International
Orff-Schulwerk Forum
Salzburg

Orff-Schulwerk *International*
Volume 3, Issue 2

ISSN 2791-4763 (Online)

The Neuroscience of Sensory Embodiment in Elemental Music/Movement Education and Therapy

Wolfgang Mastnak

Published online: Nov 2024

The Neuroscience of Sensory Embodiment in Elemental Music/Movement Education and Therapy

Wolfgang Mastnak

Introduction

AI-technologies increasingly dominate living spaces and penetrate individual lives, and while a few decades ago CNC-machines [CNC is the abbreviation of 'computer numerical control'] were above all designed to facilitate industrial work processes and make workplaces safer, today's intelligent tools suggest complex diagnoses, coordinate energy supply chains, and even create texts and pieces of art in stunning quality. By way of illustration, when the AI-generated 'painting' *Théâtre D'opéra Spatial* by Jason Allen won a prize at the Colorado State Fair's annual art competition, the New York Times (2/9/22), noted that 'artists aren't happy'. Regarding these galloping developments the question arises - which human facets will survive and in what areas of artificial intelligence will outrank human capacities?.

Nearly a century ago, Carl Orff referred to anthropological thought to design his principles of elemental music education, emphasising that the child needs empathetic educational support to develop genuine artistic talent. Being faced with today's socio-cultural changes and the rise of novel hybrid communities involving virtual communication and interaction with intelligent robots, we need to revisit anthropology and readjust our views of what is genuinely human. Considerations incline towards a new dualism consisting of outer and inner worlds, in other words, production and perception. By way of illustration, AI-devices analyse individuals' aesthetic preferences and create playlists that can consolidate attitudes towards musical genres and styles, trigger addiction-like behaviour and improve the predictability of the economic growth of the music industry. Such dynamic reinforcement loops connect the outer world of economy alongside its potential for political manipulation, and the inner world of aesthetic awareness and its creative as well as addiction-prone nature.

Akin to René Descartes' scrupulous attempts to discover ultimate epistemological certainty, which led to his famous solution 'cogito, ergo sum' (*I think, therefore I am*), our considerations about the rivalry between AI-entities and the human mind suggest that aesthetic features of human perception cannot be replaced by machines – brain-computer interfaces (Peksa & Mamchur, 2023), which also provide enormous benefits in neuro-rehabilitation, excepted. From this perspective, the title of the IOSFS convention 2024 'embodiment through engaging the senses' is completely in tune with the challenges of modern times: while advanced technologies may outdistance a large share of human capacities, they cannot replace the value of aesthetic senses and the embodied self.

Neurocognitive Construction of Embodiment

Ingenious minds such as Carl Orff and Émile Jaques-Dalcroze initiated arts-oriented educational schools of thought which are nowadays confronted with a dual challenge: on the one hand their potential 'to make the world better' (e.g. to contribute to the World Health Organisation's mental health programme, and calls for enhanced action), but on the other hand their foundation on ideas and reflective practice that no longer satisfy empirical

standards of educational and neighbouring sciences. Regarding theories of truth and philosophy of science, the notion of evidence has to be reconsidered.

Taking into account that all aesthetic sensation, creative performance and artistic expression is based on central nervous activities, neuroscience research has gained in importance in elemental music and movement education, as well as various forms of rhythmic music pedagogy (Mastnak, 2019). Such studies particularly relate to the brain mechanisms underlying aesthetic experiences (Mastnak & An, 2023) and creative processes (Mastnak, 2018) such as in the course of creative interactions in group music activities (Mastnak, 2020a). Since interdisciplinary research has pointed out that elemental music and movement education may considerably enhance personal growth, boost mental health and improve resilience, practices integrating educational and therapeutic approaches are in the ascendant (Mastnak, 2022) as well as novel models such as Music Rhythmic Therapy (Mastnak, 2020b).

The more we go into the bio-physiology and microbiology of elemental dance and movement education, the more we discover its complexity involving interconnections between aesthetic evaluation and physical abilities (Cross et al., 2011), neuroscientific facets of embodiment in expressive and healing dances (Mastnak, 2023) or molecular dynamics modulating the interplay between proprioceptive and vestibular sensory systems and locomotion (Turgay Akay's Lab, 2021). An immense wealth of single studies on these topics makes it difficult for practitioners to sense the rationale behind them, hence this article and the Convention keynote on which it is based.

