VALPARAISO UNIVERSITY

Does Pleasurable Music Indirectly Better Learning?

A Multi Modal Approach

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Honors Work in Psychology

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Overview

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Introduction

- Listening to music has been repeatedly shown to evoke emotions and influence mood
- Some researchers have found a link between emotion & mood states and the cognitive processes of memory
- Can pleasurable music be used to as a tool to better learning?

Husain et. al., 2002
Pelletier, 2004
Koelsch, 2010
Brattico E., Pearce M., 2013
Moore, 2013
Thompson et al., 2001
Mammarella et al., 2007
Nguyen & Grahn, 2017

Review of Literature

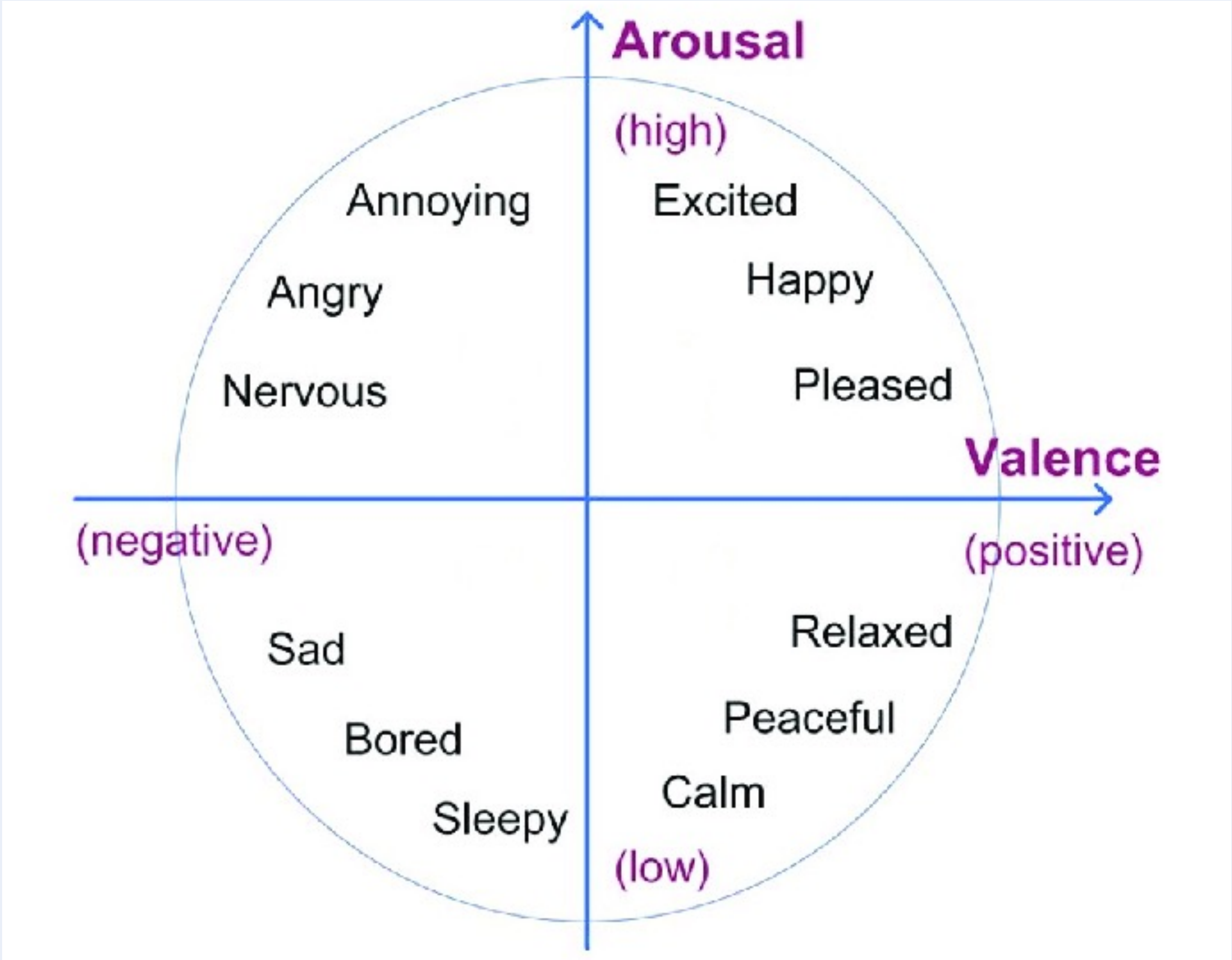
Musically Induced Emotions

"Thayer's Arousal-Valence Emotional Plane"

