Advik Rai
12/18/2024

Annotated Source List

Alluri, V., Toiviainen, P., Jääskeläinen, I. P., Glerean, E., Sams, M., & Brattico, E. (2011). Large-scale brain networks emerge from dynamic processing of musical timbre, key and rhythm. *NeuroImage*, *59*(4), 3677–3689. https://doi.org/10.1016/j.neuroimage.2011.11.019

(A. Pantelyat, personal communication, October 21, 2024). (in text citation)

Barrett, F. S., Robbins, H., Smooke, D., Brown, J. L., & Griffiths, R. R. (2017). Qualitative and Quantitative Features of Music Reported to Support Peak Mystical Experiences during Psychedelic Therapy Sessions. *Frontiers in Psychology*, *8*. https://doi.org/10.3389/fpsyg.2017.01238

Blasco-Magraner, J. S., Bernabé-Valero, G., Marín-Liébana, P., & Botella-Nicolás, A. M. (2023). Changing positive and negative affects through music experiences: a study with university students. *BMC Psychology*, *11*(1). https://doi.org/10.1186/s40359-023-01110-9

Chanda, M. L., & Levitin, D. J. (2013). The neurochemistry of music. *Trends in Cognitive Sciences*, *17*(4), 179–193. https://doi.org/10.1016/j.tics.2013.02.007

Cooper, L. (2023, September 13). *Using music as medicine - Lifesonics*. Lifesonics. https://lifesonics.com/using-music-as-medicine/

Childs-Young, L. (2023, December). IFPI's global study finds we're listening to more music in more ways than ever - IFPI. IFPI. https://www.ifpi.org/ifpis-global-study-finds-were-listening-to-more-music-in-more-ways-than-ever/

Depp, C. A., Kamarsu, S., Filip, T. F., Parrish, E. M., Harvey, P. D., Granholm, E. L., Chalker, S., Moore, R. C., & Pinkham, A. (2021). Ecological momentary facial emotion recognition in psychotic disorders. *Psychological Medicine*, *52*(13), 2531–2539. https://doi.org/10.1017/s0033291720004419

De Santana, M. A., De Lima, C. L., Torcate, A. S., Fonseca, F. S., & Santos, W. P. D. (2021). Affective computing in the context of music therapy: a systematic review. *Research Society and Development*, *10*(15), e392101522844. https://doi.org/10.33448/rsd-v10i15.22844

Devlin, K., Alshaikh, J. T., & Pantelyat, A. (2019). Music therapy and Music-Based Interventions for movement Disorders. *Current Neurology and Neuroscience Reports*, *19*(11). https://doi.org/10.1007/s11910-019-1005-0

Edwards, E., Hillaire-Clarke, C. S., Frankowski, D., Finkelstein, R., Cheever, T., Chen, W. G., Onken, L., Poremba, A., Riddle, R., Schloesser, D., Burgdorf, C., Wells, N., Fleming, R., & Collins, F. S. (2023, May). NIH Music-Based Intervention Toolkit: Music-Based Interventions for Brain Disorders of Aging. *Neurology,* 2023;100(18):868-878 https://doi.org/10.1212/WNL.0000000000206797

Gerdner, L. A. (2012). Individualized music for dementia: Evolution and application of evidence-based protocol. *World Journal of Psychiatry*, *2*(2), 26. https://doi.org/10.5498/wjp.v2.i2.26

González, E. J. S.& McMullen, K. (2020). "The Design of an Algorithmic Modal Music Platform for Eliciting and Detecting Emotion," 2020 8th International Winter Conference on Brain-Computer Interface (BCI), Gangwon, Korea (South), 2020, pp. 1-3, https://doi.org/10.1109/BCI48061.2020.9061664

Guerrero, Graciela, et al. "Internet-based Identification of Anxiety in University Students Using Text and Facial Emotion Analysis." *Internet Interventions*, vol. 34, Oct. 2023, p. 100679. https://doi.org/10.1016/j.invent.2023.100679.

Hailstone, J. C., Omar, R., Henley, S. M. D., Frost, C., Kenward, M. G., & Warren, J. D. (2009). It's not what you play, it's how you play it: Timbre affects perception of emotion in music. *Quarterly Journal of Experimental Psychology*, *62*(11), 2141–2155. https://doi.org/10.1080/17470210902765957

Hausmann, M., Hodgetts, S., & Eerola, T. (2016). Music-induced changes in functional cerebral asymmetries. *Brain and Cognition*, *104*, 58–71. https://doi.org/10.1016/j.bandc.2016.03.001

Huang, R., & Shih, Y. (2011). Effects of background music on concentration of workers. *Work*, *38*(4), 383–387. https://doi.org/10.3233/wor-2011-1141

Iwasaki, M., & Noguchi, Y. (2016). Hiding true emotions: micro-expressions in eyes retrospectively concealed by mouth movements. *Scientific Reports*, *6*(1). https://doi.org/10.1038/srep22049

Jia, S., Wang, S., Hu, C., Webster, P. J., & Li, X. (2021). Detection of genuine and posed facial expressions of emotion: Databases and Methods. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.580287

Kim, T. & Nam, J. All-in-One Metrical and Functional Structure Analysis with Neighborhood Attentions on Demixed Audio. (2023). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/10248148

(K. Kang, personal communication, October 21, 2024). (in text citation)

Kohler, C. G., Martin, E. A., Stolar, N., Barrett, F. S., Verma, R., Brensinger, C., Bilker, W., Gur, R. E., & Gur, R. C. (2008). Static posed and evoked facial expressions of emotions in schizophrenia. *Schizophrenia Research*, *105*(1–3), 49–60. https://doi.org/10.1016/j.schres.2008.05.010

Ma, L. (2022). Research on the effect of different types of short music videos on viewers' psychological emotions. *Frontiers in Public Health*, *10*. https://doi.org/10.3389/fpubh.2022.992200

Mehr, S. A., Singh, M., York, H., Glowacki, L., & Krasnow, M. M. (2018). Form and function in human song. *Current Biology*, *28*(3), 356-368.e5. https://doi.org/10.1016/j.cub.2017.12.042

Moskowitz, D. S., & Young, S. N. (2006, January 1). *Ecological momentary assessment: what it is and why it is a method of the future in clinical psychopharmacology*. https://pmc.ncbi.nlm.nih.gov/articles/PMC1325062/

Moura, F. T. (2021, January). List of companies producing music with artificial intelligence (Part 2). LiveInnovation.org. https://liveinnovation.org/list-of-companies-producing-music-with-artificial-intelligence-part-2/

Paul Ekman Group, LLC. (2024, October 11). Micro Expressions | Facial Expressions | Paul Ekman Group. Paul Ekman Group. https://www.paulekman.com/resources/micro-expressions/

Petrovsky, D. V., Bradt, J., McPhillips, M. V., Sefcik, J. S., Gitlin, L. N., & Hodgson, N. A. (2023). Tailored music listening in persons with dementia: a Feasibility randomized clinical trial. *American Journal of Alzheimer S Disease & Other Dementias®*, *38*. https://doi.org/10.1177/15333175231186728

Ramos, D., Bueno, J., & Bigand, E. (2010). Manipulating Greek musical modes and tempo affects perceived musical emotion in musicians and nonmusicians. *Brazilian Journal of Medical and Biological Research*, *44*(2), 165–172. https://doi.org/10.1590/s0100-879x2010007500148

