

Valenzuela, R., Codina, N., & Pestana, J. V. (2018). Self-determination theory applied to

flow in conservatoire music practice: The roles of perceived autonomy and competence,

and autonomous and controlled motivation. *Psychology of Music*, *46*(1), 33–48.

https://doi.org/10.1177/0305735617694502

Weinberg, M. K., & Joseph, D. (2016). If you're happy and you know it: Music engagement

and subjective wellbeing. *Psychology of Music*, *45*(2), 257–267.

https://doi.org/10.1177/0305735616659552

Weiner, B. (1972). Attribution Theory, Achievement Motivation, and the Educational

Process. *Review of Educational Research*, *42*(2), 203–215.

https://doi.org/10.3102/00346543042002203

Yang, Y., Zhang, Y., & Sheldon, K. M. (2018). Self-determined motivation for studying

abroad predicts lower culture shock and greater well-being among international students:

The mediating role of basic psychological needs satisfaction. *International Journal of

Intercultural Relations*, *63*, 95–104. https://doi.org/10.1016/j.ijintrel.2017.10.005

Appendix A

Within- and Between-Person Correlations of Study Variables with Covariates

	Age	Gender	Relationship Status[a]				Big Five					Stress[b]	Weekend
			Relation-ship	Married	Divorced	Widowed	E	A	C	N	O		
Autonomous Motivation	-.04	.01	.05	.01	.03	-.12	.09	.02	.06	-.09	.08	-.16 -.14	.01
Flow: Fluency of performance	.02	.14	.00	.04	.03	-.01	.16	.16	.28	-.29	.14	-.19 -.19	.07
Flow: Absorption	-.09	.19	.03	-.06	.05	-.02	.14	.11	.18	-.10	.17	-.09 -.15	.06
Life Satisfaction	.23	.04	-.01	.21	-.01	.03	.20	.20	.25	-.40	.02	-.35 -.27	.08
Positive Affect	.32	.05	-.10	.24	.03	.06	.21	.16	.38	-.30	.12	-.20 -.11	.02
Negative Affect	-.38	.06	.16	-.28	-.10	-.06	-.09	-.28	-.20	.49	.00	.69 .49	-.08

Note. Table depicts correlation coefficients for age, gender, relationship status and Big Five at the between-person level, stress at both the within- and

between-person level, weekend at the within-person level. E = Extraversion. A = Agreeableness. C = Conscientiousness. N = Neuroticism. O = Openness.

[a]Dummy variables; *Single* was coded as reference category.

[b]Upper values refer to the between-level, lower values to the within-level.

p < .05. **p* < .01. ***p* < .001.

Appendix B

Measurement Model and Correlations of Latent Flow (Fluency and Absorption), Positive and Negative Affect

		Within		Between		Factor correlations[a]			
		Estimate	95% CI	Estimate	95% CI	Positive Affect	Negative Affect	Flow: Fluency	Flow: Absorption
Positive Affect						-	-.007	.603	.424
	PA1	.604	[.571; .636]	.851	[.740; .962]				
	PA2	.593	[.541; .644]	.646	[.446; .846]				
	PA3	.638	[.596; .681]	.869	[.770; .968]				
	PA4	.702	[.628; .775]	.978	[.952; 1.004]				
	PA5	.689	[.659; .720]	.904	[.829; .979]				
Negative Affect						-.042	-	-.092	.007
	NA1	.274	[.189; .359]	.830	[.670; .989]				
	NA2	.224	[.109; .340]	.784	[.566; 1.003]				
	NA3	.411	[.338; .484]	.769	[.574; .964]				
	NA4	.644	[.565; .722]	.881	[.823; .939]				
	NA5	.641	[.570; .711]	.932	[.885; .978]				
Flow: Fluency of performance						.395	-.243	-	.777
	F2	.747	[.709; .785]	.913	[.879; .946]				
	F4	.645	[.599; .691]	.813	[.747; .879]				
	F5	.756	[.707; .805]	.855	[.807; .904]				
	F7	.686	[.643; .729]	.892	[.848; .936]				
	F8	.522	[.451; .593]	.830	[.758; .902]				
	F9	.502	[.433; .571]	.790	[.703; .878]				
Flow: Absorption						.390	-.151	.851	-
	F1	.529	[.479; .580]	.471	[.371; .571]				
	F3	.695	[.655; .735]	.818	[.763; .873]				
	F6	.808	[.780; .836]	.951	[.913; .989]				
	F10	.633	[.590; .675]	.792	[.717; .867]				

Note. Table depicts standardized coefficients and 95% confidence intervals. PA = Positive Affect. NA = Negative Affect. F = Flow.

[a]Values in the upper diagonal refer to the between-level, values in the lower diagonal to the within-level.

Appendix C

Path Coefficients of the Covariates in the Mediation Model (ML-SEM) of the Effect of Autonomous Motivation on Life Satisfaction, Positive and Negative Affect via Flow

		Flow: Fluency of performance	Flow: Absorption	Life Satisfaction	Positive Affect	Negative Affect
Within						
Stress		**-.173*** [-.224; -.122]**	**-.131*** [-.176; -.086]**	**-.212*** [-.255; -.170]**	-.010 [-.061; .041]	**.600*** [.523; .676]**
Weekend		.025 [-.011; .060]	.032 [-.008; .062]	.019 [-.012; .049]	-.014 [-.049; .022]	.027 [-.008; .062]
Between						
Age		-.104 [-.266; .058]	-.131 [-.282; .019]	.081 [-.004; .166]	**.270*** [.157; .383]**	.013 [-.138; .164]
Gender		**.168*** [.099; .237]**	**.163*** [.090; .236]**	.006 [-.060; .071]	-.035 [-.094; .025]	-.017 [-.070; .035]
Relation-ship status[a]	Relation-ship	.038 [-.050; .126]	-.001 [-.094; .092]	**.094* [.015; .173]**	-.067 [-.146; .013]	-.031 [-.106; .043]
	Married	.035 [-.079; .150]	.011 [-.114; .135]	**.117** [.031; .202]**	-.020 [-.120; .081]	-.063 [-.151; .024]
	Divorced	.041 [-.032; .114]	.057 [-.024; .137]	-.023 [-.091; .045]	-.027[-.090; .037]	-.044 [-.096; .009]
	Widowed	.022 [-.033; .078]	.040 [-.035; .115]	.014 [-.045; .072]	-.023 [-.087; .041]	**-.034* [-.072; .004]**
Big Five	E	.018 [-.061; .097]	.014 [-.066; .095]	**.083* [.008; .159]**	**.076* [.001; .151]**	.010 [-.047; .068]
	A	.057 [-.022; .135]	.048 [-.032; .128]	.046 [-.025; .117]	-.004 [-.072; .063]	-.071 [-.138; -.004]
	C	**.160*** [.068; .253]**	.089 [.000; .178]	**.080* [.009; .150]**	.151 [-.018; .319]	**-.084* [-.166; -.003]**
	N	**-.223*** [-.334; -.134]**	-.080 [-.181; .021]	**-.208*** [-.289; -.128]**	**-.076* [-.150; -.002]**	**.206*** [.108; .304]**
	O	**.080* [.001; .162]**	**.166*** [.081; .251]**	-.055 [-.119; .010]	-.015 [-.094; .064]	**-.019* [-.082; .045]**
Stress		.022 [-.320; .364]	.026 [-.256; .307]	**-.176*** [-.289; -.063]**	.176 [-.122; .474]	**.660*** [.530; .790]**

Note. Path coefficients are standardized. 95% confidence intervals are reported in parentheses. E = Extraversion. A = Agreeableness. C =

Conscientiousness. N = Neuroticism. O = Openness.

[a]Dummy variables; *Single* was coded as reference category.

p < .05. **p* < .01. ***p* < .001.

Appendix A2 – Manuscript 2

Koehler, F., Martin, Z. S., Hertrampf, R. S., Gäbel, C., Kessler, J., Ditzen, B., & Warth, M. (2020). Music therapy in the psychosocial treatment of adult cancer patients: A systematic review and meta-analysis. *Frontiers in Psychology*, *11*, 651. doi:10.3389/fpsyg.2020.00651

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conceptualization, formal analysis, investigation, resources, data curation, writing – original draft, writing – review and editing, project administration

Music Therapy in the Psychosocial Treatment of Adult Cancer Patients: A Systematic Review and Meta-Analysis

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Introduction: Music therapy is used as an adjunct oncological treatment aiming at the improvement of psychological and physical well-being through music. A growing body of randomized and non-randomized controlled trials has been published and reviewed recently. However, a global, quantitative assessment of the effectiveness of music therapy in adult cancer care is missing. The present study thus aims to synthesize the evidence of music therapy in different oncological treatment phases.

Methods: We conducted a pre-registered systematic review and meta-analysis (PROSPERO-ID: CRD42019133084) following standard guidelines. We searched electronic databases for studies on music therapy performed by a therapist with adult cancer patients.

Results: The narrative synthesis included thirty studies showing that music therapy overall had positive effects on a broad range of outcomes, with techniques and effects varying in different phases. During curative treatment, results were most promising with regard to anxiety, depression, and pain medication intake, while in palliative settings, improvements with regard to quality of life, spiritual well-being, pain, and stress were reported. Twenty-one studies were included in the meta-analysis which showed small but significant effects of music therapy on psychological well-being ($d = 0.35$, $p < 0.001$), physical symptom distress ($d = -0.26$, $p = 0.017$), and quality of life ($d = 0.36$, $p = 0.023$). Heterogeneity between effect sizes was small to medium. Moderator analyses identified studies with a single session of music therapy and the use of receptive techniques to produce larger effects regarding psychological well-being.

Conclusion: Music therapy can improve relevant health-outcomes in cancer patients and should therefore be offered in various treatment phases. Future research should include potential moderators such as individual information about patients to find out who benefits most from different kinds of music therapy.

Keywords: music therapy, oncology, cancer, effectiveness, randomized controlled trials, quality of life, supportive care, complementary therapies

INTRODUCTION

Music therapy is a frequently used complementary and creative arts treatment in psychosocial cancer care (Bro et al., 2018). The general goal is to relieve symptom distress and to improve quality of life of patients in various stages of an oncological disease. Particularly in advanced cancer populations and palliative care, music therapy has recently received high attention in both research and clinical care (Stützlinger et al., 2018; Warth et al., 2019a). The use of music and sounds to affect human spirit and to heal dates back to ancient times. However, the modern understanding of clinical music therapy as a psychotherapeutic health-care discipline has developed after World War II, when academic courses and trainings as well as national associations were established around the world (Edwards, 2008). Today, music therapy is defined as "the systematic use of music within a therapeutic relationship which aims at restoring, maintaining and furthering emotional, physical and mental health" (Deutsche Musiktherapeutische Gesellschaft, 2019). Highlighting the importance of the therapeutic relationship, this definition clearly distinguishes music therapy from music medicine or mere listening interventions, such as listening to prerecorded music during surgery (Bradt et al., 2016). Nowadays, various health-care settings, including psychiatry, geriatrics, palliative care and oncology, offer music therapy to promote psychological, physical, or spiritual well-being (Deutsche Musiktherapeutische Gesellschaft, 2019).

In psycho-oncological care, music therapy is recommended by national guidelines in Germany as a treatment option to alleviate anxiety or existential fears (Leitlinienprogramm Onkologie., 2014) In the course of a life-threatening illness and its treatment, patients and relatives can experience a multitude of physical, psychological, social and spiritual distress strongly impairing their quality of life (Holland et al., 2010). Therefore, a multi-professional oncological treatment team is necessary to provide both medical and non-pharmacological interventions to address the patient's diverse needs. Psychosocial interventions, like psychotherapy or creative arts therapies, particularly aim at improving psychological well-being, building coping skills, and establishing social resources (Holland et al., 2010).

For this purpose, music therapy specifically can use music as a way of non-verbal expression and communication of cancer patients. Particularly, music therapists in oncology can offer multifaceted support in dealing with anxiety related to the disease or the medical procedures, in coping with stressful physical and emotional conditions, in stabilizing mood fluctuations, and in symptom management (e.g., pain, dyspnea, fatigue). Moreover, music therapy has been used to facilitate communication in patients and relatives as well as to address spiritual needs and existential fears (Bradt et al., 2016).

Moreover, music therapy was shown to promote relaxation and thus reduce stress, respiratory problems, and pain (Stützlinger et al., 2018). To achieve these goals, music therapists can offer a wide range of techniques to cancer patients and mostly tailor their therapeutic program to the individual's needs. Generally, active techniques can be distinguished from receptive techniques. In active music therapy, the patient participates in the production of music (e.g., by singing or playing an instrument), whereas receptive music therapy guides the patient in listening to live or recorded music (Stützlinger et al., 2018). In the treatment of cancer patients, techniques mainly encompass music-assisted relaxation and imagery, songs and improvisations (Warth et al., 2015b).

Previous reviews and meta-analyses of music interventions in oncology have shown positive effects on anxiety, depression, fatigue, and pain as well as physiological parameters (heart rate, respiration rate, and blood pressure) in cancer patients (Boyde et al., 2012; Zhang et al., 2012; Archie et al., 2013; Nightingale et al., 2013; Tsai et al., 2014; Bradt et al., 2016; Bro et al., 2018; Stützlinger et al., 2018; Gramaglia et al., 2019). However, the validity of these reviews was often restricted with regard to the inclusion or exclusion of certain patient populations, outcomes or interventions, which impeded a general conclusion about the quantitative effect of music therapy in adult cancer patients. For instance, one review was limited to evidence available in Chinese (Zhang et al., 2012), while other meta-analyses included studies with underage cancer patients (Boyde et al., 2012; Bradt et al., 2016), which from a clinical point of view requires a considerably distinct therapeutic approach. Another recent meta-analysis (Bro et al., 2018) included only cancer patients who underwent curative treatment while studies investigating patients in other treatment phases (e.g., during diagnoses, rehabilitation, or palliative care) were excluded. Similarly, some reviews focused solely on palliative care (Archie et al., 2013; Gramaglia et al., 2019) or included studies with music medicine interventions (Nightingale et al., 2013; Tsai et al., 2014).

A recent health technology assessment in Germany (Stützlinger et al., 2018) specifically considered music therapy interventions with more than one session attended by full age cancer patients in all treatment phases and concluded that music therapy has a positive short-term effect on psychological outcomes in cancer patients. No evidence was found for long-term or physiological effects. However, these results are based on a systematic review without meta-analytical support. Therefore, the aim of the present review and meta-analysis was to provide a narrative and quantitative synthesis of the effects of music therapy in adult cancer patients in all stages of the disease.

MATERIALS AND METHODS

The review was conducted in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines (Liberati et al., 2009). Additionally, we performed a meta-analysis with studies providing sufficient data. At the beginning of our research, a study protocol was published in the international prospective register of systematic reviews (PROSPERO-ID: CRD42019133084).

Eligibility Criteria

Criteria for inclusion were pre-specified according to the PICOS framework (participants, interventions, comparisons, outcomes, study design) (Liberati et al., 2009) and can be seen in **Table 1**. Studies investigating adult patients with more than 80% of them having a primary cancer diagnosis of any type at

TABLE 1 | Eligibility criteria.

Domain	Inclusion criteria
Patients	• Adult cancer patients at all stages • More than 80% with a primary cancer diagnosis
Interventions	• Music therapy provided by a trained therapist • Active and receptive interventions
Comparators	• Waiting list • Treatment as usual • Active control group
Outcomes	• Not specified
Study designs	• Randomized controlled trials • Controlled clinical trials

any stage were included. Patients received either inpatient or outpatient oncological treatment. To meet the definition of music therapy, the interventions needed to be delivered by a trained therapist. Active as well as receptive interventions were included. Outcomes were not specified in the search syntax in order to get a complete list of variables measured in this context. Experimental groups could be compared to a waiting list group, a treatment as usual group or an active control group with a pretest-posttest-comparison. Randomized controlled trials as well as controlled clinical trials were accepted.

Literature Search

Electronic sources for primary studies search were the databases PubMed, PsychInfo, and CINAHL. The syntax used for literature search in PsychInfo was:

(AB oncol* OR AB cancer OR AB carcinomatosis OR AB cancer patients OR AB carcinosis OR AB palliative care OR AB leukemia OR AB carcino* OR AB neoplasm OR AB chemotherapy OR AB end of life OR AB hospice OR AB tumor OR AB malign*) AND (AB drumming ORAB choir ORAB melody OR AB music OR AB singing) AND (AB random* OR AB rct OR AB controlled trial OR AB cct OR AB clinical trial).

Additionally, relevant reviews concerning this topic and references of primary studies were hand-searched. Only studies published in English or German were included. The literature search was conducted in February 2019.

Study Selection, Data Extraction, and Risk of Bias Assessment

Detected studies were imported into Rayyan (Ouzzani et al., 2016). Two researchers independently screened abstracts and rated them according to the eligibility criteria. In case of exclusion, the most prominent reason was given. Discrepancies were resolved by discussion. Afterwards, full texts were read and if in line with eligibility criteria, data was extracted from the selected studies and entered into a coding sheet containing the PICOS categories and the Cochrane Risk of Bias Assessment Tool (**Table 2**) which helps to assess methodological study quality and was adopted for psychotherapy research (Munder and

Barth, 2017). Again, two researchers rated independently and discussed discrepancies.

Regarding the systematic review, all studies matching eligibility criteria were considered. Only studies providing sufficient data were then included in the meta-analysis. In case of missing information in the papers, authors were contacted by email. If they did not answer or could not provide the missing data, the study was excluded of the meta-analysis.

Statistical Analysis

The list of outcome variables was grouped into categories. Three of them (psychological well-being, quality of life, and physical symptom distress) were applicable for meta-analysis (i.e., more than five effect sizes per category; pre- and post-means, sample sizes per study group, and standard deviations reported). Psychological well-being encompasses outcomes such as mood, anxiety, and depression, whereas physical symptom distress includes pain, generic physical symptom scales, and fatigue. Data of other categories (spiritual and social well-being as well as biomarkers) were only considered in the narrative synthesis. If a study reported multiple outcomes of one category, the measurement or kind of outcome that was used more often in other studies was included to avoid dependencies within categories.

Effect sizes were estimated based on the difference of mean pretest-posttest change in the treatment and control group divided by the pooled standard deviation before intervention. This calculation takes most advantage of the information given in the studies as it considers baseline differences between groups (Morris, 2008) and is recommended in a recent methodological review of meta-analyses in clinical psychology (Rubio-Aparicio et al., 2017). This effect size is a variation of Cohen's d and can be interpreted correspondingly (small: $d = 0.2–0.5$, medium: $d = 0.5–0.8$, large: $d = 0.8$) (Cohen, 1992). To calculate sampling variance of standardized mean change differences, the pretest-posttest correlation for quality of life, psychological well-being, and physical symptom distress was estimated based on previous research (Warth et al., 2015a).

Meta-analysis was performed using the "metafor" package in R (Viechtbauer, 2010). As it is implausible to assume that true effect sizes in all studies are the same due to variance e.g., in participants, interventions or study designs, a random effects model was computed. Heterogeneity was analyzed with τ, Q-test, and I^2. τ describes the standard deviation of the true effect size, Q allows a significance test and I^2 is the relation of true to observed heterogeneity (Borenstein et al., 2011). Plausible sources of heterogeneity were setting of cancer treatment (inpatient vs. outpatient/mixed), treatment phase (palliative vs. curative), type of music therapy (active/mixed vs. receptive), duration of music therapy session (short ≤ 30 min vs. long ≥ 30 min), frequency of music therapy sessions (one vs. more) and type of control group (treatment as usual/waiting list vs. active control). To find out if these possible moderators explained variance between effects, their values were dichotomized due to the small amount of studies in each category, and a moderator analysis was conducted.

To test presence of publication bias, funnel plots were inspected, and Egger's regression test for asymmetry was

TABLE 2 | Study characteristics.

