1

The Musical Mind as the Recipient of Music Education

An Introduction to Critical Foundations and New Frontiers in Music Pedagogy

Wilfried Gruhn
University of Music Freiburg, Germany

Abstract

The introduction chapter reviews key moments regarding the scientific reflection about the musical mind starting in the late 20th century, when music became subject of cognitive psychology (Sloboda, Deliège, ESCOM). In this context, music perception is initially considered a process of the mind's eye and ear where the reception of sensorial input is transformed into subjective cognition. The mind "sees" or "hears" what is not physically present. Then, the musical mind is addressed through the lens of cognitive psychology (Bamberger), neurobiology (Buzsáki) and music education (Gordon). After that, it is stated that the musical mind marks a neglected domain in music education, but deserves particular attention of music educators so that music learning accounts for genuine musical contents. Consequently, future development in music pedagogy should place renewed emphasis on the cultivation of the musical mind. Music education should concern itself not only with performance skills, technical proficiency, or sociocultural discourse, but also with the cognitive and representational processes through which musical meaning is constructed.

Keywords: Audiation, cognitive sciences of music, reception, perception and cognition, musical meaning, optical/aural illusion.

Suggested citation:
Gruhn, W. (2026). The Musical Mind as the Recipient of Music Education. An Introduction to Critical Foundations and New Frontiers in Music Pedagogy. In Pérez-Aldeguer, S. (Editor), *The Musical Mind: Critical Foundations and New Frontiers in Music Pedagogy*. (pp. 1-13). Adaya Press.
https://doi.org/10.58909/adbm2691496

La mente musical como destinataria de la educación musical
Introducción a los fundamentos críticos y las nuevas fronteras de la pedagogía musical

Resumen
Este capítulo introductorio revisa momentos clave de la reflexión científica sobre la mente musical desde finales del siglo XX, cuando la música pasó a ser objeto de estudio de la psicología cognitiva (Sloboda, Deliège, ESCOM). En este contexto, la percepción musical se considera inicialmente un proceso del ojo y el oído de la mente, mediante el cual la recepción de estímulos sensoriales se transforma en cognición subjetiva. La mente "ve" u "oye" aquello que no está físicamente presente. A continuación, la mente musical se aborda desde la perspectiva de la psicología cognitiva (Bamberger), la neurobiología (Buzsáki) y la educación musical (Gordon). Seguidamente, se sostiene que la mente musical constituye un ámbito desatendido en la educación musical, aunque merece una atención particular por parte de los educadores musicales para que el aprendizaje de la música dé cabida a contenidos genuinamente musicales. En consecuencia, el desarrollo futuro de la pedagogía musical debería volver a poner el énfasis en el cultivo de la mente musical. La educación musical no debería ocuparse únicamente de las habilidades interpretativas, el dominio técnico o el discurso sociocultural, sino también de los procesos cognitivos y representacionales mediante los cuales se construye el significado musical.

Palabras clave: audiación, ciencias cognitivas de la música, recepción, percepción y cognición, significado musical, ilusión óptica e ilusión auditiva.

Introduction

When I served as Director of the Music Education Program, I was a member of the Senate at our University of Music. During one meeting, a newly elected colleague sat down beside me and introduced himself by saying, “My name is X, and I teach piano. Who are you?” I introduced myself and replied, “…and I teach music.” He appeared somewhat puzzled but said nothing, although his facial expression clearly conveyed surprise. I therefore explained that I understood what he meant: he also teaches music, albeit through the medium of the piano, whereas I teach music to prospective school music teachers by engaging and developing their musical minds. If we were to present this idea to teachers – whether instrumental, vocal, or classroom music teachers – we would likely encounter some irritation. Should we not teach students, that is, human beings rather than abstract concepts such as the musical mind? What exactly does this mean?

In this introductory chapter, I will address several related questions: What is the musical mind? How can we gain access to it? Why is it important to understand teaching and learning as processes of engaging with and expanding the musical mind whenever and wherever music is taught, rather than focusing primarily on instruments or technical skills? In this context, I am not referring merely to knowledge about music, but rather to knowledge *of* or *on* music (Schön, 1992). In fact, the term “musical mind” refers to the ensemble of cognitive, affective, neural, and representational processes through which human beings perceive, organize, understand, and assign meaning to musical experience.