Stegemann, T., Geretsegger, M., Quoc, E. P., Riedl, H., & Smetana, M. (2019). Music Therapy and Other Music-Based Interventions in Pediatric Health Care: An Overview. *Medicines*, *6*(1), 25. https://doi.org/10.3390/medicines6010025

Tueth, L. E., Haussler, A. M., Lohse, K. R., Rawson, K. S., Earhart, G. M., & Harrison, E. C. (2023). Effect of musical cues on gait in individuals with Parkinson disease with comorbid dementia. *Gait & Posture*, *107*, 275–280. https://doi.org/10.1016/j.gaitpost.2023.10.015

Yan, K. (2023, October). Exploring the feasibility of AI music Therapy — AMT Lab @ CMU. AMT Lab @ CMU. https://amt-lab.org/blog/2023/10/exploring-the-feasibility-of-ai-music-therapy

Yuan, S. H., Silverman, M. J., Cevasco-Trotter, A. M., & Wang, S. G. (2024, December). Ten Reasons Why Neurologists Should Refer Patients With Alzheimer Dementia to Music Therapy. https://doi.org/10.1212/CPJ.0000000000200357

Zimmer, C. (2024, March 19). How to Convert MP3 to MIDI for your DAW. Klangio. https://klang.io/blog/mp3-to-midi-daw/

Last year:

Agres, K. R., Dash, A., & Chua, P. (2023, April). AffectMachine-Classical: A novel system for generating affective classical music. *arXiv :2304.04915v1* https://arxiv.org/pdf/2304.04915.pdf

Summary: The **paper** documents a new way of controlling mode by using a probabilistic chord progression matrix inspired by the theme and variation form, and a new way of implementing voice

leading (also known as part writing; musical technique that combines vocal and/or instrumental progressions to create harmony) by using traditional rules. The system uses 11 musical parameters (mode, voice leading, pitch register, rhythm, tempo, velocity range, velocity variation, instrumentation, note density, harmonic progression and chord voicing) and four virtual instruments (piano, strings, clarinet, marimba) to map arousal and valence to harmonic, rhythmic and timbral features. The valence range is divided into 10 regions for mode, and the arousal range is divided into 3 regions for rhythm; this is done to generate appropriate musical content for each level of emotion. 39 musical stimuli in total are generated from the 13 different points around the arousal-valence plane for a listener study, with 11 of the 26 participants reporting having prior musical training – each trial consists of listening to a musical stimulus and rating its perceived arousal and valence on a 9-point scale. The results show that the system is very effective in conveying the intended levels of arousal and valence to listeners, with high coefficients of determination (R^2 = 0.96 for arousal and 0.90 for valence). Some asymmetrical effects between arousal and valence are also revealed, such that perceived valence is influenced by both valence and arousal parameter settings, while perceived arousal is only influenced by arousal parameter settings. The novel system has the potential to be used for applications benefiting from affective music, such as emotion mediation, biofeedback, and well-being.
Application to Research: The research is sourced from the music conservatory of the National University of Singapore and is credible. The system's use of 11 musical parameters and virtual instruments to map emotions to harmonic, rhythmic, timbral features directly works on the goal of determining the impact of melodic elements, placeable in the background section. The division of valence and arousal ranges into multiple regions to generate musical content for different emotional levels offers a good plan for the machinations behind such work, all in the background section. The listener study results showcase the effectiveness of the system in its goal of conveying the intended results, and applications shown like emotion mediation, biofeedback, and well-being provide compelling motivation behind such a development.

Anderson, A., Maystre, L., Mehrotra, R., Anderson, I., & Lalmias, M. (2020, April). ALGORITHMIC EFFECTS ON THE DIVERSITY OF CONSUMPTION ON SPOTIFY. *2020 IW3C (International World Wide Web Conference, April 20–24, 2020).* https://www.cs.toronto.edu/~ashton/pubs/alg-effects-spotify-www2020.pdf

Summary: The **paper** describes an analysis of Spotify users by their own research team, regarding the diversity of the users' music consumption (the wide range of unique genres and artists they listen to) for determining the extent to which current recommender systems impact the diversity of content users engage with now, and the ways this could influence their overall user experience (especially in terms of Spotify Premium subscriptions, possible "churning," etc. for the company). To measure this "diversity," a metric is defined with math: After cataloguing 850 million playlists, it is found that the similarity of any two tracks can be approximated as the likelihood that they co-occur in the same playlist; the diversity of a user's listening is then the mean of each of the similarities in their streamed songs, this value dubbed the "General-Specialist" (GS) score of a user. The data of 100 million Spotify Premium users is collected and each of their GS-scores are computed GS-scores one year apart, where it is revealed that these GS-scores remain remarkably stable over the course of the time period for every user, suggesting they capture a meaningful aspect of user listening and sort of a personality trait. When demographic attributes are introduced, it becomes apparent that as users get older, the "organic" (user-selected recommendation) portion of the GS-score goes up while the "programmed" (algorithmic recommendation) decreases; the former is *seven* times its complement, which is significant and also tarnishes the efficacy of the tool meant to be a replacement for the user going out and finding their own songs. It is then discussed if users who listen diversely are more or less satisfied than those who listen "narrowly." The two important business metrics of user conversion and user retention are examined through a correlational analysis, and it is found that people with more diverse listening habits are 25% more likely to buy the Premium package than those with less diversity. The paper concludes with reaffirming many of the findings are only correlational, but are consistent with a variety of causal explanations. There exists a need to find recommendation methods which prioritize diversity while still reaping the immediate benefits of relevance, all the while optimizing for the long-term advantages of delivering a diverse range of content. Application to Research: The paper itself is sourced from Spotify's own research center, so we cannot negate the possibility of inherent bias in favor of the app and itself. The brand image lends credibility to the research, though, because the company would need to uphold integrity and fact-check everything put into the studies it conducts. The concept that is crucial to the paper is that of *song embeddings*, stated to be the answer to the issue of "quantifying consumption diversity." Songs are placed into an intangible vector space which has its own share of beneficial properties: there is enough room for every song to occupy a distinct position, and the similarity between any pairwise set is captured *while ensuring* that all of these similarity-pairs are mutually consistent with each other. This idea of using mathematical sets to encapsulate all of the information we wish to compare in our experiment can be explored with the analogously enormous volume of musical patterns that can ever come into existence – algorithms seeing that one musical component elicits a neat response from a listener could then figure out several of the closest (but not always the exact same) elements to recommend to and test with the user.

