College of Science
UtahStateUniversity

Exploring the Biological Functionality of Music Throughout Human Evolution and its Potential for Current Clinical Applications in Treating Symptoms of Parkinson's Disease: A Literature Review

Abigail Lee
Utah State University
Email: abigaillaurenlee123@gmail.com
Phone: (801) 376-1074

Abstract

Background: Parkinson's Disease affects approximately 1% of individuals older than 60 years in the United States alone and causes individuals to suffer a significant reduction in quality of life. In order to combat the negative and progressive symptoms of PD, music therapy interventions including RAS (Rhythmic Auditory Stimulation) and TIMP (Therapeutic Instrumental Music Performance) have been offered as alternative, non-pharmacological therapies to address such symptoms. A literature review pertaining to the evolutionary development human musical capabilities and their connection to the symptoms of Parkinson's disease would help to uncover biological basis behind such interventions and to further explore additional clinical applications which music might have in this population.
Objectives: The literature review should uncover original biological functions of music throughout the course of human evolution. Additionally, it will hopefully present possibility of additional clinical uses for music therapy in managing the symptoms of those with Parkinson's Disease.
Methods and Materials: A brief literature review synthesizing the knowledge of at least 10 peer-reviewed articles regarding original biological functionalities of music in humans and its pertinence to PD was conducted over the course of a semester.
Outcomes: From the literature review, the effectiveness of RAS was indeed uncovered to have a biological basis as many scholars assume that music arose out of humans' ability to rhythmically entrain to external stimuli, primarily for survival reasons. Additionally, scholars found that the development of neural pathways related to rhythmic entrainment oftentimes bypass those which are negatively affected by Parkinson's Disease (primarily those within the basal ganglia network).
Conclusions: Much more research regarding the development of rhythmic entrainment in humans should be conducted to find further clinical applications which can help to manage the symptoms of PD. This is only the beginning of a long capstone project which will hopefully entail hands-on study in the future, and this research will indeed take place next semester.

Background

Parkinson's Disease affects approximately 1% individuals over the age of 60 in the United States alone. (cite 1) A diagnosis of this disease frequently means progressive bradykinesia (or slowed body movements), postural instability, rigidity, uncontrollable tremors, and an overall significant reduction in quality of life for the diagnosed.Previous published studies have predicted that the number of individuals with Parkinson's Disease in the world's top 10 most populous countries will have doubled by 2030 from 2005. (cite 2).
While many medications have been developed to help those diagnosed with this disease to cope with their condition, oftentimes individuals are unable to use pharmacologic means to help reduce their progressive symptoms and have therefore sought for alternative therapies for this purpose including music therapy. (cite 3) Various music therapy interventions including RAS (rhythmic auditory stimulation) and TIMP (therapeutic instrumental music performance) have shown promising results in providing noninvasive alternative means to help reduce the symptoms in those with Parkinson's Disease. (cite 3). Clinical trials have demonstrated how such interventions among other music therapy interventions have helped improve symptoms of individuals with Parkinson's Disease in various areas within both motor and non motor (such as emotional and social aspects) spheres. Studies are still being conducted to investigate the reasoning behind the effectiveness of music therapy in treating such a disease. However, many have speculated and confirmed that these interventions can help individuals maintain and restore some motor functionality as the use of music can bypass certain areas of the brain which are most affected by the disease.
A thorough study of human evolution and the development of the unique musical capabilities of *Homo sapiens* may reveal more about the effectiveness of such interventions and possible additional, potentially more effective, clinical applications within this population.

Objectives

- Synthesize knowledge from published articles online regarding the evolution of the musical capability of humans over time, focusing on brain structure which allow for said capabilities
- Uncover original biological functions of music
- Explore future clinical applications (if found) of music use to reduce symptoms of Parkinson's Disease

Methods and Materials

A literature review of recent peer-reviewed articles regarding the original biological functions of music, the evolution of human musical capability, and potential clinical implications stemming from this knowledge will be conducted. At least 10 articles pertaining to these subjects will be studied and their information synthesized to complete this literature review. The parameters for selecting and studying each article are as follows:

- Each article must be peer-reviewed
- Each article must be found from a reputable and reliable database (either Scopus or Springer Link within this study)
- Each article must be relatively up-to-date (published within the last 20 years)
- Each article will be selected based on its relevance to the subjects of study (i.e. Parkinson's Disease, Rhythmic Auditory Stimulation, original biological functions of music etc.)