Music as an Art Form and a Cognitive Challenge

Cognitive processes involved in perception and cognition, as well as the motor activities required for musical performance, depend on both biological mechanisms and neural activity. When we listen to music, we are not only emotionally affected through musically induced emotions but also cognitively challenged. We recognize musical structures that reflect affective content, form expectations about what may follow, and track formal relationships within the music. A rhythm may stimulate spontaneous bodily movement while simultaneously eliciting cognitive responses to pulse and meter, repetition and variation, or stability and fluctuation. These responses generate a variety of psychological reactions and arise from specific neural activities - that is, responses to sensory stimulation within the musical mind. This biological and psychological domain is where neural information is transformed into cognitive experience. Consequently, an interdisciplinary approach offers a particularly promising strategy for describing the musical mind and explaining its function, as illustrated in figure 1.

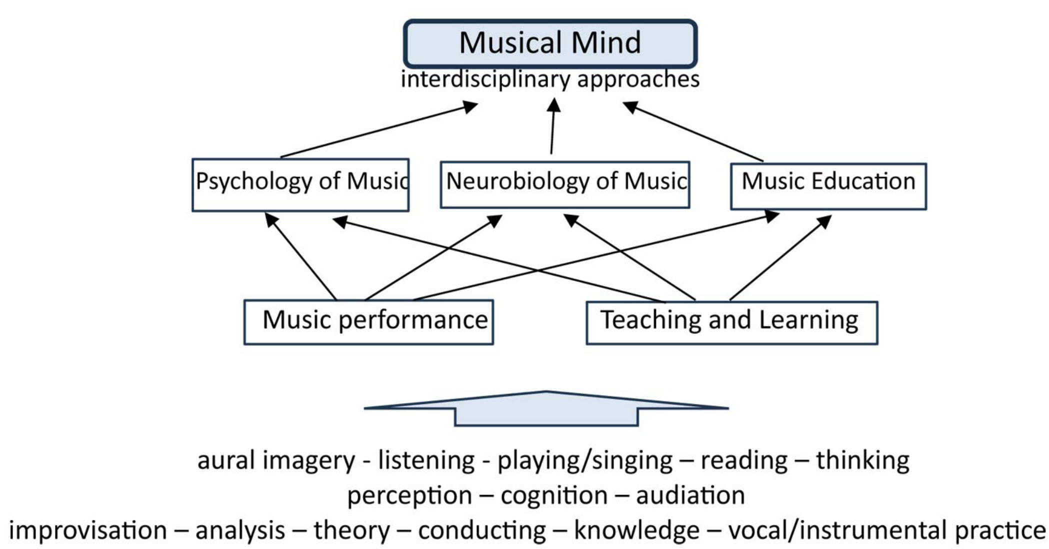


Figure 1. Interdisciplinary approaches to the musical mind (© W. Gruhn)

The human mind, insofar as it is concerned with music, encompasses the psychological and neural processes that extend beyond mere reflexive emotional reactions and judgments. These processes are intrinsically linked to the construction of meaning - that is, to how the brain enables us to recognize something as something. Once the mind becomes involved, perception is transformed into a cognitive act and may therefore be regarded as a subject of cognitive psychology (Sloboda, 1985, 2005).

Sensory input such as music acquires meaning through mental constructions triggered by neural processes. We do not simply hear a melody. Rather, we must transform the activity of neurons - specialized cells that respond selectively to specific properties such as frequency ranges, dynamics, or directional movement – into meaningful musical perceptions. A frequency becomes a tone only through this process of interpretation. From there, the mind generates musical meaning.

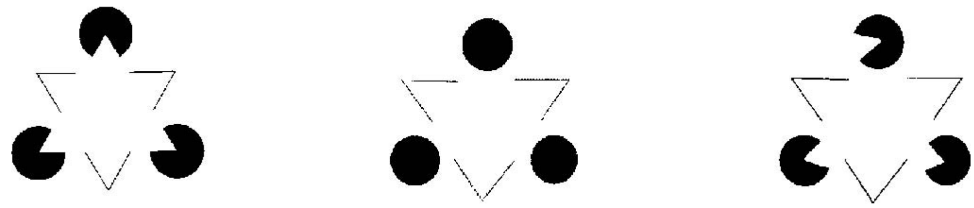
The following sections explore this process in greater detail. Any new direction in music education must take these foundations into account if it seeks to facilitate the development of musical meaning. Such an approach differs fundamentally from merely teaching students how to place their fingers correctly on an instrument or how to produce an appropriate embouchure.