Biasutti, M. (2015, May). PEDAGOGICAL APPLICATIONS OF COGNITIVE RESEARCH ON MUSICAL IMPROVISATION. *Frontiers in Psychology*. https://www.frontiersin.org/articles/10.3389/fpsyg.2015.00614/full

Summary: The **paper** inquires into pedagogical approaches for musical improvisation in the classroom, particularly through process-oriented frameworks, and builds rapport for such "learn-by-doing" methods. The real differences between improvisat ion and composition are explored, and a comprehensive table judging variables like the experimentation, reversibility and process dynamics in the two is shown. Five important pillars to musical improvisation are introduced, around which the proposed approach (and subsequently a good chunk of the paper) revolves. The concept of musical anticipation is shown, which involves foreseeing musical patterns, phrases, and elements – anticipation is shown to play a crucial role in musical decision-making, enhancing the quality of improvisation. Emotive communication is then defined as the inducement of "affective" (working on the emotions) states due to elements in the improvisation – using musical language and stylistic principles, the manipulating of relevant musical parameters (rhythmic, melodic, harmonic, dynamic, and timbre dimensions) is necessary and is shown to be present in professional work (jazz pianists). Use of repertoire is elaborated as employing prelearned melodic and rhythmic figures ("licks") as a foundation for improvisation, whereas feedback encompasses the ways musicians "judge" the direction of their freestyle during performance in order to tune that direction on-the-fly. Flow is described as a mental state characterized by complete absorption and focus on an engaging activity (improvisation here) increasing well-being and optimal performance – a positive experience for people and something to work towards. Nine aspects of flow are identified, including challenge and skill balance, clear goals, and a distorted sense of time, all of which contribute to this state of total involvement. It is noted that "group flow" is a real concept where musicians are unconsciously inspired by group interactions to generate a musical product that would not have been possible performing alone. A table regarding these 5 central elements is constructed, comprising brief descriptions and numerous methods to support these skills in budding musicians. The paper concludes with a brief summary, noting that social learning environments would work best in instruction.
Application to Research: The study contains an in-depth examination of the difference in improvisation vs. composition, which consists of very subtle details about musical creation and decision-making – this

knowledge may go to show the ways many minute musical elements impact peoples' preference in music at the subliminal level. The emphasis on communication through musical parameters definitely pertains to the research focus on using facial and eye-movement recognition to discern subtle emotional reactions to music. The concept of "flow" and its nine identified components entail creating an optimal immersive experience in music, which is one of the research aims. Insights on "group flow" are particularly intriguing, hinting at collaborative aspects that could inspire the development of personalized music suited to communal environments.

Fu, V. X., Oomens, P., Klimek, M., Verhofstad, M. H. J., & Jeekel, J. (2020, December). THE EFFECT OF PERIOPERATIVE MUSIC ON MEDICATION REQUIREMENT AND HOSPITAL LENGTH OF STAY: A META-ANALYSIS. *Annals of Surgery, Vol. 272 No. 6*. https://pubmed.ncbi.nlm.nih.gov/31356272/

Summary: The **paper** conducts a meta-analysis of 55 studies (totaling to 4968 patients), seeking to quantify the true results which perioperative (regarding the period of time surrounding a surgical procedure) music yields. Motivated by the growing interest in cutting away opioid use in surgical patients, the varied measures of patient medication dosage requirements, lengths of stays and total costs are used withal. The exhaustive literature search is specifically conducted adhering to PRISMA guidelines and yields 2,414 potential papers, and manual cross-referencing across 8 separate data is completed. A definition for "music intervention" is set and rules out studies dealing with purely nature-based audio (such as rain sounds) and live music performances / music therapists because of their inapplicability and confounding nature, respectively. An elaborate table spanning multiple pages is shown, attaching each study to their respective surgical procedures, anesthesia types, specific interventions, whether interventions began before, during, and/or after the procedure, total durations, what was given to control groups, the number of participants in each group, and the measured outcome parameters. Graphs describing the probabilities of types of bias in every study are displayed – including detection, performance, attrition and reporting bias, along with two probable causes of selection bias. Studies are classified into having a low, high or unclear risk for each bias. It is determined that a moderate risk of performance bias pervaded the family of studies, where experiments mistakenly introduce more differences between the control and experimental groups than solely the desired variate. Across all studies, it is found that perioperative music significantly reduces the postoperative opioid need in patients, with propofol amounts administered dropping by 0.72 standard deviations and midazolam by 1.07 standard deviations. Such music reduced the opioid consumption in patients by 4.4 mg MEDs (morphine-equivalent dose) across each study measuring opioid requirement over the specified period of at least 24 hours after surgery. The paper concludes by emphasizing the "safe and patient-friendly" nature of the intervention and its agreeable deficiency of any negative effects, alongside a description of how further research could take on the effect of music regarding medical complications, clinical recuperation, expenses, and integration.
Application to Research: There is empirical evidence of the positive effects of music on physical opioid need, which is great validation for possible music-as-an-intervention real-world use cases. Importance is placed on understanding patient preferences for music, which could suggest that tailoring music interventions to individual preferences would enhance their effectiveness, even to a significant degree. Medical drugs and music both have profound effects on the brain, and the capability to which they are utilized only strengthens or exacerbates those consequences – with human music targeting your emotions, but lacking the extreme precision of features needed to affect your brain directly, which is where predictive algorithms could step in.

Grimaud, A.M. & Eerola, T. (2020, April). EmoteControl: an interactive system for real-time control

of emotional expression in music. *Personal and Ubiquitous Computing 25:677–689* https://doi.org/10.1007/s00779-020-01390-7

Summary: The **paper** documents a novel, interactive computer system *EmoteControl* that allows for real-time manipulation of musical cues and emotion expression – musical cues encompass two main types: structural cues, tied to the composed score (e.g., tempo, mode), and expressive cues, utilized by performers during music rendition (e.g., timbre, articulation). A focus group with music emotion researchers. The portable version of EmoteControl shown at a science fair engages students and teachers in an interactive game where they manipulate musical cues to convey different emotions, where it is well-liked and ascertained to be fun and educational. A formal human-computer interaction (HCI) study with non-musicians supply data: 12 participants alter 3 musical pieces via the six musical features available, aiming to convey one of three prepicked emotions (sadness, joy, or anger). Participants then answer both close- and open-ended questions regarding their time with the interface, its functionality, its aesthetic. Close-ended questions also consist of 5-point Likert scales, ranging from 'extremely well' to 'not well at all', 'a great deal' to 'none at all', etc. The primary benefit of EmoteControl is in the ease of use for people lacking musical expertise, enabling users with no musical background to modify musical cues in real-time to convey diverse emotions.
Application to Research: Many of the insights from the paper belong in the Background section, being new ways in which music and the electronic device intersect. The EmoteControl system, being a newly designed prototype, comprises technology potentially very suited for an accessible musical software – EmoteControl enables people lacking musical expertise to modify musical cues in real-time. There is a valuable comparison between manipulating musical cues directly for emotional expression and the indirect method of predicting user preferences through recognized facial expressions. This source's findings from the human-computer interaction (HCI) study can contribute to discussion on the identification of musical preferences from computer vision paired with knowledge of music theory; the users' interaction with the interface, functionality, and aesthetics of EmoteControl offer parallels to how users might engage with a completed AAC-FER prototype.

