Singing

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Berbel, P., Moix, J., & Quintana, S. (2007). Music versus diazepam to reduce preoperative anxiety: a randomized controlled clinical trial. *Revista Espanola De Anestesiologia Y Reanimacion*, *54*(6), 355-358.

OBJECTIVES: To compare the effectiveness of music to that of diazepam in reducing preoperative anxiety. PATIENTS AND METHODS: Patients were randomized to 2 groups to receive diazepam or listen to music on the day of surgery and the previous day. Just before the operation, anxiety was assessed with the State-Trait Anxiety Inventory. Cortisol levels, heart rate, and blood pressure were also recorded. RESULTS: Two hundred seven patients were enrolled. No significant differences in any of the outcome measures (anxiety, cortisol level, heart rate, or blood pressure) were found between the 2 groups (music vs sedative). CONCLUSIONS: Our findings indicate that music is as effective as sedatives for reducing preoperative anxiety.

Chanda, M. L., & Levitin, D. J. (2013). The neurochemistry of music. *Trends in Cognitive Science*, *17*(4), 179-193.

Music is used to regulate mood and arousal in everyday life and to promote physical and psychological health and well-being in clinical settings. However, scientific inquiry into the neurochemical effects of music is still in its infancy. In this review, we evaluate the evidence that music improves health and well-being through the engagement of neurochemical systems for (i) reward, motivation, and pleasure; (ii) stress and arousal; (iii) immunity; and (iv) social affiliation. We discuss the limitations of these studies and outline novel approaches for integration of conceptual and technological advances from the fields of music cognition and social neuroscience into studies of the neurochemistry of music.

Dillman-Carpentier, F., & Potter, R. F. (2007). Effects of music on physiological arousal: Explorations into tempo and genre. *Media Psychology*, *10*(3), 339-363.

Two experiments explore the validity of conceptualizing musical beats as auditory structural features and the potential for increases in tempo to lead to greater sympathetic arousal, measured using skin conductance. In the first experiment, fast- and slow-paced rock and classical music excerpts were compared to silence. As expected, skin conductance response (SCR) frequency was greater during music processing than during silence. Skin conductance level (SCL) data showed that fast-paced music elicits greater activation than slow-paced music. Genre significantly interacted with tempo in SCR frequency, with faster tempo increasing activation for classical music and decreasing it for rock music. A second experiment was conducted to explore the possibility that the presumed familiarity of the genre led to this interaction. Although further evidence was found for conceptualizing musical beat onsets as auditory structure, the familiarity explanation was not supported.

Dunbar, R. I., Kaskatis, K., MacDonald, I., & Barra, V. (2012). Performance of music elevates pain threshold and positive affect: implications for the evolutionary function of music. *Evolutionary Psychology*, *10*(4), 688-702.

It is well known that music arouses emotional responses. In addition, it has long been thought to play an important role in creating a sense of community, especially in small

scale societies. One mechanism by which it might do this is through the endorphin system, and there is evidence to support this claim. Using pain threshold as an assay for CNS endorphin release, we ask whether it is the auditory perception of music that triggers this effect or the active performance of music. We show that singing, dancing and drumming all trigger endorphin release (indexed by an increase in post-activity pain tolerance) in contexts where merely listening to music and low energy musical activities do not. We also confirm that music performance results in elevated positive (but not negative) affect. We conclude that it is the active performance of music that generates the endorphin high, not the music itself. We discuss the implications of this in the context of community bonding mechanisms that commonly involve dance and music-making.

Ellis, R. J., & Thayer, J. F. (2010). Music and Autonomic Nervous System (Dys)function. *Music Perception, 27*(4), 317-326.

Despite a wealth of evidence for the involvement of the autonomic nervous system (ANS) in health and disease and the ability of music to affect ANS activity, few studies have systematically explored the therapeutic effects of music on ANS dysfunction. Furthermore, when ANS activity is quantified and analyzed, it is usually from a point of convenience rather than from an understanding of its physiological basis. After a review of the experimental and therapeutic literatures exploring music and the ANS, a "Neurovisceral Integration" perspective on the interplay between the central and autonomic nervous systems is introduced, and the associated implications for physiological, emotional, and cognitive health are explored. The construct of heart rate variability is discussed both as an example of this complex interplay and as a useful metric for exploring the sometimes subtle effect of music on autonomic response. Suggestions for future investigations using musical interventions are offered based on this integrative account.

Esch, T., Guarna, M., Bianchi, E., Zhu, W., & Stefano, G. B. (2004). Commonalities in the central nervous system's involvement with complementary medical therapies: limbic morphinergic processes. *Medical Science Monitor*, *10*(6), MS6-17.

