Chapter 6
Embodiment in Early Childhood Music Education

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Introduction

Learning is not all "in our head", but occurs from the very beginning of life through our sensory engagement with the world and through the movements and postures that provoke this sensory engagement (Hannaford, 1995; Schroeder, Wilson, Radman, Scharfman, & Lakatos, 2010). Therefore, movement and kinaesthetic awareness are key components of the physical and cognitive development of children and the search for sensory input through movement is an inborn mechanism that shapes human interaction with the world. The essential role of the body in our understanding of the world is the basic idea of the theory of embodied cognition, according to which cognitive processes are shaped by the dynamic interactions between the brain, the body and the environment (Gallagher, 2017; Shapiro, 2015). Accordingly, the body is not conceived as peripheral to meaning-making but, on the contrary, as constitutive to our experience and understanding of the world (Foglia & Wilson, 2013). From this "embodied" viewpoint, learning is ideally grounded in sensorimotor activities, involving bodily interactions with the social, cultural and physical world (Bowman, 2004).

Educational philosophers and psychologists such as Piaget, Dewey, Freire and Vygotsky have stressed the embodied and situated nature of cognition but now an increasing amount of educational research points to the importance of experience

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and its sensorimotor foundation as the basis of cognition. This more recent research shows that body movement and associated bodily sensations affect learning at different levels. One level concerns promoting children's learning *readiness* through movement. Research findings show that physical activities may promote *cognitive* aspects of learning such as attention and memory, *emotional* aspects of learning such as reduced stress and an increase of positive feelings, and *social* aspects of learning such as positive social interactions and group cohesion (Lengel & Kuczala, 2010). Another level concerns the way physical activities promote learning *effectiveness*. At this level, movement is employed to enhance the pupils' understanding of the learning content (Shoval, 2011). By integrating physical activities in learning activities such as whole-body movements, gestures or object manipulations that are congruent with a learning task, the learning process becomes more effective, resulting in higher learning gains (Paas & Sweller, 2012). Learning gains through the use of movement have been found in the educational fields of mathematics (Goldin-Meadow, Cook, & Mitchell, 2009), language (Goldin-Meadow & Alibali, 2013), science (Lindgren, Tscholl, Wang, & Johnson, 2016) and reading comprehension (Glenberg, Brown, & Levin, 2007). Through the bodily experience of concepts, they are encoded in a multimodal way and, according to scholars such as Lakoff and Johnson (1999), Washburn (2010), and Sweller (1994), this might lead to a deeper understanding of the learned content.

In the domain of education, early childhood is an age category *par excellence* in which the movement-learning connection could be fully exploited. Considering that young children have a natural inclination to move and to learn through experience, physical activities would fit in well with early childhood education. However, learning as embodiment is disappearing in early childhood education and, more and more, young children are becoming just the activity of their brains (Oenema-Mostert, Goorhuis-Brouwer, Van Boekel-Van der Mei, & Oosterhoff, 2016). This could be due to the shift from a play-based curriculum to a content-based curriculum (Bodrova, 2008) and – or – anxieties concerning touch and the safety of the child (McHugh-Grifa, 2011; Tobin, 2004). In contrast, early childhood music educators and the traditional music pedagogies of Dalcroze and Orff acknowledge children's natural inclination to move to music and often use physical activities that provide children with rich musical experiences that foster musical understanding (Bremmer, 2015, 2016). However, despite their practice-based understanding of the body's central role in learning music, these pedagogies do not seem to be informed by empirical research findings that explain these understandings (Young, 2016). Yet, gaining insight into why and how the body plays a role in learning music could lead to a more conscious and systematic employment of the body.

The theory of embodied music cognition and related empirical research findings offer a framework that can provide such insights. These research findings not only convincingly undergird the idea of the relationship between human movement and musical experience, as a cornerstone for musical understanding (Leman, 2007, 2016), they also provide a conceptual framework that describes the basic process of embodied interaction with music and, as such, of embodied learning.