Guerrier, G., Bernabei, F., Lehmann, M., Pellegrini, M., Giannaccare, G., & Rothschild, P-R. (2021, September). EFFICACY OF PREOPERATIVE MUSIC INTERVENTION ON PAIN AND ANXIETY IN PATIENTS UNDERGOING CATARACT SURGERY. *Frontiers in Pharmacology. https://doi.org/10.3389/fphar.2021.748296*

Summary: The **paper** investigates the efficacy of preoperative music intervention in reducing pain and anxiety in patients before and after undergoing eye cataract surgery, noted to be one of the most frequently performed operations in the world. Pain felt is a known factor to the surgical success, as historically patients are observed to "become uncooperative and make abrupt movements" due to this, leading to intraoperative complications. 243 patients total – 119 experimentals and 124 controls – are studied in the period from February 2017 to July 2018. Those provided the intervention go through a 20-minute music session through earphones before their surgery, while the control group simply wear earphones without music playing – all are given sleeping masks for this duration, and all promptly take a controlled dose of Midazolam (a well-known medication designed to induce sleepiness and attempt to relieve anxiety), as per standard protocol. Anxiety levels are found to be significantly lower in those given the musical intervention, with a mean reduction from 3.2 to 1.3 on the VAS-A (visual analog scale for anxiety) – this is measured via self-reporting orally and in writing. Indeed, intraoperative pain is found to be linked to preoperative anxiety levels in both sets of patients after the numbers are crunched, but both are reduced in the music group subjects; this matches up with the fact that the patients given music also report lower mean pain levels both during the surgical procedure and before discharge.

Application to Research: Note that all 243 patients studied are originally admitted to a single hospital in Paris, so while researchers attempt to ascertain a real random representation of the populace, there must be inherent regional/socioeconomic/etc. commonalities between most of the studied patients which might make them nonrepresentative of the whole. The experimenters comment on the need for further studies to determine the best “timing, cost and technology” before this intervention can be widely introduced, which could mark a gap in research to be filled. There is importance placed in the patient preferences with music intervention (“it is the act of making a choice that determines the greatest effectiveness of the [musical] procedure”) suggesting that tailored music choices could be optimal – instantly generated music composition algorithms alongside these patient preferences could enhance such interventions in many medical settings elsewhere, but determining the cost-effectiveness/necessary equipment for this amenity and whether it would be worth the potential benefits is necessary.

Haruvi, A., Kopito, R., Brande-Eilat, N., Kalev, S., Kay, E., & Furman, D. (2021, April). DIFFERENCES IN THE EFFECTS ON HUMAN FOCUS OF MUSIC PLAYLISTS AND PERSONALIZED SOUNDSCAPES, AS MEASURED BY BRAIN SIGNALS. *Arctop, Research & Development.* https://www.biorxiv.org/content/10.1101/2021.04.02.438269v1.full

Summary: The **paper** documents an experimental study which tries to figure out the attributes of sound in music that actually bring about affectation in people. Exactly 62 participants (22 female), aged 18-65, perform various tasks while listening to different types of sounds and wearing a Muse-S device to record their brain activity, but 11 are excluded from further analysis due to excessive noise in brain data and/or unreliable survey responses. Four audio conditions are compared: two music playlists by Spotify and Apple (containing 30 songs each with an average duration of 3.5 minutes per song), one real-time personalized soundscape by Endel (a company known to offer automated, AI-generated sound), and silence. The paper measures the participants’ focus levels using electroencephalography (EEG) signals and also collects self-reported surveys from the participants after each task, where they rate their focus, enjoyment, stress, and motivation levels on a scale from 0 to 1. It is found that personalized soundscapes increased the participants’ focus significantly above silence ($p=0.008$), while music playlists do not have a significant effect – the effect of sound on focus may be age-dependent, with younger participants (age<36) showing higher focus levels with any audio content than silence. A total of 136 audio features (like energy, spectral entropy, chroma coefficients, etc.) are extracted from the playlists and analyzed alongside the brain decoded focus levels, and 20 features are found with significant correlations ($p<0.05$) between their presence and the focus level. Multiple random forest regression models are trained to predict focus levels from audio features alone, and the final audio-based model achieves a Pearson correlation of 0.7 and an accuracy of 88%. Limitations are noted, such as the gender imbalance in the sample and the lack of comparison with highly personalized music playlists, and a desire for further investigation in such personalized music is expressed (since it is shown that sounds “have a distinct effect on focus”).

Application to Research: A concrete way to measure the “focus” in people before and after exposure is provided, which is useful for concrete data and can serve as evidence for the subtopic covering the medical use of AACs and their measurable affectance. There are lots of varied charts to help build the intuition on particular sounds and their specific level of affectance on people. This source also uses currently available streamnig services like Spotify, Apple Music, along with a good few others; a direct tie into recommendation algorithms to figure out particular aspects of music different people like.

Huang, C-F. & Lin, E-J. (2013). AN EMOTION-BASED METHOD TO PERFORM ALGORITHMIC COMPOSITION. *Proceedings of the 3rd International Conference on Music & Emotion (ICME3), Jyväskylä, Finland, 11th - 15th June 2013.*

https://jyx.jyu.fi/handle/123456789/41590#

Summary: The **paper** presents a novel approach to algorithmic music composition that integrates emotion into a well-studied software. Previous ventures in this field lack a structured way to generate music with specific emotional features, so the authors utilize Prof. Phil Winsor's "MusicSculptor" software and emotion "parameter mapping" to actually shape the music dynamically by manipulating various music parameters with probability controls. A 2D emotion plane with valence (the spectrum of negative to increasingly positive emotion) and arousal (the spectrum of calm to increasingly exciting music) is introduced for explanation. The authors describe how they determine desired emotion coordinates on the 2D plane and use these coordinates to create a parameter mapping table linking 16 music parameters (pitch, tempo, meter, timbre, etc.) with descriptive composition methods. The math behind the method, i.e. the use of stochastic processes and "Sieve" theory, are briefly mentioned. A flowchart is provided with the process the program takes to generate the music, beginning with the initial parameter inputs all the way to final MIDI file generation and polishing. Later in the paper, specific examples of parameter settings are provided in diagrams, including inter-onset time distribution, pitch class settings, velocity distribution, and duration range settings, all intended to adjust the emotional expression of the music in different ways. The paper concludes with highlighting the user-friendly approach to composing music, though style imitation is not currently considered. A prospect of using faster programming languages like Java or C is mentioned briefly.
Application to Research: This notion of context-based music generation as man interacts with machine: why bother?? Considering the existence of vast online libraries of music, one could explore the proposition of uniquely generated music and what it is useful for right now/in the future. It's actually really fascinating how a single set of digits can be manipulated to emulate music from various cultures around the world – this observation kind of highlights the adaptability and versatility of the proposed approach. Regarding potential advantages of algorithmic composition over handmade pieces created by professional composers - considering the comparative benefits and drawbacks could shed light on what algorithms have to offer to music, like the change-a-few-digits-to-change-the-entire-style thing. There could also be possible inquiry into how it is ensured that the "different content" generated by the algorithm is not only distinct but also aesthetically pleasing to a listener's ears. What exactly determines this "pleasing" aspect, and how would one go about measuring this? Everyone thinks they have the most refined musical taste, yet the tastes' of any two people can differ wildly, so given the inability to achieve a "one-size-fits-all" musical piece, would one have to personalize the experiment to each individual in a study?

