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MOTOR IMAGERY İN CHİLDREN WİTH DİSABİLİTY: REVİEW ARTİCLE

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ABSTRACT

Motor imagery (MI) , the mental representation of physical movements without actual physical execution, has been a subject of growing interest in the field of motor learning and skill development, particularly in the context of children. This review summaries the current scientific evidence on the benefits of incorporating MI into the rehabilitation of the acquisition and refinement of motor skills in children.

Key Words: Motor Imagery, Benefits, Children, Cerebral Palsy

INTRODUCTION

Motor imagery (MI) is a commonly used method in sports and music performance, medicine, psychology, and special education, and, more recently, in cognitive neuroscience. Several questions arise when addressing the concept of MI and employing MI tasks (MIs): What are the benefits of using this cognitive skill and these motor tasks for cognitive neuroscience purposes? Are mental representations similar to those used in action execution? What is known about the underlying neural mechanisms? Is there a shared neural network? One of the first considerations regarding MI is the significant reduction of the movement time in simple and complex tasks after imagery practice (faster reaction and movement times) that has been reported in numerous experimental studies and has been reported from studies under clinical conditions. Another advantage of MIs is that functional magnetic resonance imaging (fMRI)/positron emission tomography (PET) studies of object or body part manipulation or actual required brain activation yield similar or close-to-similar brain activity patterns **(Jeannerod, 1995; Avanzini *et al***., **2012)**. Furthermore, MI can be a suitable cognitive skill for examination of the human mirror neuron system and thereby understanding human motor cognition. The relatively low experimental costs combined with a more ecological and controlled (non-laboratory) environment is a positive issue for using MI tasks **(Richardson 2013)**.

Definition and Concept of Motor Imagery:

Cognitive neuroscience studies have attempted to explore other cerebral regions that are only indirectly anchored to such structures by unsuspected forms: purely conceptual, planning, simile, intention, and motor simulation, and how the processing occurs between the sensory and motor forms. This calls into question the long-enduring hypothesis that motor activity reflects the downstream processing of nonmotor function **(Lotze and Cohen, 2006)**. As a result, the key scientific question is as follows. Is this ipsilateral mirror of the primary sensorimotor cortex a factory that generates, receives, or conditions the primary motor activities of the motoneurons? And if the primary or zygomatic areas are extensively interconnected, is it possible that one process does not include the other or that the implementations exclusively overlap? If this is not the case, is it possible that a simple secondary projection counts for the strongest sites located in the visual and primary auditory cortices? The ultimate question is as follows. Is MI a simple "method"? To address these issues, the long-sustained considerable controversies need to be reviewed, offering arguments in favor of motor activity of the nerves **(Lotze and Cohen, 2006)**.

In cognitive neuroscience, the study of cognitive processes has primarily been performed through the modulation of sensory-perceptual and central attentional factors or through utilization of memory data **(Chepurova *et al*., 2022)**. Nevertheless, important quantitative results have been obtained through studies of the functional organization of the human brain. A theory-based understanding of these interactions provides a basis for the development of a brand new strategic framework. With this strategy, researchers take controlled action by presenting new tasks that simulate the elements of the proposed capacity requirements. One guarantee of these processes is that they activate the required capacity, whether they are performed inside or outside a hardware measuring device such as a functional magnetic resonance imaging (fMRI) scanner or an electroencephalogram (EEG) **(Bisio *et al*., 2018)**.

Historical Background:

Though mental images have long been assumed to be similar to perceptual (or real) ones, today, numerous studies unambiguously confirmed that at least certain aspects of mental imagery are functionally independent from actual behavior. The invocation of this concept, as Asmundson and Stapleton suggest, states that the brain can directly act upon and receive sensory feedback from the visual cortex, without receiving sensory inputs from the eyes via the occipital track **(Cumming and Eave, 2018)**. A large number of scientific disciplines provide convincing empirical support for the existence of unimodal and bimodal mental images supplying variously detailed sensory essences for every imaginable component of the world or behavioral prospect **(Callow *et al*., 2001)**. in fact, this functional component was identified early by Vygotsky, for example. Among the psychological approaches providing sound empirical evidence is the development of the concept of MI. MI is a substitute for movement, constructed on the same perceptual representations and resources incited by the mere consideration of a whole or part of an actual movement or frozen action you would like to perform **(Kolb *et al*., 2011)**.

