

Short-term impact of anthropogenic environment on neuroplasticity

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Societal Impact - Valorization

Chapter 6: Valorization

In universities, new methods are being used to assess the economic or social value of research. Establishing possible valorization routes in project planning brings great benefits to society and researchers. From a valorization point of view, this thesis targets different groups of scientific and non-scientific individuals in society, as briefly discussed below.

Neurological disorders caused by trauma or illness are a heavy burden not only for patients but also for their families, be they those impairing cognitive, sensory-motor functions, or autonomic nervous system (ANS) functions. New strategies to prevent and manage such neurological diseases must always be sought to reduce the risk and burden of disease. The empirical work presented in this thesis first and foremost aimed to better understand the short-term effect of **one positive anthropogenic auditory stimulus (music) on humans** and the mechanisms that underlie the observed changes. The focus was on neuroplastic changes, including the central and peripheral nervous systems (autonomic nervous systems). Therefore, the present findings are primarily of interest to the **auditory neuroscience community**, studying the neuroscience of music to appreciate the varied effects of using different modes of music (Indian classical genre) on subjective measures of stress, anxiety, cardiovascular, central nervous, and the ANS. At the time of writing this thesis, approximately 35,008 articles have been published using the MeSH word 'Music' and about 243 articles using 'Indian Music' on PubMed. The community of music neuroscience researchers has been growing in recent years for the exciting possibility of using music intervention to prevent and treat neurological problems, involving cognitive, motor, and sensory deficits. In addition to this, this thesis will capture the attention of **psychotherapists** who use cognitive behavioral therapy, mindfulness-based meditation, or different modes of relaxation therapy to reduce stress and improve the mood in emotionally or psychologically affected individuals. It is important for **music psychologists and therapists** who can decide on the number of music features and modes of music for patient-centric therapy, based on existing evidence, and that given in the current thesis. Research into emotions induced by music may also be further explored. Additionally, an improved understanding of the neuronal mechanisms that

support the auditory perception of music is of interest to other domains of cognitive neuroscience, such as **language and vision**. Language and music share common processing systems (1,2).

Although the research discussed here has been conducted in healthy volunteers, advances in its knowledge can be used to unravel more general **pathophysiological deficits** of stress, anxiety, ANS plasticity, functional and structural cortical neuroplasticity, and auditory cognition. For example, Alzheimer's disease (AD) is often associated with loss of memory and autonomic dysfunction (3). Studies using music as an intervention has shown that music often stimulates autobiographical memory centers (4), and restoration of autonomic balance is one of the main mechanisms of action through which music has an effect in Alzheimer's patients (5). Thus, the current thesis is important for **physicians, and neurologists** treating disorders with impaired neuroplasticity or ANS disorders and those involved in **neurorehabilitation and palliative care**. Importantly, the current hypothesis of neurological diseases is that stress activates the ANS, which in turn results in the activation of the neuroinflammation pathway, triggering a cascade of events that result in anxiety, depression, neurodegenerative, and neuroinflammatory disorders (6–8). Therefore, it is of utmost importance to **develop new strategies** for the prevention of ANS hyperstimulation and dysfunction. Given the significant side effects of several drugs and chemicals in the market (for example see(9)), it is high time, we analyze the non-pharmacological interventions available for the prevention and management of chronic diseases. **Non-pharmacological interventions** have been known since before modern pharmacology was developed. Recent systematic reviews declared that though non-pharmacological therapy showed promise high-quality evidence was lacking for the management of AD (10), and low to mixed-quality studies were observed for the management of pain in dementia patients (11) indicating the necessity of more rigorous design to validate the results. Our experiments in this thesis may benefit by adding to the current literature on the use of music (listening to music/playing instruments/singing) for any chronic systemic non-communicable diseases associated with autonomic dysfunction. Indeed, the inclusion of music into one's lifestyle is not a difficult task to achieve. **Artists** in collaboration with medical specialists can come up with music having

a combination of specific music features to target a particular physiological effect, and also explore long-term changes in neuroplasticity.

The second part of the thesis aimed to understand the short-term effect of **one negative anthropogenic chemical stimulus (insecticide-thiacloprid) on animals**, and the molecular mechanisms that underlie the observed changes. We observed significant changes in neuroplastic markers depending on the dose, sex, and species of animals. Pro-environmental behavior refers to acts that *benefit the natural environment, enhance environmental quality, or harm the environment as little as possible* (12). **Environmental social scientists** study human-environment interactions (also known as sustainability science and coupled human-natural systems research). This thesis contributes to understanding the relationships between humans and nature as affected not only by local and global factors but also by environmental policies. **Chemical usage and release policy** in the environment without prior analysis of its effects can harm society as a whole. The risks a chemical poses need to be identified, and publicized before registration and release into the environment. Although **agricultural workers** receive educational training through governmental and non-governmental institutions, the topics are usually around occupational acute poisoning prevention. It is necessary to educate them regarding the risks involved with long-term chronic exposure to pesticides and other chemicals, proper means of release and disposal of chemicals, and ways to reduce the exposure risk for the whole family. On the other hand, increased efforts aimed at reducing pesticides are mandatory. The findings of this study necessitate a need for regulatory action by the governmental and important international agencies to **promote alternatives for pest control** (or make them non-toxic/less toxic) eliminating the risk of pesticide exposure at source in humans and animals (particularly pregnant and children). Furthermore, **plant geneticists** can plan to investigate the probability of creating genetically modified plants as is already being tried. It is proposed through this thesis that like **clinical trials** in medicine, where every drug goes through different phases of testing for its safety and efficacy, anthropogenic chemicals that are currently present in the environment and those that are planned to be released into the environment should go through vigorous multiple steps of testing on not just target insects or pests, but also a set of non-target vertebrates, in land and aquatic environments (**preclinical trials**),

including trials in humans (at a milder dose). Only after these steps, should the **regulatory authorities** be allowed to utilize such chemicals for agricultural or home-based products. **Environmental quality standards** are required to be developed for all chemicals, and all this information should be made easily accessible to the common man. This thesis is also important for **policymakers** across the world who need to understand the impact of chemical exposures even at low concentrations on pregnant women and the developing fetus, survival, and biodiversity of animals in the land and water. This thesis highlights the neuroplastic changes caused by positive and negative stimuli, and long-term effects of developmental exposure to adverse stimuli. As a society, it is thus essential to cultivate and disseminate methods that enrich neuroplastic changes in the positive direction.

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