Study	Setting and patients	Intervention	Control group	Study design	Main findings	Outcomes included in meta-analysis
Alcântara-Silva et al. (2018)	Outpatient cancer treatment hospital, patients with gynecological cancer, $N = 164$	Music listening; 10 sessions, 35 min	TAU	RCT	Stronger increase in quality of life, stronger decrease in fatigue and depression in EG	
Allen (2010)	After care, patients with breast cancer who were in remission, $N = 11$	Music imaging (group therapy); 10 sessions, 60 min	ACG: cognitive behavioral therapy	RCT	Stronger increase in feelings of identity, family role relationship, self-esteem and body image in EG	
Bates et al. (2017)*	Inpatient blood and marrow transplantation unit, patients with lymphoma or myeloma, $N = 82$	Music listening and creating; 2 sessions, 30 min.	TAU	RCT	Less pain medication in EG, no significant difference in subjective pain perception	PSYCH: POMS
Bieligmeyer et al. (2018)*	Inpatient oncology department, patients with breast or colorectal cancer, $N = 44$	Sound bed; 1 session, 15 min	TAU	RCT	Stronger increase in well-being, quality of life and physiological symptoms in EG, no significant differences in pain and social extraversion	PSYCH: BMQ, PHYSIC: VAS
Bradt et al. (2015)*	In and outpatients from a hospital, patients with cancer (various types), $N = 31$	Music therapy (multiple techniques); 2 sessions, 20–45 min	ACG: listening to music	RCT	No significant group differences in mood, anxiety, relaxation and pain	PSYCH: VAS, PHYSIC: 11-point numeric rating scale
Burns (2001)*	Outpatient oncology offices, patients with breast or ovarian cancer, $N = 8$	Bonny method of guided imagery and music; 10 sessions, 60–90 min	Waitlist	RCT	Stronger increase in mood and quality of life in EG	PSYCH: POMS, QOL: QOL-CA
Burns et al. (2007)	Inpatient hematology oncology unit, patients with leukemia	Music imagery; 8 sessions, 45 min	TAU	RCT	No significant group difference in positive and negative effect, anxiety and quality of life	
Burns et al. (2018)	Outpatients from cancer centers, patients with various types of cancer, $N = 86$	Guided visualization with music; 1 session, 45–50 min	ACG: listening to music	RCT	Stronger increase in responsiveness and benefit finding in EG, stronger decrease in distress in CG	
Cassileth et al. (2003)*	Inpatient cancer centers, patients with lymphoma or myeloma, $N = 69$	Music listening and creating; 3–7 sessions, 20–30 min.	TAU	RCT	Stronger decrease in depression, anxiety and mood in EG	PSYCH: POMS
Chen et al. (2018)	Outpatient medical center, patients with beast cancer, $N = 52$	Music imagery; 8 sessions, 60 min	TAU	RCT	Stronger decrease of depression, helplessness, hopelessness and cognitive avoidance in EG	
Cook and Silverman (2013)	Inpatient oncology-hematology unit, patients with leukemia and other cancers, $N = 34$	Music listening and conversations; 3 sessions, 15–30 min	Waitlist	RCT	Stronger increase in spiritual well-being in EG	
Domingo et al. (2015)*	Inpatient palliative care unit, patients with advanced cancer, $N = 68$	Music therapy (multiple techniques); 4 sessions, 30*40 min	TAU	CCT	Stronger increase in well-being in EG	PSYCH: HADS, QOL: well-being single item
Dóro et al. (2017)*	Inpatient allogeneic hematopoietic stem cell transplantation unit, patients with neoplastic hematologic disorders, $N = 100$	Music singing and improvisation; 8 session, 30 min	TAU	RCT	Stronger increase in mood in EG, no significant difference in anxiety and pain	PSYCH: VAS; PHYSIC: VAS
Fredenburg and Silverman (2014)*	Inpatient adult blood and marrow transplantation unit, patients with leukemia and lymphoma, $N = 11$	Music therapy (multiple techniques); 30–45 min	Waitlist	RCT	No significant group difference	PHYSIC: MFI

(Continued)

TABLE 2 | Continued

Study	Setting and patients	Intervention	Control group	Study design	Main findings	Outcomes included in meta-analysis
Fredenburg and Silverman (2014)	Inpatient adult blood and marrow transplantation unit, patients with leukemia, lymphoma and myeloma, $N = 32$	Music therapy (multiple techniques); 1 sessions, 30 min	Waitlist	RCT	Stronger decrease of pain in EG, stronger increase in negative and positive effect in EG	
Gutgsell et al. (2013)*	Inpatient medical center, patients with advanced cancer (26 non-cancer patients), $N = 200$	Music relaxation; 1 session, 20 min	Waitlist	RCT	Stronger decrease in pain in EG	PHYSIC: 11-point numeric rating scale
Hanser et al. (2006)*	In and outpatients from breast oncology clinic, patients with breast cancer, $N = 42$	Music therapy (multiple techniques); 3 session, 45 min	TAU	RCT	Increase in relaxation, comfort and happiness in EG	QOL: FACT-G, PHYSIC: FACT-G (subscale), PSYCH: HADS
Hilliard (2003)*	Outpatient hospice, patients with advanced cancer, $N = 80$	Music therapy (multiple techniques); 2–13 sessions	TAU	RCT	Stronger increase in quality of life in EG, no significant difference in length of life or physical functioning	PSYCH: HQLI-R, QOL: HQLI-R
Horne-Thompson and Grocke (2008)*	Inpatient palliative care unit, patients with advanced cancer (1 non-cancer patient), $N = 25$	Music therapy (multiple techniques); 1 session, 20–40 min	ACG: volunteer visit	RCT	Stronger decrease in anxiety	PSYCH: ESAS, PHYSIC: ESAS
Letwin and Silverman (2017)*	Inpatient medical oncology/hematology unit, patients with various types of cancer, $N = 15$	Music listening; 2 sessions, 30–45 min	Waitlist	RCT	No significant group difference in resilience and pain	PSYCH: RSES, PHYSIC: 11-point numeric rating scale
Lin et al. (2011)*	Inpatient medical center/ hospital, patients with various types of cancer, $N = 98$	Music imagery; 1 session, 60 min	TAU	RCT	Stronger decrease in anxiety in EG, stronger increase in skin temperature in EG	PSYCH: STAI
Palmer et al. (2015)*	Inpatient university hospital, patients with (potential) breast cancer, $N = 201$	Music listening before and during surgery; 1 session	TAU	RCT	Stronger decrease in anxiety and faster recovery after surgery in EG	PSYCH: VAS
Porter et al. (2018)*	Inpatient palliative care unit, patients with advanced cancer (4 non-cancer patients), $N = 42$	Music therapy (multiple sessions); 2–6 sessions, 45 min	TAU	RCT	Stronger increase in well-being	QOL: MQoL, PSYCH: MQoL, PHYSIC: MQoL
Ramirez et al. (2018)	Inpatient palliative care, patients with advanced cancer, $N = 40$	Music relaxation, active and receptive songs; 1 session, 30 min	ACG: Conversation about music	RCT	Stronger increase in valence and arousal and well-being in EG	
Rossetti et al. (2017)*	Outpatient medical center, patients with breast or head and neck cancer, $N = 78$	Music therapy (multiple techniques); 1 session, 60 min	TAU	RCT	Stronger decrease in anxiety and distress in EG	PSYCH: STAI
Tuinmann et al. (2017)*	Inpatient medical center, patients with lymphoma, $N = 66$	Music playing, singing and listening; 8 session, 20 min.	TAU	RCT	Stronger decrease in need of analgesics and subjective pain perception in EG	QOL: EORTC QLQ-C30, PAIN: EORTC QLQ-C30
Verstegen (2016)*	Inpatient blood and marrow transplantation unit, patients with cancer, $N = 10$	Music listening and therapeutic dialogue; 2 session, 30–60 min	TAU	RCT	Stronger increase in hope in EG, no significant difference in pain	PSYCH: HHI, PHYSIC: 11-point numeric rating scale
Wang et al. (2015)	Inpatient cancer hospital, patients with lung cancer, $N = 60$	Music relaxation during surgery, music listening afterwards; 5 sessions, 60 min	TAU	RCT	Stronger decrease in anxiety, lower blood pressure and heart rate, less need for analgesics in EG	

(Continued)

TABLE 2 | Continued

Study	Setting and patients	Intervention	Control group	Study design	Main findings	Outcomes included in meta-analysis
Warth et al. (2015b)*	Inpatient palliative care, patients with cancer (2 non-cancer patients), N = 84	Music relaxation; 2 sessions, 30 min	ACG: pre-recorded mindfulness exercise	RCT	Stronger increase in relaxation and well-being and in high-frequency oscillation of the heart rate and stronger decrease in fatigue in EG, no significant difference in pain	QOL: VAS, PSYCH: EORTC QLQ C15-PAL, PHYSIC: VAS
Yates and Silverman (2015)*	Inpatient surgical oncology unit, patients with colon/rectal or uterine cancer, N = 26	Music listening; 1 session, 20–30 min	Waitlist	RCT	Stronger decrease in anxiety and in crease in relaxation in EG	PSYCH: QMS

*Studies marked with * were included in meta-analyses; TAU, treatment as usual; ACG, active control group; RCT, randomized controlled trial; CCT, controlled clinical trial; EG, experimental group; CG, Control group; PSYCH, psychological well-being; QOL, quality of life; PHYSIC, physical symptom distress; Poms, Profile of mood states; BMQ, Basler Mood Questionnaire; VAS, Visual Analogue Scale; QOL-CA, Quality of life – Cancer scale; HADS, Hospital Anxiety and Depression Scale; MFI, Multidimensional Fatigue Inventory; FACT-G, Functional Assessment of Cancer Therapy—General; HQLI-R, Hospice Quality of Life Index—Revised; ESAS, Edmonton Symptom Assessment Scale; RSES, Response to Stressful Events Scale; STAI, Stait Trait Anxiety Inventory; MQoL, McGill Quality of Life Questionnaire; EORTC QLQ-C30, Quality of Life Questionnaire; HHI, Herth Hope Index; EORTC QLQ-C15-Pal, Quality of Life Questionnaire for Palliative Care; QMS, 12-item quick mood scale.*

conducted (Egger et al., 1997). In case of asymmetry, the trim-and-fill method was applied to correct asymmetry in the funnel plot (Duval and Tweedie, 2000). In order to identify outliers and influential studies, Baujat plot was inspected and a set of diagnostics (e.g., standardized residuals, Cook's distance) was conducted. If an effect showed a pattern of deviation in graphical outputs of these statistics, it was excluded and sensitivity analysis was performed. Type I error probability was set at α = 0.05.

RESULTS

After the description of the study selection process, we provide a narrative synthesis of information from primary studies, categorized into different oncological treatment phases, and then proceed to the results of the meta-analysis. **Table 2** presents an overview of the study characteristics. Of note, nine studies described in the narrative synthesis were excluded from statistical meta-analysis due to insufficient data reporting.

Study Selection
Data base search according to our syntax resulted in $n = 363$ studies. Two additional studies were identified through other sources. After removal of duplicates $n = 228$ studies remained. Their abstracts were screened and $n = 171$ studies were removed due to reasons listed in in **Figure 1**. Full texts of the remaining $n = 57$ studies were assessed for eligibility. After that $n = 30$ studies remained for the narrative synthesis. For quantitative analysis, studies with insufficient data ($n = 7$) as well as studies with measures that did not fit into one of the outcome categories ($n = 2$) (Cook and Silverman, 2013; Ramirez et al., 2018) were excluded and $n = 21$ studies remained. The full study selection process is shown in **Figure 1**.
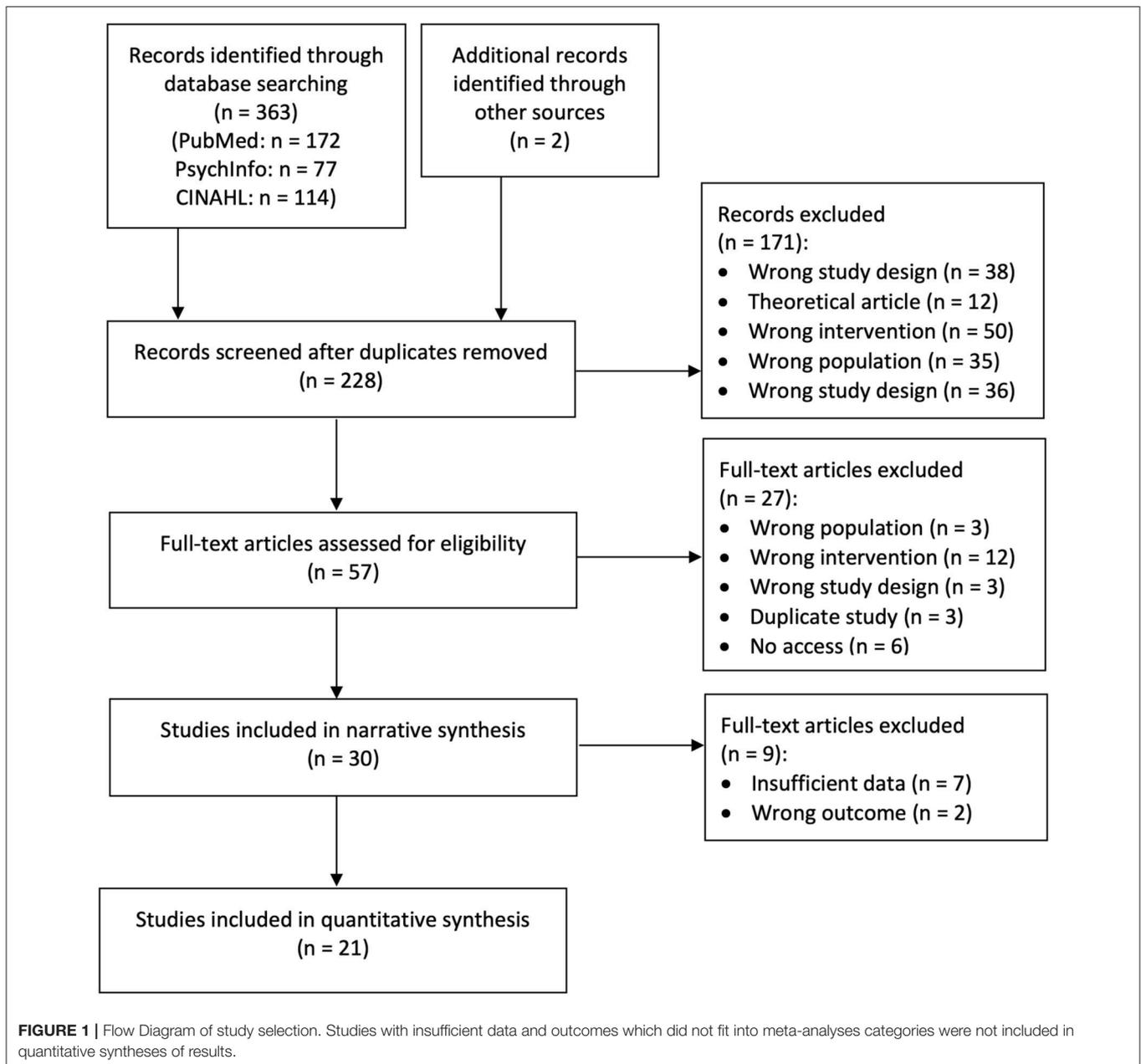
Risk of Bias Assessment
Results of risk of bias assessment can be seen in **Table 3**. Although ratings overall show high bias in all studies, the extent of different biases varies among studies. Only four studies out of 30 had low risk of bias in four categories (Palmer et al., 2015;

Warth et al., 2015a; Letwin and Silverman, 2017; Bieligmeyer et al., 2018) and five in three categories (Cassileth et al., 2003; Hanser et al., 2006; Horne-Thompson and Grocke, 2008; Bradt et al., 2015; Dóro et al., 2017).

With regard to the specific categories, the risk in randomization and allocation sequence was low or unclear in all studies, except one that was a controlled clinical trial (Domingo et al., 2015). Risk of bias in blinding of participants and personnel was high or unclear because no study reported assessment of patients' expectancies. Five studies reported blinding of outcome assessors, the others did not provide sufficient data on outcome assessment or lacked blinding of outcome assessors. Four studies showed a high risk of inappropriate handling of missing data. No study was rated high on selective outcome reporting and four studies provided a study protocol (Palmer et al., 2015; Warth et al., 2015a; Tuinmann et al., 2017; Bieligmeyer et al., 2018). Only one study provided information on treatment implementation (Allen, 2010).

Study Description and Narrative Synthesis
Music Therapy During Chemotherapy and Radiation
Ten studies examined the effects of music therapy in the course of chemotherapy or radiation treatment on diverse outcomes. Three focused specifically on music therapy as an adjunct treatment during chemotherapy. A study by Lin and colleagues investigated the effectiveness of three different study conditions in patients undergoing chemotherapy: A 1 h single music therapy session, a 30 min verbal guided relaxation, and standard care (Lin et al., 2011). Both music therapy and verbal relaxation showed to be effective in reducing chemotherapy-related anxiety compared to standard care alone. Besides, the music therapy group achieved a greater increase in skin temperature compared to the other groups. Hanser et al. (2006) compared three sessions of music therapy targeted at stress coping with standard care in breast cancer patients receiving chemotherapy. They detected positive effects on relaxation, comfort, and happiness, as well as on stress biomarkers (resting heart rate and blood pressure). A quasi-experimental trial studying the

FIGURE 1 | Flow Diagram of study selection. Studies with insufficient data and outcomes which did not fit into meta-analyses categories were not included in quantitative syntheses of results.

same population and cancer treatment found a reduction in depressive symptoms, helplessness, hopelessness, and cognitive avoidance after participation in a group music therapy program (Chen et al., 2018).

Two studies assessed the effects of music therapy in the course of radiation therapy and found reductions in anxiety and distress (Rossetti et al., 2017) as well as improvements regarding quality of life, fatigue, and depression (Alcântara-Silva et al., 2018). Techniques used in these studies encompassed listening to prerecorded music, live music therapy, and conversations with a therapist.

Five more studies were identified that studied patient populations receiving some sort of combination of chemotherapy

and radiation treatment. Three of these were RCTs by Burns and colleagues that compared music-based imagery with different control conditions. In the first study, the guided music intervention led to greater improvements in mood states and quality of life than the waitlist control group (Burns, 2001). In the second study, the authors found improvements in both study groups regarding positive and negative affect as well as fatigue and anxiety (Burns et al., 2007). In the third study by this group, single sessions of music-based imagery attained higher responsiveness to music therapy and benefit finding, whereas preferred music listening led to lower distress (Burns et al., 2018). Fredenburg and Silverman (2014) conducted two pilot RCTs with post-transplantation patients receiving chemotherapy and/or

References	RAND	ALLO	BLPP	BLOA	INCDAT	SELREP	TREAT
Alcântara-Silva et al. (2018)	Low	Unclear	High	Unclear	Unclear	Unclear	Unclear
Allen (2010)	Low	Unclear	Unclear	Unclear	Unclear	Unclear	Low
Bates et al. (2017)	Low	Low	High	Unclear	Unclear	Unclear	Unclear
Bieligmeyer et al. (2018)	Low	Low	High	Unclear	Low	Low	Unclear
Bradt et al. (2015)	Low	Low	Unclear	Low	Unclear	Unclear	Unclear
Burns (2001)	Unclear	Unclear	High	Unclear	Unclear	Unclear	Unclear
Burns et al. (2007)	Unclear	Unclear	High	Unclear	Unclear	Unclear	Unclear
Burns et al. (2018)	Low	Unclear	Unclear	Low	Unclear	Unclear	Unclear
Cassileth et al. (2003)	Low	Low	High	Unclear	Low	Unclear	Unclear
Chen et al. (2018)	Unclear	Unclear	High	High	Low	Low	Unclear
Cook and Silverman (2013)	Low	Unclear	High	High	High	Unclear	Unclear
Domingo et al. (2015)	High	High	High	Unclear	Unclear	Unclear	Unclear
Dóro et al. (2017)	Low	Low	High	Low	Unclear	Unclear	Unclear
Fredenburg and Silverman (2014)	Low	Unclear	High	High	Unclear	Unclear	Unclear
Fredenburg and Silverman (2014)	Low	Unclear	High	High	High	Unclear	Unclear
Gutgsell et al. (2013)	Low	Low	Unclear	High	Unclear	Unclear	Unclear
Hanser et al. (2006)	Low	Low	High	Low	Unclear	Unclear	Unclear
Hilliard (2003)	Low	Unclear	High	High	Unclear	Unclear	Unclear
Horne-Thompson and Grocke (2008)	Low	Low	Unclear	Low	Unclear	Unclear	Unclear
Letwin and Silverman (2017)	Low	Low	High	High	Low	Low	Unclear
Lin et al. (2011)	Low	Unclear	High	High	Low	Unclear	Unclear
Palmer et al. (2015)	Low	Low	High	Unclear	Low	Low	Unclear
Porter et al. (2018)	Low	Low	High	High	High	Unclear	Unclear
Ramirez et al. (2018)	Low	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
Rossetti et al. (2017)	Low	Unclear	High	Unclear	Unclear	Unclear	Unclear
Tuinmann et al. (2017)	Unclear	Unclear	High	Unclear	Low	Low	Unclear
Verstegen (2016)	Unclear	Unclear	High	High	Unclear	Unclear	Unclear
Wang et al. (2015)	Low	Low	High	Unclear	Unclear	Unclear	Unclear
Warth et al. (2015b)	Low	Low	Unclear	High	Low	Low	Unclear
Yates and Silverman (2015)	Unclear	Unclear	High	High	High	Unclear	Unclear

RAND, random sequence generation; ALLO, allocation concealment; BLPP, blinding of participants and personnel; BLOA, blinding of outcome assessors; INCDAT, incomplete outcome data; SELREP, selective outcome reporting; TREAT, treatment implementation.

radiation. The first study with a very low sample size found no between-group difference in fatigue compared to a waitlist control group (Fredenburg and Silverman, 2014). In contrast, the second study showed a single session of receptive music therapy with patient-selected live music to be effective with regard to reductions in negative affect and pain (Verstegen, 2016).

Hence, findings for music therapy as an adjunct treatment during radiation and chemotherapy are mixed, and allocation of studies to a certain primary treatment phase was partially ambiguous. Techniques used by music therapists were heterogeneous including relaxation and imagery, listening to music with a therapist, improvisation, and songwriting. Effects were most promising with regard to the reduction of anxiety, distress, depression, and pain.

Music Therapy During Surgery and Transplantation

Eight studies were included that focused on the use of music therapy in the course of surgery and transplantations. In one of them, lung cancer patients listened to relaxing music played by a therapist before and after surgery (Wang et al., 2015) and showed less anxiety, lower blood pressure, and heart rate parameters as well as a lower need for analgesics. Patients in Palmer and colleagues' study (Palmer et al., 2015) listened to a song before surgery and verbally reflected on it. During the operation, they listened to music chosen by the therapist. As a result, patients reported less anxiety and faster recovery in comparison to the control group. Yates and Silverman (2015) focused on the effect of music therapy after surgery and found a positive effect of receptive music therapy in combination with therapeutic conversation on anxiety and relaxation.

Another RCT studying patients undergoing blood and bone marrow transplantation (Verstegen, 2016) found no significant difference in pain but patients participating in two sessions of hope-oriented music therapy reported higher levels of hope than those in the control condition. Moreover, four studies examined the adjunct use of music therapy in the course of stem cell transplantations. In one study with two song-based music therapy sessions per week, greater improvements in mood, but

no differences in self-rated pain were observed in comparison with the control group (Dóro et al., 2017). In another trial using non-standardized interventions, patients receiving two music therapy sessions required less pain medication even though the subjective pain reduction was similar in music therapy and the control group (Bates et al., 2017). The reduction in analgesics intake was also found in a similar study, where stem cell transplantation patients additionally reported a short-term reduction of subjective pain perception (Tuinmann et al., 2017). Moreover, positive effects of music therapy on immunological parameters and frequency of toxic side effects were found (Tuinmann et al., 2017). Another study investigated music therapy with stem cell transplantation patients over a longer period of time and with varying session numbers (Cassileth et al., 2003). The music therapy group showed positive effects on depression, anxiety, and mood in comparison to the control group.