Interiano, K., Kazemi, K., Wang, L., Yang, J., Yu, Z., & Komarova, N. L. (2018, April). MUSICAL TRENDS AND PREDICTABILITY OF SUCCESSES IN CONTEMPORARY SONGS IN AND OUT OF THE TOP CHARTS. *Royal Society Open Science*. http://dx.doi.org/10.1098/rsos.171274

Summary: The **paper** examines the musical characteristics of successful songs released in the UK from a catalogue of over 500,000, to quantify the relationship between. Features used in the analysis include 12 binary variables quantifying musical properties (exactly five acoustic properties, two sound characteristics, and five moods) as well as six categorical variables classifying music into more nuanced genre categories. Random forest models to predict song success are employed, partially based on these features and also the popularity of the musician – a measure of the artist's performance in the precursory five years is taken into account as a parameter. The "success" of a song in the research context is based on its peak chart position, combined with the number of weeks the song had in the charts, used to measure long-lasting appeal. The two sources, The Official Charts and MusicBrainz, supply the data used, wholly

from the UK. There exist charts (figure 2. specifically) which show that the average features successful songs possess show an actual distinction from the mean of uncharted songs; e.g. charted songs consistently hover around the 0.02 mark for “acoustic” variable while uncharted ones are at 0.04 instead, and this distinction is consistent for many other features. Prediction accuracy using acoustic features alone did not exceed 74%, but inclusion of the super-star factor brought this up to 86%, suggesting that stardom masks the effect of the musical portion of a piece on its popularity. It is found that the positive emotion shown in chart-topping music has decreased over time – lyrical analysis reveals increased presence of anti-social words (e.g. “hate”, “kill”, etc.) and an amplified focus on the self (more singular first person pronouns). Musically, the ‘relaxedness’ and ‘danceability’ of music is shown to have grown in the 1985 - 2015 period, with a similar, possibly correlated increase in the ‘electronic’ and ‘atonal’ characteristics. General conclusions are drawn regarding the patterns observed in successful music and what divides them from the average songs – though the majority of music sampled has decreased in happiness over the years, the successful songs seem to “defy these trends” and stick out from the overall new waves. There is discussion on the possible biases in the data, with a source AcousticBrain partially relying on volunteer contributions.
Application to Research: The research paper is published in the respectable THE ROYAL SOCIETY, “world's oldest independent scientific academy” and it can be inferred that the information presented possess sufficient truth. The emotional impact of music is quantized in the paper, both in musical properties and lyrical content, which could lead to further investigation into these musical elements and their emotional effects. The finding regarding superstardom suggests that the artist influence is a very critical factor in success with listeners, and can inform further research on how artists, and their particular emotional resonances, affect listener preferences. There is analysis on how sic's emotional content has evolved and how it continues to impact listeners' emotions.
The approach of using random forest algorithms can be extended to some form of the computer vision used in facial and eye-movement recognition.

Kowald, D., Muellner, P., Zangerle, E., Bauer, C., Schedl, M., & Lex, E. (2021, February). SUPPORT THE UNDERGROUND: CHARACTERISTICS OF BEYOND-MAINSTREAM MUSIC LISTENERS. *EPJ Data Science, 10-14* *https://epjdatascience.springeropen.com/articles/10.1140/epjds/s13688-021-00268-9*

Summary: The **paper** has a focus on users with a penchant for non-mainstream music on platforms like Last.fm. The authors draw attention to their earlier work which shows consumers of non-mainstream music exhibit larger user profiles, showing a higher diversity of artists they engage with compared to mainstream music listeners. This very robust digital footprint then incurs the need for enhanced recommendations quality, and a connection is drawn to the infamous “long-tail problem” constantly mentioned when dealing with statistics, and especially recommendation systems regarding majorities/minorities of users. A comprehensive dataset “LFM-BeyMS” is assembled, encompassing listening histories of over 2000 non-mainstream music enthusiasts from Last.fm. This is done by applying unsupervised clustering to the eight manufactured characterizing acoustic features of the pieces (such as “danceability,” “valence,” and “speechiness”) documented in the >1.1 billion listening events (LEs) publicly available between January 2005 and August 2014 on the website. There is particular focus on four distinct clusters of non-mainstream music, namely Cfolk (folk), Chard (hard rock), Cambi (ambient), and Celec (electronica) – users are subsequently assigned to these clusters, resulting in four subgroups of non-mainstream music listeners (Ufolk, Uhard, Uambi, Uelec). There is a great deal of math involved. It is discovered that there exist substantial disparities in recommendation accuracy among these subgroups, with Uambi notably receiving the most accurate music recommendations, surpassing even the mainstream music listeners. It also emerges that “openness” (a plasticity trait) holds a stronger correlation with

accurate recommendations than musical "diversity" upon analysis. The paper concludes with calls to future research regarding modeling these niche subgroups effectively. There is a proposition to get to formalizing these dimensions of openness and diversity so often mentioned in MRSs, for more precise measurement and integration into final recommendations, and possible future avenues of research are mentioned using "Hofstede's cultural dimensions" and the World Happiness Report. The availability of their datasets and code in the end is done to encourage further investigation.
Application to Research: The study is noticeable for catering towards people in the "long-tail" of the music-listener distribution, which could arguably have a greater impact on the music industry than the spread of more mainstream music. It is redolent of the principle behind Zipf's law – 80% of listening events are composed of only the top ~20% songs, but the rest of the content still accounts for the majority – so a majority of artists, musicians, producers would be direct stakeholders in having their share of the music content available online be propagated through such recommendations, which can fuel research. The acoustic music features determined in the study are particularly valuable, regarding musical ideas in composition - the way which "how suitable a track is for dancing" is computed with little human intervention is interesting and provides evidence that such an abstract musical idea can be captured, in some form, with numbers on a screen. Especially since music is in the brain and changes via perspective as you move from person to person, this music-to-numbers concept is exceedingly important for future research with instant-generation, real-time-evolution composition techniques. Concrete definitions for "beyond-mainstream" music are prompted, and these descriptions are necessary for accurate ways of conveying musical information over text instead of notes on a staff or being discarded only as a certain "feeling" in the minds of some people.

Lorek, M., Bąk, D., Kwiecień-Jaguś, K., & Mędrzycka-Dąbrowska, W. (2023). The Effect of Music as a Non-Pharmacological Intervention on the Physiological, Psychological, and Social Response of Patients in an Intensive Care Unit. *Healthcare 2023, 11, 1687.* https://doi.org/10.3390/healthcare11121687

Summary: The **literature review**, conducted in the fourth quarter of 2022, discusses the 'relatively underresearched' notion of musical intervention in the ICU setting, including physiological, psychological & social the effects on patients *especially* involving delirium. 255 articles in the 5 databases [Science Direct, EBSCO, PubMed, Ovid, Scopus] are found upon initial keyword search, of which 160 are analyzed and 18 (all qualitative, meeting PICOS criteria) thoroughly examined – these selected for via the Joanna Briggs Institute (JBI) Critical Appraisal with a checklist of 11 criteria, with a table of the questions and respective studies' answers presented. A total of 1,598 participants are accounted for, with the mean age being around 60. Over 10 distinct measurement methods for quantifying patient reactions to music interventions are described in the 18 studies, with four all using the Richmond Agitation and Sedation scale. The paper makes a strong distinction between the terms "therapeutic music listening" and "music therapy," noting the latter can only be conducted by certified music therapists while the former occurs through headphones or volunteers playing live music, i.e. by staff without such specialized training. The importance of patient-focused care is underlined as recurring post-ICU symptoms like anxiety, depression, or PTSD may occur up to 90 days after an ICU stay.
Application to Research: The focus on patient outcome showcases the degree to which music can impact patients, particularly in mitigating post-ICU symptoms like anxiety, depression, and PTSD. The distinction drawn between "therapeutic music listening" and "music therapy" is particularly useful since it provides valuable understanding on how music is administered and perceived by patients. The review's emphasis on over ten distinct measurement methods for quantifying patient reactions to music interventions presents potential approaches to gauge the affective responses we aim to decipher through facial expression recognition.