Interest in the musical mind emerged prominently during the 1980s through the work of Lerdahl and Jackendoff (1983), Irène Deliège (1985), John Sloboda (1985), and Jeanne Bamberger (1991). This development was further supported by the establishment of the European Society for the Cognitive Sciences of Music (ESCOM) in 1991. Cognitive psychology, as a branch of the cognitive sciences, addresses fundamental questions concerning the musical mind. Whereas Lerdahl and Jackendoff's *A Generative Theory of Tonal Music* (1983) drew inspiration from Chomsky's theory of generative-transformational grammar with its tree-structure of syntactic functions that do not mirror neural processes in the brain, Deliège and Sloboda focused on the cognitive psychology of music perception and cognition, thereby initiating extensive empirical research in this emerging field.

Perception Through the Mind's Eye and Ear

When Steven Pinker described how the mind works (1997) he illustrated cognitive functioning through the concept of the "mind's eye" (pp. 211–298). His discussion highlights an important insight: we do not simply recognize what we see; rather, we recognize what the mind interprets from the neural activity generated within the visual cortex.

Kanizsa's triangle provides a striking example. We perceive two overlapping triangles, although not even one triangle is present in the image. Nevertheless, we perceive a white triangle positioned above a contoured other and clearly "see" the sides of the triangle (figure 2a).



a) Kanizsa's triangle b) manipulated version c) rotated white sectors

Figure 2. Kanizsa's triangle

This occurs because the mind completes interrupted contours and connects implied lines extending from the missing sectors of the black circles. Even when the white sectors are removed (figure 2b), the triangle remains perceptually present. However, when the black circles are rotated (figure 2c), the illusion gradually disappears.

Similarly, ambiguous figures can be interpreted in two different ways - for example, as either a rabbit or a duck, a young or an old woman, or a vase or two facing profiles. Yet the mind's eye perceives only one interpretation at a time, never both simultaneously (figure 3).

Figure 3. W. E. Hill, My Wife and My Mother-in-Law (1915)

Another well-known visual illusion is the Café Wall Illusion, named after a café on St Michael's Hill in Bristol, United Kingdom. The café's wall was decorated with alternating black and white tiles arranged in offset rows. Although the mortar lines separating the rows are perfectly parallel, they appear to slope upward and downward. Viewers perceive skewed lines where none actually exist (https://michaelbach.de/ot/ang-cafewall/). An ophthalmologist may explain the physiological mechanism of the illusion, yet in fact the mind's eye always sees the illusion; objective reality and subjective perception do not coincide.

When Pinker states that “the visual system is not there to entertain us with pretty patterns and colors; it is contrived to deliver a sense of the true forms and materials in the true world” (Pinker, 1997, p. 213), we are compelled to ask how the external world enters the mind and whether our senses genuinely provide an accurate representation of reality. We shall return to this question in Section 4. For the moment, it is sufficient to notice that the mind’s eye often proves more influential than sensory input alone. The long history of visual illusions (Bach, 2022) offers compelling evidence of this phenomenon.

The same principle applies to auditory perception. The mind’s ear identifies forms and structures that have developed through experience, learning, and enculturation. As Diana Deutsch (2013) demonstrated, the scale illusion arises from “illusory conjunctions of pitch and location.” In the finale (*Adagio lamentoso*) of Tchaikovsky’s *Symphony No. 6 (“Pathétique”)*, listeners do not perceive exactly what is notated in the score and what the musicians perform while playing their parts. Instead, the mind combines adjacent pitches distributed between the two violins, and between viola, and cello, creating a melody that exists primarily as a perceptual construct (figure 4).

Figure 4. P. I. Tchaikovsky, Symphony No. 6, Finale (from Gruhn, 2005, p. 24)

The perceived melody appears thematic because of a fundamental principle of auditory organization: adjacent pitches tend to be grouped together. In this sense, it is the listener who creates the melody. Similarly, electronic sound manipulations can produce the illusion of an endlessly descending pitch sequence, even though the actual pitches remain within the same range. This auditory phenomenon parallels Escher’s visual illusion of an endless staircase.

The implication is clear: the musical mind does not merely mirror the acoustic information transmitted by neurons. Rather, it relies on previous experience and musical practice to construct meanings that transcend the physical properties of sound itself.