The embodied music cognition conceptual framework that will be discussed was developed by Leman (2016). We believe this framework may serve as a useful tool for early childhood music practitioners who want to systematically design movement activities for their music lessons that enhance the understanding of music. Furthermore, an interesting aspect of this paradigm is the supportive role of interactive technologies in creating meaningful musical experiences that appeal to the embodied nature of musical interactions.

First, this chapter will take a closer look at how, according to an embodied music cognition perspective, the body facilitates the meaning-making process of music, which basic mechanisms underlie that process and what this could mean for teaching and learning music in early childhood education. Secondly, the role of interactive technologies as facilitators for an embodied approach to learning music will be discussed.

Embodied Music Cognition

Embodied music cognition is a research paradigm that studies how bodily involvement shapes the way we perceive, feel, experience, and comprehend music. The idea is that embodiment determines, to a large extent, why and how a stream of sounds is experienced as music and why engaging with music is a rewarding experience.

Enactment: Transforming Sound into Music Through Movement

When studying the nature of musical experiences, one of the basic questions that arises is how people make sense of and learn music. Making sense of music can be seen from different viewpoints, which shed different lights on the multifaceted process of musical meaning-making. According to the embodied music cognition view, music is not inherently meaningful but the musical meaning-making process is considered to be the outcome of an active bodily involvement with music (Leman, 2016). The idea is that, while interacting with music through listening, dancing or playing, a sound-movement-intention connection is established that transforms the stream of sounds into a meaningful musical experience. This transformation process, also called *enactment*, occurs through the association of patterns in the sounds (e.g. chord sequence or melody) with movement patterns (e.g. shape, direction, energy) and thereby with the intentional states (e.g. an emotion) that underlie these patterns. This connection is made possible because music and movement share certain features (Sievers, Polansky, Casey, & Wheatley, 2013). Both modalities are time-based and thus music can be experienced as a flow of movement, imbued with

a certain *quality* and with an intentional *direction* that can evoke an emotion (Stern, 2010). From this viewpoint, understanding music can be understood as a multimodal process.

According to Leman (2016), the transformation from a stream of seemingly random sounds into music is facilitated by two processes. A first process concerns the emergence of higher-level musical patterns that reduce the complexity of the sound stream when interacting with music. Such structuring of the sounds facilitates the alignment of a movement or action pattern to the music, and as such, the attribution of intentions to the music. For example, the beat is a pattern that emerges and, once found, enables a person to move more easily to the music. Note that the emergence of patterns can be culturally determined. When one is acculturated to Western European Classical music, complex polyrhythmic music (e.g. West African music) might be a real challenge to move to (Cameron, Bentley, & Grahn, 2015).

A second process concerns the elements or 'mediators' that affect the relationship between one's perception of musical patterns and their processing. These mediators determine how particular aspects of a sound pattern (e.g. subdivision of a rhythmic pattern) are selected, disambiguated or reinforced (Leman, 2016). Typical examples of such mediators are attention, knowledge, moods and movement. With regard to the latter, Phillips-Silver and Trainor (2007) found that movements mediate the musical perception of young infants. Being bounced either to a duple or triple meter appeared to affect the listening preferences of the infants, who listened longer to the rhythms with the accent patterns (i.e., meter) to which they had previously been bounced. Thus, movement becomes a mediator for the perception and meaning-making of music.

Building on the relationship between bodily experiences and musical meaning, early childhood music educators have the possibility to design *movement-based* music activities that stimulate children to make sense of music. Such activities can help children to develop a repertoire of movements that support and strengthen their sound-movement-intention connection. Furthermore, these activities can broaden their repertoire of bodily responses to music or intensify mediators influencing the process of meaning-making, but ultimately can enable children to become responsible for the meaning-making process themselves and, as such, to become autonomous learners (Custodero, 2010).

Basic Mechanisms of Enactment in Music

The general processes we have described of attributing intentions to music by associating musical and movement patterns, is rooted in several basic mechanisms: alignment, entrainment and prediction. In the following section, we will explain the concepts of alignment, entrainment and prediction, and give examples of how these concepts can be applied in early childhood music education.