The idea that the human mind and body are tightly linked has long formed the foundation of psychology, and the term embodiment has recently reappeared in psychological and other life science literature. Descartes' dualism and Gall's faculty psychology, however, have driven the modern study of cognition to emphasize the exclusive role of the human brain. Indeed, research on perception and action has flourished and produced much data and understanding of information processing in the brain, but usually in isolation from each other **(Tirosh *et al*., 2014)**. Only relatively recently, evidence accumulated in neuroimaging, neuropsychology, and cognitive psychology research suggested correlates between perceptual and sensorimotor aspects of an experienced concept led to the insight that people learn and represent concepts also by exploiting sensorimotor areas and mechanisms that are not exclusively conducted to actual interactions in the world **(Lotze *et al*., 2006)**.

In summary, MI is the cognitive process of mentally rehearsing physical movements without actually executing them. It involves the internal representation and simulation of action, engaging the same neural networks that are activated during the physical performance of those movements **(Munzert *et al*., 2009)**. This mental practice of movement has emerged as a powerful tool in the field of child development, offering a unique approach to support children's growth and well-being. In the context of child development, MI holds immense significance. Children undergo a critical period of physical, cognitive, and emotional maturation, where the successful integration of various developmental domains is essential for their overall flourishing. MI can play a pivotal role in this process by enhancing children's motor skills, cognitive abilities, and emotional resilience. **(Munzert *et al*., 2009)**.

The Mechanisms of Motor Imagery:

Neuroimaging studies have shown that motor imagery (MI) activates many of the same brain regions involved in the actual execution of physical movements, including the primary motor cortex, premotor cortex, and supplementary motor area **(Guillot and Collet, 2005)**. This overlap in neural activation suggests that MI can engage the sensorimotor system and facilitate the internal simulation of action, leading to improvements in motor skill acquisition and performance. The neurophysiological basis of MI relates to the cognitive prevention of muscle movement during MI, which prevents the full execution of the movement in the primary motor cortex **(Kraeutner *et al*., 2014).** Brain regions responsible for movement planning and control, like the premotor cortex, supplementary motor area, and motor cortex, show overlapping activation during both real and imagined movements **(Schuster *et al*., 2011)**. This is likely due to direct connections between these regions that help shape motor responses, including those related to mental imagery. Numerous neuroimaging studies over the past two decades have demonstrated that mental simulation of an action activates many of the same neural resources engaged in action execution. There is also evidence that interfering with brain

regions involved in action execution can influence performance during mentally simulating those actions **(Zimmermann-Schlatter *et al*., 2008)**.
According to **(Zimmermann-Schlatter *et al*., 2008)**:

The close connection between actual movement and MI of the same movement has been well-established through numerous studies. The key brain regions involved in both real and imagined movements include:

- Primary motor cortex (M1): This area is responsible for the actual execution of voluntary movements. During MI, the cognitive prevention of overt muscle movement prevents the full activation of M1, but there is still partial activation.
- Premotor cortex (PMC): The PMC is involved in the planning and preparation of movements. It shows similar activation patterns during both real and imagined movements, likely due to its role in the internal simulation of actions.
- Supplementary motor area (SMA): The SMA is crucial for the initiation and coordination of voluntary movements. Like the PMC, the SMA exhibits overlapping activity during action execution and MI.