Taken together, evidence on the use of music therapy during surgery and transplantation is promising, particularly with regard to the supportive management of anxiety and pain.

Music Therapy in Aftercare

In the only available pilot study on music therapy in oncological aftercare, successfully treated breast cancer patients took part in a group music therapy program over 10 weeks (Allen, 2010). Sessions encompassed receptive techniques like relaxation and imagery followed by debriefing, while the control group received cognitive behavioral psychotherapy. The small sample of 11 patients showed that patients in music therapy groups reported improved feelings of identity, family role relationship, self-esteem, and body image compared to the control group.

Music Therapy in Palliative Care

Seven trials were identified that studied palliative patient populations. One study (Warth et al., 2015a) investigated the effects of two sessions of guided music relaxation on psychological and physiological outcomes. The experimental group showed improvements in relaxation and well-being, an increase in heart rate variability and a reduction in fatigue in comparison with the active control group. Only with regard to pain, there was no significant group difference. In contrast, another study (Gutgsell et al., 2013) found an improvement in pain after one session of music relaxation with live music in palliative care compared to standard treatment. The effect of music relaxation was also supported by a study with electroencephalogram (EEG) data analysis (Ramirez et al., 2018). Patients in the music therapy group showed an increase in valence and arousal in comparison to the active control group which had loose conversations about music with the same music therapists. Moreover, questionnaires also indicated an improvement of psychological well-being through music therapy (Ramirez et al., 2018).

Other studies used a variety of techniques individually tailored to the patient's needs. For instance, in one study, terminally ill patients received at least two home visits from a music therapist (Hilliard, 2003). These patients reported a higher increase in quality of life than those with routine hospice

service only. Regarding length of life or physical functioning, no differences were found. In another study using multiple, non-standardized techniques, a single session of music therapy was superior to a volunteer visit in reducing self-reported anxiety (Horne-Thompson and Grocke, 2008). A non-randomized trial also employing various techniques found the music therapy intervention to be superior with regard to well-being, anxiety, depression, and overall symptom distress compared to standard care alone (Domingo et al., 2015). A recent pilot RCT reported high patient drop-out and found improvements for existential well-being, but not for other quality of life domains in response to music therapy (Porter et al., 2018).

Hence, evidence regarding patients with a terminal disease in palliative care settings was mixed. Standardized treatments mainly focused on relaxation techniques while the majority of studies offered tailored interventions. Effects were most promising with regard to quality of life, pain, and spiritual well-being.

## Music Therapy in Non-specified Treatment Phases

Four other studies examined the effects of music therapy on different outcomes in cancer patients, but did not specify a particular phase of cancer treatment. One study investigated a 2-days resilience-focused music therapy intervention. The authors found no significant group differences between the intervention group and the waitlist control group regarding resilience and pain (Letwin and Silverman, 2017). Another study compared music therapy and music medicine in cancer patients. They found both interventions to be equally helpful and supportive with regard to mood, anxiety, relaxation, and pain (Bradt et al., 2015). A third study examined a 10 min vibro-acoustic music therapy intervention vs. resting time within a cross-over-design. They reported immediate improvements in well-being, quality of life, and physiological changes. However, no group differences were found in pain and social extraversion (Bieligmeyer et al., 2018). The fourth study found positive effects of music therapy on spiritual well-being in comparison to standard care (Cook and Silverman, 2013). In this study, the music therapist played live music accompanied on the guitar.

Quantitative Analysis
Meta-Analysis on Psychological Well-Being

Nineteen studies reported outcomes referring to psychological well-being. As mentioned above, one outcome per study was chosen for inclusion in our meta-analysis ($k = 19$). Included psychological outcomes encompassed anxiety, depression, psychological distress and well-being, mood, emotional functioning, relaxation, hope and resilience. Measurement instruments are shown in **Table 3**. Effect sizes of three primary studies indicated significantly better psychological well-being through music therapy in comparison to control group, other studies included zero in their confidence interval (**Figure 2**).

The overall effect calculated by the random-effects model was significant and small-sized ($d = 0.35$, CI $= 0.19$–0.50, $p < 0.001$), indicating that music therapy improves psychological well-being of oncological patients in comparison to control group treatment. Heterogeneity between studies was low and not significant
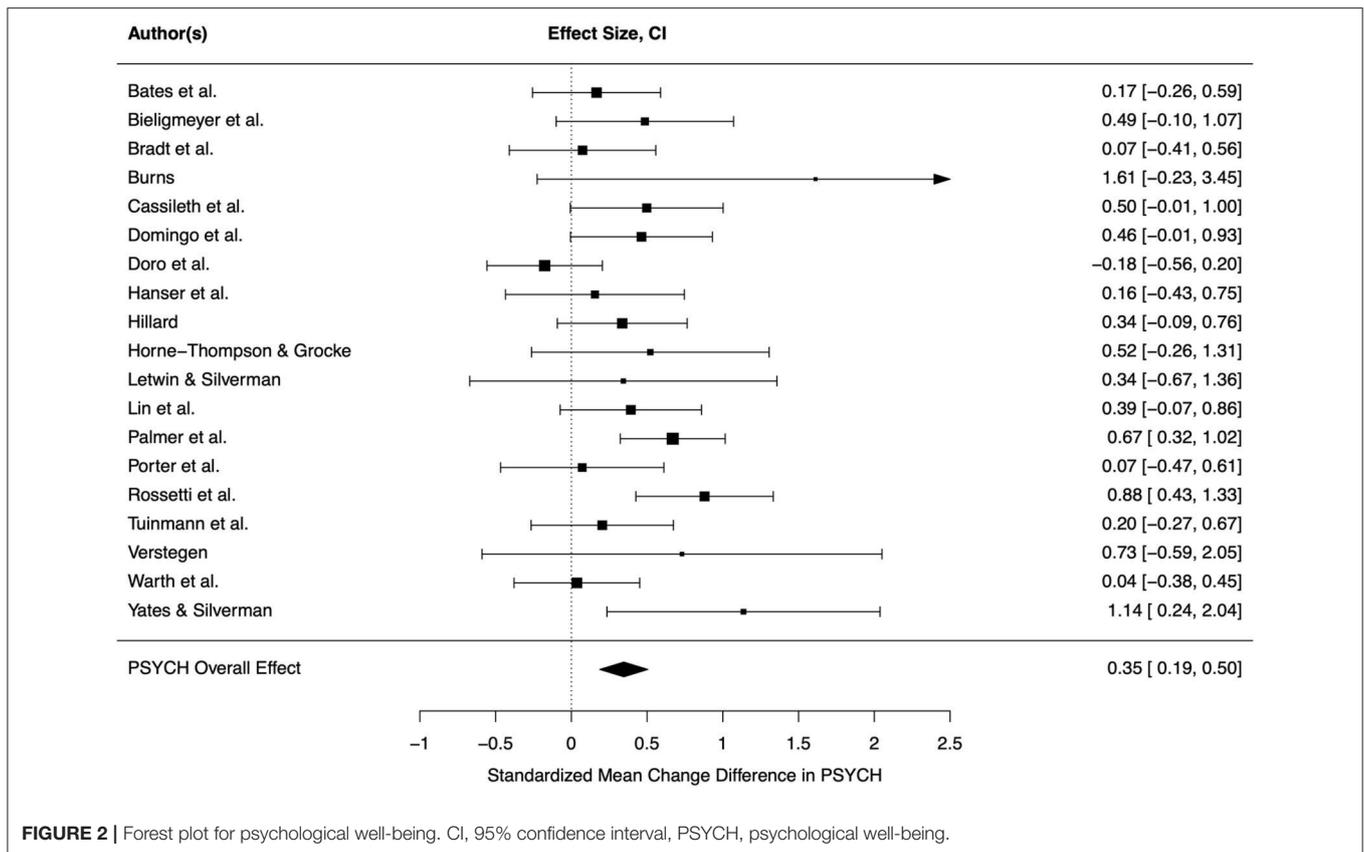
FIGURE 2 | Forest plot for psychological well-being. CI, 95% confidence interval, PSYCH, psychological well-being.

($\tau = 0.20$, $Q = 27.77$, $p = 0.066$, $I^2 = 36.39\%$). Even though not necessarily indicated, moderator analysis was conducted, and frequency of music therapy sessions had a significant moderating effect ($F = 15.79$, $p = 0.001$). Thus, heterogeneity was lower and no longer close to significance ($Q = 14.40$, $p = 0.639$, $I^2 = 0.01\%$). Surprisingly, studies with a single session of music therapy showed greater improvements ($d = 0.47$) than therapy programs involving a higher number of sessions ($d = 0.18$). Moreover, the type of music therapy was a significant moderator ($F = 6.20$, $p = 0.023$) and contributed to the observed heterogeneity ($Q = 20.06$, $p = 0.271$, $I^2 = 22.59\%$). Receptive methods ($d = 0.33$) improved psychological well-being significantly better than active or mixed methods ($d = 0.19$). Other tested moderators did not explain variance across studies ($p > 0.05$). Egger's regression test was not significant ($p > 0.05$) indicating symmetry. However, visual analysis of funnel plot showed asymmetry. As a result of using trim-and-fill method, the effect size was smaller but still significant ($d = 0.27$, CI = 0.11–0.43, $p = 0.001$).

Inspection of Baujat plot and model diagnostics showed two highly influential studies (Dóro et al., 2017; Rossetti et al., 2017). One of them was the only negative effect size (Doro: $d = -0.17$, $n = 100$) and the other one had a large, positive effect size (Rossetti: $d = 0.88$, $n = 78$). Both analyzed a large sample size in comparison to the other studies. Exclusion of these studies did not lead to change in pooled effect size ($d = 0.35$, CI = 0.21–0.48, $p < 0.001$) but heterogeneity was lower ($\tau = 0.07$, $Q = 15.27$, $p = 0.505$, $I^2 = 5.84\%$).

Meta-Analysis on Quality of Life

Seven studies reported sufficient data on quality of life. Hence, $k = 7$ effect sizes were included in our analysis. Two measured general well-being, the other studies measured quality of live. Three single studies indicated significantly better quality of life in music therapy groups in comparison to control groups, the effect sizes of the other studies included zero in their confidence interval (**Figure 3**).

A small overall effect was statistically significant ($d = 0.48$, CI = 0.11–0.85, $p = 0.019$), indicating a positive effect of music therapy on quality of life in cancer patients in comparison to control conditions. Heterogeneity across effects was moderate but not significant ($\tau = 0.26$, $Q = 11.11$, $p = 0.085$, $I^2 = 46.52\%$). The moderators were not able to explain variance across studies (all $p > 0.05$). Frequency of session was excluded as a moderator since all studies in this meta-analysis investigated more than one session. The funnel plot showed symmetry and Egger's regression test was not significant ($p > 0.05$), indicating absence of a publication bias. Based on Baujat plot and model diagnostics, one study with a large effect size ($d = 1.09$, $n = 68$) was identified as highly influential (Domingo et al., 2015). After exclusion of this study, the pooled effect size was lower, but still significant ($d = 0.36$, CI = 0.07–0.65, $p = 0.023$). Measurements of heterogeneity were all low after exclusion ($\tau = 0.00$, $Q = 4.73$, $p = 0.449$, $I^2 = 0.00\%$) hinting at a large variance within studies due to small sample sizes. No moderator analysis was thus conducted. Funnel plot

as well as Egger's regression test ($p > 0.05$) indicated no publication bias.

Meta-Analysis on Physical Symptom Distress

In the meta-analysis on physical symptom distress, $k = 12$ studies were included. Outcomes were pain (nine studies), physical well-being/symptoms (two studies) and fatigue. Measurement instruments are shown in **Table 3**. Three primary studies showed significant benefits of music therapy, while the other effect sizes did not differ significantly from zero (**Figure 4**).

The pooled effect was small-sized and significant ($d = -0.34$, CI $= -0.55$–0.13, $p = 0.004$). The included effects were heterogeneous ($\tau = 0.26$, $Q = 27.59$, $p = 0.004$, $I^2 = 55.72\%$). Variance could not be explained by the tested moderators (all $p > 0.05$). Among these, frequency of sessions was closest to significance ($F = 3.79$, $p = 0.080$) and was able to contribute to overall heterogeneity ($Q = 15.25$, $p = 0.123$, $I^2 = 39.22\%$). Again, one session led to higher improvement of physical symptoms in comparison to control condition. Funnel plot showed symmetry of study distribution and Egger's regression test result supported this assumption ($p > 0.05$). Hence, there was no indication for a publication bias.

Inspection of Baujat plot and graphical outputs of model diagnostics pointed out one highly influential study (Gutgsell et al., 2013), which examined many participants ($n = 200$) in comparison to the other studies and found a medium-sized effect size ($d = -0.77$). Exclusion of this study led to a small decrease of effect size which was still significant ($d = -0.26$, CI $= 0.06$–0.46, $p = 0.017$). Heterogeneity among effects was no longer significant ($\tau = 0.18$, $Q = 13.54$, $p = 0.300$, $I^2 = 33.09\%$). Hence, no further moderator analysis was conducted. Funnel plot as well as Egger's regression test ($p > 0.05$) indicated no publication bias.

DISCUSSION

In order to provide an overview of the impact of music therapy in adult cancer care, we conducted a systematic review and meta-analysis. We included only studies investigating music therapy performed by a therapist. Overall, we found a positive effect of music therapy on outcomes regarding psychological well-being, quality of life and physical symptom distress. With regard to different oncological treatment phases, the outcomes and techniques used in music therapy studies were heterogeneous. During curative cancer treatment, music therapy had a positive impact on well-being, anxiety, depression, mood, and pain, although findings were mixed. Interestingly, several studies showed a reduction of analgesic intake in response to music therapy in the course of surgery or transplantation. The interventions used in these treatment stages were mainly relaxation and imagery, singing, and improvisation with instruments that were feasible to play. Evidence on the effects of music therapy in aftercare is very scarce. Only one pilot study examined group music therapy after breast cancer treatment and reported positive effects on body image and feeling of identity. The validity of this finding, however, is very limited due to the extremely low sample size (Allen, 2010). In palliative populations, music therapy was successfully used to reduce anxiety and stress, and to improve spiritual and psychophysiological well-being. Findings with regard to pain reduction were mixed although the largest RCT provides promising evidence for a positive effect (Gutgsell et al., 2013). Studied techniques in these settings were either music-based relaxation or individually tailored interventions.

Considering the meta-analytical results, the effects of music therapy were small but significant for all three outcome categories. In comparison with previously reported findings (Archie et al., 2013; Bradt et al., 2016; Bro et al., 2018), the effect sizes in our meta-analysis were smaller. One reason might be the inclusion of similar outcomes in one category rather than one meta-analysis for each outcome which would have increased statistical bias due to multiple testing. Additionally, our effect size calculation method took pretest-discrepancies into account and is a more conservative method than often used posttest-comparisons (Morris and DeShon, 2002).

Heterogeneity between effect sizes was small to medium. With regard to quality of life and physical symptom distress, no moderators were found. Differences with regard to patients (inpatient/outpatient, curative/palliative treatment phase), treatment (active/receptive music therapy, duration, and frequency of sessions) or methodology (standard care vs. active control group) were not able to explain any variation in the calculated outcomes. This finding, however, does not necessarily lead to the conclusion that these and other moderating factors have no influence at all. The small number of effect sizes per outcome and the deliberate categorization of moderators may also contribute to the lack of significant findings. Moreover, other factors might be relevant which could not be monitored and tested in this analysis, such as pain medication or musical background. The moderators that explained variance between effect sizes of psychological well-being were session frequency and type of music therapy. Contrasting our expectations, studies that were limited to single sessions of music therapy produced more positive results than music therapy programs with higher session frequencies. It is possible that the first music therapy session in the work with chronically-ill cancer patients may induce strong reactions as music can instantaneously address feelings which the patient might not have been aware of. Moreover, studies with single-session music therapy often may have a less emotionally-challenging therapeutic focus, e.g., on relaxation or acute pain reduction (Gutgsell et al., 2013; Warth et al., 2015a). In an ongoing study on a biographic music therapy technique in palliative care (Warth et al., 2019b), we observe that the process of emotional and spiritual integration of past live events in some cases only starts to work after three or more sessions. Hence, the risk of wrong timing of the post-intervention assessment may be lower in single-session studies. The observed effect, however, might also be due to a methodological artifact, as the time span between pre and post assessment is very low in single-session studies and patients may remember their previous response to questionnaires. Moreover, receptive methods led to stronger improvements in psychological outcomes, which is consistent with previous meta-analytic findings on music therapy in dementia (Tsoi et al., 2018). One reason might be that active methods can be more challenging for patients due to
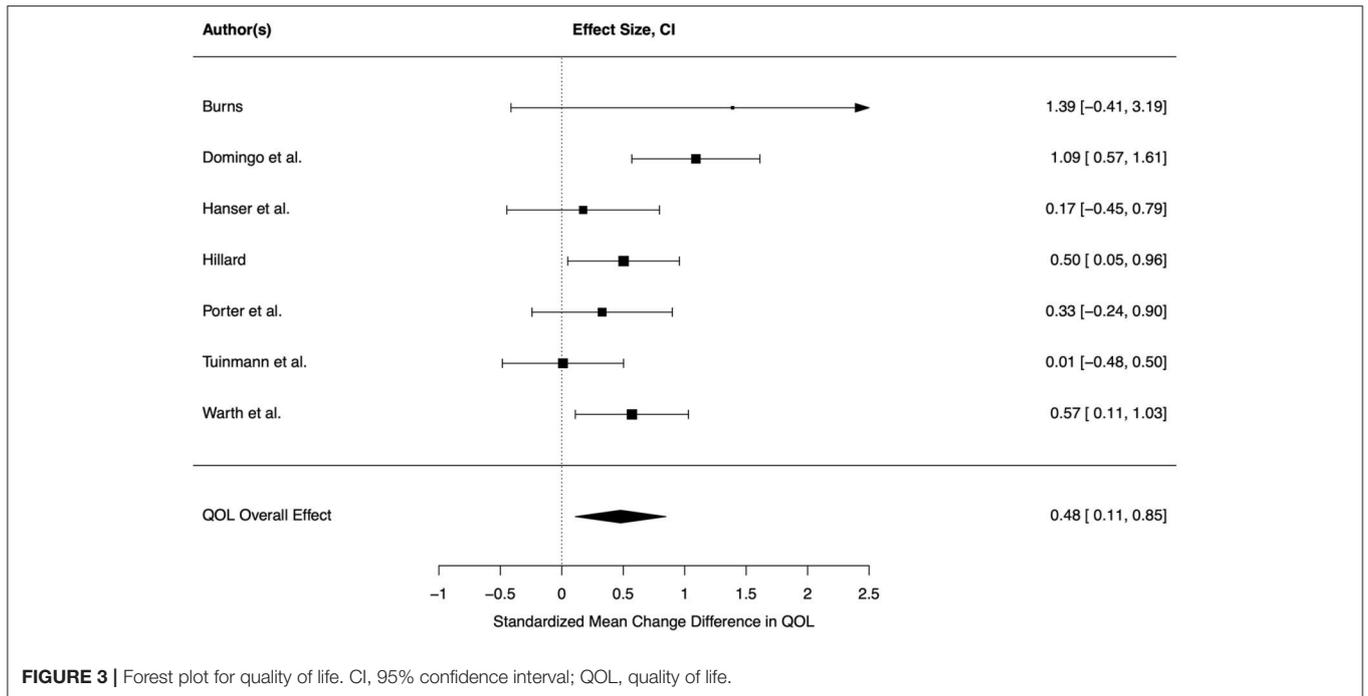
FIGURE 3 | Forest plot for quality of life. CI, 95% confidence interval; QOL, quality of life.
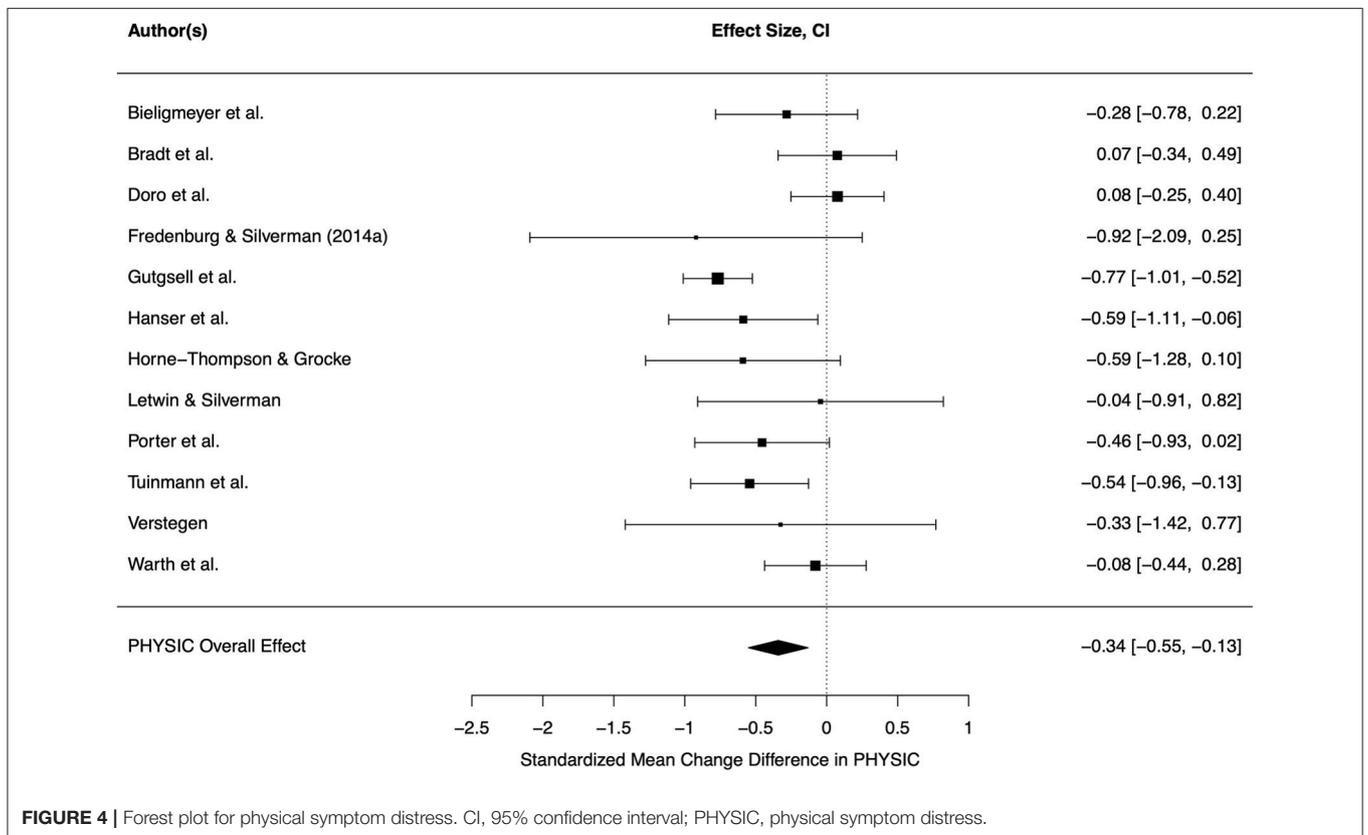
FIGURE 4 | Forest plot for physical symptom distress. CI, 95% confidence interval; PHYSIC, physical symptom distress.

insecurities or inhibition to express their feelings with music or simply because of physical weakness. Therefore, the immediate reaction of a patient to active music therapy might be less positive than the immediate reaction to receptive techniques. This is in line with Yates and Silverman (2015) describing that patients in their study tended to prefer receptive methods, especially in the first session.