After each article is selected and studied, information from each will be synthesized within a table (**Table 1**) in order toevaluate the biological basis of music therapy interventions and additional clinical applications of music for the treatment of Parkinson's Disease symptoms.

Article Title	Brief Summary	Biological Function of Music	Clinical applications for Parkinson's Disease	Other Relevant Information
"Group Dancing As The Evolutionary Origin Of Rhythmic Entrainment In Humans"	The coevolution to be able to produce metric and sonorant rhythms while also having the ability to entrain to outside rhythms appears to be uniquely human. This feature allows for significant interpersonal coordination and accordingly group functionality. The author proposes that rhythmic entrainment first evolved in the context of group dancing with body-percussion mechanisms, then evolved to dancing to percussive instruments, and then finally dancing to pitched instruments/vocalized rhythms. (Rhythm-first model)	-"Territorial display" -Group cohesion and identity -Group rhythmic entrainment to "scare off" or "confuse predators" -Group dancing and vestibular signals - "Evolved as a "dual coordination system" using rhythmic properties of entrainment and tonal properties of chorusing to increase interpersonal coordination"	-Rhythmic movement stimulates rhythmic entrainment -Group dancing promotes rhythmic entrainment	-Music and dance have intertwined purpose -Dancing promotes cooperative joint action "we-ness" -Why haven't similarly social species developed similar rhythmic entrainment abilities as humans? -Visomotor and audiomotor entrainment -Bipedal locomotion promotes visomotor and audiomotor entrainment -Group dancing is far more common across cultures than solo dancing -Rhythm evolved as a social phenomenon? (Fireflies) -Body first vs. Voice first models-implications - "Dance and music are simply two different manners of creating rhythmic patterns" -Locomotor/respiratory coupling (LRC) -More common for percussive instruments to accompany dance than vocal music (body first model?) -Rhythm and pitch are independent of one another in functionality. Rhythm has more to do with movement? -Entrainment is a social phenomenon -mirror neurons at play rhythmic entrainment -Large coordinated group dance "newly evolved capacity in humans"

Table 1.

An excerpt from the larger table synthesizing knowledge from several peer-reviewed articles exploring the original biological functions of music (column 3) throughout the course of human evolution and their potential for clinical applications for the symptom treatment of Parkinson's Disease (column 4).

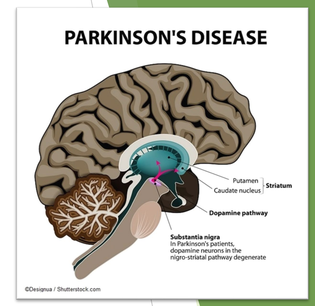

Figure 1.

The substantia nigra, a critical aspect of the basal ganglia network in releasing dopamine to allow for proper motor functionality, does not operate functionally when an individual has Parkinson's. Music therapy interventions such as RAS are able to bypass such negatively affected neural connections to help maintain and increase motor functionality.

Outcomes

Examining the neurological evolution of humans and the human capacity for musicality indeed helped to reveal why RAS and other music therapy interventions have proven effective toward the treatment of Parkinson's Disease. The literature helped to reveal the inevitable linkage between motor functionality and music receptivity in humans and the biological reasoning behind this.
While many scholars debate the original biological function of music within humans, several physical features unique to humans help to explain why our species is so receptive (both in motor as well as in cognitive, social, and emotive functions) to music. For example, some scholars propose humans adapted the ability of rhythmic entrainment (or the external perception and predictive replication of a beat) as they evolved bipedality as a means of increased stealth for hunting. Scholars assume this is why humans so easily can "tap" along to a beat or entrain to environmental rhythms seemingly effortlessly.
Additionally, scholars found that the development of neural pathways related to rhythmic entrainment oftentimes bypass those which are negatively affected by Parkinson's Disease (primarily those within the basal ganglia network). **(Figure 1.)**

Conclusions and Future Applications

The information synthesized from this literature review have helped to uncover the potential for more music applications in the treatment of Parkinson's Disease. This literature review was not intended to be an extensive search regarding the implications which understanding the original biological functions of music might have in this population but rather an examination for future study. More research should be conducted regarding the intrinsic relationship between movement and the evolution of human music capability in order to explore additional ways in which motor function might be maintained and managed for those with Parkinson's Disease.

