Chapter 4:

Theoretical contributions to the study of music and movement

The path from music to body movement involves several complex systems: our sensory system, our central nervous system, and our musculoskeletal system. My aim in this chapter is not to give a systematic account of these various systems but rather to present selected theoretical perspectives that will shed light on the correspondence between the poumtchak pattern (at a tempo from 120 to 135 bpm) and a vertical movement pattern such as head nodding or upper-body bouncing. In the illustration below, various aspects of music perception and performance are mapped according to the areas of the human brain (mainly in the right hemisphere) that may be involved with them.[62] This illustration demonstrates the complexity of music listening and its many processes and potential cerebral interactions.

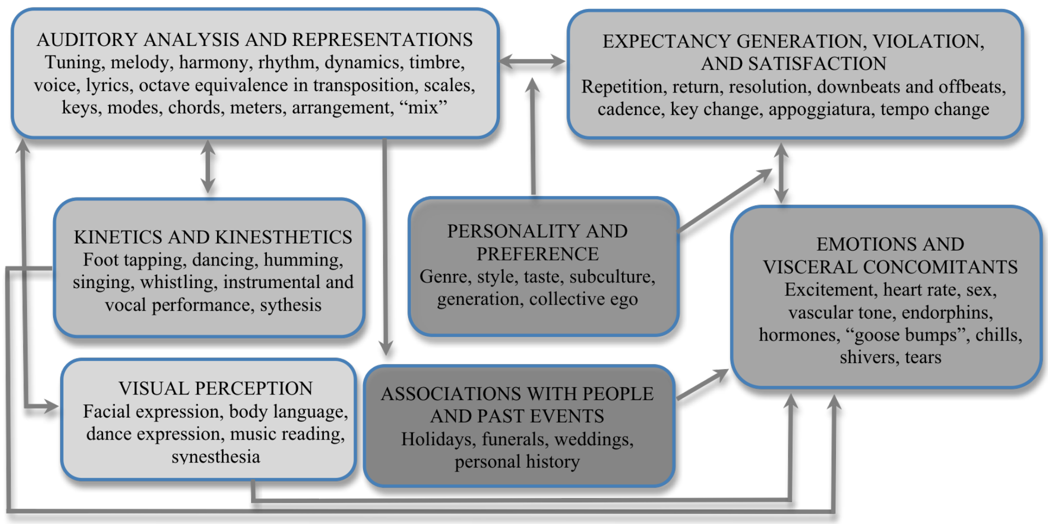

Fig. 4.1 Processes connected to music perception and performance mapped according to the areas of the human brain that may be involved with them.

Several studies have demonstrated that activity takes place in both the auditory and the premotor areas of the brain during either the perception or the production of music.[63] This overlapping of activity has been especially apparent with regard to the rhythmic aspects of music. Joyce Chen and her colleagues observed activity in the same premotor areas of

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[62] This illustration is part of a larger illustration that includes the brain and its various areas (from an article by neurologist Mark Jude Tramo; see Tramo 2001:55).
[63] For an overview, see Zatorre et al. 2007.

the brain whether subjects were asked to tap along with a rhythm or simply sat and listened without tapping along.[64] Such findings indicate the strong connection between musical rhythm and movement, whether virtual/imagined or actual/realized.

Extending our native connection between rhythm and movement to *specific* rhythmic and movement patterns is a challenging task, given the many complex processes involved in the proposed correspondence. Our sense of hearing, first of all, is profoundly influenced by our other senses – the vibration of rhythmic pulses can also be detected by skin receptors and internal receptors in muscles and joints, for example. Furthermore, we must allow for the possibility of an *interdependent* relationship between music perception and body movement so that a correspondence in the opposite "direction" (from movement to music listening) is also potentially relevant here.[65] In what follows, I will focus first on the various ways we attend to and perceive music and then on the ways motor processes are formed and activated.