BACKGROUND: Currently, complementary and alternative medicine (CAM) are experiencing growing popularity, especially in former industrialized countries. However, most of the underlying physiological and molecular mechanisms as well as participating biological structures are still speculative. Specific and non-specific effects may play a role in CAM. Moreover, trust, belief, and expectation may be of importance, pointing towards common central nervous system (CNS) pathways involved in CAM. MATERIAL/METHODS: Four CAM approaches (acupuncture, meditation, music therapy, and massage therapy) were examined with regard to the CNS activity pattern involved. CNS commonalities between different approaches were investigated. RESULTS: Frontal/prefrontal and limbic brain structures play a role in CAM. Particularly, left-anterior regions of the brain and reward or motivation circuitry constituents are involved, indicating positive affect and emotion-related memory processing--accompanied by endocrinologic and autonomic functions--as crucial components of CAM effects. Thus, trust and belief in a therapist or positive therapy expectations seem to be important. However, besides common non-specific or subjective effects, specific (objective) physiological components also exist. CONCLUSIONS: Non-specific CNS commonalities are involved in various CAM therapies. Different therapeutic approaches physiologically

overlap in the brain. However, molecular correspondents of the detected CNS analogies still have to be specified. In particular, fast acting autoregulatory signaling molecules presumably play a role. These may also be involved in the placebo response.

Eschrich, S. (2008). *Musical memory and its relation to emotions and the limbic system* (Doctoral dissertation). Retrieved from https://pdfs.semanticscholar.org/c744/e372794d1059d304034ed887b3a638e2941a.pdf

Fancourt, D., Ockelford, A., & Belai, A. (2014). The psychoneuroimmunological effects of music: a systematic review and a new model. *Brain, Behavior, and Immunity*, *36*, 15-26.

There has been a growing interest over the past decade into the health benefits of music, in particular examining its psychological and neurological effects. Yet this is the first attempt to systematically review publications on the psychoneuroimmunology of music. Of the selected sixty-three studies published over the past 22 years, a range of effects of music on neurotransmitters, hormones, cytokines, lymphocytes, vital signs and immunoglobulins as well as psychological assessments are cataloged. Research so far points to the pivotal role of stress pathways in linking music to an immune response. However, several challenges to this research are noted: (1) there is very little discussion on the possible mechanisms by which music is achieving its neurological and immunological impact; (2) the studies tend to examine biomarkers in isolation, without taking into consideration the interaction of the biomarkers in question with other physiological or metabolic activities of the body, leading to an unclear understanding of the impact that music may be having; (3) terms are not being defined clearly enough, such as distinctions not being made between different kinds of stress and 'music' being used to encompass a broad spectrum of activities without determining which aspects of musical engagement are responsible for alterations in biomarkers. In light of this, a new model is presented which provides a framework for developing a taxonomy of musical and stress-related variables in research design, and tracing the broad pathways that are involved in its influence on the body.

Fancourt, D., Williamon, A., Carvalho, L. A., Steptoe, A., Dow, R., & Lewis, I. (2016). Singing modulates mood, stress, cortisol, cytokine and neuropeptide activity in cancer patients and carers. *ecancer*, *361*(10).

There is growing evidence that psychosocial interventions can have psychological benefits for people affected by cancer, including improved symptoms of mental health and wellbeing and optimised immune responses. However, despite growing numbers of music interventions, particularly singing, in cancer care, there is less research into their impact. We carried out a multicentre single-arm preliminary study to assess the impact of singing on mood, stress and immune response in three populations affected by cancer: carers (n = 72), bereaved carers (n = 66) and patients (n = 55). Participants were excluded if pregnant or if they were currently being treated with chemotherapy, radiotherapy or oral immunosuppressive drugs. Participants were regular participants in five choirs across South Wales and took part in one hour of group singing. Before and after singing, visual analogue mood scales, stress scales and saliva samples testing for cortisol, beta-endorphin, oxytocin and ten cytokines were taken. Across all five centres and in all four participant groups, singing was associated with significant reductions in negative affect and increases in positive affect ($p < .01$) alongside significant increases

in cytokines including GM-CSF, IL17, IL2, IL4 and sIL-2rα (all $p < .01$). In addition, singing was associated with reductions in cortisol, beta-endorphin and oxytocin levels. This study provides preliminary evidence that singing improves mood state and modulates components of the immune system. Further work is needed to ascertain how this differs for more specific patient groups and whether repeat exposure could lead to meaningful, longitudinal effects.

Fruhholz, S., Trost, W., & Grandjean, D. (2014). The role of the medial temporal limbic system in processing emotions in voice and music. *Progress in Neurobiology*, *123*, 1-17.

Subcortical brain structures of the limbic system, such as the amygdala, are thought to decode the emotional value of sensory information. Recent neuroimaging studies, as well as lesion studies in patients, have shown that the amygdala is sensitive to emotions in voice and music. Similarly, the hippocampus, another part of the temporal limbic system (TLS), is responsive to vocal and musical emotions, but its specific roles in emotional processing from music and especially from voices have been largely neglected. Here we review recent research on vocal and musical emotions, and outline commonalities and differences in the neural processing of emotions in the TLS in terms of emotional valence, emotional intensity and arousal, as well as in terms of acoustic and structural features of voices and music. We summarize the findings in a neural framework including several subcortical and cortical functional pathways between the auditory system and the TLS. This framework proposes that some vocal expressions might already receive a fast emotional evaluation via a subcortical pathway to the amygdala, whereas cortical pathways to the TLS are thought to be equally used for vocal and musical emotions. While the amygdala might be specifically involved in a coarse decoding of the emotional value of voices and music, the hippocampus might process more complex vocal and musical emotions, and might have an important role especially for the decoding of musical emotions by providing memory-based and contextual associations.