Muñoz, E. & Cabedo-Mas, A. (2016). MÚSICA Y COMPETENCIAS EMOCIONALES: POSIBLES IMPLICACIONES PARA LA MEJORA DE LA EDUCACIÓN MUSICAL. *Revista Electrónica Complutense de Investigación en Educación Musical, 13,* 124-139. http://dx.doi.org/10.5209/RECIEM.51864

Summary: The **paper** explores the connection between music and emotional intelligence, beginning with discussion on relevant conclusions found in previous research. Varying arguments attempting to ascertain this connection are reviewed, including deliberation on exact music theory-based properties that bring about change in the mind, studies showing increased “interhemispheric transfer” and brain plasticity from musical practice, and a comparison between desirable and undesirable traits in musicianship with their respective impacts on emotional wellbeing. There is a focus on music instruction in elementary classroom settings, to supplement brain development in the foundational years. The paper concludes with general statements regarding the benefits of music, and also highlights the need for future research.
Application to Research: There is exploration of music theory-based properties influencing mental states and brain plasticity from musical practice, which could serve useful in decoding peoples’ subconscious musical preferences based on particular musical components. Understanding what musicians consider “desirable” in musicianship is very helpful in order to identify emotional cues from the general populace and make musical assumptions.

Nuanáin, C. Ó. & Sullivan, L. (2014, October). Real-time Algorithmic Composition with a Tabletop Musical Interface - A First Prototype and Performance. *A/M '14: Proceedings of the 9th Audio Mostly: A Conference on Interaction With Sound, No.: 9, Pages 1–7* https://dl.acm.org/doi/10.1145/2636879.2636890

Porcaro, L., Gómez, E., & Castillo, C. (2022, January). DIVERSITY IN THE MUSIC LISTENING EXPERIENCE: INSIGHTS FROM FUTURE GROUP INTERVIEWS. *Conference on Human Information Interaction and Retrieval (CHIIR '22)*. https://arxiv.org/abs/2201.10249#
Summary: The **paper** develops understanding on the unfrequented topic of musical listeners and their perception of the “diversity” found in interaction with algorithmic music recommendations, and the genre of Electronic Music (EM) is heavily focused on for the case study. It is noted that while empirical analysis has been the focus in previous music-recommender-system (Music RS) literature, foundational research (involving operational definitions on musical “diversity” and their metrics as a whole) is missing.
The study is divided into three assignments for all participants: initial evaluation of two sets of EM audio tracks for diversity based on musical features, comparison of two lists of four EM artists' photos (selecting the most diverse list based on “social salient attributes” comprising gender, skin tone, age, etc.) and the final assessment of diversity in lists containing both artists' photos and corresponding tracks, considering both musical features and artists' attributes. The authors write that all proper “personal data management” and ‘ethical protocols” are adhered to in this experiment, per the study’s affiliation with the international TROMPA project. It is found that self-identified newcomers to EM find it challenging to assess diversity, relying on generic features like tempo, while proclaimed EM “experts” use prior knowledge to categorize artists and tracks, but could inherently be introducing bias into any data gathered – one such pundit summarized this problem: *“I can feel like I can make a better decision of what is diverse… but then there is kind of a bias that comes based on the fact that I like this music a lot*.” Generally, exposure to diverse lists prompts self-reflection on prior beliefs about EM in members of the selected sample. The link between music recommendations and diversity is discussed – such diversity is said to combat monotony

by widening musical choices, offering the chance for musical discoveries to be made by the motivated listener. Some find comfort in familiar music, while others appreciate the unexpected, and not all are open to / even care about this risk – diversity's impact varies with the listener's goal (e.g., exploration vs. focused listening). Some participants note that algorithmic recommendations led them to discover new aspects of music genres they had initially disliked or held biases against; in several of these cases, this exposure eventually led them to actually enjoy and listen to these genres more frequently. A conclusion is then made that Music RS's challenge prior dislikes or prejudices in listener, possibly enabling them to rediscover previously disliked genres they would not have touched otherwise. It is noted that the study's generalizability is limited by the WEIRD population (Western, Educated, Industrialized, Rich, Democratic), and that replication with a more diverse sample could provide greater insight.
Future research could then explore long-term interactions with diversity-aware music recommendations via longitudinal studies.
Application to Research: The paper appears to be credible and well-supported – the authors have demonstrated expertise mainly as members of the Music Technology Group at their university, and has secured funding from international projects. The challenges faced by both newcomers and experts in assessing musical diversity is highlighted, which creates a room for algorithms to step in and solve these problems which even humans struggle with. The insights into how people interact with algorithmic music recommendations could inform the development of such programs. The consideration of proper personal data management and ethical protocols is also noted, which will be crucial when working on projects accessing sensitive health-related data.

Rentfrow, J. P., Goldberg, R. L., Levitin, D. J. (2011, June). The Structure of Musical Preferences: A Five-Factor Model. *J Pers Soc Psychol.* https://pubmed.ncbi.nlm.nih.gov/21299309/

Summary: The **paper** discusses the yieldings of four studies revolving around the underlying structure of peoples' preference in music, with results that indicate that five critical, genre-free factors define the mentioned. This novel model captures a broad range of musical styles and is acronymized "MUSIC" for the Mellow, Urban, Sophisticated, Intense and Campestral elementsl. The first study seeks to determine any tangible framework behind musical preferences for excerpts of recorded music, via online surveys with 15-second excerpts from 52 different pieces. About 700 to 5,000 participants are garnered and 26 genres and subgenres are identified from the most frequent occurrences in data collected. Criteria such as parallel analyses of Monte Carlo simulations and replicability are used to filter out factors, a hierarchical structure of the residue is examined, and the data resembles the well-documented "highbrow-lowbrow" pattern found in musical elitism, where 'sophisticated' dimensions are more present in classical and jezz music than country and rap. Through an analysis comparing this five-factor structure with one where demographics like sex and age are removed, congruence coefficients are calculated to be from .99 to over .999 – the underlying factors that influence these preferences are invariant regardless of gender or age. Study 2 reifies this understanding by honing in on unknown, aspiring artists and using their 94 samples in a similar experiment, as opposed to familiar music, ensuring that results from before are not merely artifacts from the pieces' popularity. Indeed, correlations strictly over .99 and even .999 are found. Study 3 aims to investigate the degree to which these established results extend, with students in separate classes at UoT Austin being blinded to one side of the test (half only rated the excerpt itself, and half only rated the genre). About 17 and 18 percent of any variance is accounted for, and the mean factor congruence is .97 (equivalence). Charts from this study closely align with those of the previous two, and their locus provides "compelling evidence" to vouch for the robustness of the MUSIC system. Study 4 is conducted based on the results found in the first 3, as an analysis of both the independent and combined effects of genre preferences and music-related attributes on MUSIC. Twenty-five "music-descriptive adjectives" touched upon in previous research are initially utilized, and through a screening process involving several disconnected experts, narrowed to a seven-tuple of music-specific attributes, and another seven-tuple of psychologically oriented ones. Then blinded participants independently rate the 52 + 94 = 146 excerpts from studies 1 and 2, and further analysis reveals high agreement (cited mean alpha values being the lowest at .68, then .81, .83, .93, .93, .99) between the two classes of attributes. It is written that using diverse musical samples spanning eras and different cultures will further aid in investigating music preference structure and determining the scope of the MUSIC model, e.g. taking into account social connotations like jazz being currently thought of as sophisticated and creative, but earlier generations considering the same music uncultured. The paper finishes with discussing future possibilities – further exploration of music preferences in context could take into account the individual's emotional state before listening, and a "fruitful direction" could be in-depth research on the affective aspects of these music preferences.