Human beings tend to assume that their perception of the world equals the perceived world as it is. Pragmatically seen, this assumption is plausible, however from an epistemological point of view it is erroneous. This contradiction gave rise to various constructivist theories such as evolutionary epistemology (Slijepcevic, 2018) and its crucial hypothesis that as much as the organism changes due to the influence of the environment, the organism's responses to induced changes affect the environment and subsequent organism-environment interactions. In this context, neurosciences elucidate a double qualitative change within the ‘triple jump’ stimulus–processing–awareness, that is firstly, the transition from physical stimuli to their biochemical representation in the nervous system, and secondly the transition from neural information to sensory perception. By way of illustration in music, the first conversion from the sound wave into its neural encoding is effected by the organ of Corti (Urata et al., 2019) in the inner ear, the second relates to activities in the auditory cortex (Chang & Kanold, 2021).

Such transitions play a crucial role for ‘embodiment through engaging the senses’ as well. While specialised units in the skin such as Meissner’s corpuscles, Merkel’s disks or Pacinian bodies transform tactile data for the sense of touch, proprioception relates to basic information about movement and posture alongside associated processing, and is merged with vestibular information about equilibrium and the environment (Ferrè & Haggard, 2015) to generate primary input for holistic embodiment. While lab-based research provides fundamental insights, applied research such as on robot-aided somatosensory training to improve proprioception and motor function in stroke survivors (Yeh et al., 2021) enhances

the holistic understanding of our body-self, as well as distinct features of embodiment. Moreover, different from former views about a certain 'one-way' construction of body awareness and sensory embodiment, recent studies have elucidated complex dynamics and highlighted that the 'awareness of embodiment enhances enjoyment and engages sensorimotor cortices' (Moffat & Cross, 2024). Such findings are of fundamental importance for dealing with embodiment in elemental music and movement education and shed light on extended application such as the promotion of mental health, as well as amelioration of depression or body-dysmorphic issues in children and adolescents.

Considering that embodiment through engaging the senses requires qualitative changes of external and internal stimuli for neural processing and conscious awareness, we are faced with the complexity of sensorimotor facets of the self, and association as well as integration cortices. While information integrating functions of the sensory and motor association cortices are well known in neuroscientific circles, recent studies (Luo et al., 2024) highlighted that functional connectivity development along the sensorimotor-association axis enhances the cortical hierarchy. Such findings substantiate the importance of sensory embodiment in elemental music educational contexts, while genetic research emphasises that sensorimotor integration and holistic self-perception are intertwined with specific gene expression (Vaissière et al., 2023). In other words, these abilities depend on the human genome and the way it determines personal growth and human features.

Embodiment-relevant stimulus integration goes hand in hand with aesthetic processing and associated dynamics between the anterior insular cortex and the orbitofrontal cortex, as well as the ventral basal ganglia (Brown et al., 2011). These interconnections shed light on aesthetic embodiment in elemental music/movement education, as well as embodied aesthetics as discussed in cognitive sciences: 'aesthetic experiences are grounded in the embodied simulation of the actions, emotions, and corporeal sensations represented in artworks' (Ticini et al., 2015). Moreover, sensorimotor integration plays a crucial role in paediatrics, e.g. in childhood dystonia and dystonic cerebral palsy (McClelland & Lin, 2021), and together with the beneficial functions of music and dance on both brain plasticity and holistic personal development, curative facets of elemental music and dance education encourage promotion of this domain. Figure 1 shows the complex connectivity of the insular cortex:

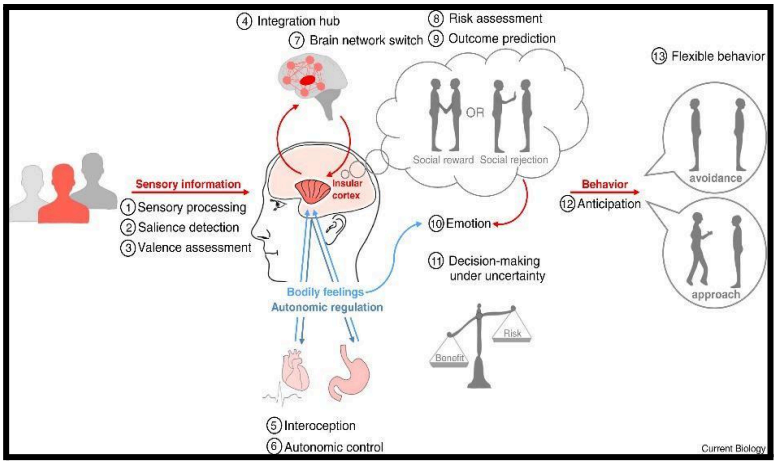

Fig 1. courtesy of Elsevier Creative Commons Attribution CC-BY 4.0, (in Gogolla, 2017)

While numerous studies elucidate facets of body image and embodiment alongside their clinical relevance (Vankerckhoven et al., 2023) in a behavioural or phenomenological way, there is still a lack of research focussing on the interconnection between embodiment and cortical midline structures, which play a crucial role in self-representation, self-identity and self-awareness (Feng et al., 2018). On the basis of translational and meta-synthetic reasoning, the present article suggests profound connections between holistic embodiment and cortical midline structures such as the ventromedial prefrontal cortex, which is also essentially involved in self-generated episodic social cognition (Konu et al., 2020), reward- and value-based decision making (Hiser & Koenigs, 2018) and self-relevant emotion processing.

Regarding embodiment through engaging the senses, this article started with the discussion of single sensory stimuli and neural transformation of encoded information, leading to complex processing and functional integration of neuro-cognitive data in the brain. The more I was dealing with higher cerebral functions, the more I approached the individually significant phenomenon of embodiment. Considering how creative activities are intertwined with dynamic network connectivity (Beaty et al., 2016), we finally suggest that embodiment through engaging the senses has to be considered a vital factor of elemental music and dance education with its multiple benefits for the development of healthy people as well as individuals with special needs. Addressing children with autism spectrum disorder, a Canadian study highlighted that music improves social communication and auditory-motor connectivity (Sharda et al., 2018), and cross-cultural studies emphasised the importance of culturally sensitive adaptations of Orff music therapy in the same clientele (Mastnak & Rong, 2021). Figure 2 shows the rich brain inter-connectivity.

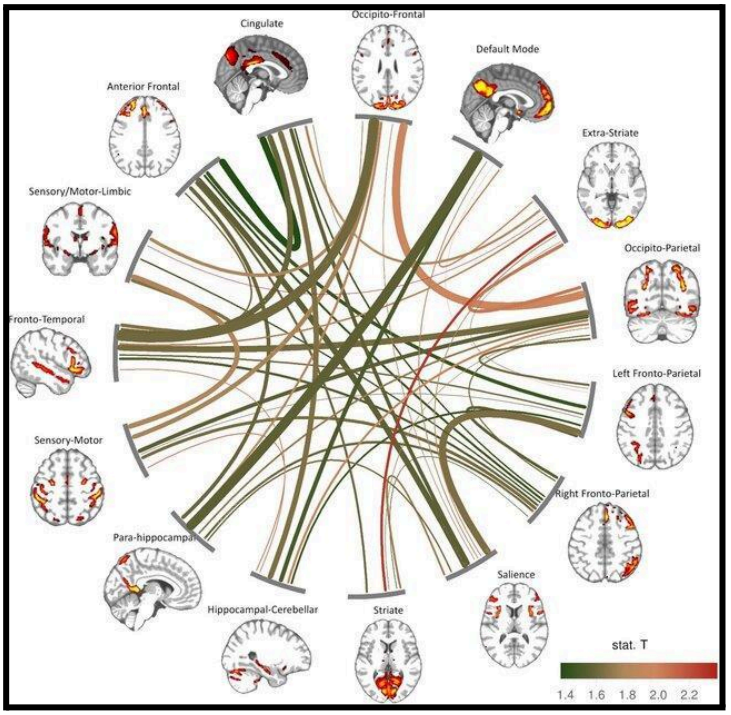

Fig 2. courtesy of nature research Creative Commons Attribution CC-BY 4.0
(in Passamonti et al., 2019)