Alignment with Music

When children move expressively to music, they intuitively start to match their physical actions to the music (Eerola, Luck, & Toiviainen, 2006). The emerging correspondence between music and movement is based on the ability to feel the music and to *align* one's movements accordingly, in response to particular aspects of the music. Some children might move to the beat, whereas others might show an emotional response, or imitate the character of the music.

The ability to align one's movements to certain musical aspects can be conceived from two viewpoints. From the first point of view, alignment becomes apparent in movement patterns. Here, Leman (2016) distinguishes between two main types of alignment. A first type, *phase alignment*, is concerned with the correspondence or synchronization of movements to salient time markers in music, for example stepping or moving the head to the beat. This type of alignment helps to establish a person's global timing framework. Note that phase alignment does not necessarily imply that a movement such as an arm movement will always coincide exactly with the beat. A child could feel the tempo of the music but might be consistently slightly too late or too early with her movements on the beat. Furthermore, moving to the beat does not necessarily mean to *every* beat. Depending on the kind of music or the tempo, phase alignment can be on the first beat, but might just as well occur on the first and third beat of a quadruple meter. The second type, *inter-phase alignment*, is concerned with what happens in-between the salient markers, or, in other words, the way the continuous expressive flow of physical actions matches the time in between the beats of the music. The expressive flow of movements in between the beats can be related to different musical aspects, such as melodic contour, rhythms, dynamics or harmonic structures.

Simply said, phase and interphase alignment refer to the way in which physical actions match with what happens in the music, i.e. on the beat and in between the beats. Depending on which aspect a learner attends to, one of both types of alignment might be more prominent. Nevertheless, as the flow of associated bodily and musical rhythms occur within an overall discrete timing framework defined by beats, meter and tempo, it is likely that phase and inter-phase alignment have mutual dependencies.

Illustration

A musical activity that addresses the different types of alignment could be that children are invited to experience the beat physically and the time in between beats. They might first be asked to think of a movement that coincides with the beat. Typically, educators focus on this kind of alignment. However, to introduce inter-phase alignment, children may be asked to think of a way to move in between the gestures or movements they are performing on the beat. By way of illustration, think of a child that pats his legs on the beat and then does a free movement with the arms in between the beats that leads to the next pat on the legs.

This might be repeated in different tempi to elicit different movement responses as the time-frame in between the beats varies. For example, a slower tempo might lead to different expressive bodily responses in between the beats.

From the second point of view, patterns are properties of certain states. Leman (2016) distinguishes between three transition processes that contribute to state changes and, thereby, to the experience of music as a pleasurable and empowering phenomenon. A first transition process concerns *predictive* processing, leading to a *sense of agency*: being able to predict what comes next in the music and to successfully *align* one's movements to music induces a feeling of being in control, and this may cause feelings of satisfaction, reward and immersion (Clarke, 2014). This process also applies to the interaction and alignment with peers, thereby possibly inducing pro-social emotions. In this case, me-agency turns into we-agency (McNeill, 1995). That is, the individual sense of agency ("I did it!") becomes valued within the collective agency of the group ("We did it!") (Pacherie, 2014).

A second transition process concerns *energetic* processing. The physical effort it takes to carry out and maintain *alignment* can lead to an increased sense of agency and to an increase in one's *arousal* level. Physical activities to music may induce physiological and psychological states of being awake, alert and excited and, thereby, improve executive functions (Byun et al., 2014) and facilitate higher cognitive functions (Audiffren & André, 2014).

The third transition process involves expressive processing, which leads to the attribution of affect value to music, such as pleasant vs. unpleasant, happy vs. sad (Roda, Canazza, & De Poli, 2014) and to a pro-social attitude. Musical patterns can affect the energetic state of a person based on their qualitative features such as degree of variation, bass drum decibel level, length and structure of motives or timbre. For example, music can be relaxing or activating and thereby generating a transfer from sound energy to motor energy and thus affecting the way movement is aligned to the music.