- A person's emotional state can be plotted on axes of arousal and valence

Tempo manipulations in music shown to affect listener arousal

Mode manipulations in music shown to affect emotional valence



Horvers, 2021
Nguyen & Grahn, 2017
Ramirez et al., 2012

Lehman & Seufert, 2017

Musical Pleasure

Listening to music has been repeatedly shown to induce bodily reactions

- music evoked chills (MECs): physiological responses to pleasure associated with both strong positive and strong negative feelings

Musical pleasure has been attributed to the uncertainty/surprise that music elicits, in combination with its predictability/familiarity

- predictive coding framework
- relates to the MEC theory of "contrastive valence"

Regardless of how and why musical pleasure is perceived, the songs clippings I used in this study have been demonstrated as pleasurable and used in other studies

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de Fleurian & Pearce, 2021

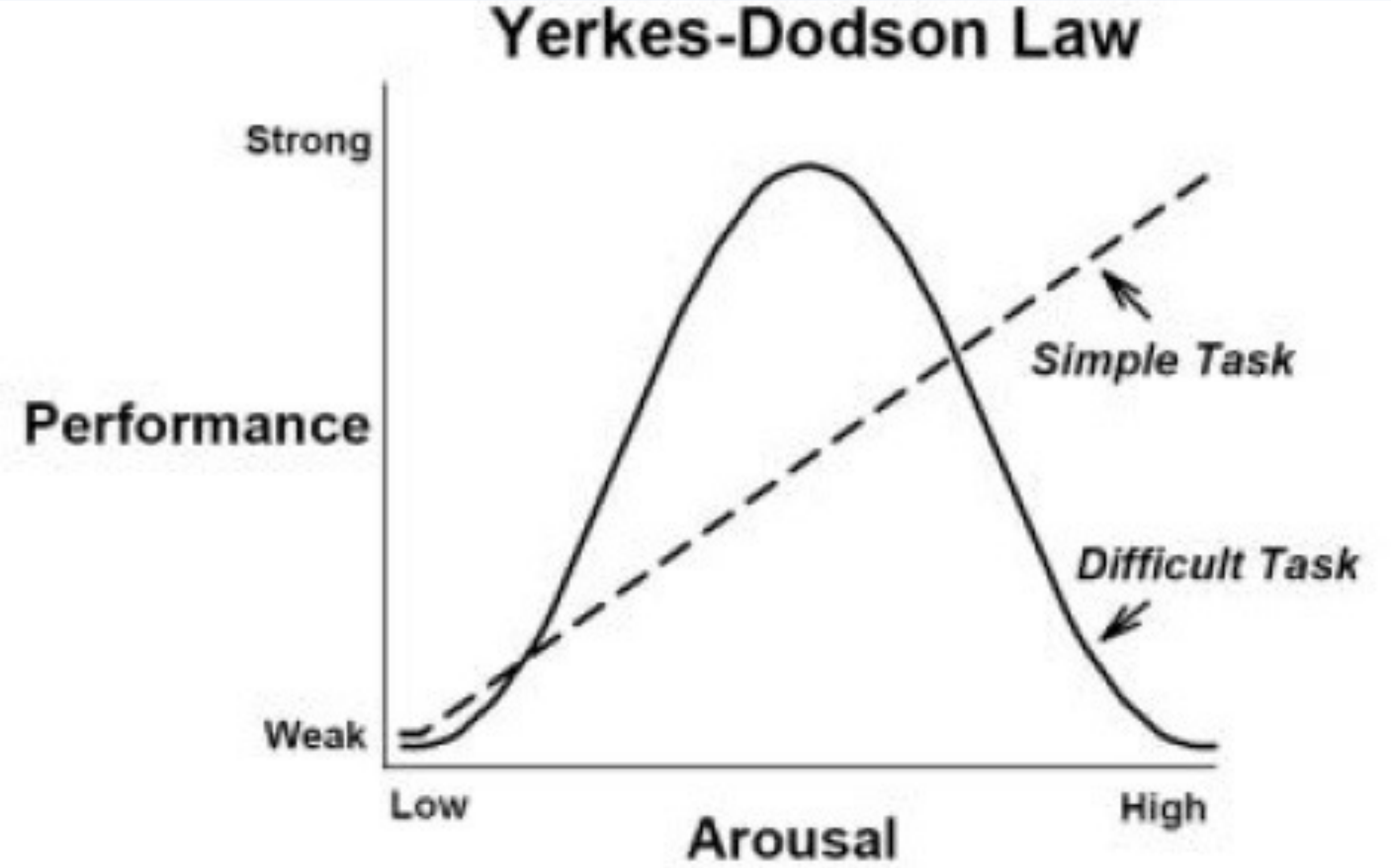
Cheung et al., 2019
Gold et al., 2019

Martínez-Molina et al., 2016
Ara et al., 2022

How Would Musical Pleasure Better Learning?

Yerkes Dodson Law

- For a difficult task, cognitive performance increases with physiological arousal, but only up to a point
- a medium arousal demonstrated as optimal



Arousal-Mood Hypothesis

- Listening to music modulates a listener's mood and arousal states, which in turn affects their cognitive performance

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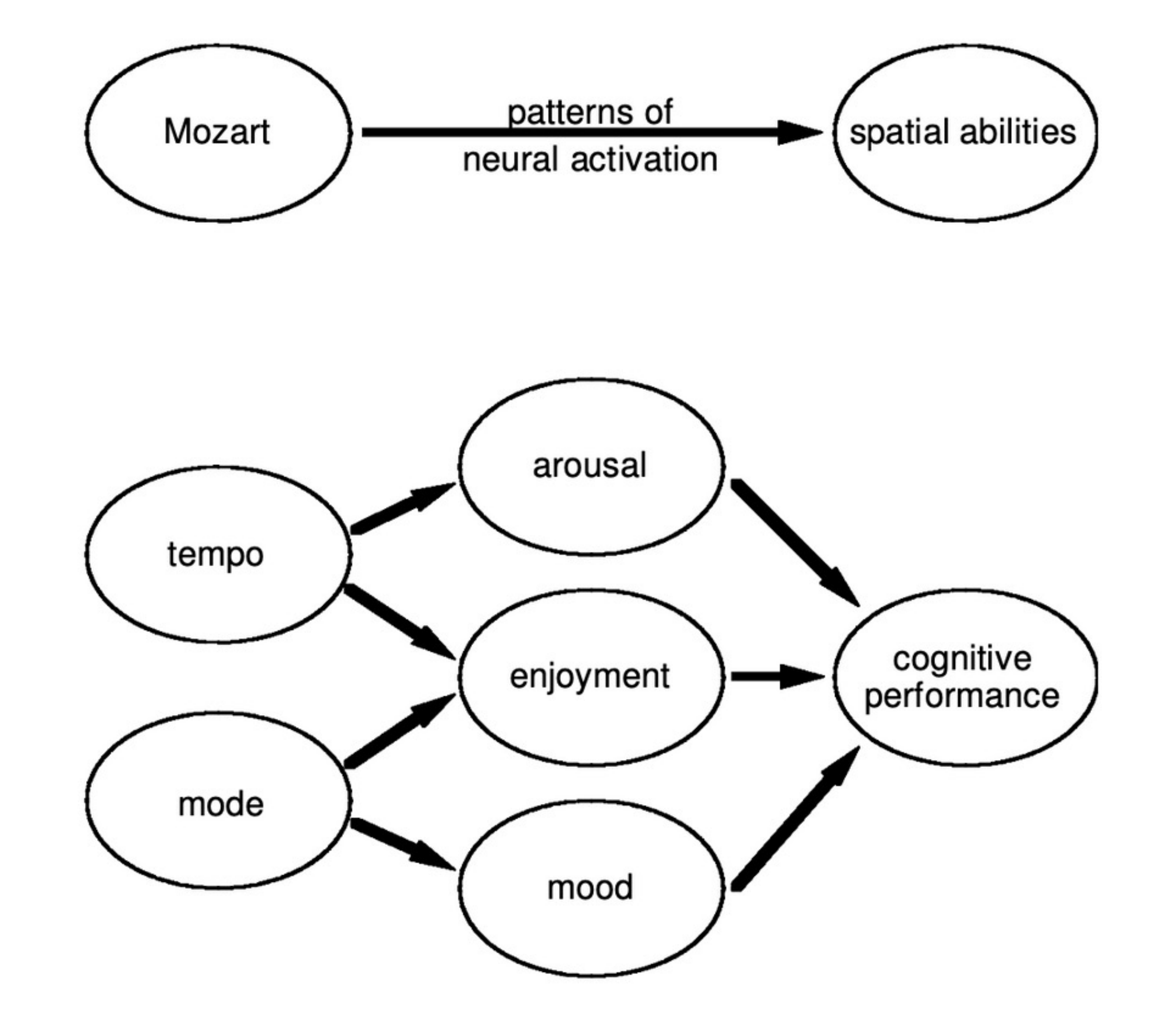
Yerkes & Dodson, 1998
Diamond, 2005