Conclusions and Prospects

There is an inner logic behind the three keynotes of the IOSFS Convention 2024, namely the synergetic potential of the three complementary aspects they focused on: phenomenological perspectives on embodiment (Marja-Leena Juntunen), cognitive-scientific approaches to embodiment (Robyn Staveley), and neuroscientific mechanisms underlying embodiment (Wolfgang Mastnak). Moreover, each of the three key notes raised questions inspiring discussions within subsequent focus groups. The neuroscientific keynote proposed to exchange views and reason about

- What is the difference between mere body perception and embodiment?
- How can we argue that embodiment through engaging the senses is important for the development of the self?
- In which way is elemental music and dance education unique for the promotion of sensory embodiment?

While the discussion circles were time-limited, issues relating to neurosciences, embodiment and elemental music and movement education call for in-depth discussion, as well as for action. In this context the author encourages the following steps and measures:

- Orff-Schulwerk institutions in different countries explore culturally typical features of embodiment involving relevant myths, philosophies, artistic practices and behavioural customs alongside their relevance to elemental music and movement education.
- Orff-Schulwerk experts compare genuine benefits of elemental music/movement education with local health statistics and epidemiological distributions relevant to embodiment. On this basis they promote networking to enlarge beneficial implementation such as in inclusive education, paediatric oncology or health-promotion oriented classroom education.
- Orff-Schulwerk practitioners seek interdisciplinary research on elemental music and movement education, neuroscientific approaches included, and promote translational and applied sciences to enhance specific benefits in practical areas. This idea also inspired coining the term ‘translational elemental arts education’.
- Orff-Schulwerk educators encourage the establishment of new academic programmes that particularly focus on culturally sensitive and cross-cultural Orff-Schulwerk as well as its health promoting, therapeutic and rehabilitative potential. This also includes novel syndromes such as post-corona typical communication issues, retreat into virtual worlds and inclination towards body-dissociation and pathological embodiment.

References

Beaty, R.E., Benedek, M., Silvia, P.J. & Schacter, D.L. (2016) Creative Cognition and Brain Network Dynamics. *Trends in Cognitive Sciences*, 20(2), 87-95. https://doi.org/10.1016/j.tics.2015.10.004.

Brown, S., Gao, X., Tisdelle, L., Eickhoff, S.B. & Liotti, M. (2011) Naturalizing aesthetics: brain areas for aesthetic appraisal across sensory modalities. *Neuroimage*, 58(1), 250-258. https://doi.org/10.1016/j.neuroimage.2011.06.012.

Chang, M. & Kanold, P.O. (2021) Development of Auditory Cortex Circuits. *Journal of the Association for Research in Otolaryngology*, 22(3), 237-259. https://doi.org/10.1007/s10162-021-00794-3.

Cross, E.S., Kirsch, L., Ticini, L.F. & Schütz-Bosbach, S. (2011) The impact of aesthetic evaluation and physical ability on dance perception. *Frontiers in Human Neuroscience*, 5, 102. https://doi.org/10.3389/fnhum.2011.00102.

Feng, C., Yan, X., Huang, W., Han, S. & Ma, Y. (2018) Neural representations of the multidimensional self in the cortical midline structures. *Neuroimage*, 183, 291-299. https://doi.org/10.1016/j.neuroimage.2018.08.018.

Ferrè, E.R. & Haggard, P. (2015). Vestibular-Somatosensory Interactions: A Mechanism in Search of a Function? *Multisensory Research*, 28(5-6), 559-579. https://doi.org/10.1163/22134808-00002487.

Gogolla, N. (2017) The insular cortex. *Current Biology*, 27(12), R580-R586. https://doi.org/10.1016/j.cub.2017.05.010

Hiser, J. & Koenigs, M. (2018) The Multifaceted Role of the Ventromedial Prefrontal Cortex in Emotion, Decision Making, Social Cognition, and Psychopathology. *Biological Psychiatry*, 83(8), 638-647. https://doi.org/10.1016/j.biopsych.2017.10.030.