Illustration

> *At a certain moment, the children might be asked to pick out one of their peer's movement responses on the beat, and to perform that movement together, e.g. patting their legs. When all the children manage to pat together, the discrete sounds of the individual taps will merge and start sounding as one. This may start feeling as if the "me" dissolves into the "we". However, it is not always easy to arrive at this point, because children have to adopt another child's movement response and this might require attention and effort. When they do succeed, it not only boosts their sense of agency but also induces feelings of excitement and the confidence to be fully expressive.*

The mutual reinforcement of the three transition processes affects feelings of reward (as we explain later), which then not only reinforces alignment but also the process of entrainment, being the compelling force that drives the human tendency to synchronize with music (Clayton, 2012).

Entrainment in Music

Aligning with music entails observable patterns of bodily responses to music. Such alignment happens within a global timing framework that is established through the synchronization of movements with salient time markers in the music, such as the

beat. Synchronizing is a very natural human response. Imagine yourself taking a walk with a friend – sooner or later you will find that your footsteps will unconsciously start synchronizing and your bodies will sway together in the same walking rhythm (e.g. Bargh & Chartrand, 1999; Bennet, Schatz, Rockwood, & Wiesenfeld, 2002). This process of being *pulled* towards synchronization has been called *entrainment* and helps one to align with music (Clayton, Sager, & Will, 2004). In general, the concept of entrainment refers to 'the coordination of temporally structured events through interaction' (ibid, p. 3). Note that events can be interpreted broadly: from heartbeats that synchronize to moving and dancing together (Clayton et al., 2004). Entrainment not only allows for precision and flexibility in timing between people, but also for a sense of participation and emotional bonding between them (Phillips-Silver, Aktipis, & Bryant, 2010).

Remarkably, entrainment also happens between people and music. People are pulled to synchronise motor output to sensory input, as when synchronizing physical actions with salient elements in the music, such as the beat (e.g. Ilari, 2015; Large, 2000; Phillips-Silver et al., 2010). By attracting or pulling people towards the beat, entrainment enables three sensorimotor mechanisms: finding, keeping and even being the beat and thus enables the emergence of a person's overall timing framework (phase alignment). *Finding* the beat is the process of recognizing the regularity in time of salient markers that allows *keeping* the beat, and eventually *being* the beat. Note that from finding to being, a transition occurs in effort. Finding the beat requires effort, but once the beat has been found and prediction runs smooth, it no longer requires effort, and energy is freed up to spend on other aspects of the musical interaction.

Illustration

> *To evoke the experience of entrainment, children might be invited to walk around the classroom freely whilst carefully listening to the sounds of their feet on the ground and to trying to walk in such a manner that the stepping of their feet sounds together. At first, this might require some effort and attention of the children ("finding"). At a certain point, they will manage to sound together, but this will require some effort too ("keeping"). The educator may then pick up on the average tempo and perform some music on, for example, the drums or piano that synchronize with the beat of the children's footsteps. Adapting the tempo of the music to the sound of the stepping feet might stimulate the illusion that the stepping causes the music ("being"). Changing the tempo of the music can provoke the necessity to re-adapt and engage in a new cycle of finding, keeping and being the beat.*

Entrainment, however, does not necessarily occur automatically or smoothly. First of all, the ability to entrain only emerges when certain conditions are met. A child must be able to *detect* the salient moments in the music (e.g. beat), to *perform* rhythm patterns (e.g. the music itself), and to *adapt* the performance of rhythm patterns to fit the overall timing framework (Phillips-Silver et al., 2010). Furthermore, the process of entrainment is influenced by human factors such as motor variability (Demos et al., 2014) and preferred tempo resulting from biomechanics and neuronal clocks (Styns, Van Noorden, Moelants, & Leman, 2007). For example, several studies have looked at the spontaneous synchronization of children with music and conclude that not only synchronization is easier or better when the tempo of the music is close to the preferred tempo of the child, but the preferred tempo can also change over time (e.g. Van Noorden, De Bruyn, Van Noorden, & Leman, 2017).