Goodall, D., & Etters, L. (2005). The therapeutic use of music on agitated behavior in those with dementia. *Holistic Nursing Practice*, *19*(6), 258-262.

Clinically, nursing has long recognized dementia behaviors--agitation, aggression, wandering, and general confusion--to be a significant patient problem as well as a major stress to nursing staff and caregivers. Although there is no cure, much can be done to improve these patients' daily care and, ultimately, their quality of life.

Huron, D. (2011). Why is Sad Music Pleasurable? A Possible Role for Prolactin. *Musicae Scientiae*, *15*(2), 146-158.

A hedonic theory of music and sadness is proposed. Some listeners report that nominally sad music genuinely makes them feel sad. It is suggested that, for these listeners, sad affect is evoked through a combination of empathetic responses to sad acoustic features, learned associations, and cognitive rumination. Among those listeners who report sad feelings, some report an accompanying positive affect, whereas others report the experience to be solely negative. Levels of the hormone prolactin increase when sad – producing a consoling psychological effect suggestive of a homeostatic function. It is proposed that variations in prolactin levels might account for the variability

in individual hedonic responses. Specifically, it is conjectured that high prolactin concentrations are associated with pleasurable music-induced sadness, whereas low prolactin concentrations are associated with unpleasant music-induced sadness.

Khalfa, S., Bella, S. D., Roy, M., Peretz, I., & Lupien, S. J. (2003). Effects of relaxing music on salivary cortisol level after psychological stress. *Annals of the New York Academy of Sciences*, *999*, 374-376.

The goal of the study was to determine whether relaxing music (as compared to silence) might facilitate recovery from a psychologically stressful task. To this aim, changes in salivary cortisol levels were regularly monitored in 24 students before and after the Trier Social Stress Test. The data show that in the presence of music, the salivary cortisol level ceased to increase after the stressor, whereas in silence it continued to increase for 30 minutes.

Koelsch, S. (2009). A neuroscientific perspective on music therapy. *Annals of the New York Academy of Sciences, 1169*, 374-384.

During the last years, a number of studies demonstrated that music listening (and even more so music production) activates a multitude of brain structures involved in cognitive, sensorimotor, and emotional processing. For example, music engages sensory processes, attention, memory-related processes, perception-action mediation ("mirror neuron system" activity), multisensory integration, activity changes in core areas of emotional processing, processing of musical syntax and musical meaning, and social cognition. It is likely that the engagement of these processes by music can have beneficial effects on the psychological and physiological health of individuals, although the mechanisms underlying such effects are currently not well understood. This article gives a brief overview of factors contributing to the effects of music-therapeutic work. Then, neuroscientific studies using music to investigate emotion, perception-action mediation ("mirror function"), and social cognition are reviewed, including illustrations of the relevance of these domains for music therapy.

Kreutz, G., Bongard, S., Rohrmann, S., Hodapp, V., & Grebe , D. (2004). Effects of choir singing or listening on secretory immunoglobulin A, cortisol, and emotional state. *Journal of Behavioral Medicine*, *27*(6), 623-635.

The present study investigates the effects of choir music on secretory immunoglobulin A (S-IgA), cortisol, and emotional states in members of a mixed amateur choir. Subjects participated in two conditions during two rehearsals 1 week apart, namely singing versus listening to choral music. Saliva samples and subjective measures of affect were taken both before each session and 60 min later. Repeated measure analyses of variance were conducted for positive and negative affect scores, S-IgA, and cortisol. Results indicate several significant effects. In particular, singing leads to increases in positive affect and S-IgA, while negative affect is reduced. Listening to choral music leads to an increase in negative affect, and decreases in levels of cortisol. These results suggest that choir singing positively influences both emotional affect and immune competence. The observation that subjective and physiological responses differed between listening and singing conditions invites further investigation of task factors.

Krout, R. E. (2007). Music Listening to Facilitate Relaxation and Promote Wellness: Integrated Aspects of Our Neurophysiological Responses to Music. *The Arts in Psychotherapy*, *34*(2), 134-141.

Wellness as a movement for both healthy persons and those with diagnosed diseases has been growing in both popularity and acceptance by consumers and the health industry. Wellness in part includes an individual's positive attitude towards, and active engagement in the health environment in which they function. A focus of wellness can include techniques and methods that people can use in their lives to combat stress and facilitate relaxation. Music as a sound medium has been used as part of wellness programs in a variety of ways, including as a sonic background for relaxation experiences. In this article, the role of music listening to positively affect neurophysiological and emotional responses related to relaxation is examined. Neurological bases of music listening and sound processing are reviewed, with emphasis on how music is processed by the limbic and related biological systems, including endocrine and hormonal responses. Suggestions for how consumers may use music listening in their own wellness and relaxation regimens are provided, including descriptions of which music to consider, where to obtain it, and how to use it.

Laura, D., Sylvie, J., & Aurore, S. (2015). The Effects of Music Therapy on Anxiety and Depression. *Annals of Depression and Anxiety, 2*(4), 1057.

