

# Music Enhances Brain Development in Premature Infants: A Literature Review

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## ABSTRACT

Preterm infants have a high risk of neurodevelopmental problem with a decrease of functional capacity of brain network. Without early intervention, it will develop as long-lasting brain network deficiency. We examine the studies of music effect on early life of preterm infants in neonatal intensive care units (NICU). It founds that music has a positive correlation with brain development in preterm infants. The preterm infants exposed with repetitive music as NICU environment enrichment have a chance to develop brain as good as the term infants and have long-lasting beneficial effects on brain development.

**Keywords:** music; brain development; preterm infant

## INTRODUCTION

A high risk of developing brain structural and functional network alterations associated with preterm birth [1]. This concept is known as encephalopathy of prematurity. Histologic condition called Encephalopathy of prematurity (EOP) is common in preterm infants and characterized by cerebral white matter injury/periventricular leukomalacia with deficits associated neuronal/axonal [2]. Thus, preterm infants have a deficit in neurological outcomes. High prevalence of neuropsychiatric impairment in childhood and adolescence commonly found in preterm birth. Studies showed that children with preterm birth had decreased cerebral volumes at 7–15 years of age. It includes cortical grey matter, cortical white matter, the basal ganglia, and the cerebellum, which is smaller volumes in preterm children than in age-matched term controls [3].

Neonatal intensive care unit (NICU) environments enriched by music may positively affect preterm infants who receive intensive care [4]. Several studies have found the effect of listening to music on premature infants and have demonstrated a stabilizing effect on heart rate and respiration, i.e., reduced number of apneic and bradycardic events per day, increased resting energy expenditure, increased feeding, increased body weight, and more mature sleep patterns; most of these studies reported a beneficial effect on at least one of these outcomes [5]. Therefore, repetitive listening to music in newborns may also affect brain development, raising the question of whether listening to music early postnatally improves brain development in preterm infants.

## METHODS

The search for articles published from the years 2007–2022 in PubMed, in which the MeSH terms were used "Music", "Cognitive", "Premature", "Infant", "Brain", "Children". The use of Boolean "and" was used.

The criteria for inclusion were articles from all countries published during the previous ten years in English languages. An additional filter was used to choose the subject by age, from newborn until adolescent (0–18 y.o).

## LITERATURE REVIEW

### Music

Music is a form of sound with organized elements, including melody, rhythm, harmony, timbre, and style. Music is a language of feeling. It has rhythms the same as life rhythms, and any other things like major and minor keys show human feelings and truth that language cannot approach. When it played in different nodes, music would result in different emotions. This has emotional significance, whether happy or sad. Major chords are composed to be cheerful, and minor perceived to be sad. The tempo also impacts emotion, with slower music seeming more sadness than faster rhythms. Music enhances welfare, reduces stress, and distracts patients from unpleasant symptoms [6].

### Domains of Intelligence

Music is a form of sound with organized elements, include Intelligence is a general mental ability for learning, memorizing, calculating, reasoning, and solving problems. Razmjoo (2008) divided Intelligence into three domains: the analytical, introspective, and interactive domains [7].

#### • Analytic domain

The analytic domain is the Intelligence that promotes analyzing and incorporating data into the schema. It consists of logical/mathematical, musical/rhythmic, and naturalist. Logical/mathematical use to understand the underlying principles of a causal system. Musical/rhythmic is the human capacity to recognize patterns or manipulate them. The naturalist is the ability to differentiate among living things. In principles, analytical Intelligence is the thinking process to solve a problem (heuristic processes).

#### • Interactive domain

Intelligence allows learners to explore their environment with interaction. It consists of verbal/linguistic, interpersonal, and kinesthetic. Verbal/linguistic is the ability to use languages to express an idea, thought, or mind and to understand others the same way as unity. Interpersonal is the capacity of the human being to interact and understand each other. Kinesthetic is the ability to use the whole part of the body to solve a problem or make a product.