Predicting Music

Alignment and entrainment are fundamental processes of an embodied interaction with music. They are closely connected to a third basic mechanism, namely the process of prediction. Establishing a global timing framework through the mechanisms of entrainment and aligning is based on the ability to sense what comes next (to predict how the music unfolds) and the ability to predict the outcome of a movement, such as hitting a drum or reaching a point in space to the beat. An embodied cognition approach assumes that together with the biomechanical constraints of the body (such as the length and form of our legs and arms; e.g. Dahl & Huron, 2007), our state of arousal (feeling fatigued or being energetic) characterizes the way we interact and predict music. From this perspective, prediction or anticipation of music is viewed as the expected outcome of *bodily-mediated* perceptions and physical actions with music, rather than the expected outcome of a direct line between music and the brain.

Leman (2016) distinguishes between different interaction situations with music that are determined by predictive control. When the prediction of music is successful, the self-generated sensory information that stems from playing or moving to the music no longer requires conscious monitoring (*attenuation)* and attention is freed up for other elements in the musical interaction, such as concentrating on the melody or the actions of others.

Illustration

The children can be asked to work in pairs (mutual entrainment) and imitate each other's inter-phase alignment response to the music that is being played. Imitating this response might require some effort and continuous monitoring with regard to the direction, or speed of the movement. This can prevent the children from focusing on and adequately synchronizing with the music. Once the child can effortlessly imitate her peer, she no longer needs to pay attention to her own movements and the child then can concentrate on the music and on the joyful interaction with the other child.

Interestingly, Leman (2016) observes that interaction with music can become easier by facilitating the prediction of a certain channel in music, such as timing, over other channels, such as melody or harmony (*facilitation*).

Illustration

Once the children are used to performing a movement on each beat of the music, for example, a quadruple meter, they can be asked to only do the movement on a specific beat, for example, the first beat, or the first and third beat. This could be more difficult for children as the time in between their phase alignment responses is lengthened. However, different strategies can help children to optimise their feeling of timing in between the phase alignment responses. Children can step all the beats of, for example, a quadruple meter by using a specific movement pattern (see Fig. 6.1*) that helps them to localise where the first beat in the meter occurs. However, a child can get fully preoccupied with executing his movement pattern and loose connection with the music. Therefore, the educator may ask the children to stand in a circle so they can observe each other whilst*

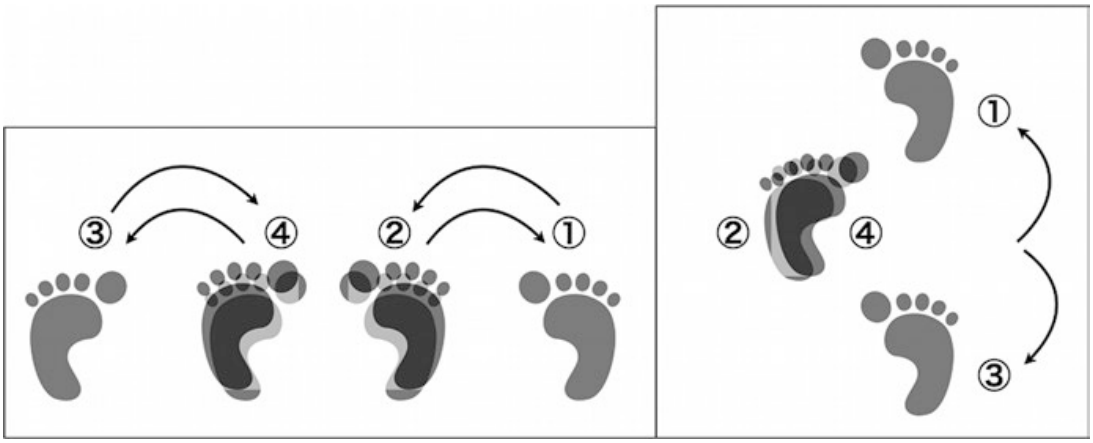

Fig. 6.1 Two examples of feet patterns in a quadruple meter

performing the movement pattern. Now the process of entrainment will help them to align their movements to those of their peers. As soon as the group can perform the movement pattern to the music as a whole (phase alignment), a sense of we-agency might be elicited, allowing the children to focus their attention on a different type of movement response. A child can be invited to stand in the middle of the circle and perform an additional movement based on the melody (interphase alignment), such as showing its contour with the arms or upper body, whilst maintaining the movement pattern in the feet. This then can be imitated by the group.