Leong, V., Byrne, E., Clackson, K., Georgieva, S., Lam, S., & Wass, S. (2017). Speaker gaze increases information coupling between infant and adult brains. *PNAS*, *114*(50), 13290-13295.

When infants and adults communicate, they exchange social signals of availability and communicative intention such as eye gaze. Previous research indicates that when communication is successful, close temporal dependencies arise between adult speakers' and listeners' neural activity. However, it is not known whether similar neural contingencies exist within adult–infant dyads. Here, we used dual-electroencephalography to assess whether direct gaze increases neural coupling between adults and infants during screen-based and live interactions. In experiment 1 (n = 17), infants viewed videos of an adult who was singing nursery rhymes with (i) direct gaze (looking forward), (ii) indirect gaze (head and eyes averted by 20°), or (iii) direct-oblique gaze (head averted but eyes orientated forward). In experiment 2 (n = 19), infants viewed the same adult in a live context, singing with direct or indirect gaze. Gaze-related changes in adult–infant neural network connectivity were measured using partial directed coherence. Across both experiments, the adult had a significant (Granger) causal influence on infants' neural activity, which was stronger during direct and direct-oblique gaze relative to indirect gaze. During live interactions, infants also influenced the adult more during direct than indirect gaze. Further, infants vocalized more frequently during live direct gaze, and individual infants who vocalized longer also elicited stronger synchronization from the adult. These results demonstrate that direct gaze strengthens bidirectional adult–infant neural connectivity during communication. Thus, ostensive social signals could act to bring brains into mutual temporal alignment, creating a joint-networked state that is structured to facilitate information transfer during early communication and learning.

Lerner, Y., Papo, D., Zhdanov, A., Belozersky, L., & Hendler, T. (2009). Eyes Wide Shut: Amygdala Mediates Eyes-Closed Effect on Emotional Experience with Music. *PLOS One, 4*(7), e6230.

The perceived emotional value of stimuli and, as a consequence the subjective emotional experience with them, can be affected by context-dependent styles of processing. Therefore, the investigation of the neural correlates of emotional experience requires accounting for such a variable, a matter of an experimental challenge. Closing the eyes affects the style of attending to auditory stimuli by modifying the perceptual relationship with the environment without changing the stimulus itself. In the current study, we used fMRI to characterize the neural mediators of such modification on the experience of emotionality in music. We assumed that closed eyes position will reveal interplay between different levels of neural processing of emotions. More specifically, we focused on the amygdala as a central node of the limbic system and on its co-activation with the Locus Ceruleus (LC) and Ventral Prefrontal Cortex (VPFC); regions involved in processing of, respectively, 'low', visceral-, and 'high', cognitive-related, values of emotional stimuli. Fifteen healthy subjects listened to negative and neutral music excerpts with eyes closed or open. As expected, behavioral results showed that closing the eyes while listening to emotional music resulted in enhanced rating of emotionality, specifically of negative music. In correspondence, fMRI results showed greater activation in the amygdala when subjects listened to the emotional music with eyes closed relative to eyes open. More so, by using voxel-based correlation and a dynamic causal model analyses we demonstrated that increased amygdala activation to negative music with eyes closed led to increased activations in the LC and VPFC. This finding supports a system-based model of perceived emotionality in which the amygdala has a central role in mediating the effect of context-based processing style by recruiting neural operations involved in both visceral (i.e. 'low') and cognitive (i.e. 'high') related processes of emotions.

Levitin, D. (2006). *This is your brain on music: The science of a human obsession*. New York, N.Y.: Dutton.

Limb, C. J., & Braun, A. R. (2008). Neural Substrates of Spontaneous Musical Performance: Improvisation. *PLOS One*, *3*(2), e1679.

To investigate the neural substrates that underlie spontaneous musical performance, we examined improvisation in professional jazz pianists using functional MRI. By employing two paradigms that differed widely in musical complexity, we found that improvisation (compared to production of over-learned musical sequences) was consistently characterized by a dissociated pattern of activity in the prefrontal cortex: extensive deactivation of dorsolateral prefrontal and lateral orbital regions with focal activation of the medial prefrontal (frontal polar) cortex. Such a pattern may reflect a combination of psychological processes required for spontaneous improvisation, in which internally motivated, stimulus-independent behaviors unfold in the absence of central processes that typically mediate self-monitoring and conscious volitional control of ongoing performance. Changes in prefrontal activity during improvisation were accompanied by widespread activation of neocortical sensorimotor areas (that mediate the organization and execution of musical performance) as well as deactivation of limbic structures (that

regulate motivation and emotional tone). This distributed neural pattern may provide a cognitive context that enables the emergence of spontaneous creative activity.

Livesey, L., Morrison, I., Clift, S., & Camic, P. (2012). Benefits of choral singing for social and mental wellbeing: qualitative findings from a cross-national survey of choir members. *Journal of Public Mental Health*, *11*(1), 10-26.