Acknowledgements

Thank you to my incredible mentor throughout this literature review, Dr. Jessica Habashi for helping me find a topic which fascinates me and presents true need for research. An additional thank you to my program director, Dr. Maureen Hearns for also helping me to explore this topic and witness firsthand the effectiveness of Music Therapy. Lastly, thank you to the USU Department of Biology and Honors Program for providing this research opportunity.

References

1. Brown, S. (2022). Group dancing as the evolutionary origin of rhythmic entrainment in humans. *New Ideas in Psychology*, *64*, 100902. https://doi.org/10.1016/j.newideapsych.2021.100902
2. Machado Sotomayor, M. J., Arufe-Giráldez, V., Ruiz-Rico, G., & Navarro-Patón, R. (2021). Music therapy and parkinson's disease: A systematic review from 2015–2020. *International Journal of Environmental Research and Public Health*, *18*(21), 11618. https://doi.org/10.3390/ijerph182111618
3. Clark, C. N., Downey, L. E., & Warren, J. D. (2015). Brain disorders and the biological role of music. *Social Cognitive and Affective Neuroscience*, *10*(3), 444–452. https://doi.org/10.1093/scan/nsu079
4. Patel, A. D. (2021). Vocal learning as a preadaptation for the evolution of human beat perception and synchronization. Philosophical Transactions of the Royal Society B: Biological Sciences, 376(1835), 20200326. https://doi.org/10.1098/rstb.2020.0326
5. Larsson, M. (2013). Self-generated sounds of locomotion and ventilation and the evolution of human rhythmic abilities. Animal Cognition, 17(1), 1–14. https://doi.org/10.1007/s10071-013-0678-z
6. Patel, A. D. (2014). The Evolutionary Biology of Musical Rhythm: Was Darwin wrong? PLoS Biology, 12(3). https://doi.org/10.1371/journal.pbio.1001821
7. Buard, I., Lattanzio, L., Stewart, R., Thompson, S., Sjoberg, K., Hookstadt, K., Morrow, M., Holden, S. K., Sillau, S., Thaut, M., & Kluger, B. (2021). Randomized controlled trial of neurologic music therapy in parkinson's disease: Research rehabilitation protocols for mechanistic and clinical investigations. Trials, 22(1). https://doi.org/10.1186/s13063-021-05560-7
8. Dorsey, E. R., Constantinescu, R., Thompson, J. P., Biglan, K. M., Holloway, R. G., Kieburtz, K., Marshall, F. J., Ravina, B. M., Schifitto, G., Siderowf, A., & Tanner, C. M. (2006). Projected number of people with parkinson disease in the most populous nations, 2005 through 2030. Neurology, 68(5), 384–386. https://doi.org/10.1212/01.wnl.0000247740.47667.03
9. Gazewood, J. D., Richards, D. R., Clebak, K. (2013). Parkinson disease: An update. *American Family Physician, 87*(4), 267-273. https://www-scopus-com.dist.lib.usu.edu/record/display.uri?eid=2-s2.0-84874913947&origin=reflist&sort=plf-f&cookieSet=1&rr=17ec7c0ddc4f6da1&src=s&st1=&st2=&sid=E9E5CBF1AFAEE9C5F3AFAEEA4C2F1A1F.wsnAw8kcdt7IPYLO0V48gA%3a1&sot=b&sdt=b&sl=0&s=TITLE-ABS-KEY%28music%29+AND+TITLE-ABS-KEY%28parkinson%27s+disease%29&relpos=0&citeCnt=0&searchTerm=
10. Dickson, D. W. (2018). Neuropathology of parkinson disease. Parkinsonism & Related Disorders, 46. https://doi.org/10.1016/j.parkreldis.2017.07.033
11. Designua. (n.d.). Parkinsons Disease. Shutterstock.com. Retrieved from https://www.shutterstock.com/image-illustration/parkinsons-disease-crosssection-human-brain-showing-230529538.