Addressing the Musical Mind Through the Lens of Cognitive Psychology

Jeanne Bamberger (1924 – 2024) was among the first scholars to precisely observe and describe the developmental trajectories of musical learning in a young child. In her seminal study (Bamberger, 1991), she documented the learning process of a boy whom she called *Jeff*, showing how his mental representation of a simple children's song, *Twinkle, Twinkle, Little Star*, gradually evolved over time. Jeff's developing understanding became visible through the way he arranged Montessori bells to perform the song. Initially, he used multiple bells for the various pitches of the melody without establishing a systematic relationship among them. Later, however, he attempted to perform the song using only one bell for each pitch. This required him to reorganize both the physical arrangement of the bells and the sequence of his movements. Such a change was possible because his internal representation of the melody had changed. The transformation of his mental representation was reflected in both the new spatial arrangement of the bells (bell-path) and the way he used them (action-path).

In earlier investigations of children's invented musical notations, Bamberger identified several developmental stages of musical representation, ranging from *figural* to *metric* and ultimately to *formal* representations (Bamberger, 1991, pp. 46, 226ff.). Mental representations of music develop from direct pictorial imitations of actions (figural representations), through representations based on counting and sequencing individual events (metric representations), to increasingly abstract conceptions of musical structure (formal representations). When Jeff eventually reached the formal stage, he arranged the bells systematically according to the structure of a major scale. This new representation enabled him not only to play *Twinkle, Twinkle, Little Star* but also to perform any other melody in the major mode. His musical understanding had become transferable because it was now grounded in an abstract representation rather than a specific action sequence.

From this perspective, musical learning can be understood as a progressive transformation of mental representations. Learning involves a shift from figural toward formal representations, accompanied by the gradual consolidation of neural representations in subcortical structures.

This distinction becomes evident in musical practice. Most trained musicians can immediately sing a major triad because they possess a stable formal representation of it. However, many people experience difficulty when asked to sing the first inversion of a minor triad from a given starting tone. In such situations, they often resort to counting intervals or calculating inversions intellectually, thereby relying on metric or figural representations rather than formal ones.

Based on this distinction, Bamberger differentiates between *path-makers* and *map-makers* (figure 5). Path-makers rely on sequential actions and procedural knowledge, whereas map-makers operate with abstract mental representations that allow flexible navigation within a musical system.

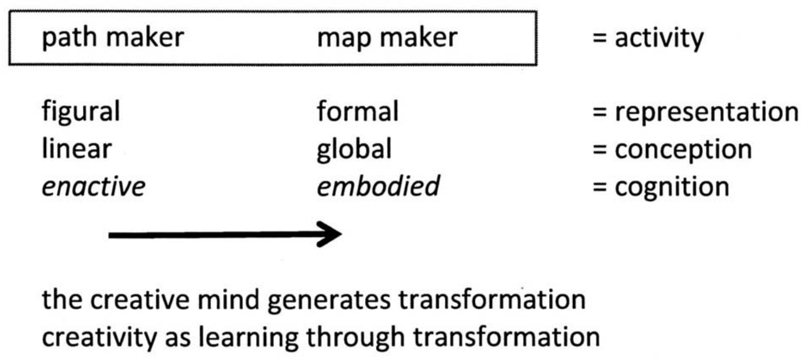


Figure 5. According to Jeanne Bamberger (2013): From Path-Making to Map-Making

The development of mental representations is a key factor in the evolution of musical thinking. Edwin Gordon described this process through the concept of *audiation* (Gordon, 1980/2012). Audiation refers to the capacity to assign meaning to music by internally comprehending and organizing musical sounds. The quality of audiation depends directly on the sophistication of the underlying musical representations. In this sense, audiation is a psychological construct that explains music learning as a process of progressively transforming mental representations. It forms the foundation of Gordon's Music Learning Theory and provides a framework for understanding how musical meaning develops. Both Gordon and Bamberger place mental representation at the centre of musical cognition and, consequently, at the centre of the musical mind (Bamberger, 2013; Gruhn, 2011, 2021).

Their work demonstrates that genuine music learning is not merely the acquisition of technical skills or factual knowledge; rather, it involves the gradual construction of increasingly sophisticated mental representations through which musical meaning becomes accessible.