Finally, ambiguities in the music in terms of perceptual or affective-expressive content may hinder prediction. For example, music can be interpreted in different meters (e.g. duple meter vs. triple) or in different emotions (e.g. happy vs. sad). The ambiguity introduces uncertainty and interferes with pattern detection and with the emergence of higher level patterns that enable the enactment process. As such it becomes more difficult to couple states (e.g. sadness vs. happiness) to patterns (e.g. minor mode vs. short notes) and thereby to associate intentions with the music. Movement can reduce that uncertainty by aligning to the music in such a way that a certain content is favoured (disambiguation). For example, movement can be used to disambiguate metrical ambiguity such as binary versus ternary groupings of the beat (e.g. Naveda & Leman, 2009) or dancing a sad or happy choreography to ambiguous music influences the perceived expression in the music (Maes & Leman, 2013).

Illustration

Standing in a circle, the children listen to a familiar piece of music. The educator's aim is for the children to learn to hear different lines in the music, such as the bass line versus the melody. As children tend to focus on the melody, they might be uncertain about the bass line. To help them distinguish the bass line from the melody, the educator might introduce a movement that aligns to the bass line and thereby scaffolds the children in hearing the bass line.

To summarize this section, the process of turning sounds into meaningful music occurs through the association of movement and musical patterns, thereby facilitating the attribution of intentions to the music. This process has its roots in several basic mechanisms (alignment, entrainment, prediction) that not only support the cognitive processing of music but also facilitate its affective processing. This is an empowering process that leads to the expressive interaction with music.

Musical Interaction, Reward and Expression

Interacting with music is a rewarding activity. Neurobiological findings indicate that music affects the human reward system, a brain structure that is key to our motivation, behaviour and psychological makeup (Dubé & Le Bel, 2003; Zatorre & Salimpoor, 2013). According to Leman (2016), this rewarding nature stems from the expressive alignment with music, based on the use of musical patterns to enact musical expression. As such, feelings of reward through music are intrinsically related to the ability to anticipate and predict how the music unfolds (Huron, 2006; Salimpoor, Zald, Zatorre, Dagher, & McIntosh, 2015). Leman's argument is that the interaction with music involves the combination of the three interaction-reward states that were described in the section on alignment: agency, arousal, and valence. The three-state transition processes run parallel and, together with pattern processing, establish a *cognitive-motivational loop* that generates the rewarding and empowering nature of musical experiences: the mutual reinforcement of the three transition processes affects reward. The processing of expressive patterns involves the tight coupling between patterns and reward. Based on prediction, effort and expression as the major ingredients of the enaction process, the pattern processing that underlies alignment and entrainment involves the co-occurrence of arousal, positive valence and the feeling of being in control.

An interesting viewpoint is the idea that the rewarding nature of musical interaction is modulated by our innate expressive system through which the pro-social value of musical interaction is activated. Interacting with music appeals to the human urge to evoke expressive responses from others in order to establish an interaction that is rewarding for both (Leman, 2016). This expressive system involves the sensitivity (perception) to expressive elements in the music and the ability to generate expressive responses (action) to these elements. Such responses have a *biological origin*; reflexes as manifested in the urge to express oneself, and a *cultural origin* that involves the control of these reflexes as shaped by implicit and explicit learning processes. This means that musical activities that integrate movement not only support the development of controlling reflexes, also broaden the development of a learned repertoire of musical responses.

Technology Supporting Embodied Music Learning

The embodied music cognition research paradigm has a firm connection to interactive technologies, due to the use of sensor technologies that enable the measurement of bodily involvement in all kinds of musical interactions. An important research strategy of this paradigm is to optimize ecologically valid situations by integrating these sensor technologies in interactive music systems through which participants in experiments can engage in meaningful musical activities. This has led to a variety of applications that not only enable quantitative approaches to the study of the body in musical experience but also create new kinds of learning environments that bring opportunities to exploit the value of embodiment for learning and interaction.