In all three categories, exclusion of studies after sensitivity analysis led to smaller but still significant effect sizes. With regard to psychological well-being and physical symptom distress, the excluded studies were highly influential but also relevant because they had large sample sizes in comparison to the other studies (Gutgsell et al., 2013; Dóro et al., 2017; Rossetti et al., 2017). Regarding quality of life, the identified highly influential study was the only non-randomized controlled trial (Domingo et al., 2015) and therefore likely to be biased.

Limitations

One of the key strengths of this review is the inclusion of only music therapy studies distinguishing the effects from other music interventions without a therapeutic relationship. Therefore, our conclusions can be applied for the evaluation and practical improvement of music therapy. Additionally, the categorization of effects in different oncological treatment phases constitutes a precise overview of the patients' needs in each phase and helps to design specific music therapeutic interventions for different cancer stages.

However, there are some limitations that should be considered for interpretation of results. First of all, seven studies could not be included in our meta-analyses due to insufficient data limiting the generalizability of our results. Second, risk of bias was high in all studies which may be due to the Cochrane tool for assessment originally developed for general randomized controlled trials. Even though it was adjusted for psychotherapy research (Munder and Barth, 2017), many studies performed poorly in this assessment. Another critical issue refers to the small number of studies included, especially in the meta-analysis on quality of life, as well as the small sample sizes of some studies. These factors might contribute to an underpowered analysis. Furthermore, due to missing evidence in the studies, we cannot draw conclusions about long-term effects of music therapy in psycho-oncology. As the number of sessions partially moderated the effects in our analysis, future studies are encouraged to employ longitudinal study designs to assess the long-term impact. With regard to moderators, interesting factors like experiences with and preferences of music (Bro et al., 2018) could not be taken into account because they are rarely assessed in studies. Still, as the individual relationship with music plays a key role in music therapy, further research should consider examining aspects of the patients' musical background, such as subjective value of music in one's life, years of musical and instrumental training and

years of active musical participation, preference of musical style or prior amount of experience with music therapy, as potential modulating variables. Another possible influence which studies often do not report is pain medication. However, it could be an interesting control variable as cancer patients especially in palliative care settings often receive high pain medication and its effect might be confounded with the effect of music therapy on pain.

CONCLUSION

Considering the results of the present systematic review and meta-analysis, we found mixed, but overall positive and significant effects of music therapy on psychological well-being, quality of life and physical symptom distress in different phases of oncological treatment. As the diagnosis and treatment of cancer is often accompanied by challenging physical symptoms and psychological distress, even small improvements through music therapy may be relevant for patients with oncological diseases. With regard to research, studies on music therapy are encouraged to reduce risk of bias, e.g., through publishing primary and secondary outcomes in a study protocol, and to assess long-term effects of music therapy. In addition, potential moderators should be included in the measurements, such as individual information about patients, to find out who benefits most from different kinds of music therapy and to provide techniques that fit the individual needs of a patient.

AUTHOR CONTRIBUTIONS

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REFERENCES

Alcântara-Silva, T. R., de Freitas-Junior, R., Freitas, N. M. A., de Paula Junior, W., da Silva, D. J., Machado, G. D. P., et al.

(2018). Music therapy reduces radiotherapy-induced fatigue in patients with breast or gynecological cancer: a randomized trial. *Integr. Cancer Ther.* 17, 628–635. doi: 10.1177/15347354187 57349

Allen, J. L. (2010). *The effectiveness of group music psychotherapy in improving the self-concept of breast cancer survivors* (Dissertation). Temple University, Philadelphia, PA, USA.

Archie, P., Bruera, E., and Cohen, L. (2013). Music-based interventions in palliative cancer care: a review of quantitative studies and neurobiological literature. *Support Care Cancer* 21, 2609–2624. doi: 10.1007/s00520-013-1841-4

Bates, D., Bolwell, B., Majhail, N. S., Rybicki, L., Yurch, M., Abounader, D., et al. (2017). Music therapy for symptom management after autologous stem cell transplantation: results from a randomized study. *Biol Blood Marrow Transplant.* 23, 1567–1572. doi: 10.1016/j.bbmt.2017.05.015

Bieligmeyer, S., Helmert, E., Hautzinger, M., and Vagedes, J. (2018). Feeling the sound–short-term effect of a vibroacoustic music intervention on well-being and subjectively assessed warmth distribution in cancer patients—a randomized controlled trial. *Complement. Ther. Med.* 40:171–178. doi: 10.1016/j.ctim.2018.03.002

Borenstein, M., Hedges, L. V., Higgins, J. P., and Rothstein, H. R. (2011). *Introduction to Meta-Analysis*: John Wiley & Sons.

Boyde, C., Linden, U., Boehm, K., and Ostermann, T. (2012). The use of music therapy during the treatment of cancer patients: a collection of evidence. *Global Adv. Health Med.* 1, 24–29. doi: 10.7453/gahmj.2012.1.5.009

Bradt, J., Dileo, C., Magill, L., and Teague, A. (2016). Music interventions for improving psychological and physical outcomes in cancer patients. *Cochrane Database Syst. Rev.* doi: 10.1002/14651858.CD006911.pub3

Bradt, J., Potvin, N., Kesslick, A., Shim, M., Radl, D., Schriver, E., et al. (2015). The impact of music therapy versus music medicine on psychological outcomes and pain in cancer patients: a mixed methods study. *Support Care Cancer* 23, 1261–1271. doi: 10.1007/s00520-014-2478-7

Bro, M. L., Jespersen, K. V., Hansen, J. B., Vuust, P., Abildgaard, N., Gram, J., et al. (2018). Kind of blue: a systematic review and meta-analysis of music interventions in cancer treatment. *Psycho Oncol.* 27, 386–400. doi: 10.1002/pon.4470

Burns, D. S. (2001). The effect of the bonny method of guided imagery and music on the mood and life quality of cancer patients. *J. Music Ther.* 38, 51–65. doi: 10.1093/jmt/38.1.51

Burns, D. S., Azzouz, F., Sledge, R., Rutledge, C., Hincher, K., Monahan, P. O., et al. (2007). Music imagery for adults with acute leukemia in protective environments: a feasibility study. *Supportive Care Cancer.* 16, 507–513. doi: 10.1007/s00520-007-0330-z

Burns, D. S., Meadows, A. N., Althouse, S., Perkins, S. M., and Cripe, L. D. (2018). Differences between supportive music and imagery and music listening during outpatient chemotherapy and potential moderators of treatment effects. *J. Music Ther.* 55, 83–108. doi: 10.1093/jmt/thy001

Cassileth, B. R., Vickers, A. J., and Magill, L. A. (2003). Music therapy for mood disturbance during hospitalization for autologous stem cell transplantation: a randomized controlled trial. *Cancer* 98, 2723–2729. doi: 10.1002/cncr.11842

Chen, S.-C., Chou, C.-C., Chang, H.-J., and Lin, M.-F. (2018). Comparison of group vs self-directed music interventions to reduce chemotherapy-related distress and cognitive appraisal: an exploratory study. *Supportive Care Cancer* 26, 461–469. doi: 10.1007/s00520-017-3850-1

Cohen, J. (1992). A power primer. *Psychol. Bull.* 112, 155–159. doi: 10.1037/0033-2909.112.1.155

Cook, E. L., and Silverman, M. J. (2013). Effects of music therapy on spirituality with patients on a medical oncology/hematology unit: a mixed-methods approach. *Arts Psychother.* 40, 239–244. doi: 10.1016/j.aip.2013.02.004

Deutsche Musiktherapeutische Gesellschaft (2019). Musiktherapie.

Domingo, J. P., Matamoros, N. E., Danés, C. F., Abelló, H. V., Carranza, J. M., Ripoll, A. I. R., et al. (2015). Effectiveness of music therapy in advanced cancer patients admitted to a palliative care unit: a non-randomized controlled, clinical trial. *Music Med.* 7, 23–31.

Dóro, C. A., Neto, J. Z., Cunha, R., and Dóro, M. P. (2017). Music therapy improves the mood of patients undergoing hematopoietic stem cells transplantation (controlled randomized study). *Supportive Care Cancer.* 25, 1013–1018. doi: 10.1007/s00520-016-3529-z

Duval, S., and Tweedie, R. (2000). A nonparametric "trim and fill" method of accounting for publication bias in meta-analysis. *J. Am. Stat. Assoc.* 95, 89–98. doi: 10.1080/01621459.2000.10473905

Edwards, J. (Ed.). (2008). *The Use of Music in Healthcare Contexts: A Select Review of Writings From the 1890s to the 1940s Voices: A World Forum for Music Therapy.* University of Bergen.

Egger, M., Davey Smith, G., Schneider, M., and Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *BMJ* 315, 629–634. doi: 10.1136/bmj.315.7109.629

Fredenburg, H. A., and Silverman, M. J. (2014). Effects of cognitive-behavioral music therapy on fatigue in patients in a blood and marrow transplantation unit: a mixed-method pilot study. *Arts Psychother.* 41, 433–444. doi: 10.1016/j.aip.2014.09.002

Gramaglia, C., Gambaro, E., Vecchi, C., Licandro, D., Raina, G., Pisani, C., et al. (2019). Outcomes of music therapy interventions in cancer patients. a review of the literature. *Crit. Rev. Oncol. Hematol.* 138, 241–254. doi: 10.1016/j.critrevonc.2019.04.004

Gutgsell, K. J., Schluchter, M., Margevicius, S., DeGolia, P. A., McLaughlin, B., Harris, M., et al. (2013). Music therapy reduces pain in palliative care patients: a randomized controlled trial. *J. Pain Symptom Manage.* 45, 822–831. doi: 10.1016/j.jpainsymman.2012.05.008

Hanser, S. B., Bauer-Wu, S., Kubicek, L., Healey, M., Manola, J., Hernandez, M., et al. (2006). Effects of a music therapy intervention on quality of life and distress in women with metastatic breast cancer. *J. Soc. Integr. Oncol.* 4, 116–124. doi: 10.2310/7200.2006.014

Hilliard, R. E. (2003). The effects of music therapy on the quality and length of life of people diagnosed with terminal cancer. *J. Music Ther.* 40, 113–137. doi: 10.1093/jmt/40.2.113

Holland, J. C., Breitbart, W. S., Jacobsen, P. B., Lederberg, M. S., Loscalzo, M. J., and McCorkle, R. (2010). *Psycho-Oncology*. New York, NY: Oxford University Press. doi: 10.1093/med/9780195367430.001.0001

Horne-Thompson, A., and Grocke, D. (2008). The effect of music therapy on anxiety in patients who are terminally ill. *J. Palliat. Med.* 11, 582–590. doi: 10.1089/jpm.2007.0193

Köhler, F., Martin, Z., Hertrampf, R., Gäbel, C., Keßler, J., Ditzen, B., et al. (2019). Music therapy in psycho-oncology. *Der Onkol.* 25:1103–1109. doi: 10.1007/s00761-019-0646-6

Leitlinienprogramm Onkologie. (2014). *Psychoonkologische Diagnostik, Beratung und Behandlung Von Erwachsenen Krebspatienten.* AWMF-Registernummer: 032/051OL. Available online at: http://leitlinienprogramm-onkologie.de/Leitlinien.7.0.html

Letwin, L., and Silverman, M. J. (2017). No between-group difference but tendencies for patient support: a pilot study of a resilience-focused music therapy protocol for adults on a medical oncology/hematology unit. *Arts Psychother.* 55:116–125. doi: 10.1016/j.aip.2017.06.002

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gotzsche, P. C., Ioannidis, J. P., et al. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ.* 339:b2700. doi: 10.1136/bmj.b2700

Lin, M. F., Hsieh, Y. J., Hsu, Y. Y., Fetzer, S., and Hsu, M. C. (2011). A randomised controlled trial of the effect of music therapy and verbal relaxation on chemotherapy-induced anxiety. *J. Clin. Nursing* 20, 988–99. doi: 10.1111/j.1365-2702.2010.03525.x

Morris, S. B. (2008). Estimating effect sizes from pretest-posttest-control group designs. *Organ. Res. Methods* 11, 364–386. doi: 10.1177/1094428106291059

Morris, S. B., and DeShon, R. P. (2002). Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. *Psychol. Methods* 7, 105–125. doi: 10.1037/1082-989X.7.1.105

Munder, T., and Barth, J. (2017). Cochrane's risk of bias tool in the context of psychotherapy outcome research. *Psychother. Res.* 2017:1–9. doi: 10.1080/10503307.2017.1411628

Nightingale, C. L., Rodriguez, C., and Carnaby, G. (2013). The impact of music interventions on anxiety for adult cancer patients: a meta-analysis and systematic review. *Integr. Cancer Ther.* 12, 393–403. doi: 10.1177/1534735413485817

Ouzzani, M., Hammady, H., Fedorowicz, Z., and Elmagarmid, A. (2016). Rayyan-a web and mobile app for systematic reviews. *Syst. Rev.* 5:210. doi: 10.1186/s13643-016-0384-4

Palmer, J. B., Lane, D., Mayo, D., Schluchter, M., and Leeming, R. (2015). Effects of music therapy on anesthesia requirements and anxiety in women undergoing

ambulatory breast surgery for cancer diagnosis and treatment: a randomized controlled trial. *J. Clin. Oncol.* 33:3162. doi: 10.1200/JCO.2014.59.6049

Porter, S., McConnell, T., Graham-Wisener, L., Regan, J., McKeown, M., Kirkwood, J., et al. (2018). A randomised controlled pilot and feasibility study of music therapy for improving the quality of life of hospice inpatients. *BMC Palliat. Care* 17:125. doi: 10.1186/s12904-018-0378-1

Ramirez, R., Planas, J., Escude, N., Mercade, J., and Farriols, C. (2018). EEG-based analysis of the emotional effect of music therapy on palliative care cancer patients. *Front. Psychol.* 9:254. doi: 10.3389/fpsyg.2018.00254

Rossetti, A., Chadha, M., Torres, B. N., Lee, J. K., Hylton, D., Loewy, J. V., et al. (2017). The impact of music therapy on anxiety in cancer patients undergoing simulation for radiation therapy. *Int. J. Radiat. Oncol. Biol. Phys.* 99, 103–110. doi: 10.1016/j.ijrobp.2017.05.003

Rubio-Aparicio, M., Marin-Martinez, F., Sanchez-Meca, J., and Lopez-Lopez, J. A. (2017). A methodological review of meta-analyses of the effectiveness of clinical psychology treatments. *Behav. Res. Methods* 50, 2057–2073. doi: 10.3758/s13428-017-0973-8

Stützlinger, H., Eisenmann, A., Laschkolnig, A., Mathis-Edenhofer, S., Pfabigan, D., and RÄhrling, I. (2018). Krebs: kann eine begleitende musiktherapie zu besseren behandlungsergebnissen beitragen? *ThemenCheck Medizin.* 2018:185.

Tsai, H. F., Chen, Y. R., Chung, M. H., Liao, Y. M., Chi, M. J., Chang, C. C., et al. (2014). Effectiveness of music intervention in ameliorating cancer patients' anxiety, depression, pain, and fatigue: a meta-analysis. *Cancer Nurs.* 37, E35–E50. doi: 10.1097/NCC.0000000000000116

Tsoi, K. K. F., Chan, J. Y. C., Ng, Y. M., Lee, M. M. Y., Kwok, T. C. Y., and Wong, S. Y. S. (2018). Receptive music therapy is more effective than interactive music therapy to relieve behavioral and psychological symptoms of dementia: a systematic review and meta-analysis. *J Am Med Dir Assoc.* 19, 568–76 e3. doi: 10.1016/j.jamda.2017.12.009

Tuinmann, G., Preissler, P., Böhmer, H., Suling, A., and Bokemeyer, C. (2017). The effects of music therapy in patients with high-dose chemotherapy and stem cell support: a randomized pilot study. *Psycho Oncol.* 26, 377–384. doi: 10.1002/pon.4142

Verstegen A. (2016). *Effects of hope-based music therapy on hope and pain in hospitalized patients on blood and marrow transplant unit: a convergent parallel mixed-methods pilot study* (Master's thesis). University of Minnesota, Minneapolis, MN, United States. Retrieved from: http://hdl.handle.net/11299/183312

Viechtbauer, W. (2010). Conducting meta-analyses in R with the metafor package. *J. Stat. Softw.* 36, 1–48. doi: 10.18637/jss.v036.i03

Wang, Y., Tang, H., Guo, Q., Liu, J., Liu, X., Luo, J., et al. (2015). Effects of intravenous patient-controlled sufentanil analgesia and music therapy on pain and hemodynamics after surgery for lung cancer: a randomized parallel study. *J. Alternat. Complement. Med.* 21, 667–672. doi: 10.1089/acm.2014.0310

Warth, M., Kessler, J., Hillecke, T. K., and Bardenheuer, H. J. (2015b). Music therapy in palliative care - a randomized controlled trial to evaluate effects on relaxation. *Dtsch Arzteblatt Int.* 112, 788–794. doi: 10.3238/arztebl.2015.0788

Warth, M., Kessler, J., Koehler, F., Aguilar-Raab, C., Bardenheuer, H. J., and Ditzen, B. (2019a). Brief psychosocial interventions improve quality of life of patients receiving palliative care: a systematic review and meta-analysis. *Palliat. Med.* 33, 332–345. doi: 10.1177/0269216318818011

Warth, M., Kessler, J., Kotz, S., Hillecke, T. K., and Bardenheuer, H. J. (2015a). Effects of vibroacoustic stimulation in music therapy for palliative care patients: a feasibility study. *BMC Complement Altern Med.* 15:436. doi: 10.1186/s12906-015-0933-8

Warth, M., Koehler, F., Weber, M., Bardenheuer, H. J., Ditzen, B., and Kessler, J. (2019b). "Song of Life (SOL)" study protocol: a multicenter, randomized trial on the emotional, spiritual, and psychobiological effects of music therapy in palliative care. *BMC Palliat. Care* 18:14. doi: 10.1186/s12904-019-0397-6

Yates, G. J., and Silverman, M. J. (2015). Immediate effects of single-session music therapy on affective state in patients on a post-surgical oncology unit: A randomized effectiveness study. *Arts Psychother.* 44:57–61. doi: 10.1016/j.aip.2014.11.002

Zhang, J.-M., Wang, P., Yao, J.-X, Zhao, L., Davis, M. P., Walsh, D., et al. (2012). Music interventions for psychological and physical outcomes in cancer: a systematic review and meta-analysis. *Supportive Care Cancer* 20, 3043–3053. doi: 10.1007/s00520-012-1606-5

Appendix A3 – Manuscript 3

Warth, M.*, **Koehler, F.*,** Brehmen, M., Weber, M., Bardenheuer, H. J., Ditzen, B., & Kessler, J. (in press). 'Song of Life': Results of a multicenter randomized trial on the effects of biographical music therapy in palliative care. *BMC Palliative Medicine.* doi: 10.1177/02692163211010394
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Friederike Köhler's contribution according to the contributor roles taxonomy (CRediT) author statement (Allen et al., 2019):
methodology, software, formal analysis, investigation, data curation, writing – original draft, writing – review and editing, visualization

Original Article

"Song of Life": Results of a multicenter randomized trial on the effects of biographical music therapy in palliative care

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Abstract

Background: Awareness for the importance of psychological and spiritual needs in patients with terminal diseases has increased in recent years, but randomized trials on the effects of psychosocial interventions are still rare.

Aim: To investigate the efficacy of the "Song of Life" music therapy intervention regarding the emotional and psycho-spiritual dimensions of quality of life.

Design: Patients were randomly assigned to either "Song of Life" or a relaxation intervention. "Song of Life" is a novel three-session music therapy intervention working with a biographically meaningful song. Primary outcome was the improvement in psychological quality of life. Secondary outcomes included spiritual well-being, ego-integrity, momentary distress, and global quality of life and the explorative assessment of treatment satisfaction (patient and family member version). Intention-to-treat analysis was conducted including adjustment for multiple testing in secondary outcomes.

Setting/participants: Between December 2018 and August 2020, 104 patients receiving specialized palliative care were recruited from two palliative care wards.