Addressing the Musical Mind Through the Lens of Neurobiology

Now, we will take the lens of neurobiology to investigate the musical mind. Over recent decades, research into the neurobiology of music has expanded dramatically. This development is reflected in the continuing conference series *The Neurosciences and Music*, the proceedings of which are published by the New York Academy of Sciences since 2003. Numerous studies have examined brain structures and neural activity associated with musical performance, singing, listening, thinking, remembering, and imagining music. As a result, we now possess extensive knowledge about the neural correlates of musical behaviour. Yet one fundamental question has remained unresolved: How does music from the external world come into our mind and create meaning? This question reflects the classical philosophical problem of identity and difference, particularly as discussed within German Idealism (Fichte, Hegel). Neural activity can be measured because neurons respond selectively to specific sensory properties of sound, such as frequency, intensity, or directional movement. However, neurons themselves remain “blind” to the expressive qualities of music – the emotional energy of a melody, the tension of a harmonic progression, or the drive of a rhythm. These are precisely the qualities listeners experience and to which they respond emotionally and physically.

Recent research by György Buzsáki has provided important new insights into this problem and has fundamentally reshaped our understanding of how the brain constructs reality (Buzsáki, Peyrache *et al.*, 2014; Buzsáki, 2019, 2022). Based on extensive empirical research, Buzsáki challenges the traditional *outside-in* model of perception and proposes instead an *inside-out* paradigm.

For many years, the outside-in model dominated neuroscience. According to this framework, information from the external world is transmitted to the brain through sensory receptors, where it is transformed into internal representations. However, this model cannot adequately explain how sensory signals become meaningful. As Buzsáki (2022) asks, how are “photons falling on the retina transformed into a recollection of a summer outing”? Sensory neurons may register physical stimuli, but they do not themselves perceive objects or meanings.

To address this problem, Buzsáki proposes the inside-out model. According to this perspective, cognition of the external world begins not with passive reception but with internal neuronal activity. “Neural circuits that initiate an action […] send commands to the muscles that control the eyes and other bodily sensors and enhance the brain’s ability to identify the nature and location of initially ambiguous incoming signals from the senses” (ibd.). These internal activations generate signals – known as corollary discharge – helping the brain interpret ambiguous sensory input and identify meaningful features of the environment by sending “notifications to sensory and higher order brain areas” (ibd.)

Perception and cognition therefore emerge through action. Perception is not a passive process of receiving information; rather, it is an active process through which organisms engage with their surroundings. As Buzsáki argues, cognition can be understood as *internalized action*. Neural activity becomes increasingly independent of immediate sensory input and enables meaningful interaction with the environment. In his words, “disengaged neural activity” (ibd.) constitutes the essence of cognition.

This perspective fundamentally changes our understanding of how the mind works. Meaning is not simply imported from the external world into the brain. Instead, internally generated neural activity enables individuals to project structure onto sensory experiences and thereby construct meaning. Such a view has important implications for music education (Gruhn, 2025). If perception and action are intrinsically linked, then musical learning must involve active engagement with music. The development of perception and cognition depends upon action-oriented experiences that allow learners to construct musical meaning for themselves.

This completely new understanding of neural processing also raises important questions concerning artificial intelligence. Current large language models (LLMs), such as ChatGPT, largely operate according to principles that resemble the traditional outside-in paradigm. They process vast amounts of information and generate responses based on statistical probabilities derived from training data. However, they do not interact with information through embodied action in the way humans do. Recent studies examining the cognitive and neurological implications of artificial intelligence (Chen, Wang *et al*., 2025; Kosmyna & Hauptmann, 2025) have highlighted some of the limitations of this approach. Nevertheless, Buzsáki (2022) argues that future developments in artificial intelligence may require systems that emulate inside-out processes—systems capable of generating internal models and acting upon their environments rather than merely processing incoming data. At present, however, artificial intelligence does not contribute significantly to the refinement of the musical mind. Musical understanding remains grounded in embodied action, lived experience, and the active construction of meaning—processes that are uniquely human.

The Musical Mind: A Neglected Domain of Music Education

The insights gained from cognitive psychology and contemporary neurobiology converge on a common conclusion: musical understanding is not passively received but actively constructed. Consequently, music education must be concerned not only with musical products and performances but also with the development of mental structures through which musical meaning emerges. On the contrary, when reflecting on contemporary music education in public schools, one notices that educational praxis has shifted toward practical music-making activities, such as songwriting, sound experimentation, composing with digital media, and, increasingly, the use of artificial intelligence in creative processes. At the same time, important sociocultural themes have gained prominence, including feminism in music, postcolonial perspectives, the critique of Western cultural dominance, issues of equity and social justice, intersectionality, music as social practice, and discourse-oriented approaches to music education. These developments have undoubtedly enriched the field and addressed significant educational and societal concerns. Nevertheless, there is a risk that the central question of how individuals learn music as music may gradually recede into the background. As Keith Swanwick argued many years ago, music education must remain concerned with teaching and learning music musically (Swanwick, 1999). If this focus gets lost, music education risks neglecting its own distinctive subject matter.