Konu, D., Turnbull, A., Karapanagiotidis, T., Wang, H.T., Brown, L.R., Jefferies, E. & Smallwood, J. (2020) A role for the ventromedial prefrontal cortex in self-generated episodic social cognition. *Neuroimage*, 218:116977. https://doi.org/10.1016/j.neuroimage.2020.116977.

Luo, A.C., Sydnor, V.J., Pines, A., Larsen, B., Alexander-Bloch, A.F., Cieslak, M., Covitz, S., Chen, A.A., Esper, N.B., Feczko, E., Franco, A.R., Gur, R.E., Gur, R.C., Houghton, A., Hu, F., Keller, A.S., Kiar, G., Mehta, K., ... & Satterthwaite. T.D. (2024) Functional connectivity development along the sensorimotor-association axis enhances the cortical hierarchy. *Nature Communications*, 15(1), 3511. https://doi.org/10.1038/s41467-024-47748-w.

Mastnak, W. & An, L. (2023) Aesthetics and the Human Nature. Interdisciplinary and Cross-cultural Perspectives of Rhythmic-Musical Interactions. *Musik-, Tanz- und Kunsttherapie*, 33(2), 223-232.

Mastnak, W. & Guo, R. (2021) An evaluation of Chinese Orff Music Therapy for children with autism in China. *Good Autism Practice*, 22(1), 78-86.

Mastnak, W. (2018) Creativity. Neuropsychological conditions, music educational perspectives, and health related benefits. *Musik-, Tanz- und Kunsttherapie* (Pabst Science Publishers), 28(1), 54-62. https://doi.org/10.13140/RG.2.2.30675.86560

Mastnak, W. (2019) Eurythmics and the Brain. A Neuroscientific Perspective. *Le Rythme 2019 – Scientific Perspectives / Artistic Research*, 103-115. FIER (Fédération Internationale des Enseignements de Rythmique). https://doi.org/10.13140/RG.2.2.31095.29601.

Mastnak, W. (2020a) Creative interactions in music: A neuroscientific perspective. In A. Sangiorgio & W. Mastnak (Eds.) *Creative Interactions. Dynamic Processes in Group Music Activities*, 5-20. University of Music and Performing Arts Munich.

Mastnak, W. (2020b) Music Rhythmic Therapy – A Novel Versatile Add-On-Support in Paediatrics. *Journal of Pediatrics Research Reviews & Reports*, 2(3), 1-10. https://doi.org/10.13140/RG.2.2.14055.11685.

Mastnak, W. (2022) Musik & Bewegung – Pädagogik & Therapie. Eine neurowissenschaftlich-anthropologische Perspektive. In A.M. Kalcher (Ed.), *Orff im Wandel der Zeit. Kunst trifft Pädagogik* [= Orff-Forschung und Diskurse, Bd. 1], 239-267. Reichert Verlag.

Mastnak, W. (2023) The Neuroscience of Dance Therapy. *The World Arts and Embodiment Forum 2023 Proceedings*, 7-9. The Hague (NL): Inspirees International Publishing.

McClelland, V.M. & Lin, J.P. (2021) Sensorimotor Integration in Childhood Dystonia and Dystonic Cerebral Palsy-A Developmental Perspective. *Frontiers in Neurology*, 12, 668081. https://doi.org/10.3389/fneur.2021.668081.

Moffat, R. & Cross, E.S. (2024) Awareness of embodiment enhances enjoyment and engages sensorimotor cortices. *Human Brain Mapping*, 45(10), e26786. https://doi.org/10.1002/hbm.26786.

Passamonti, L., Riccelli, R., Indovina, I., Duggento, A., Terracciano, A. & Toschi, N. (2019) Time-resolved connectome of the five-factor model of personality. *Scientific Reports*, 9(1), 15066. https://doi.org/10.1038/s41598-019-51469-2.

Peksa, J. & Mamchur, D. (2023) State-of-the-Art on Brain-Computer Interface Technology. *Sensors* (Basel), 23(13), 6001. https://doi.org/10.3390/s23136001.