The general perspectives on perceptual/cognitive processes put forward by the theories of embodied cognition and the ecological approach to perception will inform my discussion. Embodied cognition recognizes a mode of understanding wherein "body and mind are brought together,"[66] in the sense that the body's impact on cognition must be accounted for when we consider otherwise "mental" processes.[67] The ecological approach to perception originates in the work of psychologist James J. Gibson (1904–1979), who was particularly concerned with the impact of our moving body on perception. Drawing heavily upon evolutionary biology, Gibson saw the process of perception mainly as a search for what the environment around us has to offer.[68]

Attention and Perception

In a dance club, our senses are overwhelmed with stimuli: music, lights, dancing and moving individuals, faces, clothing, voices, laughter, smells, tastes, and so on. How, then, might a simple repeating alternation of a bass drum and a hi-hat sound compete for our attention?

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[64] Chen et al. 2008.

[65] The sound system, volume level, type of event, conditions of the physical listening environment, and so on also influence the outcome of a listening experience.

[66] Varela et al. 1991:27.

[67] In their influential book on embodied cognition from 1991, Francisco Varela and his colleagues point specifically to Buddhist meditative psychology, where reflection is a form of experience that is *performed* with an awareness of one's physical presence.

[68] Gibson 1979.

Musical sound from speakers is energy in the form of waves in the air that propagate according to their frequency content, loudness, and acoustics of the surroundings. These waves cause vibrations in our ears that in turn become impulses in our central nervous system, and our attention processes register some and ignore others.[69] Gibson's concept of "affordance" will help us clarify those processes.

AFFORDANCES OF THE POUMTCHAK PATTERN

Gibson based his work upon evolutionary biology's role in perception, given that human beings evolved from animals and therefore share their perceptual capacities: "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill . . . It implies the complementarity of the animal and the environment."[70] When sensing our surroundings, Gibson believes that we actively select only the information that we anticipate will be significant to us and ignore the rest. On the dancefloor at a club, this means that the people talking loudly somewhere behind us are much easier ignored than the musical sound from the speakers, which contributes significantly to what we are at the club to *do*. It demands our attention, particularly as we begin to couple rhythmic bodily movement to it. It is *useful* to us; the chatter at the bar, on the other hand, is not.

Gibson, significantly, sees perception and action as closely connected.[71] We do not hear sounds and *subsequently* interpret their meaning, but instead understand them directly and intuitively. We therefore can act on them instantly. From the evolutionary perspective, of course, animals that lack this ability have less chance of survival.[72] Crucial to the ecological approach, then, is the notion that we are not passive receivers but *active collectors* of information: "Perceiving is an act, not a response, an act of attention, not a triggered impression, an achievement, not a reflex."[73] Gibson links perception and action very closely in any human encounter with the outside world;

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[69] Space prohibits a detailed description of the physiological processes of sensory transduction.
[70] Gibson 1979:127.
[71] Graham Pike and Graham Edgar point to Gibson's occasionally ambiguous explanations of the processes that actually link perception to action. They see his description of the ways in which the perceptual system *resonates* with the information from the surrounding environment, without the intervention of cognitive processes, as lacking as an explanation of, for example, how a memory of prior experiences affects the actions (see Pike and Edgar 2005, 80–90).
[72] According to an article by Stephanie Pain (1999) in the magazine *New Scientist,* the California ground squirrel has evolved to be able to determine a rattlesnake's size and body temperature (a warm snake is more dangerous than a cold one) by its rattling sound. This information is used to instantly gauge the threat the snake represents.
[73] Gibson 1979:149.

perception leads to actions that in turn lead to new perception. This perception-action cycle is basic to the processes involved when we attend to our environments.[74]

While Gibson's work primarily deals with visual perception, Eric F. Clarke's *Ways of Listening* from 2005 extends Gibson's conclusions to aural perception, and especially music.

> The interdependence between perception and action that is emphasized in ecological theory suggest that every perceptual experience will bear the trace of an action component. In the case of music, these traces are not hard to find—they are displayed overtly in the foot-tapping, head-nodding, and body-swaying that are commonly observed in even the most constrained circumstances of the Western art music tradition.[75]

The correspondence between the musical poumtchak pattern and a vertical movement pattern seems to resonate with the perception-action cycle that Clarke describes.[76] The musical sounds are perceived with their afforded actions: the bass drum affords downward movement, while the hi-hat affords upward movement. Therefore we attend specifically to these sounds despite many potential distractions because they are coupled with certain specific actions. We respond actively only to those affordances that matter. With electronic dance music, we attend to those auditory patterns or specific sounds that afford movement, and when we respond to them, we initiate a self-reinforcing perception-action cycle (the patterns become more and more present to us as we move to them).