One of the last internationally influential music psychologists to devote sustained attention to the processes of musical aptitude and music learning was Edwin Gordon (1927 – 2015). Through his Music Learning Theory (Gordon, 1980/2012; 1990/2003), Gordon investigated the internal mechanisms, developmental stages, and structures underlying music learning. In doing so, he placed the musical mind at the centre of his theoretical framework.

The primary aim of Gordon's approach was to enable children to derive meaning from the music they sing, play, hear, and imagine. This perspective aligns remarkably well with Buzsáki's neurobiological model discussed in the previous section. Music teaching ultimately addresses the mind rather than the auditory cortex. Neural structures may provide the biological basis for musical activity, but musical meaning is constructed within the musical mind. It is there that sounds become organized, interpreted, and experienced as music.

Through extensive observation and empirical testing, Gordon developed a comprehensive model of skill-learning sequences that guides teachers in fostering audiation. Audiation – the ability to think music internally through tonal and rhythmic representations – constitutes the core of meaningful musical understanding. Genuine music learning begins when learners can internally organize and comprehend musical structures rather than merely reproduce sounds mechanically (Gruhn, 2018).

An important practical application of this principle can be found in Nicholas Bannan's concept of *Harmony Signing* (Bannan, 2020). In this approach, students learn to use gestures that represent tonal functions. As a result, they become capable of demonstrating what they hear and singing what they show represented through gestures. For "musicality is not only about cooperation and communication. As important, and essential to the development of the capacity for the forms of communication … is *representation*: how the individual responds to what the senses perceive so as to accord it meaning, file it in memory, and retrieve it as a rehearsed response" (ibd, p. 4). Such approach teaches musical phenomena immanently, that is, from within the musical experience itself. They do not rely primarily on verbal explanations or abstract concepts that must be memorized independently of sound. Instead, signs, gestures, images, notation, and language derive their significance from the sounds and musical relationships they represent. Only when such symbols are connected to musical sound do they acquire meaning and become effective tools for musical thought.

Through this process, learners develop ownership of musical knowledge. Musical understanding ceases to be a collection of externally imposed concepts and becomes an internally organized system of meanings through which individuals can think, communicate, and create musically.

Conclusion: Educating the Musical Mind

If perception is fundamentally what we do, and if cognition emerges from internalized action, then learning to perceive, recognize, and understand music must involve action, movement, engagement, and participation. Musical understanding cannot be reduced to the passive reception of information. Rather, it develops through purposeful interaction with musical phenomena and through the construction of increasingly sophisticated mental representations. This insight has far-reaching implications for music education. In an age increasingly shaped by digital technologies and artificial intelligence, there is a temptation to delegate cognitive tasks to external systems. Yet cognition itself depends upon activity. Technologies based on large language models can process and generate information, but they cannot replace the embodied actions through which human beings develop musical understanding. To the extent that such technologies relieve learners of their own cognitive and musical engagement, they may even undermine some of the very processes that facilitate genuine learning.

Consequently, future developments in music pedagogy should place renewed emphasis on the cultivation of the musical mind. Music education must concern itself not only with performance skills, technical proficiency, or sociocultural discourse, but also with the cognitive and representational processes through which musical meaning is constructed. The musical mind should therefore be regarded as the primary domain of music learning and teaching. Such a perspective opens promising new foundations and frontiers for music pedagogy. It shifts the focus from the mere acquisition of musical skills to the development of musical understanding; from the reproduction of sounds to the construction of meaning; and from teaching music as an external object to educating the musical mind as the locus of musical experience.

Ultimately, music education succeeds not when students merely perform music correctly, but when they learn to think, feel, understand, and communicate musically. The cultivation of the musical mind is therefore not simply one objective among many – it is the very foundation upon which meaningful music education rests. This would shift the emphasis from the acquisition of musical skills to the development of musical understanding, or: from music *learning* to *music* learning.