Purpose – The aim of this study is to explore the benefits of choral singing for mental wellbeing and health as perceived by a cross-national sample of amateur choral singers. Design/methodology/approach – Data consisted of written responses to open-ended questions. These were derived from 169 participants selected from a larger dataset reporting high and low levels of emotional wellbeing on the WHOQOL-BREF questionnaire. A majority of participants were female and aged over 50. A thematic analysis was followed by a content analysis and Pearson chi square analyses. Comparisons were made between different ages, genders and nationalities and participants with high and low reported emotional wellbeing. Findings – The analysis revealed multiple themes covering perceived benefits in social, emotional, physical, and cognitive domains. There were no significant differences in frequency of themes across any of the participant sociodemographic and wellbeing categories. The results indicate that benefits of singing may be experienced similarly irrespective of age, gender, nationality or wellbeing status. Research limitations/implications – Implications for further research include future use of validated instruments to measure outcomes and research into the benefits of singing in other cultures. The results of this study suggest that choral singing could be used to promote mental health and treat mental illness. Originality/value – This study examines a cross-national sample which is larger than previous studies in this area. These findings contribute to understanding of the complex and interacting factors which might contribute to wellbeing and health, as well as specific benefits of singing.

McCraty, R., Barrios-Choplin, B., Atkinson, M., & Tomasino, D. (1998). The effects of different types of music on mood, tension, and mental clarity. *Alternative Therapies in Health and Medicine*, *4*(1), 75-84.

This study investigated the impact of different types of music on tension, mood, and mental clarity. A total of 144 subjects completed a psychological profile before and after listening for 15 minutes to four types of music (grunge rock, classical, New Age, and designer). With grunge rock music, significant increases were found in hostility, sadness, tension, and fatigue, and significant reductions were observed in caring, relaxation, mental clarity, and vigor. In contrast, after listening to the designer music (music designed to have specific effects on the listener), significant increases in caring, relaxation, mental clarity, and vigor were measured; significant decreases were found in hostility, fatigue, sadness, and tension. The results for New Age and classical music were mixed. Feeling shifts among subjects were observed with all types of music. Designer music was most effective in increasing positive feelings and decreasing negative feelings. Results suggest that designer music may be useful in the treatment of tension, mental distraction, and negative moods.

Muller, V., & Lindenberger, U. (2011). Cardiac and Respiratory Patterns Synchronize between Persons during Choir Singing. *PLOS One*, *6*(9), e24893.

Dyadic and collective activities requiring temporally coordinated action are likely to be associated with cardiac and respiratory patterns that synchronize within and between people. However, the extent and functional significance of cardiac and respiratory between-person couplings have not been investigated thus far. Here, we report interpersonal oscillatory couplings among eleven singers and one conductor engaged in choir singing. We find that: (a) phase synchronization both in respiration and heart rate variability increase significantly during singing relative to a rest condition; (b) phase synchronization is higher when singing in unison than when singing pieces with multiple voice parts; (c) directed coupling measures are consistent with the presence of causal effects of the conductor on the singers at high modulation frequencies; (d) the different voices of the choir are reflected in network analyses of cardiac and respiratory activity based on graph theory. Our results suggest that oscillatory coupling of cardiac and respiratory patterns provide a physiological basis for interpersonal action coordination.

Nilsson, U. (2008). The anxiety- and pain-reducing effects of music interventions: a systematic review. *AORN Journal, 87*(4), 780-807.

Musical interventions have been used in health care settings to reduce patient pain, anxiety, and stress, although the exact mechanism of these therapies is not well understood. This article provides a systematic review of 42 randomized controlled trials of the effects of music interventions in perioperative settings. Music intervention had positive effects on reducing patients' anxiety and pain in approximately half of the reviewed studies. Further research into music therapy is warranted in light of the low cost of implementation and the potential ability of music to reduce perioperative patient distress.

Pearce, E., Launay, J., & Dunbar, R. I. (2015). The ice-breaker effect: singing mediates fast social bonding. *Royal Society Open Science*, *2*(10), 150221.

It has been proposed that singing evolved to facilitate social cohesion. However, it remains unclear whether bonding arises out of properties intrinsic to singing or whether any social engagement can have a similar effect. Furthermore, previous research has used one-off singing sessions without exploring the emergence of social bonding over time. In this semi-naturalistic study, we followed newly formed singing and non-singing (crafts or creative writing) adult education classes over seven months. Participants rated their closeness to their group and their affect, and were given a proxy measure of endorphin release, before and after their class, at three timepoints (months 1, 3 and 7). We show that although singers and non-singers felt equally connected by timepoint 3, singers experienced much faster bonding: singers demonstrated a significantly greater increase in closeness at timepoint 1, but the more gradual increase shown by non-singers caught up over time. This represents the first evidence for an 'ice-breaker effect' of singing in promoting fast cohesion between unfamiliar individuals, which bypasses the need for personal knowledge of group members gained through prolonged interaction. We argue that singing may have evolved to quickly bond large human groups of relative strangers, potentially through encouraging willingness to coordinate by enhancing positive affect.

Pereira, C. S., Teixeira, J., Figueiredo, P, Xavier, J., Castro, S. L., & Brattico, E. (2011). Music and Emotions in the Brain: Familiarity Matters. *PLOS One*, *6*(11), e27241.