Results: No significant differences were found regarding psychological and global quality of life, but "Song of Life" participants reported significantly higher spiritual well-being ($p = 0.04$) and ego-integrity ($p < 0.01$), as well as lower distress ($p = 0.05$) than patients in the control group. Both patients' and family members' treatment satisfaction was higher after "Song of Life" with large between-group effect sizes on items asking for meaningfulness ($d = 0.96$) and importance ($d = 1.00$).

Conclusions: Our findings provide evidence that "Song of Life" is an effective and meaningful biographical music therapy intervention to facilitate psycho-spiritual integration in terminally ill patients.

Trial Registration: German Clinical Trials Register (DRKS)—DRKS00015308 (date of registration: September 7th 2018).

Keywords

Music therapy, palliative care, cancer, randomized controlled trial, end-of-life, quality of life, spiritual well-being, distress, ego-integrity

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What is already known about the topic:

- Patients nearing the end of life report high needs for emotional and spiritual support.
- Although the use of psychosocial interventions including life review and creative arts-based techniques is immensely valued in clinical practice, recent guidelines, reviews, and reports have repeatedly called for high-quality studies on their efficacy.

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What this paper adds:

- Findings show that biographical music therapy can effectively facilitate psycho-spiritual integration of past life events.
- The intervention was further effective in reducing patients' momentary distress and was perceived as meaningful and important by both patients and family members.

Implications for practice, theory or policy:

- Together with previous findings, music therapy has been shown to be effective with regard to a number of clinically relevant outcomes including pain, quality of life, and spiritual well-being.
- The present study therefore marks an important step towards an evidence-based rationale for the use of music therapy in palliative care.
- The "Song of Life" intervention should be recommended to address emotional and existential needs in terminally ill patients nearing the end of life.

Background

The diagnosis and course of a terminal disease is one of the most distressing life events with a detrimental impact on the physical, emotional, spiritual, and social well-being of the individual and their relatives.[1] While medical interventions effectively treat physical symptoms like pain,[2] the mission of palliative care is to provide holistic support of patients on all levels of well-being.[3] For instance, one third of palliative care patients suffer from depression, adjustment, or anxiety disorders.[4] Therefore, psychosocial interventions have emerged to specifically address emotional difficulties and spiritual concerns regarding meaning in life,[5] including cognitive-behavioral therapy, mindfulness, life review or meaning-centered interventions, and creative arts-based therapies.[6–8] Research on these treatments provides evidence for improvements in depression and quality of life, particularly in advanced cancer patients.[9–12] However, the majority of these interventions were designed for patients in non-final stages of the disease requiring a session number that is hard to achieve in patients nearing the end of life. Palliative care settings often deal with unique conditions necessitating respective adjustments in intervention protocols.[13]

A recent meta-analysis summarized studies using brief interventions with four sessions or less showing improvements in quality of life and reductions in emotional and existential distress.[14] Most of these studies focused on life review techniques or music therapy. The common therapeutic focus of life review interventions (e.g. dignity therapy[15–17]) lies on the patient's biography and the attempt to create a legacy,[7,18] as generativity and ego-integrity (i.e. achieving a sense of meaning and acceptance of past life events) were postulated as important developmental tasks at the end of life.[19,20] While a recent meta-analysis provided evidence for improvements in psychological well-being, efficacy trials revealed inconsistent findings concerning quality of life and dignity.[21]

Creative arts therapies offer an alternative way for terminally ill patients to regulate emotions and integrate life experiences on a psycho-spiritual level.[22] Music therapy has been a substantial part of palliative care since its beginnings[23] and aims at the improvement of quality of life by alleviating physical and emotional burden as well as through enabling communication and spiritual experiences.[24] Common definitions of music therapy emphasize the importance of the therapeutic relationship combined with musical and verbal techniques, and thereby contrast music listening interventions which do not require the presence of a trained therapist.[25] Music therapy techniques encompass receptive (e.g. music and imagery), creative (e.g. songwriting), recreative (e.g. instrument playing), and combined (e.g. musical life review) methods,[26] which usually are customized to the individual's needs.[27] Previous trials on the efficacy of music therapy in palliative care reported beneficial effects regarding the improvement of quality of life, general well-being,[28,29] and spiritual well-being,[30,31] as well as the reduction of pain[32] and anxiety.[33] No study has systematically evaluated biographical music therapy in a clinical trial in palliative care yet.

Therefore, the aim of the present study was to investigate the efficacy of the newly developed, pilot-tested[34] biographical music therapy technique "Song of Life" (SOL) with palliative care patients. Working with a biographically meaningful song, SOL integrates elements of life review interventions and creative arts therapies. Hence, we hypothesized the SOL to have more beneficial effects on the psychological and spiritual domain of quality of life than a non-specific psychosocial control treatment.

Methods

Study design

This multicenter randomized controlled trial compared the effects of the SOL music therapy intervention plus usual care as the experimental group with a relaxation intervention (RELAX) plus usual care as the control group in a

parallel design. Patients in both groups participated in three sessions of 20–30 min duration. We additionally recruited family members for participation in an assessment of treatment satisfaction. The trial was preregistered at the German Clinical Trials Registry (DRKS00015308) and received approval by the local ethics committees. Methods and procedures have been published in a study protocol.[35]

Setting

Study sites were the University Palliative Care Unit at St. Vincentius Hospital, Heidelberg University Hospital, Germany, and the Interdisciplinary Palliative Care Unit at the University Medical Center of the Johannes Gutenberg University of Mainz, Germany.

Randomization, masking, and blinding

Randomization to one of the two study arms was based on a computer-based block randomization sequence (block size = 8) stratified by study site, which was created by a researcher not involved in recruitment, assessment, or treatment. Sequentially numbered opaque envelopes were opened after the patient had provided informed consent and completed baseline assessment. Adhering to recommendations regarding blinding of participants, we (a) used an active control group without the patient knowing which one was the experimental group and (b) implemented an expectancy measure at baseline,[36] assessed via the item "I expect the study intervention to be helpful to me" (agreement, 1–5). While patients were blind to the study hypothesis, blinding of therapists and outcome assessors was not feasible.

Participants

Patients from these palliative care wards were included if they (a) received palliative treatment according to OPS 8-982/OPS 8-98e (German modification of International Classification of Procedures in Medicine; ICPM) or had an estimated life expectancy of <12 months,[37] (b) were ≥18 years old, and (c) were able to provide informed consent. Patients were excluded if they (d) did not speak German language, (e) had a clinical estimation of life expectancy <1 week, or (e) showed cognitive or auditory impairments, or psychiatric symptoms. Patients were asked to name a family member or another close person to be included in an evaluation of treatment satisfaction. Family members were included if they (a) were ≥18 years old and (b) spoke German language.

Sampling and recruitment

Based on the medical record and information from the physician, eligible patients from the two palliative care units were contacted at bedside consecutively between December 2018 and August 2020. All patients were informed about the study goals, procedures, risks, and benefits and were asked to provide written informed consent. Family members were contacted after allocation of the patient to one of the interventions and were also asked to provide informed consent before inclusion in the study (Figure 1).

Interventions

The SOL intervention was a new pilot-tested[34] music therapy technique, in which therapist and patient explored and identified a biographically meaningful and emotionally arousing song in the first session. This song was played live to the patient in the second session by the therapist in a lullaby style (i.e. 3/4 or 6/8 rhythm, slow tempo) with guitar or e-piano and voice, while the session was audio-recorded. A CD or flash drive containing the edited recording was handed over to the patient as a possible legacy in the third session. Both patient and therapist listened to the recording and reflected on feelings and memories, guided by pre-defined questions. Conversations in the last session were again audio-recorded.

Sessions in the control group consisted of three standardized relaxation interventions focusing on (a) muscle relaxation, (b) breathing, and (c) imaginary journey, plus a brief inquiry at the end of each session. Relaxation and mindfulness exercises were chosen as they proved to be feasible, safe, and potentially effective in seriously ill patients,[10] but were non-specific with regard to psycho-spiritual integration processes targeted in the SOL intervention. Hence, exercises did not contain any biographical, spiritual, or musical content, and were delivered in person by the study therapists. Detailed intervention manuals are presented in Appendix A.

In both groups, sessions were preferably carried out on three consecutive days, but deviations from this schedule were possible (e.g. for organizational reasons or if wished by the patient). The two study therapists were trained music therapists with a wide range of experience and were employed at the two participating palliative care wards. The study therapists participated in a 36-h training program conveying all intervention procedures. Moreover, study therapists were asked to rate their perception of adherence to the intervention protocol for each patient and of the musical realization of the SOL (e.g. using rhythm, tempo, and dynamics in accordance with the training and manual; see Appendix A) on a scale from 1 ("not at all") to 5 ("very good"). Moreover, audio recordings in the experimental group (sessions 2 and 3) were rated by a research assistant for protocol adherence (e.g. interview topics covered; see Appendix A) on a self-developed treatment integrity scale (1–5). Further, study therapists received supervision by the principal investigator

STUDY PERIOD							
Pre-allocation (patients)			**Post allocation (patients)**			**Family members**	
	Enrolment	Allocation	First visit (baseline)	Second visit	Third visit	First contact	Follow-up
TIMEPOINT[a]	-t2	-t1	0 (T0)	1 day	2 days (T1)	1 week	8-16 weeks
ENROLMENT:							
Eligibility screen	X						
Informed consent	X						
Allocation		X					
Recruitment of family members			◆———————————◆				
INTERVENTIONS							
SOL			◆———————◆				
RELAX			◆———————◆				
ASSESSMENTS							
Demographical data/medical record			X				
Psychological quality of life (MQOL-R)			X		X		
Ego-integrity (BMGE)			X		X		
Spiritual well-being (FACIT-Sp)			X		X		
Momentary distress (pre-to-post session, NCCN Distress Thermometer)			X	X	X		
Global quality of life (MQOL-R)			X		X		
Treatment satisfaction (patient, FQ)					X		
Treatment satisfaction (familty member, FQ)						X	X

Figure 1. Figure 2 SPIRIT figure: schedule of enrolment, interventions and assessments.
SPIRIT: standard protocol items: recommendations for interventional trials; SOL: "Song of Life" music therapy; RELAX: relaxation intervention; MQOL-R: McGill quality of life questionnaire–revised); BMGE: brief measure of generativity and ego-integrity; FACIT-Sp: functional assessment of chronic illness therapy-spiritual well-being; NCCN: national comprehensive cancer network; FQ: feedback questionnaire.
[a]Deviations from the schedule were possible.

after 25%, 50%, and 75% of recruitment completion to maintain high treatment fidelity, where therapists were asked to describe cases, treatment progress, or difficulties and received feedback by the supervisor.

Data collection

After obtaining written informed consent, research staff initiated baseline assessment (T0) of outcome measures listed below and afterwards opened an envelope with the group assignment. Each of the three intervention sessions contained a pre-to-post single-item assessment of momentary distress. Post-intervention outcome data (T1) was immediately assessed after session 3.

Family members who provided informed consent completed a brief evaluation of treatment satisfaction after the intervention (T1) and again after 8–16 weeks (T2) either in person or by phone. The rationale of these follow-up assessments was to gather indirect information on the endurance of treatment effects, as previous trials showed that time spans for patient outcome assessments of more

than 1 week were not feasible in palliative care research.[31] Figure 1 gives an overview of the assessment procedures.

Outcome measures

The working mechanism of the SOL intervention was assumed to include the emotional and spiritual processing and integration of past life events. Outcomes have been chosen in accordance with this assumption and a detailed rationale for the selection of study outcomes can be found in the study protocol.[35]

The primary study outcome was the pre-to-post change (T0-T1) in *psychological quality of life* (range: 0–10) as measured by the psychological subscale of the validated McGill Quality of Life Questionnaire – Revised (MQOL-R),[38] which contains four items asking for anxiety and depression in the past 2 days.

Secondary outcomes included the 5-item *ego-integrity* subscale (1–5) of the validated Brief Measure of Generativity and Ego-Integrity[20] (BMGE) for the assessment of acceptance and the sense of meaning regarding

one's past life. Changes in non-religious aspects of *spiritual well-being* were measured by the validated 8-item meaning/peace-scale (0–32) of the Functional Assessment of Chronic Illness Therapy – Spiritual Well-Being (FACIT-Sp), which is commonly used in palliative care research.[39,40] Due to the intervention duration of 3 days, the item time frame was reduced from 7 to 3 days. Moreover, we assessed patient's momentary *distress* before and after each session by use of the modified version of the validated single-item (0–10) NCCN Distress Thermometer asking for acute distress.[41,42] For consistency with other outcome measures, we analyzed the two distress scores before the first session and after the last. The MQOL-R's single item (0–10) on *global quality of life* during the past 2 days additionally served as a secondary endpoint.[38]

Outcome assessment was complemented by modified versions of the Feedback Questionnaire (FQ), in the patient[16] and family member[43] version. The FQ is a non-validated retrospective measure frequently used in research on biographical interventions in palliative care. Both versions used eight items (agreement from 1 to 5) to cover the *perception of treatment satisfaction* (T1: patients and family members, T2: family members only). All questionnaires were delivered by research assistants who were not involved in the treatment process. The timing of assessments is displayed in Figure 1.

Statistical analyses

A priori calculations with G*Power[44] assuming a medium-sized effect of Cohen's $d = 0.50$[45] on the primary outcome, statistical power of $(1–ß) = 0.8$, a type-I error probability of $\alpha = 0.05$, a correlation between covariate and outcome of $\rho = 0.6$, and an attrition rate of 25% revealed an optimal sample size of $N = 104$ patients for this study. The rationale for the estimation of parameters has been discussed in the study protocol.[35]

Hypotheses were tested by intention to treat[46] in the statistical environment R.[47] We first calculated analyses of covariance (ANCOVA) with a multiply imputed dataset (MI), using the baseline score as a covariate, treatment and study site[48] as fixed factors, and the post-intervention score as the outcome. We created 20 imputations and combined the statistical results using the *R* package "mice."[49] Effect sizes (Cohen's *d*) and 95% confidence intervals (CI) were computed according to Morris'[50] formula for pretest-posttest-control-group designs and were visualized with the funnel plot function in the "metaphor"[51] package. Next, sensitivity analysis with all available data (AAD) was calculated by multilevel modeling using the "lme4" package.[52] We chose to conduct analyses with both ANCOVA (MI) and multilevel modeling (AAD) as different approaches to handle missing data and expected similar results. Parameters were obtained via restricted maximum likelihood (REML) estimation. We computed a random-intercept model including the pre- and post-intervention scores as the outcome, and time, treatment, time × treatment, and study site as fixed factors. Concerning the analyses of secondary outcomes, we accounted for the false discovery rate (FDR) in multiple comparisons employing the Benjamini-Hochberg correction and report adjusted *p*-values.[53] Both α and the FDR were set on 0.05. Group differences on the FQ were exploratively analyzed on an item level[16] using Cohen's *d* and 95 % CIs calculated with the "effectsize"[54] package, as this non-validated measure does not allow for calculation of a composite score.

Results

Of the 574 patients assessed for eligibility between December 2018 and August 2020, $N = 104$ consented to participate and were randomly assigned to either SOL ($n = 52$) or RELAX ($n = 52$). Among those included, $n = 100$ patients (98.0%) completed session 1, $n = 89$ completed session 2 (85.6%), and $n = 82$ (78.8%) completed the entire intervention protocol. Eighty-one patients (77.9%) provided complete outcome data, hence, the attrition rate in the present study was 22.1%. The patient flow chart is shown in Figure 2.

The majority of patients was female ($n = 77$, 74.0%) and all but $n = 2$ patients were primarily diagnosed with advanced cancer ($n = 102$, 98.1%). The mean age was $M = 66.1$ years (SD = 12.0). As Table 1 shows, study groups were comparable with regard to age, sex, diagnosis, functional status, and treatment expectancy. On average, therapists rated their subjective overall adherence to the treatment protocols at 3.52 (SD = 0.82) in the experimental group and 3.74 (SD = 0.94) in the control group. In the experimental group, the musical adherence in session 2 received an average rating of $M = 3.50$ (SD = 0.90) by the therapists and of $M = 4.47$ (SD = 0.67) by the research assistant. Adherence to the interview guidelines in session 3 (SOL) was rated 3.36 (0.90) by the research assistant. The majority of chosen songs were associated with a meaningful life phase, close relationships, or important life event, while other songs represented the lifelong companionship and consolation through music in the patient's biography.

ANCOVA showed no statistically significant differences between groups in the primary outcome psychological quality of life ($F = 0.13$, $p = 0.72$, Table 2). With regard to secondary outcomes, patients reported significantly higher spiritual well-being ($F = 5.53$, $p = 0.04$) and ego-integrity ($F = 16.03$, $p < 0.01$) after SOL than after RELAX. Effect sizes were medium to large for both spiritual well-being ($d = 0.52$) and ego-integrity ($d = 0.72$, Figure 3). Further, momentary distress was significantly lower after SOL ($F = 4.49$, $p = 0.05$), with a medium effect size of $d = -0.51$. Findings with regard to global quality of life showed a small between-group effect favoring the SOL ($d = 0.28$), but differences were not statistically significant
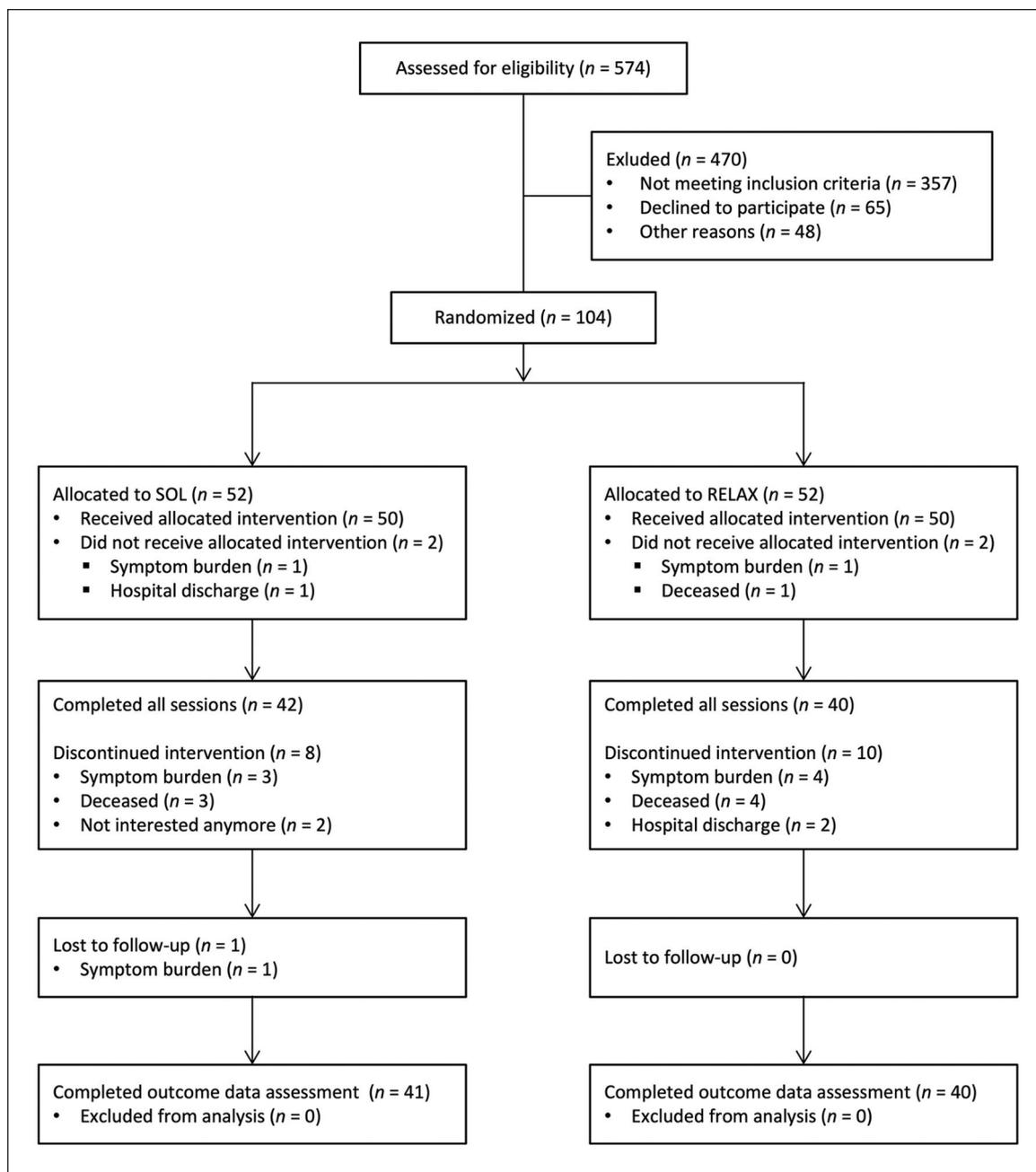
Figure 2. Patient flow chart.
SOL: "Song of Life" music therapy; RELAX: relaxation intervention.

($F = 0.71$, $p = 0.40$). Sensitivity analyses using multilevel modeling with AAD yielded identical test results (Table 2).

Table 3 lists results of the explorative analyses for the FQ. Overall, patients and family members reported a positive impact of both interventions. Effect sizes between groups were medium to large or large, all favoring SOL over RELAX. In the patient version, large effect sizes were found on the items "Participating in the intervention made me feel that life was more meaningful" ($d = 0.96$) and ". . . was important to me" ($d = 1.00$). For family members, large between-group effect sizes were identified for the

items ". . . made me feel something lasts from the patient" ($d = 2.03$) and ". . .will be helpful and comforting to our family" ($d = 1.14$), both immediately after the intervention (T1) and at follow-up (T2).

