

# Auditory-Motor Entrainment with Synchronization Function from External Auditory Stimuli

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## Article Info

### Article History:

**Received:** 19 January, 2025

**Accepted:** 27 January, 2025

**Published:** 05 February, 2025

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DOI: <https://doi.org/10.36266/JBSR/197>

## Abstract

Humans can present remarkable ability to synchronize their behaviors of external auditory stimuli through a process as auditory-motor entrainment. It has several crucial aspects, which are neuroscientific, physiological, psychological and social points of view. People show characteristic responses, including music and pulse regulation, synchronization with physical movement, coupling with breathing and synchronization in groups. Among them, the rhythm of music enhances the synchronization of human physical movements. In addition, dancing and marching activities create an emotional uplift by matching the rhythm. This behavior strengthens the sense of unity with the physical movement, rhythm of music and psychological positive efficacy.

**Keywords:** Auditory-motor entrainment; External auditory stimuli; Auditory-Motor Synchronization (AMS); Physical movement; Rhythm of music

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## Commentary

Mutual relationship is found between music and pulse. When listening to music, the beats and rhythms with precise periodicity naturally affect the human pulse and heartbeat. It has been called Auditory-Motor Synchronization (AMS). For example, music with a familiar rhythm can bring the heartbeat closer to the beat, and the general natural movements of the body are also synchronized with it. This phenomenon is used extensively in energy management and stress relief. As similar phenomena, synchronization with physical movement would be meaningful. The rhythm of music enhances the synchronization of human physical movement as AMS [1]. As previous reports, when dancing and marching activities are performed in the regular rhythm, such activities may produce a heightened feeling for the activity. Such fact strengthens the sense of unity between the movement of the body and the music. Humans can present remarkable ability to synchronize their behaviors of external auditory stimuli through a process as auditory-motor entrainment [2]. Positive effects of rhythmic entrainment have been known for adult cases with neurological movement disorders. From these situation, neural mechanisms of auditory-motor entrainment and synchronization has attracted attention for recent years.

As regards to the Auditory-Motor Entrainment, several crucial aspects are present. From each perspective, we will highlight the key points about the mechanism by which this phenomenon occurs in the followings [2].

**1. Neuroscientific Aspect:** The connection between the auditory

and motor cortices is an important mechanism. The rhythm of music activates not only the auditory cortex, which processes hearing, but also the motor cortex and cerebellum, which control movement. This connection creates a mechanism for preparing the body to move based on an external rhythm. The involvement of mirror neurons is important for this mechanism [3]. When we observe the movements of others or hear music, our mirror neurons react, trying to imitate them. This makes it easier to synchronize movements with others and dance in groups.

**2. Physiological Aspect:** The rhythm of the heartbeat and breathing occurs. The beat of the music affects the rhythm of the heartbeat and breathing [4]. Music with a slow tempo promotes relaxation, while a fast tempo causes a state of excitement. This phenomenon is also used as an effect of music in yoga and meditation. The linkage of muscles and nerves is important for this. The rhythm of music also affects the rhythm of muscle tension and relaxation. For example, the reason why marathon runners can easily maintain their pace when listening to music with a constant tempo is the result of this physiological synchronization.

**3. Psychological Aspects:** The formation of a sense of group unity is important in situations involving many people. Rhythmic movements enhance group unity and cooperation [5]. For example, military marches and traditional dances make use of this effect. Emotional euphoria plays a role in this. Synchronizing with the rhythm stimulates the release of dopamine in the brain, which brings about a sense of pleasure and accomplishment. This leads to the enjoyment of dancing to music and motivation to

exercise.

**4. Social Aspects:** Each person also has different cultures and sense of rhythm. Different rhythmic patterns exist depending on the culture in which they were born and raised. For example, the four-beat rhythm of Western music and the complex polyrhythms found in African music cause different entrainment. This is where the impact on collaboration comes into play. It has been shown that sharing rhythm improves efficiency and performance in group work and team sports.

The combination of the above four multifaceted mechanisms has caused entrainment to have a strong influence on human behavior and sensations [2].

How does the rhythm of music affect people? People show characteristic responses in the following four areas.

1. Music and pulse regulation: When listening to music, the precise periodic beat and rhythmic stimulation naturally influences the human pulse and heart rate [6]. For example, music with a familiar rhythm makes the heart rate closer to that beat. In addition, the general natural movements of the body are synchronized with the rhythm. This phenomenon would be also effective for energy management and stress relief.

2. Synchronization with physical movement: The rhythm of music enhances the synchronization of human physical movements [7]. For example, dancing and marching activities create an emotional uplift by matching the rhythm. This behavior strengthens the sense of unity with the physical movement and also related music.

3. Coupling with breathing: When exercising or listening to music, the synchronized phenomenon can be observed for pulse, breathing, and physical movements with the same rhythm. This has been called as "coupling" for respiratory, circulation and movement. In other words, the rhythm of music affects the rhythm of breathing, and then the movement of the entire body is performed efficiently. This coupling contributes to improved performance, especially in rhythmic exercises such as running and dancing. The reason is that when the rhythms of cardiorespiratory dynamics are synchronized, both functions proceed smoothly and effortlessly.

4. Synchronization in groups: Entrainment has also a positive effect in group activities [8]. For example, in traditional dances and military marches, rhythm enhances the sense of unity of the group. At the same time, it also enables each person to move in a coordinated manner. When these continue, the efficiency of not only the individual but also the entire group improves.

From recent neuroscience advances, deeper understanding for neural mechanisms may be underlying sensorimotor synchronization. They have used neuroimaging techniques associated with various spatial and temporal properties. Reviews were conducted by identified 22 studies in addition to earlier auditory-motor research [9]. Furthermore, they added various cortico-subcortical structures which involved auditory-motor entrainment and synchronization [10]. In the latest report, detail perspectives have been summarized concerning auditory-motor

entrainment and synchronization [2].

In summary, some perspectives concerning AMS were described. During this period, both short-term training and rhythm complexity showed positive efficacy [1]. When the Auditory-Motor Entrainment is compared with musician and ordinary people, the former with much musical training shows greater accuracy for synchronization to the music beat than the latter without musical training so far [11]. Consequently, clinical and basic research for Auditory-Motor Entrainment and AMS and related themes will be developed in the future. It will contribute leading people for well-being and welfare.

**Conflict of Interest:** The authors declare no conflict of interest.

**Funding:** There was no funding received for this paper.

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