The importance of music in our daily life has given rise to an increased number of studies addressing the brain regions involved in its appreciation. Some of these studies controlled only for the familiarity of the stimuli, while others relied on pleasantness ratings, and others still on musical preferences. With a listening test and a functional magnetic resonance imaging (fMRI) experiment, we wished to clarify the role of familiarity in the brain correlates of music appreciation by controlling, in the same study, for both familiarity and musical preferences. First, we conducted a listening test, in which participants rated the familiarity and liking of song excerpts from the pop/rock repertoire, allowing us to select a personalized set of stimuli per subject. Then, we used a passive listening paradigm in fMRI to study music appreciation in a naturalistic condition with increased ecological value. Brain activation data revealed that broad emotion-related limbic and paralimbic regions as well as the reward circuitry were significantly more active for familiar relative to unfamiliar music. Smaller regions in the cingulate cortex and frontal lobe, including the motor cortex and Broca's area, were found to be more active in response to liked music when compared to disliked one. Hence, familiarity seems to be a crucial factor in making the listeners emotionally engaged with music, as revealed by fMRI data

Phaneuf, M. (n.d.). *Music as a nursing intervention, not as crazy as it sounds*. Retrieved from www.prendresoin.org/wp-content/uploads/.../Music_as_a_nursing_intervention.pdf

Remington, R. (2002). Calming Music and Hand Massage with Agitated Elderly. *Nursing Research*, *51*(5), 317-323.

BACKGROUND: Agitated behavior is a widespread problem that adversely affects the health of nursing home residents and increases the cost of their care. OBJECTIVE: To examine whether modifying environmental stimuli by the use of calming music and hand massage affects agitated behavior in persons with dementia. METHOD: A four group, repeated measures experimental design was used to test the effect of a 10-minute exposure to either calming music, hand massage, or calming music and hand massage simultaneously, or no intervention (control) on the frequency and type of agitated behaviors in nursing home residents with dementia (N = 68). A modified version of the Cohen-Mansfield Agitation Inventory was used to record agitated behaviors. RESULTS: Each of the experimental interventions reduced agitation more than no intervention. The benefit was sustained and increased up to one hour following the intervention ($F = 6.47$, $p<.01$). The increase in benefit over time was similar for each intervention group. When types of agitated behaviors were examined separately, none of the interventions significantly reduced physically aggressive behaviors ($F = 1.93$, $p=.09$), while physically nonaggressive behaviors decreased during each of the interventions ($F = 3.78$, $p< 01$). No additive benefit resulted from simultaneous exposure to calming music and hand massage. At one hour following any intervention, verbally agitated behavior decreased more than no intervention. CONCLUSION: Calming music and hand massage alter the immediate environment of agitated nursing home residents to a calm structured surrounding, offsetting disturbing stimuli, but no additive benefit was found by combining interventions simultaneously.

Sanal, A. M., & Gorsev, S. (2013). Psychological and physiological effects of singing in a choir. *Psychology of Music*, *42*(3), 420-429.

This randomized controlled trial aimed to quantify the effects of choir singing on emotional state and anxiety levels of singers. Salivary amylase, PANAS (Positive and Negative Affect Schedule) and STAI-s/-t(State-Trait Anxiety Inventory) were applied before and after a 1-hour single choir session for an experimental group (n = 35) and unstructured time for control group (n = 35). Amylase decreased in the experimental group but increased in the control group ($p > 0.05$ for Fgroup; $p = 0.014$ for Ftestbygroup). Follow-up analysis showed this interaction to be due to baseline differences between the two groups. Negative affect decreased in the experimental group and increased in the control group ($p > 0.05$ for Ftest and Fgroup; $p = 0.006$ for Ftest by group). A decrease in positive affect was found between the pre- and post-test for the control group ($p = 0.023$ for Ftest; $p = 0.004$ for Ftest by group). State anxiety decreased in the experimental group and increased in the control group ($p > 0.05$ for Ftest and Fgroup; $p = 0.001$ for Ftest by group). Singing in a choir was found to have a positive impact on psychological indicators of affect and anxiety, however, its physiological effect could not be shown using salivary amylase in this study.

Scherer, K. R., & Zentner, M. R. (2001). Emotional effects of music: Production rules. In P. N. Juslin & J. A. Sloboda (Eds.), *Series in affective science. Music and emotion: Theory and research* (pp. 361-392). New York, NY: Oxford University.

This chapter provides a formalization of the processes whereby music produces emotional effects in the listener while reviewing pertinent evidence and suggesting future research. The formalization of emotional effects of music consists in defining the affective changes that music is supposed to produce in the listener and identifying the determinants of the listening situation (including the musical structure of the piece, the performer's interpretation, relevant listener state and trait characteristics, and respective context). The authors discuss the relative weighting of the different determinants and the type of interaction in producing the affective outcome. They also distinguish central routes (i.e implicating the central nervous system in emotion generation) and peripheral routes (based on direct effects on the peripheral nervous systems with ensuing proprioceptive feedback to central areas) by which to process emotion. The authors suggest that by linking research on the emotional expressiveness of music more directly to the progress in the affective sciences, it may be possible to design empirical studies that yield results that can be interpreted against a background of theoretical predictions. (PsycINFO Database Record (c) 2016 APA, all rights reserved)

Schwilling, D., Vogeser, M., Kirchhoff, F., Schwaiblmair, F., Boulesteix, A. L., Schulze, A., & Flemmer, A. W. (2015). Live music reduces stress levels in very low-birthweight infants. *Acta Paediatrica, 104*(4), 360-367.