Discussion

Main findings/results of the study

Overall, our findings provide evidence that the innovative SOL technique has a positive impact on emotional and

spiritual components of palliative care patients' quality of life. In particular, we found significant treatment benefits with medium effect sizes regarding higher spiritual well-being and ego-integrity in the SOL group. Since patients nearing the end of life name existential fears regarding meaning in life as a fundamental challenge,[55] these results suggest that SOL provides relief through facilitating the experience of a sense of connectedness with life and oneself. Corroborating research on other life review techniques, the present study adds to the promising potential of biographical interventions with terminally ill patients pointing to personal meaningful music as a valuable legacy. In addition, the significant reduction of distress through SOL music therapy hints at an acute relief of burden as well. Patients at the end of life commonly report a high level of psychological distress involving unpleasant emotional experiences, so even a short-term decrease might be of clinical importance to alleviate the patients' suffering.[57,58] Similar to other studies investigating psychosocial interventions with advanced cancer patients, we found no significant differences between the study groups with regard to more general outcomes.[16] As our primary outcome contained items on general depression and anxiety, the measurement might not depict the actual content and goals of SOL (i.e. psycho-spiritual integration processes). Additionally, without a third study arm receiving usual care only, we cannot make conclusions about the effects of either SOL or RELAX on the MQOL-R domains in comparison to no add-on treatment. Further, as patient-reported outcomes may depend on the individual interpretation of items, future research may include external

Table 1. Baseline sample characteristics.

Characteristic	SOL	RELAX
Participants per site (*n*, %)		
Study site 1	24 (23.1%)	24 (23.1%)
Study site 2	28 (26.9%)	28 (26.9%)
Age (*M*, SD, years)	67.75 (11.5)	64.46 (12.37)
Sex (*n*, % female)	41 (78.8%)	36 (69.2%)
Cancer type (%, *n*)		
Gastrointestinal	30.8% (16)	26.9% (14)
Gynecologic	28.8% (15)	26.9% (14)
Skin	9.6% (5)	9.6% (5)
Lymphatic	5.8% (3)	9.6% (5)
Thoracic	9.6% (5)	15.4% (8)
Other	13.5% (7)	9.6% (5)
Non-cancer	1.9% (1)	1.9% (1)
Karnofsky performance status scale (*M*, SD, 0–100)	42.88 (15.51)	48.46 (20.71)
Treatment expectancy (*M*, SD, 1–5)	3.74 (0.69)	3.81 (0.60)

SOL: "Song of Life" music therapy (experimental group); RELAX: relaxation intervention (control group); M: mean; SD: standard deviation.

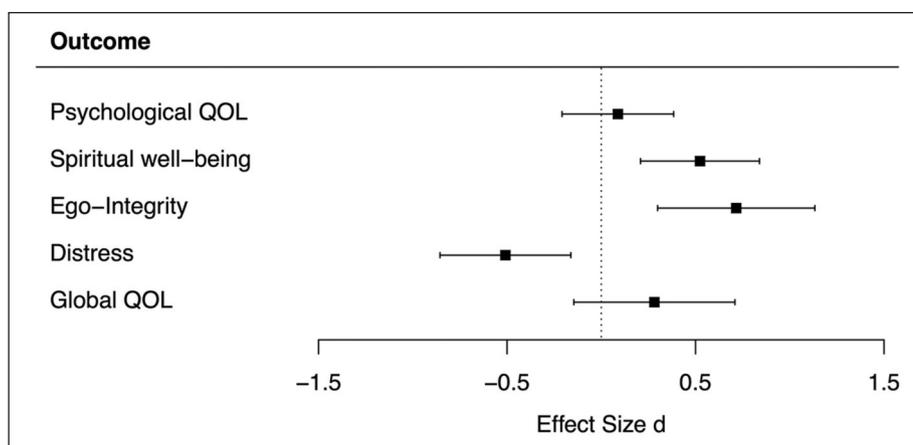**Table 2.** Results for primary and secondary outcomes.

	Descriptive statistics and effect sizes (AAD)							ANCOVA (MI)		MLM (AAD)	
	SOL			RELAX			*d* (CI)[a]				
	N	*M*	*SD*	*N*	*M*	*SD*		*F*	*p*[b] Value	*b*	*p*[b] Value
Psychological quality of life (MQOL-R, range = 0–10)											
Baseline (T0)	52	5.22	2.25	52	5.50	2.74					
Post-intervention (T1)	41	5.46	2.07	40	5.51	2.44	0.09 (−0.21, 0.38)	0.13	0.721	0.07	0.859
Meaning/peace (FACIT-Sp, range = 0–32)											
Baseline (T0)	50	20.40	4.45	50	22.70	4.32					
Post-intervention (T1)	41	22.32	5.09	40	22.30	5.17	0.52 (0.21, 0.84)	5.53	0.039*	2.45	0.006*
Ego-integrity (BMGE, range = 1–5)											
Baseline (T0)	51	3.20	0.52	52	3.34	0.66					
Post-intervention (T1)	41	3.58	0.57	40	3.29	0.59	0.72 (0.30, 1.13)	16.03	<0.001*	0.47	0.001*
Distress (NCCN distress thermometer, range = 0–10)											
Baseline (T0)	50	5.66	2.50	50	4.82	2.54					
Post-intervention (T1)	42	3.33	2.43	40	3.78	2.54	-0.51 (−0.86, -0.16)	4.49	0.046*	−1.18	0.017*
Global quality of life (MQOL-R, range = 0–10)											
Baseline (T0)	52	4.50	2.10	52	4.92	2.46					
Post-intervention (T1)	41	5.73	2.05	40	5.50	2.32	0.28 (-0.15, 0.71)	0.71	0.401	0.61	0.254

SOL: "Song of Life" music therapy; RELAX: relaxation intervention; ANCOVA: analysis of covariance; MLM: multilevel modeling; MI: multiple imputation; AAD: all available data; M: mean; SD: standard deviation; MQOL-R: McGill quality of life questionnaire–revise); FACIT-Sp: functional assessment of chronic illness therapy-spiritual well-Being; BMGE: brief measure of generativity and ego-integrity; NCCN: national comprehensive cancer network.
[a]Effect size variant of Cohen's *d* for pretest-posttest-control group designs.[55]
[b]*p*-Values were adjusted by the Benjamini-Hochberg correction in secondary outcomes.[48]
*Statistically significant ($p < 0.050$).

Figure 3. Effect sizes and 95% confidence intervals for primary and secondary outcomes.
QOL: quality of life; d: effect size according to Morris;50 positive effect size indicates higher increase in SOL than in RELAX.

Table 3. Explorative results for feedback questionnaire.

Participating in the intervention...	Post-intervention (T1, AAD)					Follow-up (T2, AAD)				
	SOL		RELAX			SOL		RELAX		
Patient evaluation	n	M (SD)	n	M (SD)	d [95% CI]	n	M (SD)	N	M (SD)	d [95% CI]
. . . was helpful to me	40	4.30 (0.69)	40	3.80 (0.88)	0.63 [0.18, 1.08]	–		–		–
. . . was satisfactory	40	4.55 (0.71)	40	3.98 (0.80)	0.76 [0.30, 1.21]	–		–		–
. . . made me feel that life was more meaningful	40	3.60 (0.98)	40	2.58 (1.15)	0.96 [0.49, 1.42]	–		–		–
. . . met my expectations	36	4.22 (0.72)	39	3.64 (0.93)	0.69 [0.23, 1.16]	–		–		–
. . . was or will be of help to my family	39	3.56 (0.99)	39	2.69 (1.24)	0.78 [0.32, 1.24]	–		–		–
. . . helped me to accept the way things are	40	3.70 (0.79)	40	3.05 (1.11)	0.68 [0.22, 1.13]	–		–		–
. . . was important to me	40	4.35 (0.70)	40	3.53 (0.93)	1.00 [0.53, 1.47]	–		–		–
. . . is something I would recommend to others	40	4.70 (0.52)	39	4.33 (0.58)	0.67 [0.22, 1.12]	–		–		–
Family member evaluation										
. . . was helpful to the patient	23	4.52 (0.59)	19	3.58 (0.90)	1.26 [0.59, 1.93]	17	4.59 (0.51)	9	3.67 (0.87)	1.42 [0.52, 2.32]
. . . was satisfactory to the patient	23	4.61 (0.50)	19	3.63 (1.01)	1.26 [0.60, 1.93]	16	4.38 (0.50)	9	3.44 (1.13)	1.19 [0.31, 2.08]
. . . made the patient feel life was meaningful	23	3.43 (1.12)	20	2.60 (1.14)	0.74 [0.12, 1.36]	16	3.13 (1.02)	9	2.00 (1.00)	1.11 [0.23, 1.98]
. . . helped to alleviate the patient's suffering	22	4.23 (0.75)	20	3.20 (0.89)	1.25 [0.58, 1.91]	17	4.12 (0.70)	9	3.22 (1.20)	1.00 [0.14, 1.85]
. . . was helpful to me	23	3.78 (1.04)	19	2.95 (1.31)	0.71 [0.09, 1.34]	17	3.76 (1.15)	9	2.44 (1.24)	1.12 [0.25, 1.99]
. . . will be helpful and comforting to our family	22	3.86 (1.04)	19	2.53 (1.31)	1.14 [0.48, 1.81]	17	3.82 (1.19)	9	2.00 (1.12)	1.57 [0.65, 2.49]
. . . made me feel something lasts from patient	23	3.91 (1.16)	19	1.89 (0.74)	2.03 [1.28, 2.78]	17	3.82 (1.07)	9	1.67 (0.87)	2.14 [1.13, 3.14]
. . . is something I would recommend to others	23	4.83 (0.39)	20	4.15 (0.88)	1.02 [0.39, 1.66]	17	4.88 (0.33)	9	4.22 (0.83)	1.20 [0.32, 2.07]

Range = 1–5 (agreement); SOL: "Song of Life" music therapy; RELAX: relaxation intervention; AAD: all available data; M: mean; SD: standard deviation; d: effect size Cohen's *d*; CI: confidence interval.[56]

assessments, for example, by clinicians, as well. Regarding the explorative evaluation of treatment satisfaction (FQ), patients and family members in the SOL group rated the intervention more favorably on all items. Single-item effect sizes point to a profound personal relevance and perceived meaningfulness of the SOL. Family members, in particular, considered SOL benefits to be enduring and helpful to the whole family. The large between-groups effect sizes at both T1 and T2 on the item ". . . made me feel something lasts from the patient" highlights the important difference that the created legacy (SOL recording) might have made for the (bereaved) family member.

Limitations

With regard to the selection of an appropriate comparator for the experimental intervention, the Declaration of Helsinki demands the effects of a new intervention to be tested against those of the best proven intervention.[59] Usual-care-only groups may therefore be considered unethical in palliative care research and may also threaten the internal validity of a study through attention bias and lack of blinding.[36] Therefore, we decided to compare two active psychosocial therapies which may partially explain the non-significant findings regarding psychological and global quality of life. Moreover, the generalizability of findings may be limited as 74% of participants were female. Ad-hoc analysis of sex differences in the observed treatment effects showed that effect sizes for the increase in spiritual well-being were larger in women while the observed distress reductions were more pronounced in men. This finding is consistent with previous research suggesting that women may be more open to development in gratitude and compassion, while men may have a stronger disease- or health-related focus.[58] Further, the patient assessment only contained two measurement times, as long-term assessment plans were proven to be unfeasible considering an average hospital stay of less than 2 weeks.[31,60] The present attrition rate of 22.1% is comparable to other studies and we addressed the issue of missing data integrating findings from different statistical approaches.[61] We implemented the T2 family member follow-up to evaluate the endurance of effects, but also faced recruitment challenges and high attrition rates increasing the likelihood of selection bias in these results. At T2 among the family members that participated, only 28.6% of patients were alive. Of note, there was a great amount of family members who declined to participate at T2 due to the recent loss of their loved one.

What this study adds

Findings from this multicenter RCT suggest that SOL music therapy can serve as an effective psychosocial treatment in palliative care to facilitate psycho-spiritual integration and reduce distress in patients nearing the end of life. Future studies may continue to explore optimal study outcomes and should address the importance of patient characteristics (e.g. sex, cultural background) in order to tailor biographical interventions to the individual's situation and needs.

Author contributions

MWA and FK analyzed the data and drafted the manuscript. JK, HJB, MWE and BD contributed significantly to the design and conception of the study. MB and FK collected data. MWA, FK, MWE, MB, HJB, BD, and JK critically revised the present version of the manuscript. MWA, FK, MWE, MB, HJB, BD, and JK gave final approval of the version to be published. All authors declare that they had full access to the data in the study and accept responsibility to submit for publication.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data management and patient consent

This study was conducted in accordance with the Declaration of Helsinki and the ICMJE Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals. The trial was approved by the Ethics Committee of the Medical Faculty of Heidelberg University on July 5th 2018 (S-398/2018) and by the Landesärztekammer Rheinland-Pfalz on August 30th 2018 (2018–13496). Participants were only included if they provided written informed consent.

Disclosure of stakeholder investments (CONSORT SPI extension)

MW developed the SOL intervention (together with Josien van Kampen) and was also involved in the design, analysis, and reporting of the trial. He was not involved in the assessments and study therapies.

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Data management and sharing

The dataset for this study is accessible in the heiDATA repository under the following identifier: https://doi.org/10·11588/data/Z4XZQ7.

Supplemental material

Supplemental material for this article is available online.

References

1. Holland JC, Breitbart WS, Jacobsen PB, et al. *Psycho-oncology*. New York: Oxford University Press, 2010.
2. Potter J, Hami F, Bryan T, et al. Symptoms in 400 patients referred to palliative care services: prevalence and patterns. *Palliat Med* 2003; 17: 310–314.
3. World Health Organization. WHO definition of palliative care; http://www.who.int/cancer/palliative/definition/en (2015, accessed 30 April 2015).
4. Mitchell AJ, Chan M, Bhatti H, et al. Prevalence of depression, anxiety, and adjustment disorder in oncological, haematological, and palliative-care settings: a meta-analysis of 94 interview-based studies. *Lancet Oncol* 2011; 12: 160–174.
5. Rodin G. Research on psychological and social factors in palliative care: an invited commentary. *Palliat Med* 2013; 27: 925–931.
6. Kumar S, Morse M, Zemenides P, et al. Psychotherapies for psychological distress in the palliative care setting. *Psychiatr Ann* 2012; 42: 133–137.
7. Teo I, Krishnan A and Lee GL. Psychosocial interventions for advanced cancer patients: a systematic review. *Psycho Oncol* 2019; 28: 1394–407.
8. Rodin G, An E, Shnall J, et al. Psychological interventions for patients with advanced disease: implications for oncology and palliative care. *J Clin Oncol* 2020; 38: 885–904.
9. Uitterhoeve RJ, Vernooy M, Litjens M, et al. Psychosocial interventions for patients with advanced cancer-a systematic review of the literature. *Br J Cancer* 2004; 91: 1050–1062.
10. Zimmermann FF, Burrell B and Jordan J. The acceptability and potential benefits of mindfulness-based interventions in improving psychological well-being for adults with advanced cancer: a systematic review. *Complement Ther Clin Pract* 2018; 30: 68–78.
11. Breitbart W, Rosenfeld B, Pessin H, et al. Meaning-centered group psychotherapy: an effective intervention for improving psychological well-being in patients with advanced cancer. *J Clin Oncol* 2015; 33: 749–754.
12. Rodin G, Lo C, Rydall A, et al. Managing Cancer and Living Meaningfully (CALM): a randomized controlled trial of a psychological intervention for patients with advanced cancer. *J Clin Oncol* 2018; 36: 2422–2432.
13. von Blanckenburg P and Leppin N. Psychological interventions in palliative care. *Curr Opin Psychiatry* 2018; 31: 389–395.
14. Warth M, Kessler J, Koehler F, et al. Brief psychosocial interventions improve quality of life of patients receiving palliative care: a systematic review and meta-analysis. *Palliat Med* 2019; 33: 332–345.
15. Martinez M, Arantzamendi M, Belar A, et al. 'Dignity therapy', a promising intervention in palliative care: a comprehensive systematic literature review. *Palliat Med* 2017; 31: 492–509.
16. Chochinov HM, Kristjanson LJ, Breitbart W, et al. Effect of dignity therapy on distress and end-of-life experience in terminally ill patients: a randomised controlled trial. *Lancet Oncol* 2011; 12: 753–762.
17. Mai SS, Goebel S, Jentschke E, et al. Feasibility, acceptability and adaption of dignity therapy: a mixed methods study achieving 360 degrees feedback. *BMC Palliat Care* 2018; 17: 73.
18. Wang CW, Chow AY and Chan CL. The effects of life review interventions on spiritual well-being, psychological distress, and quality of life in patients with terminal or advanced cancer: a systematic review and meta-analysis of randomized controlled trials. *Palliat Med* 2017; 31: 883–894.
19. Erikson JM. *The life cycle completed: Extended version with new chapters on the ninth stage of development*. New York, NY: W. W. Norton & Company, 1998.
20. Vuksanovic D, Dyck M and Green H. Development of a brief measure of generativity and ego-integrity for use in palliative care settings. *Palliat Support Care* 2015; 13: 1411–1415.
21. Xiao J, Chow KM, Liu Y, et al. Effects of dignity therapy on dignity, psychological well-being, and quality of life among palliative care cancer patients: a systematic review and meta-analysis. *Psycho Oncol* 2019; 28: 1791–802.
22. Salmon D. Music therapy as psychospiritual process in palliative care. *J Palliat Care* 2001; 17: 142–146.
23. Munro S and Mount B. Music therapy in palliative care. *Can Med Assoc J* 1978; 119: 1029–1034.
24. McConnell T and Porter S. Music therapy for palliative care: a realist review. *Palliat Support Care* 2017; 15: 454–464.
25. Bruscia KE. *Defining music therapy*. 2nd ed. Gilsum, NH: Barcelona Publishers, 1998.
26. Clements-Cortes A. Development and efficacy of music therapy techniques within palliative care. *Complement Ther Clin Pract* 2016; 23: 125–129.
27. Koehler F, Martin Z-S, Hertrampf R-S, et al. Music therapy in the psychosocial treatment of adult cancer patients: a systematic review and meta-analysis. *Front Psychol* 2020; 11: 651.
28. Warth M, Kessler J, Hillecke TK, et al. The effectiveness of receptive music therapy in palliative care: results of a randomized, controlled trial. *Nord J Music Ther* 2016; 25: 82–83.
29. Hilliard RE. The effects of music therapy on the quality and length of life of people diagnosed with terminal cancer. *J Music Ther* 2003; 40: 113–137.
30. Wlodarczyk N. The effect of music therapy on the spirituality of persons in an in-patient hospice unit as measured by self-report. *J Music Ther* 2007; 44: 113–122.
31. Porter S, McConnell T, Graham-Wisener L, et al. A randomised controlled pilot and feasibility study of music therapy for improving the quality of life of hospice inpatients. *BMC Palliat Care* 2018; 17: 125.

32. Gutgsell KJ, Schluchter M, Margevicius S, et al. Music therapy reduces pain in palliative care patients: a randomized controlled trial. *J Pain Symptom Manag* 2013; 45: 822–831.

33. Horne-Thompson A and Grocke D. The effect of music therapy on anxiety in patients who are terminally ill. *J Palliat Med* 2008; 11: 582–590.

34. Warth M, Kessler J, van Kampen J, et al. 'Song of Life': music therapy in terminally ill patients with cancer. *BMJ Support Palliat Care* 2018; 8(2): 167–170.

35. Warth M, Koehler F, Weber M, et al. "Song of Life (SOL)" study protocol: a multicenter, randomized trial on the emotional, spiritual, and psychobiological effects of music therapy in palliative care. *BMC Palliat Care* 2019; 18: 14.

36. Munder T and Barth J. Cochrane's risk of bias tool in the context of psychotherapy outcome research. *Psychother Res* 2018; 28(3): 347–355.

37. Hui D, Nooruddin Z, Didwaniya N, et al. Concepts and definitions for "actively dying," "end of life," "terminally ill," "terminal care," and "transition of care": a systematic review. *J Pain Asymptom Manag* 2014; 47: 77–89.

38. Cohen SR, Sawatzky R, Russell LB, et al. Measuring the quality of life of people at the end of life: the McGill Quality of Life Questionnaire-Revised. *Palliat Med* 2017; 31: 120–129.

39. Cella DF, Tulsky DS, Gray G, et al. The Functional Assessment of Cancer Therapy scale: development and validation of the general measure. *J Clin Oncol* 1993; 11: 570–579.

40. Peterman AH, Fitchett G, Brady MJ, et al. Measuring spiritual well-being in people with cancer: the functional assessment of chronic illness therapy—Spiritual Well-being Scale (FACIT-Sp). *Ann Behav Med* 2002; 24: 49–58.

41. Mehnert A, Müller D, Lehmann C, et al. Die deutsche version des NCCN distress-Thermometers. *Zeitschrift für Psychiatrie Psychologie und Psychotherapie* 2006; 54: 213–223.

42. Linehan K, Fennell KM, Hughes DL, et al. Use of the distress thermometer in a cancer helpline context: can it detect changes in distress, is it acceptable to nurses and callers, and do high scores lead to internal referrals? *Eur J Oncol Nurs* 2017; 26: 49–55.

43. McClement S, Chochinov HM, Hack T, et al. Dignity therapy: family member perspectives. *J Palliat Med* 2007; 10: 1076–1082.

44. Faul F, Erdfelder EL, Lang AG, et al. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods* 2007; 39: 175–191.

45. Cohen J. A power primer. *Psychol Bull* 1992; 112: 155–159.

46. White IR, Carpenter J and Horton NJ. Including all individuals is not enough: lessons for intention-to-treat analysis. *Clin Trials* 2012; 9: 396–407.

47. R Core Team. *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing, https://www.R-project.org/ (2018, accessed July 24, 2020).

48. Feaster DJ, Mikulich-Gilbertson S and Brincks AM. Modeling site effects in the design and analysis of multi-site trials. *Am J Drug Alcohol Abuse* 2011; 37: 383–391.

49. van Buuren S and Groothuis-Oudshoorn K. mice: Multivariate imputation by Chained Equations in R. *J Stat Softw* 2011; 45: 1–67.

50. Morris SB. Estimating effect sizes from pretest-posttest-control group designs. *Organ Res Methods* 2008; 11: 364–386.