Husain et al., 2002
Nguyen & Grahn, 2017

Other Hypotheses

The Mozart Effect

- 1993 - better cognitive perfomance, specifically on tests of spatial reasoning, when listening to music composed by Mozart
- Many studies have failed to reproduce finding
- Adapted Vivaldi Effect (2006) - more synonymous with the Arousal-Mood Hypothesis and stronger evidence



Rauscher, Shaw, & Ky, 1993
Nantais & Schellenberg, 1999
Rauscher & Shaw, 1998
Thompson et al., 2001
Mammarella et al., 2007
Husain et al., 2002
Irish et al., 2006

Other Hypotheses, cont.

Context Dependent Memory

- Encoding Specificity Principle - memory is better when retrival context is the same as encoding context
- Memory shown to be significantly better when mood is congruent between encoding and retrieval
- Same has been seen when arousal is congruent
- Arousal-Mood Hypothesis has been demonstrated as difficult to test because it is not mutually exclusive from context-dependent memory

The White Noise Effect

- Relaxation technique first thought to be an “arouser” that promotes learning
- Thought to diminish auditory distraction

Standing et al., 2008
Mead & Ball, 2007
Balch & Lewis, 1996
Nguyen & Grahn, 2017
Mammeralla et al., 2007

When Music Hurts Cognition?

Cognitive theory of multimedia learning

- Introduction of music during the reading of a passage with both texts and figures damages comprehension
- Adding music and sounds during retention task can overload a learner's auditory working memory

Yerkes Dodson Law

- Distraction/over arousal
- Difficult task

"changing state effects"

- high arousal music contains more distinct auditory events per amount of time

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Mammarella et al., 2007
Moreno & Mayer, 2000
Mayer, 2014
Nguyen & Grahn, 2017
Yerkes & Dodson, 1998

Hypothesis

I expected to demonstrate that pleasurable music indirectly affects learning by influencing arousal

- I expected EDA data to show that listening to music manufactures a more ideal arousal state
- I expected participants to score better on the memory tests they “studied” for and “took” with background music
- I expected to see memory score variation among participants with differing levels of executive functioning and sensitivity to music reward

Methodology

Sample	• Volunteers from undergraduate psychology classes at VU • Between 18 and 23 years old • About 39% of the participants indicated that they "pretty much always" listen to music while studying; only one indicated that they "never" do
Research Instruments	• Initial Questionnaire • Barcelona Music Reward Questionnaire • D-KEFS Color-Word Test and Tower Test • CVLT-3 and RAVLT • BIOPAC MP160 EEG machine • Congruent EDA equipment • "Pleasurable" Western Classical Music
Data Gathering	• DKEFS scored on Psych Corp scoring program • CVLT-3 scored on Pearson Q-global • RALVT scored by hand using norms (Geffen et al., 1990) • Average raw Skin Conductance Level (EDA) was collected in 30 second increments • EEG data collected and saved for future use

Methodology, cont.