For example, 'Besound' is an application intended to support young children in learning the basic elements of composition. Rhythm, melody, and harmony are explored by mimicking objects or characters, whereby the qualities of whole-body movements are analysed in real-time and used to control sound (Volpe, Varni, Addessi, & Mazzarino, 2012). Another example is the Music Paint Machine (MPM), an application that engages young music learners in a multimodal experience when learning how to play a musical instrument (Nijs & Leman, 2014, 2015). Using a combination of movement and music, children are enabled to make a digital painting. The concept of the MPM was embedded within the framework we have described. Through the combination of music, movement and creative visualisation, this application seeks to address the basic mechanisms of enactment. Based on the flexibility of the system, teachers can design a variety of practices ranging from free explorations with music, sound and visuals to activities based on direct instructions that guide young learners in a stepwise manner towards a specific educational goal (see Nijs, 2017, Nijs & Leman, 2014, 2015).

Departing from the concept of the Music Paint Machine, a consortium of universities (Ghent University, Rotterdam Erasmus), universities of the arts (Rotterdam, Amsterdam), the creative industry (The Patching Zone) and a cultural organisation (CKC Zoetermeer) is developing Singewing Space at the time of writing. This is a web-based interactive application for augmented blended music learning, based on an 'embodied' approach to music learning. The tool is designed to be used in and beyond the classroom, connecting face to face learning to distance learning (*blended*) and introducing the use of sensors in online learning (*augmented*). Using motion capturing and sound recording, the system will integrate the possibility to play, sing and move to music, alone or with different users at the same time (see Fig. 6.2). It will enable children to (1) collaboratively *create* a visualisation of music in a virtual environment, (2) generate sounds through physical movements therefore enabling the possibility to *respond* musically to each other's musical creations through physical actions, (3) *adapt* what is being or has been created, and (4) *reflect* on the musical experience.