51. Viechtbauer W. Conducting meta-analyses in R with the metafor package. *J Stat Softw* 2010; 36: 1–48.

52. Bates D, Mächler M, Bolker B, et al. Fitting linear mixed-effects models using lme4. *J Stat Softw* 2015; 67: 1–48.

53. Benjamini Y, Heller R and Yekutieli D. Selective inference in complex research. *Philos Trans A Math Phys Eng Sci* 2009; 367: 4255–4271.

54. Ben-Shachar M, Makowski D and Lüdecke D. Compute and interpret indices of effect size. *CRAN R package*. 2020.

55. Grossman CH, Brooker J, Michael N, et al. Death anxiety interventions in patients with advanced cancer: a systematic review. *Palliat Med* 2018; 32: 172–184.

56. Viechtbauer W. Confidence intervals for the amount of heterogeneity in meta-analysis. *Stat Med* 2007; 26: 37–52.

57. Kelly B, McClement S and Chochinov HM. Measurement of psychological distress in palliative care. *Palliat Med* 2006; 20: 779–789.

58. Luna MJ, Ameli R, Sinaii N, et al. Gender differences in psycho-social-spiritual healing. *J Womens Health* 2019; 28: 1513–1521.

59. World Medical Association. World medical association declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA* 2013; 310: 2191–2194.

60. Ostgathe C, Alt-Epping B, Golla H, et al. Non-cancer patients in specialized palliative care in Germany: what are the problems? *Palliat Med* 2011; 25: 148–152.

61. Hui D, Glitza I, Chisholm G, et al. Attrition rates, reasons, and predictive factors in supportive care and palliative oncology clinical trials. *Cancer* 2013; 119: 1098–1105.

Appendix A4 – **Manuscript 4**

Koehler, F., Kessler, J., Stoffel, M., Weber, M., Bardenheuer, H. J., Ditzen, B., & Warth, M. (under revision). Psychoneuroendocrinological effects of music therapy versus mindfulness in palliative care: Results from the 'Song of Life' randomized controlled trial. *Supportive Care in Cancer*.

Friederike Köhler's contribution according to the contributor roles taxonomy (CRediT) author statement (Allen et al., 2019):
methodology, software, formal analysis, investigation, data curation, writing – original draft, writing – review and editing, visualization

Psychoneuroendocrinological effects of music therapy versus mindfulness in palliative care: Results from the 'Song of Life' randomized controlled trial

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Abstract

Purpose

Although research on psychosocial interventions in palliative care provided evidence for their effectiveness regarding patient-reported outcomes, few studies have examined their psychobiolocial effects yet. Therefore, the purpose of the present work as part of an overarching study was to investigate differential effects of music therapy versus mindfulness on subjective distress and both neuroendocrine and autonomic stress biomarkers.

Methods

104 patients from two palliative care units were randomly assigned to three sessions of either music therapy or mindfulness. Before and after the second session (completed by 89 patients), participants rated their momentary distress and provided three saliva samples for cortisol and α-amylase analysis. Furthermore, photoplethysmography recordings were continuously assessed to calculate mean heart rate and heart rate variability. Data were analyzed using multilevel modeling of all available data and sensitivity analysis with multiply imputed data.

Results

Between 67 % and 75 % of the maximally available data points were included in the primary analyses of psychobiological outcomes. Results showed a significant time*treatment effect on distress ($b = -0.83$, $p = .02$) indicating a greater reduction in the music therapy group. No interaction effects were found in psychobiological outcomes (all $p > .05$), but multilevel models revealed a significant reduction in cortisol ($b = -0.06$, $p = .01$) and mean heart rate ($b = -7.89$, $p = .05$) over time following either intervention.

Conclusion

Findings suggest a beneficial effect music therapy on distress while no differential psychobiological treatment effects were found. Future studies should continue to investigate optimal stress biomarkers for psychosocial palliative care research.

Background

Palliative and supportive care aims at the relief of suffering in patients facing a life-threatening disease addressing their needs holistically on a physical, psychological, social, and spiritual level. Therefore, psychsocial interventions from various disciplines have been developed with a therapeutic focus on emotional, spiritual, or interpersonal consequences of a terminal disease and its symptoms, or more broadly, on the relief of stress.

The bio-psycho-social model assumes a reciprocal influence among all three levels contributing to health and disease. For instance, chronic psychosocial stress can affect cancer risk and tumor progression by facilitating inflammatory processes and weakening the immune system [11]. Additionally, the diagnosis and treatment of the illness itself may be highly strenuous, which can further increase stress-related symptoms [17]. In this context, psychosocial interventions were hypothesized to reduce stress [12] and to impact clinical outcomes via pathways on a biological, psychological, and social level [5, 6].

To monitor possible alterations in stress regulatory systems, cancer research has attended to cortisol and α-amylase as well as heart rate variability (HRV) as non-invasive markers of stress [28, 44]. In the presence of a stressor, the body responds by activating two neuroendocrine pathways involving the hypothalamus-pituitary-adrenal (HPA) and the sympathetic-adreno-medullary (SAM) system [11]. As the primary endpoint of the HPA axis, cortisol is released via the adrenal cortex, impacting fundamental physiological processes, such as metabolism and the immune and cardiovascular systems [17]. The SAM axis regulates the sympathetic responses to stress by initiating the release of norepinephrine and epinephrine via the adrenal medulla. At the salivary glands, these catecholaminewere were found to increase the secretion of the enzyme α-amylase into saliva [20]. While not always consistent, the majority of studies observed elevated cortisol and α-amylase levels in advanced cancer patients as well as flattened diurnal cortisol patterns compared to other diseases or healthy controls [1, 27, 28, 30, 31, 36].

To investigate the role of the parasympathetic nervous system (PNS) via the vagus nerve, HRV has been introduced as a cardiac index of autonomic flexibility based on the observation that variability in

successive heartbeats mirrors the organism's ability to flexibly adapt to environmental challenges [32]. High HRV has been associated with resilience, social engagement, wellbeing, and psychological flexibility [25] and can be increased by internal and external stimuli, such as mindfulness [2] or music [16]. With regard to oncological diseases, research found lower HRV compared to healthy participants [8] and provides evidence for HRV as a predictor of survival in advanced cancer patients [10].

Research investigating interventions based on cognitive behavioral therapy, music therapy, relaxation, mindfulness, and yoga demonstrated beneficial effects on neuroendocrine, autonomic, and immune parameters in cancer patients [9, 22, 24, 33]. In palliative care settings or in patients nearing the end of life, however, there is a particular lack of research on the psychobiological effects of psychosocial interventions, possibly due to the patients' weak health status, high medication intake, severe sympotoms of xerostomia or nausea, and high attrition rates [43]. The available studies either focused on music therapy or mindfulness using brief and flexible intervention protocols considering the unique conditions in palliative care [34, 39]. Two studies found a decrease of perceived distress and heart rate, but no changes in HRV in response to brief and standardized mindfulness interventions [21, 40]. Another study on the effects of a music therapy showed a stronger increase in HRV, peripheral blood flow, and self-rated relaxation compared to prerecorded mindfulness [37, 38]. In a pilot study, palliative care patients receiving a single music therapy session reported increased existential well-being, but showed no differences in cortisol levels compared to the control group [3]. In contrast, another pilot study with hospice patients observed a reduction in cortisol levels after a music intervention, but lacked a control group [19].

The original aim of the present randomized controlled trial was to evaluate the efficacy of a three-session biographical music therapy intervention ('Song of Life'; SOL) compared to a control relaxation/mindfulness treatment in palliative care [42]. The results reported in a previous publication showed significant beneficial pre-to-post intervention effects of music therapy on self-rated psycho-spiritual quality of life. [41]. Due to the paucity of research linking psychological with biological effects of psychosocial interventions in palliative care, we additionally aimed to explore stress biomarker trajectories in response to both interventions during the second session, in which a

biographically meaningful song was played live to the patient. The present work will therefore focus on the psychobiological assessment of intervention effects during the second session2.

Methods

Study design

In a multicenter randomized controlled design, the present study had two trial conditions in parallel assignment: SOL music therapy plus usual care in the experimental group (EG) versus a relaxation/mindfulness intervention (RELAX) plus usual care as the control group (CG). The study was conducted at the University Palliative Care Unit at St. Vincentius Hospital, Heidelberg University Hospital, Germany, and the Interdisciplinary Palliative Care Unit at the University Medical Center of the Johannes Gutenberg University of Mainz, Germany. The trial was approved by the two responsible ethical review boards, and was preregistered at the German Clinical Trials Registry (DRKS00015308). A study protocol with methods and procedures had been published prior to trial conduction [42].

Participants

Eligible patients were 18 years or older, received specialized palliative treatment according to OPS 8-982/OPS 8-98e (German modification of International Classification of Procedures in Medicine; ICPM) or had an estimated life expectancy of < 12 months, and could provide informed consent. Exclusion criteria were no proficiency in German language, a clinical estimation of life expectancy < 1 week, cognitive and auditory impairments, and psychiatric symptoms.

Randomization, masking, and blinding

A computer-based block randomization sequence (block size = 8) was used to allocate participants with stratification by study site before the commencement of the study and was unknown to the research staff conducting the study. Allocation concealment was achieved through opening sequentially numbered opaque envelopes after the participant had provided written informed consent and finished baseline assessment. For blinding of participants, we used an active control group while

patients were not informed about the intervention under investigation. Blinding of therapists and outcome assessors was not feasible (single-blind).

Procedures

Patients were asked to sign the consent form and to complete a baseline assessment. Research staff afterwards opened an envelope with the group assignment. Both interventions consisted of three 20-30 minute-sessions, each with a pre-to-post assessment of momentary distress.

The second session (S2) was complemented by psychobiological assessments (combining self-reports with physiological and biochemical measures) as this session contained the live music performance. During this session, patients were asked to deliver 3 salivary samples in 20 minute-intervals for cortisol and α-amylase measurement, immediately before (T0) and after the session (T1) and at follow-up (T2, Fig.1)), in order to capture biological stress gradients over time. A photoplethysmography (PPG) sensor (biosignalplux, Lisbon, Portugal) was placed on the index finger of the patient's non-dominant hand to assess the cardiovascular response in a continuous recording during S2, as well as 20 minutes later as a follow-up 5-min-segment (parallel to saliva sample T2). To address the impact of confounding factors, patients were asked to refrain from eating and drinking an hour before the session, if possible. Further, we assessed potentially confounding variables (e.g. eating, drinking, wake-up) in a short interview before and after each session and documented medication intake.After the last session (S3), research staff completed post-intervention outcome assessment.

<insert Fig. 1>

Interventions

Both interventions were carried out by two music therapists who were employed at the participating palliative care wards who were trained in all intervention procedures. The SOL music therapy in the EG began with a first session (S1) of conversation between therapist and patient aiming to determine a biographically meaningful and emotionally arousing song. In S2, the therapist sang this song live accompanied by guitar or e-piano and modified to a lullaby style (slow 3/4 or 6/8 rhythm), while the

performance was audio-recorded. The therapist gave the edited recording to the patient in S3 and discussed feelings and memories by pre-defined questions.

Patients in the relaxation/mindfulness intervention (CG) participated in three standardized sessions of muscle relaxation (S1), mindful focus on the breath (S2), and imagery (S3), with a short inquiry at the end of each session. Techniques did not involve any musical, spiritual, or biographical themes. The target session S2 consisted of a standardized mindful breathing exercise, in which patients were instructed to become aware of different facets of the breath (e.g. duration, bodily sensations, breaks) non-judgementally. The 15-minute exercise was followed by a debriefing asking for arising feelings and thoughts. Detailed intervention manuals have been published [41].

Outcome measures

Before and after S2, patients were asked to rate momentary distress using a modified version of the NCCN Distress Thermometer [14] ranging from 0 ("no distress") to 10 ("extreme distress") [15].

Salivary cortisol (sCort) and α-amylase (sAA) were repeatedly assessed by means of saliva samples (T0-T2; Fig. 1). To minimize variance due to diurnal cortisol patterns, the second session always took place between 2 pm and 6 pm. Salivette® (Sarstedt, Nümbrecht, Germany) devices were used for saliva sampling. Patients were asked to chew on the synthetic swab for 1 minute. Salivettes were later centrifuged and the aliquoted saliva was stored in polypropylene vials at the laboratory of the Institute of Medical Psychology, Heidelberg, Germany. Acommercially available enzyme-linked immunosorbent assay (ELISA; DES6611; Demeditec Diagnostics, Kiel, Germany) was used to analyze concentration of sCort (ng/ml). Concentrations of sAA (U/ml) were quantified using a kinetic colorimetric kit with reagents from Roche (Roche Diagnostics, Mannheim, Germany). The intra-assay coefficient of variation (CV) was 3.05 % for sCort and 3.87 % for sAA. The inter-assay CV was 3.82 % for sCort and 8.37 % for sAA.

In addition, continuous PPG recordings served to assess participants' cardiac autonomic response in terms of beat-to-beat variations in heart rate. We derived inter-beat-intervals (IBI) between successive heartbeats in milliseconds for three time segments of 5 min duration corresponding to T0-T2 [23]

(Fig. 1). Research commonly associates the root mean square of successive differences (RMSSD) with parasympathetic activity and ability to recover [26]. We thus used RMSSD as a marker of vagally-mediated HRV and the mean heart rate (mHR) as a general biomarker of autonomic activity.

Statistical analysis

Due to the hierarchical data structure (repeated observations on Level 1 nested in patients on Level 2), we performed multilevel modeling (MLM) in the statistical environment R. In an intention-to-treat approach, primary analysis was performed based on all available data (AAD). MLM parameters were obtained via maximum likelihood (ML) estimation with the R package 'lme4' [7], while *p*-values for fixed effects were calculated via 'lmerTest'. Separate multilevel models were computed to predict distress, sCort, sAA, mHR, and RMSSD. Based on visual inspections of variable distributions, sCort, sAA and RMSSD were log transformed to approximate normality in the distribution of model residuals. Outliers beyond three standard deviations from the mean were excluded.

All outcome models included fixed predictors for time (0, 1, 2), treatment (contrast coded; 0 = RELAX, 1 = SOL), time*treatment, and study site (0, 1). If visual inspection of data revealed evidence for a non-linear trajectory over time, we added a quadratic polynomial for the 'time' variable (0, 1, 4), which was the case in mHR and RMSSD. If likelihood ratio tests revealed a significantly improved model fit with the quadratic term, this model was selected as final.

To test the hypotheses, we built random-intercept models with preselected covariates which were recommended in previous literature for psychobiological outcomes [4, 29, 35, 43]. These covariates included sex (0 = male, 1 = female) and age (years) for all outcomes as well as corticosteroid medication, sedative medication (0 = no intake, 1 = intake) and time since last meal (minutes) for sCort. All models were further estimated including a random slope of time to test for intraindividual variation. However, likelihood ratio tests comparing the nested models indicated no significantly improved model fit with an additional random effect of time, so random-intercept models were maintained. Both continuous predictors (age, time since last meal) were measured on level 2, and were centered on the grand mean. Each final model was graphically assessed for violations of central model assumptions (e.g., using qq-plots, or plots of residuals against predictors and fitted values).

Finally, we replicated the described models with multiply imputed data (MID) for sensitivity analyses with regard to missing data. To that end, we created sets of 20 multilevel imputations for each model and pooled the results with the R package 'mitml' [13]. Although analyses were explorative, based on literature and previous research [38, 40, 41], we postulated beneficial treatment effects of both interventions (decrease of distress, sCort, sAA, mHR and increase of RMSSD) and hypothesized these effects to be significantly more pronounced in the music therapy group.

Sample size calucalations were presented in the study protocol [42].

Results

Between December 2018 and August 2020, a total of 574 patients were assessed for eligibility. Of the $N = 104$ patients randomized, $N = 89$ completed session two including the pre-to-post session assessment of momentary distress. Among maximally available $n = 267$ samples, $n = 178$ samples (66.6 %) were finally analyzed for sCort, $n = 188$ (70.4 %) for sAA, $n = 199$ (74.5 %) for mHR, and $n = 195$ (73.0 %) for RMSSD. Missingness in the sCort/sAA data occurred as samples could either not be collected due to xerostomia or nausea or as samples did not contain enough liquid for the assays (i.e. < 50 µl for sCort and < 10µl for sAA). The main reason for loss of data in the PPG recordings was measurement artifacts caused by movement or reduced peripheral blood flow (Fig. 2). The patient sample for analysis consisted of mainly women ($n = 66$, 74.2 %) with a mean age of $M = 65.8$ years. $n = 87$ participants (97.8 %) had a primary diagnosis of advanced cancer (Tab. 1). There were no significant group differences for all outcome measures at T0, with the exception of mean heart rate indicating a lower mean heart rate at T0 in the SOL group ($t(197) = 1.99$, $p = .05$).

<insert Fig. 2>

<insert Tab. 1>

Table 2 depicts the results of multilevel modeling of treatment effects. Analysis of momentary distress showed a statistically significant time*treatment interaction indicating a greater reduction for SOL participants (M1: $b = -0.83$, $p = .02$). Means and standard errors are illustrated in Figure 3.

<insert Tab. 2>

<insert Fig. 3>

Figure 4 displays means and standard errors for psychobiological data. With regard to all psychobiological outcomes, we found no statistically significant time*treatment interaction in the AAD set (all p > .05). However, multilevel modeling showed a significant main effect of time (linear) in sCort (M3: b = -0.08, p < .001) indicating that cortisol concentration decreased over time in both interventions with no differences between groups. Moreover, both the linear (M7: b = -3.65, p = .03) and quadratic trend of time (M7: b = 0.78, p = .05) were statistically significant for mHR, suggesting a U-shaped trajectory for both SOL and RELAX. In addition, mHR was generally higher in the RELAX than in the SOL group, which was represented by a main effect of treatment (M7: b = -7.89, p = .05).

Sensitivity analyses with MID yielded the same patterns of findings regarding the time*treatment interactions, i.e. a significant interaction effect for distress (M2: b = -0.75, p = .04) and the absence of time*treatment interactions in all psychobiological outcomes (all p > .05). MID provided further support for the observed overall linear decrease in sCort (M4: b = -0.09, p < .001). However, no significant main effect of treatment and no quadratic main effect of time were found in mHR (M8: both p > .05).

<insert Fig. 4>

Discussion

As one of the first studies to integrate psychobiological stress marker assessments, the present trial aimed to investigate potential working mechanisms of psychosocial interventions in palliative care by exploring differential effects of music therapy and mindfulness with regard to distress, sCort, sAA, mHR and HRV. In line with previous research on music therapy in palliative care [37], our findings provide evidence for a reduction of self-rated momentary distress in both groups and a significantly stronger reduction in SOL participants (without significant group differences in distress at T0). One reason for the superiority of SOL might be the higher emotional involvement of SOL participants as

they received a live performance of a biographically meaningful song while patients in the mindfulness group participated in a standardized mindful breathing exercise.

With regard to psychobiological outcomes, we found no differential treatment effects contrary to the hypothesis. Corresponding to previous inconsistent evidence on psychobiological effects of psychosocial interventions in palliative care [3, 18, 21, 28], we were unable to show superiority in terms of one treatment being more efficient than the other in affecting stress marker trajectories. One of the main reasons may be the overlapping working mechanisms between the two psychosocial treatments (e.g. therapeutic alliance, attention, empathy) and the lack of a third usual-care study arm. While primary and secondary endpoints of the parent trial were tailored to the SOL intervention (i.e. questionnaires on psycho-sprritual integration), psychobiological stress markers may respond more broadly to interpersonal and empathic care, regardless of the specific technique. Accordingly, sCort and mHR decreased from T0 to T1 in both groups in terms of descriptive statistics and significant main effects of time possibly indicating an effect of both interventions although a third usual-care-only study arm would be required to test this conclusionAnother explanation for the lack of differential psychobiological effects might be associated with challenges in data collection in palliative care [43]. Although we chose the cotton swab particularly as a non-invasive assessment, a considerable number of patients was not able to use it at all or to tolerate it long enough due to xerostomia or nausea. The discrepancy between the number of samples collected and samples successfully assayed might mirror the weakened capacity of the participants' salivary glands to produce enough liquid for analysis. Correspondingly, photoplethysmography also faced data losses due to technical problems, movement artifacts, and reduced blood flow in the patients' limbs.

The major strength and novelty of the present study was the integration of self-ratings with markers of HPA-axis and ANS reactivity in the evaluation of psychosocial interventions in palliative care. However, one particular limitation was the abovementioned high attrition rate in both salivary and photoplethysmographic sampling. We therefore analyzed data with an intention-to-treat approach using both AAD and MID in sensitivity analysis. Still, the study might have been statistically underpowered to detect small differential effects due to missing data. Of note, the different self-report

and biological stress markers assessed here, have individual time frames to respond (immediate response in subjective markers, mHR and sAA, more delayed responses in sCort). Therefore, an additional and later assessment might have captured potential differences between the interventions. Future research might include large-scale samples or a larger number of repeated measurements to counteract these difficulties. Another limitation was the lack of a usual-care-only group, which would have allowed for examining whether the two psychosocial interventions had more beneficial psychobiological effects than no treatment.

Conclusion

Findings from this RCT suggest a beneficial effect of the SOL music therapy intervention on distress compared to mindfulness exercises. However, no differential treatment effects were found with regard to cortisol, α-amylase, mean heart rate and HRV. Future studies should continue to investigate optimal psychobiological measurement methods in this field in order to complement the evaluation of effectiveness of psychosocial treatments on a subjective level.

Conflicts of interest

The authors declare that there is no conflict of interest.

Ethics approval

This study was conducted in accordance with the Declaration of Helsinki and the ICMJE Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals. The trial was approved by the Ethics Committee of the Medical Faculty of Heidelberg University on July 5th 2018 (S-398/2018) and by the Landesärztekammer Rheinland-Pfalz on August 30th 2018 (2018–13496).

Consent to participate

Participants were only included if they provided written informed consent to participate.

Consent for publication

Participants were only included if they provided written informed consent for publication.

Availability of data and material (data transparency)

The dataset for this study will be made available on request from the corresponding author.