#### • Introspective domain

The introspective domain consists of intrapersonal, visual Intelligence, and existential. Introspective means it requires introspection from the learners by looking inward on themselves and their beliefs to make sense of new learning and an emotional connection to their own experiences. Intrapersonal is self-understanding. Visual/spatial Intelligence presents the spatial world internally in mind. Existential is the capacity to understand the human meaning of life.

Different bits of Intelligence are located in different brain areas and can work independently or together.

#### Neuroscience of Music

Supramarginal gyrus during music listening, followed by the precentral and inferior frontal gyrus. The temporal lobe is associated with auditory processing information and memory encoding. The supramarginal gyrus has a function in phonological processing and emotional responses [8]. The precentral gyrus is responsible for executing voluntary movements. The inferior frontal gyrus is a crucial region for language comprehension and production. So, music listening is a complexity of auditory, memory, language, and emotions.

Studies using positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) found that listening to music engages a large bilateral cerebral area, known as the limbic and paralimbic structures [9]. Marked changes in emotions and movement provided and provoked by music which ingrained into our evolutionary development. The associations mentioned above suggest that music stimulates the brain [6].

#### Music and Neuroplasticity

Music helps the development of our brain through human neural processing, which involves a very complex mechanism and a wide bilateral network of cortical and subcortical areas, integrating several brain areas such as auditory, cognitive, sensory-motor, and emotional functions [10]. Formation of brain networks integrated by music through increased synapses in gray matter as evidenced by the larger size of gray matter in MRI [11]. Musicians also have more developed white matter connections between the motor cortex and spinal cord [12] and the occipital lobe with anterior temporal regions.

Research conducted by Arjmand et al. showed that music increases functional activity in several parts of our brain [13]. Auditory regions, part of the temporal lobe, known to be critical in the processing of acoustic information, including spectral and temporal cues, controlling attention-related auditory processes [14] and providing feedback for proper motor execution during musical performance [15]. The inferior frontal gyrus is also involved during spatial and visuospatial localization of audio, auditory-motor mapping, processing of musical syntax, and sight reading, all skills that are practiced and mastered during music learning and which are essential for playing a musical instrument.

Finally, playing an instrument requires intense and independent bimanual motor control and training, which impacts callosal microstructure and interhemispheric connectivity [16]. In particular, differences associated with musical training have been reported in the anterior segment of the corpus callosum, including the premotor and auxiliary motor areas, and in the mid-body callosum, which consists of fibers connecting the primary sensorimotor cortex. [17].

#### Music Correlation with Brain Development

Music has several benefits for cognitive stimulation. It enhances the high-level cognitive brain network. The premature infant has impaired functional networks, and with early music intervention, the functional connectivity has increased. Auditory enrichment of the NICU environment has long-lasting effects on brain development. It found that the duration of music listening has a positive correlation with auditory, visuospatial, and thalamic region brain networks. Auditory brain networks help children to study language and word understanding [18]. In China, piano-trained children can differentiate words better than non-trained. Auditory stimulation with various tones makes the children hear the words better [19]. Hence, they are predicted to have good linguistic Intelligence. A visuospatial brain network will create the excellent ability to transform the visual image. It is essential to help gross and fine motor skills develop faster. Consequently, they know the environment as well as a term birth infant. Early postpartum music exposure has effects in affective and emotional processing. Music involves the limbic and paralimbic areas associated with emotional processes. During their NICU stay, music listening by preterm infants became familiar and thus more salient, resulting in increased RS-Fc (resting state-functional connectivity) of their salience network. Early postnatal music intervention enhanced connectivity in brain circuitry, which is the RS-Fc of the salience network responsible for sensory perception and regions involved in salience processing previously found to be altered in preterm infants. Thus it generates appropriate cognitive, behavioral, and executive responses [18].

#### CONCLUSIONS

The comprehensive effects of music on brain function, including auditory perception, language processing, attention and memory, emotion and mood, and motor skills, have suggested the function of music as a therapeutic tool for preterm infants at risk for neurodevelopmental problems. It found that repetitive music listening as NICU auditory enrichment for preterm infants has long-lasting beneficial effects on brain development.

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