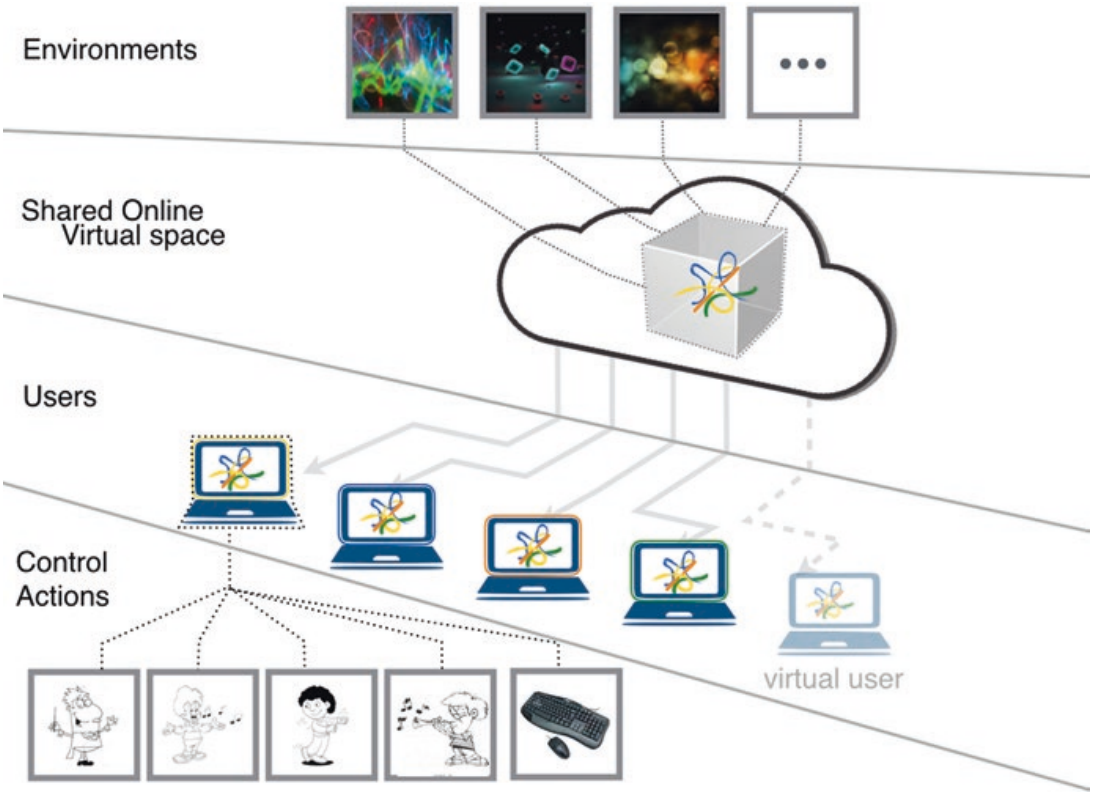

Fig. 6.2 The concept of Singewing Space. Different users can interact in a shared online virtual space, by choosing an action control (e.g., play, sing, move, keyboard)

We believe that Singewing Space has a large potential in the domain of early childhood music education. Although music technology can be met with some apprehension by early childhood music educators, it has the potential to open up learning opportunities for young children and to bridge music educational practices with the musical lives of young children at home (Young, 2009). Singewing Space allows for the transformation of musical ideas in visual representations and movements and for the transformation of visuals and movements into new musical ideas. Young (2009) notes that young children are strongly inclined to transform and see connections between different modalities and when they change musical ideas from one form to another it can generate new musical ideas and make new connections possible. Furthermore, transforming music in other modalities such as visuals and movements has the possibility to highlight certain musical aspects and to make them easier for children to share and understand. Due to the possibilities of the multimodal approach, Singewing Space implements the framework of embodied music cognition as presented in this chapter. Through the combination of music with visuals and movement the process of enactment and its basic mechanisms are addressed and this scaffolds the music learning process. For example, Singewing Space can visualise the beat automatically (phase alignment), but the movements in-between the beats (interphase alignment) can be visualised on the basis of a child's hand movement. Also, as it will be possible to track several children, differ-

ent users can be presented, for example with different coloured lines, and thus participatory creativity can be stimulated by co-creating a visualisation on the basis of music and movement.

Conclusion

Music learning is all about learning how to make sense of music. In early childhood music education, it is essential to design musical activities that provide children with rich musical experiences, provoking and supporting musical meaning-making.

Musical meaning-making can be seen from different perspectives, ranging from the sociological, the anthropological to the psychological. This chapter presented a psychological viewpoint, based on the theory of embodied music cognition This viewpoint starts from the idea that, at a fundamental level, musical meaning emerges from the process of enactment, an intentionality induction mechanism based on the association of sounds and movement patterns. The coupling of pattern processing to agency, arousal and affect leads to the rewarding effect of interactions with music. As such, the body plays an essential role at the highest levels of meaning-making of music.

In line with this viewpoint, it is important for music education to actively address this fundamental role of the body in musical meaning formation. Understanding the basic mechanisms of the enactment process, namely alignment, entrainment and prediction, can provide practitioners with insights that inform the systematic design of movement-based musical activities that promote children's embodied understanding of music. These basic mechanisms also provide lenses through which practitioners can observe the development of the children's understanding of music.

Technology provides the possibility to translate the theory of embodied music cognition and its research findings into a powerful learning environment. Implementing a multimodal approach based on the use of movement sensors and visualisation, these kinds of learning environments may support embodied music learning and participatory sense-making through co-creation based on collaborative enactment.

In conclusion, an embodied music cognition perspective might serve as a valuable tool for early childhood music practitioners for employing music learning activities that encourage children to connect sound and movement in a meaningful, expressive and fulfilling way. Vice versa, through practice, early childhood music researchers may be provoked to address more fundamental questions and issues about the body in relation to musical mean-making. As the theory of embodied cognition is still in development, it holds the future promise to connect to the broad and rich range of sources and theories on musical meaning making and embodied music learning.

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