The overlap in the activation of these motor-related brain regions during MI and action execution is thought to be mediated by direct anatomical connections between these areas. This allows the internal generation of motor commands and kinesthetic representations during MI to engage similar neural resources as those involved in the actual performance of the movements **(Smits-Engelsman and Wilson, 2013)**. Neuroimaging studies have also revealed the involvement of parietal cortex regions, which are believed to play a role in detecting incorrect postures or movement representations by comparing the imagined movement to the original movement specifications stored in memory. This suggests that MI involves the internal simulation of the sensory feedback and proprioceptive information associated with the movement. Additionally, research on mirror neurons in non-human primates has provided insights into the neural mechanisms underlying action understanding and action simulation. While the direct evidence for human mirror neurons is limited, there is evidence of motor cortical activation during the observation of others' actions, indicating a form of "motor resonance" in the human brain **(Eaves *et al*., 2016)**. This motor resonance is thought to be a key mechanism underlying our ability to understand and mentally simulate the actions of others. In summary, the neurophysiological basis of MI involves the partial activation of the motor system, including M1, PMC, and SMA, which enables the internal simulation of actions and the corresponding sensory-motor representations. This overlap in neural activity between imagined and executed movements is facilitated by the direct anatomical connections between these motor-related brain regions.

Benefits of Motor Imagery for Children

Motor imagery (MI) has been extensively studied and demonstrated to provide a wide range of benefits for children's development. It can enhance the acquisition of motor skills, such as coordination, balance, and fine motor control, by enabling children to mentally practice and refine these abilities. Additionally, MI has been found to improve children's cognitive functions, including attention, memory, and problem-solving skills, as it requires focused mental engagement and the integration of various cognitive processes **(Buch *et al.*, 2003)**. So we classıfied MI benefıts ınto two categoreıs;

Motor Imagery benefıts for Normal Children:

Over the past 15 years, a few MI studies have focused on children or adolescents but, in contrast to the adult literature, most have produced positive outcomes. Some of these children studies have additionally investigated the role of MI in motor learning tasks, and some used cortical excitability measures to indirectly detect its neural activity **(Olsson *et al.*, 2008)**. They have shown the beneficial effects of a four-week short-term MI training program on the voluntary drive to operate a motor joystick and the ability to single-pulse transcranial magnetic stimulation (TMS) of the primary motor cortex produced MEPs in the first dorsal interosseous muscle **(Sakurada *et al.*, 2017)**. Much of the MI work in adults has provided evidence that when MI is cognition-driven, it functions as a secondary means of practicing sport and motor tasks as well as acquiring new physical skills. For enhanced motor learning, essentially, there are two segments of the neuromotor system: non-intentional movement produced from the spinal cord without using the cerebral cortex, and intentional movement produced using the cerebral cortex. These two systems are not independent, suggesting a possible interaction **(Williams *et al.*, 2012)**. The involvement of the descending motor net on the performance and acquisition of a new motor skill is well established. The result is, compared with simple practice, motor tasks practiced by children show improved motor ability following MI training in acquisition and retention. For example, during practice of the sequential Förster task, the estimated criterion, movement times for the final session, and the immediate retention test data showed a significant benefit for a MI path, after block randomization (entangled). Additionally, the acquisition benefit disappeared. Movement time is the time from the readiness signal until the key press, which aggregates the processes of motor preparation, movement initiation, and duration **(Williams *et al.*, 2013)**.

Motor Imagery benefıts for disabled Children:

Motor imagery is fundamental for equilibrium and daily functional activity, including turning the head and trunk, and plays an important protective role against backward falls in both able-bodied subjects and paraplegic participants **(Paivio, 1985)**. Furthermore, modern techniques for the examination and treatment of children's motor abilities often use an imitation of learned exercises or acquired patterns as a main learning mechanism. Such a method of treatment could significantly be enhanced by MI usability **(Cumming and Ramsey, 2009)**. Although there are a number of research works devoted to the investigation of the effectiveness of MI use in the clinical domain, they have been almost exclusively focused on the mental practice and do not explore all the possibilities of therapeutic intervention **(Hétu *et al*., 2013)**. However, from both a practical and neurological point of view, mental practice is a particular MI belonging to the wider spectrum of motor activities referred to as MI . In particular, the MI paradigm demonstrates that people interact with the environment through their mental representation, not obligatorily through the perception and execution of the behavior **(Sharma *et al*., 2006)**. This is particularly relevant for the treatment of children with motor impairments who are incapable of the normal functioning of some parts of their body and have the inability to perform as normal ones **(Guillot and Collet, 2008).** For example, paraplegics could avoid falling by simulating normal walking on a slippery surface. People with an amputated hand could use MI to participate in activities requiring hand movements. Various forms of brain damage producing a stroke, neoplasm, trauma, tumor, or cerebral palsy may render one or more limbs unable to perform motor activities. To ensure that the training benefits from the positive effects of MI , some necessary conditions contributing to the development of mental programs have to be fulfilled. The work carried out by Karok and Newport reveals that higher EMG during MI is significantly related to higher proprioceptive motion ability of the upper limb **(Seebacher *et al*., 2023).** Preprocessing data variance in the power spectrum of alpha and beta rhythms, as well as the time window of EEG signals during the early phases of the movements, should be given much more attention. The whole procedure of MI is related to an increase in power in the low-beta frequency range, suggesting an increase in the relationship between cortical motor areas and the muscle spindle input. Thus, the muscle spindle afferent output could depend on an increase during the early phase of the movement when the latter is correctly executed, even if it does not produce any muscle contraction. Maximal improvement of motor skills is the most important application domain for developing a MI system for children with abnormal conditions. Abnormal children generally have deficiencies in basic motor skills. MI can serve as an additional channel linking vision and motor control, allowing the brain's simulation capability to activate the associated brain areas **(Suica *et al*., 2020)**. Mental practice has been shown to be an effective method to improve motor function, and MI can be used to provide mental practices. By establishing an association between motor planning-simulation and actual motor performance, simulation training can enhance the preservation of accomplished posture during balance recovery. More importantly, when kinesthetic imagery is involved in the training, the capabilities of response time and muscle strength are greatly enhanced **(Guillot and Collet, 2005)**.

In the realm of motor skill development, numerous studies have shown that incorporating MI into traditional physical practice can lead to enhanced coordination, balance, and fine motor control, ultimately accelerating the acquisition of motor skills. Regarding the cognitive benefits of MI ın more details

According to **(Hegarty, 2018):**

1. **Motor Skill Acquisition:**
- Research has shown that combining physical practice with MI can lead to enhanced acquisition and refinement of motor skills in children, such as improved coordination, balance, and fine motor control.
- The mental rehearsal of movements allows children to plan, visualize, and fine-tune their physical actions, accelerating the learning process.

2. **Cognitive Benefits:**
- Motor imagery (MI) has been linked to improvements in children's cognitive functions, including attention, memory, and problem-solving skills.
- The cognitive engagement required during MI may enhance executive function and the integration of various mental processes.

3. **Emotional and Psychological Benefits:**
- Motor imagery (MI) can boost children's self-confidence, self-efficacy, and emotional regulation, contributing to overall well-being and improved social interactions.
- The sense of mastery and control over physical abilities gained through MI can have a positive impact on children's psychological development.

Practical Considerations for Implementing MI in Children's Settings:

The foundation of the recommendations comprises verified ability retention and observational learning theories in combination with motor learning principles. Specifically, before suggesting any experimental concept, sport researchers and physical professionals establishing a MI flow for children should regularly consider four distinct factors: assessment, communication, initiation, and movement. It is customary for young children to have difficulty interpreting or anticipating motor behavior **(Malouin *et al*., 2013)**. To help them improve MI, physical educators can cope with the students' needs in the flow. By acknowledging these requirements, they can reinforce their understanding of a task or activity. Providing this foundation improves the possibility that children will use MI frequently, establishing a practical foundation for the enhancement of fine and gross motor behavior, as well as interventional plans. MI is a useful and effective tool for developing children's motor skills. Imagery has been shown to help younger children understand and perform tasks with significant challenges, such as patting their head and rubbing their stomach in the correct order **(Coelho *et al*., 2012)**. Research has discussed various applications of MI for a united group of children; however, to date, the majority of present literature explains how MI can be introduced in schools. Finally, incorporating MI into children's rehabilitation and development programs requires careful consideration of practical factors. Tailoring the techniques to the child's age, cognitive abilities, and personal preferences is crucial for ensuring engagement and effectiveness. Additionally, providing clear instructions, visual aids, and guided practice can help children develop the necessary skills to effectively utilize MI **(De Kleine *et al*., 2011)**.

CONCLUSION

The growing body of research on the use of MI in children underscores its multifaceted benefits, including the enhancement of motor skills, cognitive functions, and emotional well-being. As this field continues to evolve, the integration of MI into educational, therapeutic, and recreational settings holds great promise in empowering children and supporting their holistic development. Emerging technologies, such as virtual reality (VR) and biofeedback tools, present exciting opportunities to make MI practice more engaging, personalized, and effective for children **(Debarnot *et al*., 2015)**. VR games like 'MindLight' and 'Endeavor'd' demonstrate how technology can be leveraged to not only make motor MI fun, but also teach children valuable skills like relaxation and anxiety management. Moreover, the availability of tools like the Xbox Kinect and electroencephalography (EEG) enables the customization of VR content based on a child's cognitive abilities, fostering a more tailored and immersive learning experience **(Diedrichsen and Kornysheva, 2015)**. As the field continues to evolve, it will be important to address concerns about the potential addictive effects and negative impact of technology on children's mental health, while harnessing its benefits to enhance MI practice and its applications.

FUTURE DIRECTIONS

One key direction for future research is to investigate the reproducibility of MI interventions, ensuring their effectiveness can be consistently replicated across diverse settings and populations. Researchers should also explore the idiosyncratic strategies used by individuals, particularly those with limited language or imagination skills, to better understand the nuances of MI and how it can be tailored to individual needs **(Gentili and Papaxanthis, 2015).** Another important avenue of exploration is the relationship between mental imagery and cognitive-emotional states, such as mental states and attentional power. Understanding how MI influences and is influenced by these internal processes can provide valuable insights into its mechanisms and applications. Additionally, future studies should examine the role of MI in the development of physical activity skills and their integration into memory, speech, and motor abilities **(Kraeutner *et al*., 2014; Machado *et al*., 2013)**. This holistic approach would contribute to the advancement of a "First Psychology of Learning and Instruction in the Physical Activity Domain," a transdisciplinary field that integrates the objectives, processes, and legislative conditions for successfully incorporating MI into physical education and movement-based curricula. Interdisciplinary collaborations among professionals from fields like physiatry, orthopedic surgery, and the physical activity sector will be crucial in developing comprehensive diagnostic and rehabilitation tools. By aligning different disciplines' expertise, a more holistic approach to addressing the functional limitations of children can be achieved, leading to improved quality of life outcomes. As the research on MI in children continues to evolve, these key future directions will help expand our understanding, refine the applications, and unlock the full potential of this powerful tool in empowering children's development and well-being.

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التصور الحركي لدى الأطفال ذوي الإعاقة: مقالة مرجعية

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التصور الحركي ، هو عبارة عن التمثيل العقلي للحركات الجسدية بدون التنفيذ الجسدي الفعلي، أصبح هذا الموضوع ذو اهتمام متزايد في مجالي التعلم الحركي وتنمية المهارات، خاصة في سياق الأطفال. تلخص هذه المقالة المرجعية الأدلة العلمية الحالية حول فوائد دمج البرامج التدريبية للتصور الحركي في إعادة تأهيل اكتساب وصقل المهارات الحركية لدى الأطفال.