Application to Research: The paper is a little "dated" as it is from 12 years ago, but still represents the cutting-edge techniques in machine learning, computer vision, and musical analysis at the time. It extensively comprises the technique of Principal Component Analysis (PA) with varimax rotation, which seems promising to use in any statistical analysis, although faster and more suited algorithms may exist now. If one could find newer papers including this paper in their references, those papers could point to those newer solutions.

Predicting music preferences based on various components like melodic elements, chord progressions, timbre, tempo, etc. is a central topic the paper is focused around – provides a base for the claim that the underlying elements influencing these preferences are consistent, and algorithms excel at finding and using such lay-low patterns. Understanding the affective aspects of music preferences, as suggested in the paper, will play a massive role in using music as a possible therapeutic intervention.

Hewett, A. (2021, March). Music Can "Hack" The Brain [Video]. @adamhewett1854, Northwestern University. https://www.youtube.com/watch?v=IrsXxF0PQS0 '

Wang, Y. (2021, December). MUSIC COMPOSITION AND EMOTION RECOGNITION USING BIG DATA TECHNOLOGY AND NEURAL NETWORK ALGORITHM. *Hindawi Computational Intelligence and Neuroscience*. https://www.hindawi.com/journals/cin/2021/5398922/

Summary: The **paper** Neural networks (NN)s, including convolutional NNs, recurrent NNs, and even multi-layer perceptrons are delved into. The MCNN structure involves adjusting the Long Short-Term Memory (LSTM) generation network's probability distribution through a Reward function and applying music theory rules for intelligent style generation. The author compares the algorithm to the "idea of the chess game. "

Application to Research: The research potential.

Wiafe, A. & Fränti, P. (2023, January.) Affective algorithmic composition of music: A systematic review. *Applied Computing and Intelligence 3 (1): 27–43*. https://www.aimspress.com/article/doi/10.3934/aci.2023003

Summary: The **systemic review** examines 18 studies over six years and showcases essential findings across various dimensions of AAC. Despite claims from others of significant growth in AAC research, the

review period reveals insufficient attention in actuality, with the study distribution peaking in 2015. Definitions of AAC systems vary among studies, and the lack of a unified definition encourages the production of one: “technology that use algorithms to compose music with the intent to modulate or induce a listener’s affective state.” Two primary categories of emotional models (categorical and dimensional) are present across studies, with dimensional models focusing on valence-arousal dimensions dominating. Seven unique ML techniques are utilized in the AAC systems presented, including supervised, unsupervised, and reinforcement learning; SVMs, ANNs, and Monte Carlo methods were among the prominently used techniques, but there existed niche uses of Gaussian mixture models, Markov chains, dynamic programming and Evolutionary algorithms (which actually mimic the behavior of biological natural selection). Harmony, rhythm and dynamics are the most commonly manipulated musical features in such AACs (with 11, 10, 9 studies) with runner-ups timbre, melody, mode, tempo being used in about a third each, and the outlier being articulation with exactly one study to back it. Self-reporting is the main method being used for validating emotional experiences in participants currently. Regarding practical applications; of the eighteen, eight studies stated the use of AACs in composing background music (especially for real-time games), four studies focused on generic emotional recognition research, two specified therapeutic purpose and the remaining four did not state a clear domain. The need for more comprehensive literature on AAC system design is discussed, along with an observation of how 0 studies considered design context. The paper concludes with affirming that the current lack of accessible papers can deter potential researchers from exploring the field of AAC, and future research should aim to present these models “clearly and concisely.”
Application to Research: Precisely delineating AACs gives the clarity necessary to explore them. Presented is a slew of algorithms, and the relative frequency with which these algorithms are used in worldwide studies is shown too which serves extremely useful for choosing methods more studies use for their determined reasons, as well as seeing the niche side and assessing why those researchers picked underused methods. The same goes for particular musical aspects like harmony and articulation.
The overview of dimensional models with valence-arousal is a good basis for understanding how computer analysis on music and emotion has been working so far and what can be improved. These technological aspects would all go in the section describing how the prototype-project was produced and its underlying mechanisms, with both music and informatics theory.
The notable absence of context consideration shown in many studies is something to fill in for.

Williams, D., Hodge, V. J., & Wu, C-Y. (2020, November). On the use of AI for Generation of Functional Music to Improve Mental Health. *Front. Artif. Intell. 3:497864* doi.org/10.3389/frai.2020.497864

Summary: The **paper** combines machine learning, biophysiological measurements, and psychological evaluation to create an artificial system capable of influencing peoples’ affective states through music, with the goal to shift users from negative mental states (e.g., fear, anger) to positive ones (e.g., mindfulness, calmness) using AI-generated music tailored to their emotional needs. Lines between the terms “affective state,” “emotion,” and “mood” are drawn, and it is the duration of the user-response that is found to determine the distinctions. Initially, 53 listeners rank musical excerpts to produce a labeled dataset to feed into the algorithm – each participant evaluates four musical excerpts, two calm or positive (N1 and N2) and two anxious or negative excerpts (S1 and S2), in a bipolar ranking across six pairs choosing the positive in each pair (N1vsS1, S2vsN2, S1vsN2, N1vsS2, S1vsS2 and N1vsN2). For the real music generation, a “transformative algorithm based on a second order Markov-model with a musical feature matrix” is employed, ensuring sufficient labeled pieces for biofeedback evaluation, and such labels are given to newly generated music using MIDI and Mel-Frequency Cepstral Coefficients for a more nuanced representation – the entire behind-the-scenes setup is denoted as a system of hidden

Markov models and abbreviated HMM. For gauging, it is proprosed that galvanic skin response (GSR) be used as a marker of psychological arousal to assess emotional states and as a control signal for training the algorithms; GSR data correlates directly with perceived negativity, validating its use in evaluating emotional responses. The Shimmer3 wireless GSR device is employed to detect the GSR and is initially calibrated for individual baseline signals. In the final prototype, there is an incorporation of a feedback loop to adapt corpus scores based on the user's affective response – this iterative process serves as a fitness function that selects the most effective music. Listeners effectively differentiate affective states using differently synthesized timbres – shorter, broader pitch range music tends to be perceived as more negative. It is shown that familiarity significantly influences emotional responses; Familiar movie soundtracks evoke higher GSR amplitude but lower negative self-reports, indicating that result. An increased GSR is noticed in each music excerpt, regardless of whether the excerpts are generated by the HMM model or not. The paper concludes by noting that generative music technology has the potential to produce "infinite soundtracks in sympathy with a listener's bio-signals" cyclically. The authors propose further work in three major challenges: extracting meaningful control information from body signals, designing effective generative music technology, and considering application-specific needs.
Application to Research: All authors are from the University of York, UK and specialize in the relevant fields. The paper is sourced from the reputed *Frontiers* journal and is reviewed multiple times by different people – it took a full year and a sixth for the paper to go from receipt to publication, and it follows that the source is credible. The paper demonstrates a very sophisticated approach to generating tailored music, complete with many details about algorithms and software used and references to the theory behind them. The central idea of "biofeedback loops" exceedingly synergizes with the research goals for music being synthesized in real-time based on user reaction. This study uses the galvanic skin response as a determinant, but it may be argued that facial recognition could do a better job of capturing raw emotion from the user as the face can show so many different signals compared to a patch of skin.