Code availability (software application or custom code)

The code will be made available on request from the corresponding author.

Authors' contributions

All authors contributed significantly to the design and conception of the study. Marco Warth and Friederike Koehler analyzed the data and drafted the manuscript. Jens Kessler, Martin Stoffel, Martin Weber, Hubert J. Bardenheuer, and Beate Ditzen critically revised the present version of the manuscript. All authors gave final approval of the version to be published and declare that they had full access to the data in the study and accept responsibility to submit for publication.

References

1. Abercrombie HC, Giese-Davis J, Sephton S, Epel ES, Turner-Cobb JM, Spiegel D (2004) Flattened cortisol rhythms in metastatic breast cancer patients Psychoneuroendocrinology 29: 1082-1092
2. Adler-Neal AL, Waugh CE, Garland EL, Shaltout HA, Diz DI, Zeidan F (2020) The Role of Heart Rate Variability in Mindfulness-Based Pain Relief The Journal of Pain 21: 306-323
3. Allmendiger DC (2016) Randomisierte kontrollierte klinische Studie zur Überprüfung der Wirksamkeit von Musiktherapie zur Reduktion von Stress sowie deren Einfluss auf die Lebensqualität bei Palliativpatienten [Randomized clinical trial to evaluate the efficacy of music therapy to reduce stress and improve quality of life in palliative care patients] [Dissertation] Homburg/Saar: Universität des Saarlandes
4. Antelmi I, de Paula RS, Shinzato AR, Peres CA, Mansur AJ, Grupi CJ (2004) Influence of age, gender, body mass index, and functional capacity on heart rate variability in a cohort of subjects without heart disease Am J Cardiol 93: 381-385
5. Antoni MH (2013) Psychosocial intervention effects on adaptation, disease course and biobehavioral processes in cancer Brain Behav Immun 30: S88-S98
6. Antoni MH, Dhabhar FS (2019) The impact of psychosocial stress and stress management on immune responses in patients with cancer Cancer 125: 1417-1431
7. Bates D, Mächler M, Bolker B, Walker S (2015) Fitting Linear Mixed-Effects Models Using lme4 Journal of Statistical Software 67: 1-48
8. Caro-Morán E, Fernández-Lao C, Galiano-Castillo N, Cantarero-Villanueva I, Arroyo-Morales M, Díaz-Rodríguez L (2016) Heart Rate Variability in Breast Cancer Survivors After the First Year of Treatments: A Case-Controlled Study Biol Res Nurs 18: 43-49
9. Charalambous A, Giannakopoulou M, Bozas E, Paikousis L (2015) A Randomized Controlled Trial for the Effectiveness of Progressive Muscle Relaxation and Guided Imagery as Anxiety Reducing Interventions in Breast and Prostate Cancer Patients Undergoing Chemotherapy Evid Based Complement Alternat Med 2015: 270876
10. Chiang JK, Kuo TB, Fu CH, Koo M (2013) Predicting 7-day survival using heart rate variability in hospice patients with non-lung cancers PLoS One 8: e69482
11. Dai S, Mo Y, Wang Y, Xiang B, Liao Q, Zhou M, Li X, Li Y, Xiong W, Li G, Guo C, Zeng Z (2020) Chronic Stress Promotes Cancer Development Front Oncol 10
12. Engel GL (1977) The need for a new medical model: a challenge for biomedicine Science 196: 129-136
13. Grund S, Robitzsch A, Luedtke O (2019) mitml: Tools for multiple imputation in multilevel modeling. In: Editor (ed)^(eds) Book mitml: Tools for multiple imputation in multilevel modeling, City.
14. Mehnert A, Müller D, Lehmann C, Koch U (2006) Die deutsche Version des NCCN Distress-Thermometers Zeitschrift für Psychiatrie, Psychologie und Psychotherapie 54: 213-223
15. Mehnert A, Müller D, Lehmann C, Koch U (2006) Die deutsche Version des NCCN Distress-Thermometers [The German Version of NCCN Distress Thermometer] Zeitschrift für Psychiatrie, Psychologie und Psychotherapie 54: 213-223
16. Mojtabavi H, Saghazadeh A, Valenti VE, Rezaei N (2020) Can music influence cardiac autonomic system? A systematic review and narrative synthesis to evaluate its impact on heart rate variability Complement Ther Clin Pract 39: 101162
17. Moreno-Smith M, Lutgendorf SK, Sood AK (2010) Impact of stress on cancer metastasis Future Oncol 6: 1863-1881
18. Nakayama H, Kikuta F, Takeda H (2009) A pilot study on effectiveness of music therapy in hospice in Japan J Music Ther 46: 160–172
19. Nakayama H, Kikuta F, Takeda H (2009) A pilot study on effectiveness of music therapy in hospice in Japan Journal of music therapy 46: 160-172
20. Nater UM, Rohleder N (2009) Salivary alpha-amylase as a non-invasive biomarker for the sympathetic nervous system: current state of research Psychoneuroendocrinology 34: 486-496
21. Ng CG, Lai KT, Tan SB, Sulaiman AH, Zainal NZ (2016) The Effect of 5 Minutes of Mindful Breathing to the Perception of Distress and Physiological Responses in Palliative Care Cancer Patients: A Randomized Controlled Study J Palliat Med 19: 917-924

22.   Palma S, Keilani M, Hasenoehrl T, Crevenna R (2020) Impact of supportive therapy modalities on heart rate variability in cancer patients – a systematic review Disabil Rehabil 42: 36-43

23.   Quintana DS, Heathers JAJ (2014) Considerations in the assessment of heart rate variability in biobehavioral research Front Psychol 5 5: ArtID: 805

24.   Rao RM, Vadiraja HS, Nagaratna R, Gopinath KS, Patil S, Diwakar RB, Shahsidhara HP, Ajaikumar BS, Nagendra HR (2017) Effect of Yoga on Sleep Quality and Neuroendocrine Immune Response in Metastatic Breast Cancer Patients Indian J Palliat Care 23: 253-260

25.   Shaffer F, McCraty R, Zerr CL (2014) A healthy heart is not a metronome: An integrative review of the heart's anatomy and heart rate variability Front Psychol 5 5: ArtID: 1040

26.   Shaffer F, McCraty R, Zerr CL (2014) A healthy heart is not a metronome: an integrative review of the heart's anatomy and heart rate variability Frontiers in psychology 5: 1040-1040

27.   Sharpley CF, Christie DRH, Bitsika V, Agnew LL, Andronicos NM, McMillan ME, Richards TM (2017) Neurobiological and psychological evidence of chronic stress in prostate cancer patients Eur J Cancer Care (Engl) 26

28.   Sharpley CF, Christie DRH, Bitsika V, Agnew LL, Andronicos NM, McMillan ME, Richards TM (2017) The use of salivary cortisol as an index of chronic stress that correlates with depression in prostate cancer patients Psychooncology 26: 1400-1402

29.   Strahler J, Skoluda N, Kappert MB, Nater UM (2017) Simultaneous measurement of salivary cortisol and alpha-amylase: Application and recommendations Neurosci Biobehav Rev 83: 657-677

30.   Sultan A, Pati AK, Chaudhary V, Parganiha A (2017) Circadian rhythm characteristics of salivary alpha-amylase – a potential stress marker, in breast cancer in- and out-patients: a follow-up study Biological Rhythm Research 49: 680-696

31.   Suzuki K, Ichikawa T, Furuse H, Tsuda T, Tokui K, Masaki Y, Okazawa S, Kambara K, Inomata M, Yamada T, Miwa T, Matsui S, Kashii T, Taniguchi H, Hayashi R, Tobe K (2015) Relationship of the urine cortisol level with the performance status of patients with lung cancer: a retrospective study Support Care Cancer 23: 2129-2133

32.   Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996) Heart rate variability. Standards of measurement, physiological interpretation, and clinical use Eur Heart J 17: 354-381

33.   Vadiraja HS, Raghavendra RM, Nagarathna R, Nagendra HR, Rekha M, Vanitha N, Gopinath KS, Srinat BS, Vishweshwara MS, Madhavi YS, Ajaikumar BS, Ramesh BS, Nalini R, Kumar V (2009) Effects of Yoga Program on Cortisol Rhythm and Mood States in Early Breast Cancer Patients Undergoing Adjuvant Radiotherapy: A Randomized Controlled Trial Integrative Cancer Therapie 8

34.   von Blanckenburg P, Leppin N (2018) Psychological interventions in palliative care Current opinion in psychiatry 31: 389-395

35.   Voss A, Schroeder R, Heitmann A, Peters A, Perz S (2015) Short-term heart rate variability - influence of gender and age in healthy subjects PLoS One 10: e0118308

36.   Wan C, Couture-Lalande ME, Narain TA, Lebel S, Bielajew C (2016) Salivary Alpha-Amylase Reactivity in Breast Cancer Survivors Int J Environ Res Public Health 13: 353

37.   Warth M, Kessler J, Hillecke TK, Bardenheuer HJ (2015) Music Therapy in Palliative Care - A Randomized Controlled Trial to Evaluate Effects on Relaxation Dtsch Arzteblatt Int 112: 788-794

38.   Warth M, Kessler J, Hillecke TK, Bardenheuer HJ (2016) Trajectories of Terminally Ill Patients' Cardiovascular Response to Receptive Music Therapy in Palliative Care J Pain Symptom Manage 52: 196-204

39.   Warth M, Kessler J, Koehler F, Aguilar-Raab C, Bardenheuer HJ, Ditzen B (2019) Brief psychosocial interventions improve quality of life of patients receiving palliative care: A systematic review and meta-analysis Palliat Med 33: 332-345

40.   Warth M, Koehler F, Aguilar-Raab C, Bardenheuer HJ, Ditzen B, Kessler J (2020) Stress-reducing effects of a brief mindfulness intervention in palliative care: Results from a randomised, crossover study Eur J Cancer Care (Engl): e13249

41. Warth M, Koehler F, Brehmen M, Weber M, Bardenheuer HJ, Ditzen B, Kessler J (under review) 'Song of Life (SOL)': Results of a multicenter randomized trial on the effects of biographical music therapy in palliative care Palliat Med

42. Warth M, Koehler F, Weber M, Bardenheuer HJ, Ditzen B, Kessler J (2019) "Song of Life (SOL)" study protocol: a multicenter, randomized trial on the emotional, spiritual, and psychobiological effects of music therapy in palliative care BMC Palliat Care 18: 14

43. Warth M, Stoffel M, Koehler F, Bardenheuer HJ, Kessler J, Ditzen B (under review) Characteristics of salivary cortisol and alpha-amylase as psychobiological study outcomes in palliative care research BMC Palliat Care

44. Zhou X, Ma Z, Zhang L, Zhou S, Wang J, Wang B, Fu W (2016) Heart rate variability in the prediction of survival in patients with cancer: A systematic review and meta-analysis J Psychosom Res 89: 20-25

Table 1. Baseline characteristics of sample for analysis (*N* = 89)

Characteristic	SOL	RELAX
Participants per site (*n*, %)		
Study site 1	21 (23.60 %)	21 (23.60 %)
Study site 2	23 (25.84 %)	24 (26.97 %)
Age (*M*, *SD*, years)	68.07 (11.52)	63.58 (11.98)
Sex (*n*, % female)	34 (77.3 %)	32 (71.1 %)
Cancer type (%, *n*)		
Gastrointestinal	31.8 % (14)	26.7 % (12)
Gynecologic	27.3 % (12)	28.9 % (13)
Skin	9.1 % (4)	8.9 % (4)
Lymphatic	6.8 % (3)	11.1 % (5)
Thoracic	11.4 % (5)	11.1 % (5)
Other	11.4 % (5)	11.1 % (5)
Non-cancer	2.3 % (1)	2.2 % (1)
Karnofsky performance status scale (*M, SD*, 0-100)	43.86 (16.17)	50.22 (21.27)
Treatment expectancy (*M, SD*, 1-5)	3.74 (0.73)	3.76 (0.61)

Note. SOL = "Song of Life" music therapy, RELAX = Relaxation intervention

Table 2. Results of multilevel modeling with all available data (AAD) and multiply imputed data (MID)

Outcome	distress[a]				sCort (log)[b]				sAA (log)[c]				mean heart rate[d]				RMSSD (log)[d]			
	M1 (AAD)		M2 (MID)		M3 (AAD)		M4 (MID)		M5 (AAD)		M6 (MID)		M7 (AAD)		M8 (MID)		M9 (AAD)		M10 (MID)	
Fixed effects	Est.	*p*	Est.	*p*	Est.	*p*	Est.	*p*	Est.	*p*	Est.	*p*	Est.	*p*	Est.	*p*	Est.	*p*	Est.	*p*
Intercept	**4.87**	**.00**	**4.77**	**.00**	**2.29**	**.00**	**2.24**	**.00**	**3.88**	**.00**	**4.94**	**.00**	**88.17**	**.00**	**88.11**	**.00**	**2.47**	**.00**	**2.45**	**.00**
Treat	**1.44**	**.04**	1.27	.10	0.23	.33	0.28	.14	0.27	.38	0.13	.67	**-7.89**	**.05**	-5.54	.12	0.22	.17	0.22	.19
Time1	**-0.88**	**.00**	**-0.87**	**.00**	**-0.08**	**.00**	**-0.09**	**.00**	0.01	.81	-0.05	.22	**-3.65**	**.03**	-2.30	.11	0.02	.40	0.02	.42
Time2	-		-		-		-		-		-		**0.78**	**.05**	0.44	.22	-	-	-	-
Time1*Treat	**-0.83**	**.02**	**-0.75**	**.04**	-0.04	.20	-0.02	.50	-0.11	.23	-0.03	.72	6.00	.06	4.06	.18	-0.04	.37	-0.02	.68
Time2*Treat	-		-		-		-		-		-		-1.32	.11	-0.91	.23	-	-	-	-
Random effects (variances)																				
Intercept L2	4.33		4.28		0.67		0.66		0.55		1.26		142.84		131.47		0.29		0.30	
Residual variance	1.28		1.32		0.03		0.03		0.14		0.18		6.95		7.25		0.06		0.07	
Model fit																				
AIC	745.71				169.51				235.17				1267.61				212.59			
BIC	767.98				207.28				260.26				1303.84				242.05			
N																				
Observations (L1)	178				172				120				199				195			
Patients (L2)	89				62				47				74				72			

Note. sCort = salivary cortisol; sAA = salivary alpha-amylase; RMSSD = root mean square of successive differences; M = Model; AAD = all available data; MID = multiply imputated data; Est. = Estimate; Treat = treatment (0 = relaxation intervention; 1 = "Song of Life music" therapy); Time1 = linear trend of time (0, 1, 2); Time2 = quadratic trend of time (0,1,4); L = level; AIC = Akaike Information Criterion; BIC = Bayesian information criterion; bold effects were statistically significant on the level of $p < .05$; [a] distress models were statistically controlled for 'study site'; [b] sCort models were statistically controlled for 'study site', 'sedative medication', 'corticosteroid medication', 'time since last meal', 'sex','age'; [c] sAA models were statistically controlled for 'study site', 'sex','age', [d] mean heart rate and RMSSD models were statistically controlled for 'study site','sex', 'age'

Figure captions

Figure 1. Timing of outcome assessments in intervention session 2

Note. SOL = "Song of Life" music therapy, RELAX = relaxation intervention, T = time point, sCort = salivary cortisol, sAA = salivary α-amylase, HRV = heart rate variability

Figure 2. Patient and sample flow chart

Note. SOL = "Song of Life" music therapy, RELAX = relaxation, S = session, sCort = salivary cortisol, sAA = salivary α-amylase, mHR = mean heart rate, RMSSD = root mean square of successive differences

Figure 3. Means and standard errors of momentary distress (NCCN Distress Thermometer)

Note. SOL = "Song of Life" music therapy, RELAX = relaxation, T = time point

Figure 4. Means and standard errors of sCort, sAA, mHR, and RMSSD

Note. sCort = salivary cortisol, sAA = salivary α-amylase, mHR = mean heart rate, RMSSD = root mean square of successive differences, SOL = "Song of Life" music therapy, RELAX = relaxation, T = time point

Curriculum Vitae

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EDUCATION

since 2018	**Ph.D. Program in Psychology** Faculty of Behavioural and Cultural Studies, Heidelberg University, Germany Mentor: Beate Ditzen, Ph.D.
2015 – 2018	**M.Sc. in Developmental and Clinical Psychology** Heidelberg University, Germany Final Grade: 1.1
2011 – 2015	**B.Sc. in Psychology** University of Jena, Germany Final Grade: 1.2
2008 – 2009	**Exchange School Year** in Olavarría, Argentina
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EMPLOYMENT HISTORY

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2018 – 2021	**Research Associate** Institute for Medical Psychology, Center for Psychosocial Medicine, University Hospital Heidelberg, Germany
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2014	**Student Research Assistant** German Aerospace Center, Space and Aviation Psychology, Hamburg, Germany
2012 – 2014	**Student Research Assistant** Personality Psychology and Psychological Assessment, University of Jena, Germany

SCHOLARSHIPS AND AWARDS

2021	**Congress Scholarship** for the ICMPC/ESCOM conference "Connectivity and diversity in music cognition" in Sheffield, UK, provided by Graduate Academy of Heidelberg University
2021	**Congress Scholarship** for the conference „Neurosciences and Music" in Aarhus, Netherlands, provided by Graduate Academy of Heidelberg University
2019	**Congress Award and Scholarship** for the conference „Music and Psychology" in Belgrade, Serbia, provided by Society of Education, Music, and Psychology Research (SEMPRE)
2017	**Research Intern Scholarship** Funding of 3-month research internship at Helping and Happiness Lab, Simon Fraser University Vancouver, Canada, provided by German Academic Exchange Service (DAAD) Mentor: Lara Aknin, Ph.D.
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PEER-REVIEWED JOURNAL ARTICLES

Koehler, F., Kessler, J., Stoffel, M., Weber, M., Bardenheuer, H. J., Ditzen, B., & Warth, M. (under revision). Differential psychoneuroendocrinological effects of two psychosocial interventions in palliative care: Results from the 'Song of Life' randomized trial. *Supportive Care in Cancer.*

Koehler, F., Martin, Z. S., Hertrampf, R. S., Gäbel, C., Kessler, J., Ditzen, B., & Warth, M. (2020). Music therapy in the psychosocial treatment of adult cancer patients: A systematic review and meta-analysis. *Frontiers in Psychology*, *11*, 651. doi:10.3389/fpsyg.2020.00651

Koehler, F., Martin, Z. S., Hertrampf, R. S., Gaebel, C., Kessler, J., Ditzen, B., & Warth, M. (2019). Musiktherapeutische Ansätze in der Psychoonkologie. *Der Onkologe*, *25*(12), 1103-1109.

Koehler, F. & Neubauer, A. B. (2020). From music making to affective well-being in everyday life: The mediating role of need satisfaction. *Psychology of Aesthetics, Creativity and the Arts*, *14*(4), 493–505. doi: 10.1037/aca0000261

Koehler, F., Warth, M., Ditzen, B., & Neubauer, A. B. (in press). Motivation to make music matters: Daily autonomous motivation, flow and well-being. *Psychology of Aesthetics, Creativity and the Arts*. doi: 10.1037/aca0000409

Neubauer, A. B., Lerche, V., **Koehler, F.,** & Voss, A. (2020). What do you (think you) need? Perceived vs. observed effects of need fulfillment on well-being. *Journal of Research in Personality, 86*. doi: 10.1016/j.jrp.2020.103938.

Sicorello, M., Neubauer, A.B., Stoffel, M., **Koehler, F.,** Voss, A., & Ditzen, B. (in press). Psychological structure and neuroendocrine patterns of daily appraisals. *Psychoneuroendocrinology.*

Warth, M., Kessler, J., **Koehler, F.,** Aguilar-Raab, C., Bardenheuer, H. J., & Ditzen, B. (2019). Brief psychosocial interventions improve quality of life of patients receiving palliative care: A systematic review and meta-analysis, *Palliative Medicine*, *33*(3), 332-345. doi: 10.1177/0269216318818011

Warth, M., **Koehler, F.,** Aguilar-Raab, C., Bardenheuer, H. J., Kessler, J., & Ditzen, B. (2020). Stress-reducing effects of a brief mindfulness intervention in palliative care: Results from a randomized, crossover study. *European Journal of Cancer Care*, *29*(5). doi:10.1111/ecc.13249

Warth, M.*, **Koehler, F.*,** Brehmen, M., Weber, M., Bardenheuer, H. J., Ditzen, B., & Kessler, J. (in press). 'Song of Life (SOL)': Results of a multicenter randomized trial on the effects of biographical music therapy in palliative care. *BMC Palliative Medicine.* doi: 10.1177/02692163211010394

Warth, M.*, **Koehler, F.*,** Weber, M., Bardenheuer, H. J., Ditzen, B., & Kessler, J. (2019). "Song of Life (SOL)" study protocol: a multicenter, randomized trial on the emotional, spiritual, and psychobiological effects of music therapy in palliative care. *BMC Palliative Care*, *18*(14). doi: 10.1186/s12904-019-0397-6

Warth, M., Stoffel, M., **Koehler, F.,** Kessler, J., Bardenheuer, H. J., & Ditzen, B. (under revision) Characteristics of salivary cortisol and alpha-amylase in palliative care research: Results from a randomized crossover trial. *BMC Palliative Care*.

Warth, M., Zoeller, J., **Koehler, F.,** Aguilar-Raab, C., Kessler, J., & Ditzen, B. (2020). Psychosocial Interventions for Pain Management in Advanced Cancer Patients: a Systematic Review and Meta-analysis. *Current Oncology Reports*, *22*(1). doi:10.1007/s11912-020-0870-7

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**Promotionsausschuss der Fakultät für Verhaltens- und Empirische Kulturwissenschaften
der Ruprecht-Karls-Universität Heidelberg**
Doctoral Committee of the Faculty of Behavioural and Cultural Studies of Heidelberg University

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für die Fakultät für Verhaltens- und Empirische Kulturwissenschaften**
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