AIM: Music might benefit preterm infants in stressful, intensive care environments. However, data on stress level indicators, determined by salivary cortisol levels, are scarce. We evaluated the effect of live harp music on the stress level indicators of preterm infants in a neonatal intensive care unit (NICU). METHODS: We exposed 20 stable preterm infants to music for 15 min on three consecutive days. Saliva was

collected before the music was played and 25 min and 4 h after it ended. Salivary cortisol levels were measured by liquid chromatography-tandem mass spectrometry and vital signs, oxygen saturation, bradycardia, apnoeas and oxygen desaturations were recorded. Pain levels were assessed by the Bernese Pain Scale for Neonates. RESULTS: Salivary cortisol was significantly lower 25 min (18.9 nmol/L [3.9-35.6] p = 0.001) and 4 h after music (17.4 nmol/L [3.9-35.3] p = 0.003) than at baseline 4 h before exposure (19.5 nmol/L [7.2-51.1]). After music, the number of apnoeas and oxygen desaturations was significantly reduced on all three, days and the number of bradycardia episodes on day one. Pain scores significantly improved after music on all 3 days. CONCLUSION: Exposure to live music reduced salivary cortisol and had beneficial effects on the physiologic parameters of stable preterm infants in a NICU.

Shakespeare, T., & Whieldon, A. (2017). Sing Your Heart Out: community singing as part of mental health recovery. *Medical Humanities* Published Online First: 25 November 2017.

This paper reports on a qualitative evaluation of a Norfolk-based network of community singing workshops aimed at people with mental health conditions and the general public. The aims of the study were (a) to evaluate the effectiveness of the Sing Your Heart Out (SYHO) project and (b) to identify the key features which made the project distinctive. The study draws on 20 interviews with participants, two focus groups with organisers and workshop leaders, and participative observation over a 6-month period. Interviewees all reported improvement in or maintenance of their mental health and well-being as a direct result of engagement in the singing workshops. For most it was a key component, and for some the only and sufficient component in their recovery and ongoing psychological stability. SYHO was regarded as different from choirs and from most other social groups and also different from therapy groups, music or otherwise. The combination of singing with an inclusive social aspect was regarded as essential in effecting recovery. The lack of pressure to discuss their condition and the absence of explicit therapy was also mentioned by most participants as an important and welcome element in why SYHO worked for them. The combination of singing and social engagement produced an ongoing feeling of belonging and well-being. Attendance provided them with structure, support and contact that improved functioning and mood. We conclude that the SYHO model offers a low-commitment, low-cost tool for mental health recovery within the community.

Stewart, N. A. J., & Lonsdale, A. J. (2016). It's better together: The psychological benefits of singing in a choir. *Psychology of Music*, *44*(6), 1240-1254.

Previous research has suggested that singing in a choir might be beneficial for an individual's psychological well-being. However, it is unclear whether this effect is unique to choral singing, and little is known about the factors that could be responsible for it. To address this, the present study compared choral singing to two other relevant leisure activities, solo singing and playing a team sport, using measures of self-reported well-being, entitativity, need fulfilment and motivation. Questionnaire data from 375 participants indicated that choral singers and team sport players reported significantly higher psychological well-being than solo singers. Choral singers also reported that they considered their choirs to be a more coherent or 'meaningful' social group than team sport players considered their teams. Together these findings might be interpreted to suggest that membership of a group may be a more important influence on the

psychological well-being experienced by choral singers than singing. These findings may have practical implications for the use of choral singing as an intervention for improving psychological well-being.

Tarr, B., Launay, J., & Dunbar, R. I. (2014). Music and social bonding: "self-other" merging and neurohormonal mechanisms. *Frontiers in Psychology*, *5*, 1096.

It has been suggested that a key function of music during its development and spread amongst human populations was its capacity to create and strengthen social bonds amongst interacting group members. However, the mechanisms by which this occurs have not been fully discussed. In this paper we review evidence supporting two thus far independently investigated mechanisms for this social bonding effect: self-other merging as a consequence of inter-personal synchrony, and the release of endorphins during exertive rhythmic activities including musical interaction. In general, self-other merging has been experimentally investigated using dyads, which provide limited insight into large-scale musical activities. Given that music can provide an external rhythmic framework that facilitates synchrony, explanations of social bonding during group musical activities should include reference to endorphins, which are released during synchronized exertive movements. Endorphins (and the endogenous opioid system (EOS) in general) are involved in social bonding across primate species, and are associated with a number of human social behaviors (e.g., laughter, synchronized sports), as well as musical activities (e.g., singing and dancing). Furthermore, passively listening to music engages the EOS, so here we suggest that both self-other merging and the EOS are important in the social bonding effects of music. In order to investigate possible interactions between these two mechanisms, future experiments should recreate ecologically valid examples of musical activities.

Unwin, M. M., Kenny, D. T., & Davis, P. J. (2002). The Effects of Group Singing on Mood. *Psychology of Music*, *30*(2), 175-185.