Williams, D., Kirke, A., Miranda, E., Daly, I., Hwang, F., Weaver, J., & Nasuto, S. (2017, May). Affective Calibration of Musical Featuresets in an Emotionally Intelligent Music Composition System. *ACM Transactions on Applied Perception, Volume 14, Issue 3, Article No.17, pp 1–13* https://dl.acm.org/doi/10.1145/3059005

Summary: The **paper** presents a prototype AAC system that uses 16-channel feed-forward artificial neural network to generate music with targeted emotional qualities based on a matrix of musical features derived from literature, based on a 12-bar piano music input. Five musical features are manipulated to imply different affective states: tempo, mode, pitch range, timbre, and amplitude. The system generates 99 musical excerpts for each iteration, each lasting 20 seconds, and then adjusts the musical feature mappings based on the listener ratings, which are collected using a 9x9 grid with self-assessment manikins (SAM) for valence and arousal. The system is evaluated by conducting a three-stage listener evaluation with 36 participants, who rate the emotional content of the generated music on a two-dimensional affective space of valence and arousal. The paper concludes by noting the prototype AAC system is capable of creating short sequences of music with a slight improvement on the range of emotion found in a stimulus set comprised of traditionally composed musical excerpts, achieving a 17% improvement in overall coverage across the conceptual emotion space and a 42.5% relative improvement on the spread of the target rating compared to a real-world stimulus set.
Application:

Woods, K. J. P., Sampaio, G., James, T., Przysinda, E., Hewett, A., Spencer, A.E., Morillon, B., & Loui, P. Stimulating music supports attention in listeners with attentional difficulties. https://doi.org/10.1101/2021.10.01.462777

Summary: The **paper** documents an investigation into how music with different levels of acoustic amplitude modulation affects the sustained attention in people with varying levels of attentional difficulties as measured by the ADHD Self-Report Scale, through four experiments. Experiment 1 tests how music with fast (not usually occurrent in music, labeled "AM+Music") or slow amplitude modulations ("Control-Music") or pink noise affected the performance of 149 participants on a sustained-attention-to-response task (SART) – It is found that high-ASRS participants performed better with AM+Music than with other conditions ($F(2,170)=5.02$, $p=0.008$) while low-ASRS participants showed no difference between conditions. In experiment 2, fMRI is used to measure brain activity during the same SART and music conditions as in 1; it is found that AM+Music elicits higher activity in multiple brain regions (especially in the salience, executive function, and default mode networks) and more so in high-ASRS than in low-ASRS participants ($p<.05$ FDR-corrected). AM+Music was also associated with higher activity in the sensorimotor and visual networks during correct responses, suggesting enhanced motor and visual processing. In experiment 3, EEG is used to measure stimulus-brain coupling during the same SART and music conditions as in Experiments 1 and 2. It is revealed that AM+Music induced stronger phase-locking activity at multiple frequencies, especially in the beta range (12-30Hz), and more so in high-ASRS than in low-ASRS participants; phase-locking activity increased over time in high-ASRS participants during AM+Music. In the final experiment 4 titled "Parametric manipulation of modulation rate and depth," new music stimuli that differ only in the rate or depth of added amplitude modulation is created, and their effects on SART performance in high- and low-ASRS participants is tested. The 16Hz modulation rate and high modulation depth results in the best performance in high-ASRS participants, while low-ASRS participants show no difference between conditions; beta-band modulation may have a specific role in enhancing sustained attention in people with attentional difficulties.
Application to Research: This paper could significantly contribute to the background section and provide insights into the potential effects of music modulation on attention, another use case of the affect from AACs. The specific musical element of modulation and its influence on cognitive states is introduced, and is a blatant example of music theory and its role in affect. Discussing the experiments' outcomes, especially the varying effects of different modulation rates and depths on sustained attention, could highlight the intricate relationship between specific musical parameters and cognitive functions in different people. The use of fMRI and EEG measurements to study brain activity and stimulus-brain coupling during music exposure further provides a scientific basis for the music-to-mind mechanism.

Zatorre, R. (2018, March). From Perception to Pleasure: How Music Changes the Brain [Video]. TED Conferences, TEDxHECMontréal. https://www.ted.com/talks/dr_robert_zatorre_from_perception_to_pleasure_how_music_changes_the_brain
Summary: The **TEDxMontreal presentation** begins with speaker Dr. Zatorre sharing an anecdote about how encountering the music of Béla Bartók as a teenager led him to develop a passion for both music and science. The longstanding human connection to music is showcased, dating back 40,000 years, and its importance even in the primitive era of humanity is emphasized. Specific neural pathways involved in perceiving and producing music (particularly the superior temporal gyrux, or auditory cortex), including the intricate connections between the auditory and motor systems in the brain, are shown. The remarkable plasticity of the brain is discussed, particularly in people who undergo musical training, where the auditory-motor system is "fine-tuned… to a remarkable degree." A demonstration of the precision to which violinists move their bowstrokes is shown, as swirls trailing a point on the bow are displayed tracing tight repetitions and figure eights during a classical partita performance. There is a critical role

played in structural changes of the brain regarding the age at which training begins, supported with charts. Thereafter, the striatum, "reward system of the brain," is explored since it is activated during pleasurable experiences. It is shown how music, though not essential for survival like food or reproduction, still engages this same reward system. Indeed, experiments are shown supporting the idea that the value people assign to music correlates with increased activity and even anatomical changes in the striatum, further reinforcing the connection between music and pleasure. The notion is introduced that this sway over the cognitive-emotional system is what ultimately gives music its transformative power. A conclusion is reached with a call for the unification of science and art, underscoring the potential for innovation through the exploration of their intersection.

Application to Research: The TEDx Talk highlights the known profound impact of music on the human brain, showing the intricate neural pathways involved in perceiving and producing music – understanding this could be increasingly useful in developing AI systems that can analyze and generate music in a way that resonates with human emotional intelligence, and even those which can learn from human feedback to improve composition ability. Given the emphasis on brain plasticity, particularly in those undergoing musical training, it's implied that early exposure to music can lead to more significant structural changes in the brain – this insight could pave the way for possible personalized music-based interventions in healthcare, especially for being tailor-made to specific age groups. Finally, the exploration of the striatum as the brain's "reward system" in response to music could be harnessed in designing tech AI/ML stuff catering to a variety of preferences and emotional states in people.