References

Bach, M. (2022). *Optische Täuschungen und andere außergewöhnliche Sehphänomene* Kaden.

Bach, M. (o. J.). *Sehphänomene und optische Täuschungen* (https://michaelbach.de/ot/index-de.html)

Bamberger, J. (1991). *The mind behind the musical ear.* Harvard University Press.

Bamberger, J. (2013). *Discovering the musical mind. A view of creativity as learning.* Oxford University Press.

Bannan, N. (2020). *First Instruments. Teaching music through harmony signing.* Oxford University Press.

Buzsáki, G., Peyrache, A., & Kubie, J. (2014). Emergence of Cognition from Action. *Cold Spring Harb Symp Quant Biol*, *79*, 41-50. https://doi.org/10.1101/sqb.2014.79.024679

Buzsáki, G. (2019). *The brain from inside out*. Oxford University Press.

Buzsáki, G. (2022). How the brain 'constructs' the outside world. *Scientific American, 326*(6), 36-43. https://doi.org/10.1038/scientificamerican0622-36

Chen, Y., Wang, Y., Wüstenberg, T., Kizilcec, R. F., Fan, Y., Li, Y., Lu, B., Yuan, M., Zhang, J., Zhang, Z., Geldsetzer, P., Chen, S., & Bärnighausen, T. (2025). Effects of generative artificial intelligence on cognitive effort and task performance: study protocol for a randomized controlled experiment among college students. *Trials*, *26*(1), 244. https://doi.org/10.1186/s13063-025-08950-3

Deutsch, D. (2013). Grouping mechanisms in music. In D. Deutsch (Ed.), *The Psychology of Music. (3rd ed.)* (pp. 183 - 248). Elsevier.

Gordon, E. E. (1980, [8]2012). *Learning sequences in music. A contemporary music learning theory.* GIA Publ.Inc.

Gordon, E. E. (1990, [3]2003). *A music learning theory for newborn and young children.* GIA Publications Inc.

Gruhn, W. (2011). Music learning in early childhood. A Review of psychological, educational, and neuro-musical research. In R. Colwell & P. Webster (Eds.), *MENC Handbook of research on music learning, vol. 2* (pp. 256 - 289). Oxford University Press.

Gruhn, W. (2018). Audiation. - Grundlage und Bedingung musikalischen Lernens. In W. Gruhn & P. Röbke (Eds.), *Musiklernen* (pp. 94 - 109). Helbling.

Gruhn, W. (2021). The musical mind - ein neues Forschungsfeld im Schnittpunkt von Musikwissenschaft und Musikpädagogik. In C. Breitfeld, U. Jung-Kaiser, & B. Vedder (Eds.), *Musikpädagogik und Musikwissenschaft. Renaissance einer Wechselbeziehung verwandter Disziplinen (Kompendium Musikpädagogik 11,* pp. 101 - 113). Laaber-Verlag.

Gruhn, W. (2022). *Hören als Handeln. Eine neurophysiologische Theorie der musikalischen Wahrnehmung.* Olms.

Gruhn, W. (2025). How is perception related to action? A neurophysiological perspective on music perception and learning. *Music Education Research*, *27*(3), 295-303. https://doi.org/10.1080/14613808.2025.2504406

Kosmyna, N., & Hauptmann, E. (2025). Your brain on chatGPT (MIT Study, preprint). https://arxiv.org/pdf/2506.08872v1

Pinker, S. (1997). *How the mind works*. Norton & Company.

Schön, D. A. (1992). *The reflective practitioner.* Routledge.

Sloboda, J. A. (2005). *Exploring the musical mind*. Oxford University Press.

Sloboda, J. A. (1985). *The musical mind. The cognitive psychology of music.* Oxford University Press.

Swanwick, K. (1999). *Teaching music musically*. Routledge.

Wilfried Gruhn is professor emeritus of music education. PhD in musicology 1967. He taught at the Universities of Music in Saarbrücken, Essen and Freiburg where he retired 2003. 1995 – 1997 president of the International Research Alliance of Institutes for Music Education (RAIME); 2000 – 2004 ISME Board Member; 2003 – 2009 director of the Gordon Institute of early childhood music learning in Freiburg; 2009 founder and first president of the International Leo-Kestenberg-Society. His research areas include historical research on music education and empirical studies on perception, cognition and the neurobiological foundations of music learning.