Data Analysis	The following information was put into IBM SPSS • Digitized questionnaire responses • Reported Barcelona Music Reward Questionnaire scores: “mood regulation,” “emotion evocation,” and “total reward” • Raw “short-delay free recall” or “retention” scores on the memory tests • Average baseline Skin Conductance Level, with music and without music • Average Skin Conductance Level (SCL) during memory tests, with music and without music • Raw D’KEFS executive functioning scores: “Condition 3: inhibition” and “Condition 4: inhibition/switching” on the Color-Word Interference Test, “Total Achievement Score” and “Move Accuracy Ratio” on the Tower Test Various Repeated Measures General Linear Model Analyses were run

Results

A trend was found, $F(1.0, 16.0) = 3.516$, $p = 0.085$, when average SCL during memory testing in the music condition was compared to average SCL in the no music condition

- Participant SCL was generally higher in the music condition than in the no music condition

No significant difference was found between

- Memory retention in the music and no music conditions
- Average baseline SCL in the music and no music conditions
- Baseline and testing SCL in the music condition
- Baseline and testing SCL in the no music condition

When various executive functioning covariates were removed, no relationship pertinent to the study's questions was found to be significant

- Significant differences when "music reward" and "mood regulation" scores were removed during the comparison of average EDA during music and no music conditions

Post Hoc Analysis

Because repeated measures linear analyses did not demonstrate any significant relationships, the charactersitics of the few participants were performed better with music than without music were examined

- Three performed better (P20, P10, and P11)
- Two performed substantially better (P20 and P10)

Observations

- Both demonstrated lower SCL (baseline and testing) when listening to music than when not
  - presence of music seemed to decrease their arousal
  - contrary to general trend of the sample
- Both had 4+ years of musical experience playing a band instrument
- All three participants demonstrated above average executive functioning

Limitations and Conclusion

This study failed to demonstrate that listening to pleasurable music indirectly betters learning

It also failed to demonstrate that listening to pleasurable music significantly influences arousal (EDA)

- Could be largely due to the small sample size (n=18)

However, this study provided avenues for further research

- Who cognitively benefits from music? Who does not?
- Which historical or personal characteristics are most at play when it comes to cognitively benefiting from background music?

Limitations and Conclusion, cont.

The ability to benefit from music is likely due to a combination of factors

- musical experience
- musical sensitivity
- musical liking
- musical preference
- inherent arousal
- arousal malleability
- the direction of musical arousal
- auditory working memory capacity
- executive functioning

Implications and Recommendations

Recommendations

- More research untangling the web of potential historical and personal characteristics that effect how background music impacts learning
- Taking personality differences into consideration (Eysenck, 1967; Mitchell & Kumari, 2016)
- Examination of EEG data
- More research on the cognitive effects of background music on specific clinical populations

Practical Implications

- A clear list of attributes describing who will most likely cognitively benefit from music and who will not
  - education
  - music therapy
  - understanding of cognition and memory