This study explored the effects of singing on the mood of singers. Participants, a community sample of volunteers, were randomly assigned to either a singing (experimental) or a listening to singing (control) group. The singers participated in a half-hour session of singing while the listeners sat and listened to the singing group. The Profile of Mood States Questionnaire (P.O.M.S.) was administered immediately before and after the singing session and again one week later. Multivariate analyses of variance (MANOVA) (3 x 2 factorial with three levels of time and two levels of group) were conducted on each of the P.O.M.S. subscales. Multivariate F tests indicated that significant changes occurred on the P.O.M.S. sub-scales (tension, anger, fatigue, vigour and confusion) for both the singing and listening groups over time. There was no significant group-time interactions indicating that both groups responded in a similar fashion to the singing session, although the effects for singing were more robust. The results of this study indicate that both singing and listening to singing can alter mood immediately after participation in a short singing session, and that some of these effects were evident in the P.O.M.S. scores one week later. These results suggest that a longer and more vigorous singing session is needed to obtain additional benefits of singing over listening.

Updike, P. A. (1990). Music Therapy Results for ICU Patients. *Dimensions of Critical Care Nursing*, *9*(1), 39-45.

The following investigation studied the physiological and emotional responses to taped music programs of patients in coronary and surgical Intensive Care Units (ICU). Previous studies have investigated physiological or psychological impact individually, but rarely explored the effects simultaneously. The results of this study support music therapy as a nursing intervention which supports the holistic care of the critically ill patient.

Updike, P. A., & Charles, D. M. (1987). Music Rx: physiological and emotional responses to taped music programs of preoperative patients awaiting plastic surgery. *Annals of Plastic Surgery*, *19*(1), 29-33.

This study investigated the physiological and emotional responses of patients awaiting an elective plastic surgery procedure to a 30-minute taped music program. The study replicated in part the research study of Bonny entitled "Music Rx." Values for the physiological variables of systolic blood pressure, diastolic blood pressure, pulse rate, mean arterial pressure (MAP), and double product index (DPI) were obtained before and after the music listening. These data were analyzed via a repeated measures t-test using each subject as her or his own control. The convenience sample of 10 was nonrandomized. Emotional responses were evaluated by means of an open-ended, nondirective questionnaire developed around 5 categories of depression, sadness, and despair; psychological isolation and defensiveness; anxiety; difficulty of medical management; and preoccupation with pain. Process recordings and documented verbal and body language were used before and after the music to identify themes and mood states expressed by patients. Every physiological variable decreased in value at the less than .001 level of significance. The most significant emotional effect appeared to be an experienced shift in patients' awareness toward a more relaxed, calm state. The most critical conclusion is that music listening appeared to effect desirable pattern shifts in physiological and emotional states in the presurgical setting for those patients studied.

Vickhoff, B., Malmgren, H., Astrom, R., Nyberg, G., Ekstrom, S., Engwall, M., Snygg, J., … Jornsten, R. (2013). Music structure determines heart rate variability of singers. *Frontiers in Psychology, 4*(334).

Choir singing is known to promote wellbeing. One reason for this may be that singing demands a slower than normal respiration, which may in turn affect heart activity. Coupling of heart rate variability (HRV) to respiration is called Respiratory sinus arrhythmia (RSA). This coupling has a subjective as well as a biologically soothing effect, and it is beneficial for cardiovascular function. RSA is seen to be more marked during slow-paced breathing and at lower respiration rates (0.1 Hz and below). In this study, we investigate how singing, which is a form of guided breathing, affects HRV and RSA. The study comprises a group of healthy 18 year olds of mixed gender. The subjects are asked to; (1) hum a single tone and breathe whenever they need to; (2) sing a hymn with free, unguided breathing; and (3) sing a slow mantra and breathe solely between phrases. Heart rate (HR) is measured continuously during the study. The study design makes it possible to compare above three levels of song structure. In a separate case study, we examine five individuals performing singing tasks (1–3). We collect data with more advanced equipment, simultaneously recording HR, respiration, skin

conductance and finger temperature. We show how song structure, respiration and HR are connected. Unison singing of regular song structures makes the hearts of the singers accelerate and decelerate simultaneously. Implications concerning the effect on wellbeing and health are discussed as well as the question how this inner entrainment may affect perception and behavior.

Yamasaki, A., Booker, A., Kapur, V., Tilt, A., Niess, H., Lillemoe, K. D., … Conrad, C. (2012). The impact of music on metabolism. *Nutrition*, *28*(11-12), 1075-1080.

The study of music and medicine is a rapidly growing field that in the past, has been largely focused on the use of music as a complementary therapy. Increasing interest has been centered on understanding the physiologic mechanisms underlying the effects of music and, more recently, the suggested role of music in modulating metabolic responses. Research has established a role for music in the regulation of the hypothalamic-pituitary axis, the sympathetic nervous system, and the immune system, which have key functions in the regulation of metabolism and energy balance. More recent findings have shown a role for music in the metabolic recovery from stress, the regulation of gastric and intestinal motility, the moderation of cancer-related gastrointestinal symptoms, and the increase of lipid metabolism and lactic acid clearance during exercise and postexercise recovery. The purpose of this article is to summarize the most current understanding of the mechanisms by which music affects the metabolic responses in the context of potential applications.