Clarke observes that "music affords dancing, worship, co-ordinated working, persuasion, emotional catharsis, marching, foot-tapping, and a myriad other activities of a perfectly tangible kind."[77] In other words, a musical sound event can have many affordances. Typically, one or two affordances may dominate, however, while others may be present only remotely. A poumtchak pattern at the beginning of a dance track can afford foot tapping, head nodding, dancing, or (virtual) playing along, as well as assorted mental activities such as recognizing the producer's style, recalling the track from another time or place, figuring out what production techniques are being used, and so on. Gibson does not limit the affordance to either absolutely subjective or absolutely objective relations; it may be totally contextually dependent, completely basic and universal, or some combination of the two. Certain affordances can be handled

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[74] The term "perception-action cycle" was first introduced by the psychologist Ulric Neisser (see Neisser 1976).
[75] Clarke 2005:62.
[76] See Clarke 2005:19ff for further discussion of the perception-action cycle.
[77] Clarke 2005:38.

simultaneously, without complication or competition, because they activate discrete parts of, or systems within, our bodies; others in fact comprise rival interpretations. These mostly unconscious choices guide our attention processes, or the act of hearing. The social context also helps to determine how (or which) affordances will be perceived; if no one in the club has started to dance yet, for example, a dance track will typically afford only more modest movements, such as foot tapping or head nodding.

ENTRAINMENT AND ATTENTIONAL ENERGY

The work of Gibson also inspired the research of neuropsychologist Mari Riess Jones, particularly around her use of the entrainment concept.[78] A centerpiece of her theories about attention and expectation in music, this compelling concept directly addresses the fact that rhythmic processes tend to adjust themselves to other occurring rhythms.[79] Presented with music with an isochronous rhythm, which is typical for a club environment, we might then be expected to respond by synchronizing our foot tapping or head nodding to it. Jones assumes that in such cases our attentiveness will oscillate,[80] determining in turn how we perceive various subtleties of rhythm, time, and pulse in music. She makes three assumptions regarding our "entrainment" to such events. First, she describes time as fundamentally related to event structure,[81] explaining that events may be "driving rhythms" or "environmental happenings arising from animate or inanimate activities."[82] Second, she describes time as it exists in the structures of inherently rhythmic organisms with diverse biological oscillations (such as ourselves) – our physiological systems or processes function as "driven rhythms." Finally, she considers the interaction between event time and organism time, or a driving rhythm and a driven rhythm. In line with ecological theories of adaptation in environmental processes, she concludes: "Rhythmic organisms interact, more or less effectively, with

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[78] My summary of Jones's theoretical perspectives is largely based upon her book chapter "Attention and Timing" from 2004, which is in turn based on earlier studies (see Jones 1976, 1990 and 1992). Her productive work with Edward W. Large is presented in their joint article titled "The Dynamics of Attending: How People Track Time-Varying Events" from 1999.

[79] The notion of entrainment dates back to the seventeenth century, when Christiaan Huygens noticed that two pendulum clocks placed on a common support would eventually synchronize with one another. See Clayton et al. 2005:4ff for a historical overview of the concept.

[80] A relevant topic beyond the scope of the present study concerns neural activation patterns: psychologist Daniel N. Stern, for example, points to "oscillatory" neural processes in describing how "adaptive oscillators" act like clocks and how their rate of neural firing can be "adjusted to match the rate of an incoming stimulation" (Stern 2004:80). Miriam Zacksenhouse has also identified "intrinsic oscillators" in neural circuits as the "basic building blocks of central pattern generators" (Zacksenhouse 2001:301).

[81] See also Gibson 1979:93ff.