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References

- Ara, A., Parra-Tíjaro, J., & Marco-Pallarés, J. (2022). Music-evoked pleasantness modulates theta synchronization within a fronto-temporal music-related network. Psychology of Aesthetics, Creativity, and the Arts. Advance online publication. doi:10.1037/aca0000549.
- Baird, A., Samson, S. (2015). Music and dementia. In E. Altenmüller, S. Finger, F. Boller (Eds.), Progress in Brain Research (Vol 217., pp. 207-235). Elsevier. doi: 10.1016/bs.pbr.2014.11.028.
- BIOPAC Systems, Inc. EDA introduction guide.
- BIOPAC Systems, Inc. Guide to EEG.
- Brattico, E., Pearce, M. (2013). The neuroaesthetics of music. Psychology of Aesthetics, Creativity, and the Arts, 7(1), 48-61. doi: 10.1037/a0031624.
- Cheung, V.K.M., Harrison, P.M.C., Meyer, L., Pearce, M.T., Haynes, J., Koelsch, S. (2019). Uncertainty and surprise jointly predict musical pleasure and amygdala, hippocampus, and auditory cortex activation. Current Biology, 29, 2084-4092. doi: 10.1016/j.cub.2019.09.067.
- De Fleurian, R., Pearce, M.T. (2021). Chills in music: a systematic review. APA Psychological Bulletin, 147(9): 890-920. doi: 10.1037/bul0000341.
- Diamond, D.M. (2005). Cognitive, endocrine and mechanistic perspectives on non-linear relationships between arousal and brain function. Nonlinearity in Biology, Toxicology, and Medicine, 3(1):1-7. doi: 10.2201/nonlin.003.01.001.
- Geffen, G., Moar, K.J., O'Hanlan, A.P., Clark, C.R., Geffen, L.B. (1990). Performance measures of 16- to 86-year-old males and females on auditory verbal learning test. The Clinical Neuropsychologist, 4:1, 45-63. doi: 10.1080/13854049008401496.

References

- Gold, B.P., Pearce, M.T., Mas-Herrero, E., Dagher, A., Zatorre, R.J. (2019). Predictability and uncertainty in the pleasure of music: a reward for learning? Journal of Neuroscience, 39(47): 9397-9409. doi: 10.1523/JNEUROSCI.0428-19.2019.
- Greene, C.M., Bahri, P., Soto, D. (2010). Interplay between Affect and Arousal in Recognition Memory. PLoS ONE 5(7): e11739. doi: 10.1371/journal/pone.0011739.
- Horvers, A., Tombeng, N., Bosse, T., Lazonder, A.W., Molenaar, I. (2021). Detecting emotions through electrodermal activity in learning contexts: A systematic review. Sensors, 21, 7869. doi: 10.3390/s21237869.
- Husain, G., Thompson, W.F., & Schellenberg, E. G. (2002). Effects of musical tempo and mode on arousal, mood and spatial abilities. Music Percept. 20, 151-171. doi: 10.1525/mp.2002.20.2.151.
- Irish, M., Cunningham, C.J., Walsh, J.B., Coakley, D., Lawlor, B.A., Robertson, I.H., Coen, R.F. (2006). Investigating the enhancing effect of music on autobiographical memory in mild Alzheimer's disease. Dementia and Geriatric Cognitive Disorders. 22(1): 108-120. doi: 10.11590/000093487.
- Kaiser, J. (2015). Dynamics of auditory working memory. Frontiers in Psychology, 6, 613. doi: 10.3389/fpsyg.2015.00613.
- Koelsch, S. (2010). Towards a neural basis of music-evoked emotions. Trends in Cognitive Science, 14(3), 131-137. doi: 10.1016/j.tics.2010.01.002.
- Lehmann, J.A.M. & Seufert, T. (2017). The influence of background music on learning in the light of different theoretical perspectives and the role of working memory capacity. Frontiers in Psychology, 8:1902. doi: 10.3389/fpsyg.2017.01902.
- Mammarella N., Fairfield, B., Cornoldi C. (2007). Does music enhance cognitive performance in healthy older adults? the vivaldi effect. Aging Clinical and Experimental Research, 19: 394-399.