Richard, V., Holder, D. & Cairney, J. (2021) Creativity in Motion: Examining the Creative Potential System and Enriched Movement Activities as a Way to Ignite It. *Frontiers in Psychology*, 12, 690710. https://doi.org/10.3389/fpsyg.2021.690710.

Sharda, M., Tuerk, C., Chowdhury, R., Jamey, K., Foster, N., Custo-Blanch, M., Tan, M., Nadig, A. & Hyde, K. (2018) Music improves social communication and auditory-motor connectivity in children with autism. *Translational Psychiatry*, 8(1), 231. https://doi.org/10.1038/s41398-018-0287-3.

Slijepcevic, P. (2018) Evolutionary epistemology: Reviewing and reviving with new data the research programme for distributed biological intelligence. *Bio Systems*, 163, 23-35. https://doi.org/10.1016/j.biosystems.2017.11.008.

Ticini, L. F., Urgesi, C., & Calvo-Merino, B. (2015) Embodied aesthetics: Insight from cognitive neuroscience of performing arts. In A. Scarinzi (Ed.), *Aesthetics and the embodied mind: Beyond art theory and the Cartesian mind-body dichotomy*, 103–115. Springer Science + Business Media. https://doi.org/10.1007/978-94-017-9379-7_7

Turgay Akay's Lab (2021) Relative Contribution of Proprioceptive and Vestibular Sensory Systems to Locomotion: Opportunities for Discovery in the Age of Molecular Science. *International Journal of Molecular Sciences*, 22(3), 1467. https://doi.org/10.3390/ijms22031467.

Urata, S., Iida, T., Yamamoto, M., Mizushima, Y., Fujimoto, C., Matsumoto, Y., Yamasoba, T. & Okabe, S. (2019) Cellular cartography of the organ of Corti based on optical tissue clearing and machine learning. *eLife*, 8, e40946. https://doi.org/10.7554/eLife.40946.

Vaissière, T., Michaelson, S., Creson, T., Goins, J., Fürth, D., Balazsfi, D., Rojas, C., Golovin, R., Meletis, K., Miller, C.A., O'Connor, D. & Rumbaugh, G. (2023) Sensorimotor Integration Supporting Perception Requires Syngap1 Expression in Cortex. *bioRxiv* [Preprint], 27, 2023.09.27.559787. https://doi.org/10.1101/2023.09.27.559787.

Vankerckhoven, L., Raemen, L., Claes, L., Eggermont, S., Palmeroni, N. & Luyckx, K. (2023) Identity Formation, Body Image, and Body-Related Symptoms: Developmental Trajectories and Associations Throughout Adolescence. *Journal of Youth and Adolescence*, 52(5), 1114. https://doi.org/10.1007/s10964-023-01760-3.

Yeh, I.L., Holst-Wolf, J., Elangovan, N., Cuppone, A.V., Lakshminarayan, K., Cappello, L., Masia, L. & Konczak, J. (2021) Effects of a robot-aided somatosensory training on proprioception and motor function in stroke survivors. *Journal of Neuroengineering and Rehabilitation*, 18(1), 77. https://doi.org/10.1186/s12984-021-00871-x.

Wolfgang Mastnak holds six doctoral degrees in medical sciences, sports sciences, mathematics, arts therapies, music education and psychology, as well as professional diplomas as psychotherapist and moto-therapist. His artistic profile includes piano, singing and composition. Being a full member of the European Academy of Sciences and Arts and the New York Academy of Sciences he was internationally honoured with awards such as *2000 Outstanding Intellectuals of the 21st Century* (International Biographical Centre Cambridge) and *Great Minds of the 21st Century* (American Biographical Institute). He is professor of Beijing Normal University, Shandong University and the University of Music and Theatre in Munich. His main research areas include arts therapies (e.g. music-, dance-, drama-, film- & TV-therapy), interdisciplinary music education, cross-cultural psychosomatics and psychiatry, multimodal health education, sports therapy, long-term cardiac rehabilitation, perinatal health, applied neurosciences, quantum consciousness, philosophy of science and research methodology. He has published about 250 scientific articles and 20 books.