[82] Jones 2004:50.

dynamic flow patterns of events via *entrainment*: An event's driving rhythm shapes an organism's driven rhythm through adaptations of period and phase. This entrainment process extends to rhythms that reflect the ebb and flow of attending energy."[83] In music, the driving rhythm is the energy a track passes along, while the driven rhythm is our perception of or action upon this energy. During this process we might "attend to" a flow of sound events as we orient ourselves: "Attending entails a synchronization of many internal attending periodicities with corresponding time spans within an event."[84]

Jones suggests that the process of attending is not stable or uniform but "requires a selective allocation of attending energy at critical points in time."[85] Within the dynamics of this process she describes "anticipatory attending" and "reactive attending": the first involves the expected onset of the relevant sound in an already recognized pattern, while the second involves the unexpected onset (or sound) or violated pattern. When synchrony is achieved through anticipatory attending, interestingly, "it ensures that attention is allocated *just before* the onset of an expected sound."[86] This form of synchronization resembles a phase-lock between the oscillation formed by expected sounds (in the music) and the oscillation formed by our anticipatory attending.

Entrainment models illuminate both music that is inclined to synchronicity and music that incorporates more challenging rhythmic strategies (time variations, early/late onsets, and so on). The poumtchak pattern is certainly of the former type: the four-to-the-floor bass drum pattern and upbeat hi-hat pattern offer clear, regular indications of orientation. Based on Jones's illustrations of how period and phase govern the entrainment of an internal oscillator to a stimulus's timing, I have made illustrations that demonstrate these mechanisms in relation to the poumtchak pattern.[87]

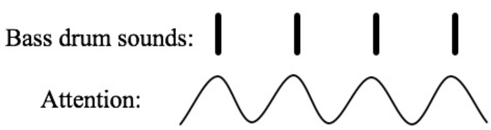

Figure 4.2: Attention illustrated as an oscillation in relation to a repeated bass drum sound, with the peak of the phase representing the peak of attention (which is located just before the expected sound).

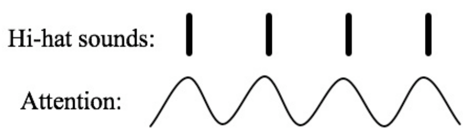

Figure 4.3: Attention illustrated as an oscillation in relation to a repeated hi-hat sound, with the peak of the phase representing the peak of attention (which is located just before the expected sound).

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[83] Loc. cit. Emphasis in the original.
[84] Loc. cit.
[85] Loc. cit.
[86] Ibid.:52.
[87] Ibid.:53, 57.

When the two patterns are brought together, the occurrences of expected sounds double in number.

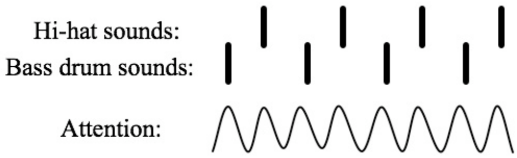

Figure 4.4: Attention illustrated as an oscillation, with the peak of the phase (the peak of attention) located just before the expected sound.

A characteristic feature of the poumtchak pattern in relation to other patterns in groove-oriented music is the multitude of reference points in its rhythmic structure. Moreover, the basic beat in club-oriented dance music is often kept more or less unaltered for very long periods.[88] This multitude of reference points, and their stability, makes the chances of a phase-lock (synchronization) extremely good. Jones writes: "When an event is rhythmically regular (i.e., very coherent) phase synchrony tends to be high and a narrow attentional pulse develops, indicating precise temporal expectations."[89] The poumtchak pattern's strict rhythmical regularity easily accommodates this precise temporal expectation. This is significant for two reasons. First, in electronic dance music tracks where the poumtchak pattern is present, there are often specific periods where the bass drum drops out (the "breakdown"). During the breakdown, then, listeners will be able to maintain their entrained oscillation even in the absence of the anticipated sound of the bass drum, and building up to the bass drum's reappearance in fact represents an excellent opportunity for DJs/producers to tease and excite their dancers. Second, the poumtchak pattern accommodates what Jones calls "attunement shifts," which "[direct] some attending energies away from the referent period to another level."[90] Thus various other rhythmic patterns can be attended to while one is still phase-locked to the poumtchak pattern.[91] Jones calls this flexibility "skilled attending" to various event

[88] In the illustrations, the oscillations representing attention are portrayed as uniform waves, though it is in fact likely that attention will peak in particular at the introduction of the pattern or when the pattern is interrupted by a conflicting sound or a shift in character. "Habituation" refers to a reduction in degree of response after a stimulus has been repeated several times; it may occur at various points and reduces one's attentional energy (Purves et al. 2008:330). The complementary energy from a moving body probably shapes these processes; moreover, the poumtchak pattern normally occurs in connection with other rhythmic patterns, and these combinations will of course impact habituation as well.