References

- Martínez-Molina, N., Mas-Herrero, E., Rodríguez-Fornells, A., Zatorre, R.J., Marco-Pallarés, J. (2016).Neural correlates of specific musical anhedonia. Proceedings of the National Academy of Sciences. doi: 10.1073/pnas.1611211113.
- Mayer, R.E. (2022). Cognitive Theory of Multimedia Learning. In R.E. Mayer (Ed.), The Cambridge Handbook of Multimedia Learning (pp. 43-71). Cambridge University Press. Millidge, B., Seth, A., Buckley, C.L. (2022). Predictive Coding: a Theoretical and Experimental Review. doi: 10.48550/arXiv.2107.12979.
- Mitchell, R.L.C., Kumari, V. (2016). Hans Eyesenck's interface between the brain and personality: Modern evidence on the cognitive neuroscience of personality. Personality and Individual Differences, 103: 74-81. doi: 10.1016/j.paid.2016.04.009.
- Moore, K.S. (2013). A systematic review on the neural effects of music on emotional regulation: Implication for music therapy practice. Journal of Music Therapy, 50, 198-242. doi: 10.1093/jmt/50.3.198.
- Moreno, R., Mayer, R.E. (2000). A coherence effect in multimedia learning: the case for minimizing irrelevant sounds in the design of multimedia instructional messages. Journal of Educational Psychology, 92(1): 1170125. doi: 10.1037//0022-0663.92.1.117. Nantais, K.M., Schellenberg, E.G. (1999). The mozart effect: an artifact of preference. Psychological Science. doi: 10.1111/1467-9280.00170.
- Nguyen, T., Grahn, J.A. (2017). Mind your music: the effects of music-induced mood and arousal across different memory tasks. Psychomusicology: Music, Mind, Brain, 27(2): 81-94. doi: 10.1037/pmu0000178.
- Nelson, J., McMillion, P. (2018) Neuroscientific applications for expressive therapies. In S. Degges-White & N. Davis (Eds.), Integrating Expressive Arts into Counseling Practices (pp.251-258). New York: Springer.
- Pelletier, C.L. (2004). The effect of music on decreasing arousal due to stress: a meta-analysis. Journal of Music Therapy, 3, 192-214. doi: 10.1093/jmt/41.3.192.

References

- Raglio, A., Galandra, C., Sibilia, L., Esposito, F., Galeta, F., et al. (2016). Effects of active music therapy on the normal brain: fMRI based evidence. Brain Imaging and Behavior, 10, 182-186. doi: 10.1007/s11682-015-9380-x.
- Ramirez, R., Vamvakousis, Z. (2012). Detecting emotion from EEG signals using the emotive epoc device. Brain Informatics, 175-184. doi: 10.1007/978-3-642-35139-6_17. Ramirez, R., Palencia-Lefler, M., Giraldo, S., Vamvakousis, V. (2015). Musical neurofeedback for treating depression in elderly people. Frontiers in Neuroscience, 9:354. doi: 10.3389/fnins.2015.00354.
- Ramirez, R., Planas, J., Escude, N., Mercade, J., Farriols, C. (2018). EEG-based analysis of the emotional effect of music therapy on palliative care cancer patients. Frontiers in Psychology, 9:254. doi: 10.3389/fpsyg.2018.00254.
- Rauscher, F.H., Shaw, G.L., Ky, K.N. (1993). Music and spatial task performance. Nature, 365, 611. doi: 10.1038/365611a0.
- Rauscher, F.H. & Shaw, G.L. (1998). Key components of the Mozart effect. Perceptual and Motor Skills, 86(3, Pt.1), 835-841. doi: 10.2466/pms.1998.86.3.835.
- Standing, L.G., Bobbitt, K.E., Boisvert, K.L., Dayholos, K.N., & Gagnon, A.M. (2008). People, Clothing, Music, and Arousal as Contextual Retrieval Cues in Verbal Memory. Perceptual and Motor Skills, 107(2), 523-534. doi: 10.2466/pms.107.2.523-534.
- Thompson W.F., Schellenberg, E.G., Husain, G. (2001). Arousal, mood, and the mozart effect. Psychological Science,12(3). doi: 10.1111/1467-9280.00345.
- Wallace, W.T. (1994). Memory for music: Effect of melody on recall of text. Journal of Experimental Psychology: Learning, Memory, and Cognition, 20(6), 1471-1485. doi: 10.1037/0278-7393.20.6.1471.
- Yerkes, R.M., Dodson J.D. (1908). The relation of strength of stimulus to rapidity of habit formation. Journal of Comparative Neurology and Psychology. doi: 10.1002/cne.920180503.

Q&A

Thank you for listening!