[89] Jones 2004:54.

[90] Jones & Boltz 1989:470.

[91] In Albert S. Bregman's book *Auditory Scene Analysis: The Perceptual Organization of Sound* (1990) he explains stream segregation in the perceptual processes of the human auditory system. His theories can elucidate how we group the various entries of a complex sound mix into separate streams.

levels. During a track there might be periods where dancers/listeners completely leave the referent level of the basic beat to attend (and move) to other patterns. Such shifts may be encouraged by certain emphases in the musical production, or the music may offer several event levels simultaneously, among which the dancers may choose.

Jones is primarily focused on perceptual processes involving how we attend to and perceive time and rhythm in music, so she does not discuss if or how body movements are then activated by the music. Ethnomusicologist Martin Clayton, on the other hand, observed physical movements (playing and beat marking) to determine how synchronized actions in music performance occur. His study focused on the production of music and thus included those motor processes that activate movements and he encountered "the emergence of complex hierarchies of entrained movement patterns in the course of producing music."[92] These observations might also be relevant for a clubgoer's head nodding or foot tapping, though those movement patterns may be simpler than the movements linked to the musicians in Clayton's study.

The poumtchak pattern has repeating sounds that clearly attract attention, and Gibson's and Jones's theories both shed light on how a listener/dancer who is familiar with the poumtchak pattern perceptually responds to it by allocating attentional energy to the sounds that constitute the basic beat and then entraining to the rhythmic structure of the music.[93] But how is this process then taken to the level of specific synchronized body movements?

Motor Processes

The skeletal muscles contract when the muscle fibres are excited by motor neurons, and these contractions (and relaxations) of the muscles produce body movement.[94] In what follows I will first discuss how motor memory related to vertical movement patterns is formed on a more general level. Then I will discuss how these movement patterns are activated, and why the poumtchak pattern seems to be particularly effective at doing so.

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[92] Clayton 2007:51.
[93] See Naish 2005 and unit 4 of Purves et al. 2008 for further descriptions of attention processes.
[94] For a good introduction to motor processes; see David A. Rosenbaum's book *Human Motor Control* (1991).

MOTOR MEMORY AND PERCEPTUAL LEARNING

We store information on how to perform physical tasks in our memories, and we are typically able to access this information in a straightforward and immediate fashion.[95] The series of motor actions required to ride a bike, for example, comes without thinking, but to consciously account for them takes much more effort. This information is encoded through bodily participation; when we first learn to ride a bike, we must consciously perform the required actions in the proper succession; later on however, we simply *do* them. So how is this type of motor learning accomplished for vertical movement patterns that are performed in response to a musical rhythm?

Returning to the ecological approach to perception and the close link between perception and action, we appear to learn actions related to perceptual inputs through both individual and guided experiments throughout our lives. Gibson sees all knowledge as an extension of perception:

> The child becomes aware of the world by looking around and looking at, by listening, feeling, smelling, and tasting, but then she begins to be *made* aware of the world as well. She is shown things, and told things, and given models and pictures of things, and then instruments and tools and books, and finally rules and short cuts for finding out more things. Toys, pictures, and words are aids to perceiving, provided by parents and teachers. They transmit to the next generation the tricks of the human trade. The labors of the first perceivers are spared their descendants.[96]

Through what Gibson describes as "perceptual learning processes" our knowledge of the world around us matures.[97] The members of a new generation inherit the "tricks of the human trade" from their parents and other role models, who teach them how to act based upon their own experiences. In a milieu where dancing is a common activity, then, we learn how to move to music, and movement becomes a likely affordance of music. If we, on the other hand, grow up in a milieu where dancing is not common, music that appeals especially to movement makes no sense. Dance music's affordances are therefore perceived differently, and the poumtchak pattern is no exception.

In describing perceptual learning processes, Eric Clarke also emphasizes that we become "increasingly sensitive to distinctions within the stimulus information that were always there but previously undetected."[98] Perceptual learning processes allow us to

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[95] See, for example, Snyder 2000:chap. 6 and Rutherford 2005 for descriptions of long-term memory.
[96] Gibson 1979:258; emphasis in the original.
[97] His wife, the psychologist Eleanor J. Gibson, has also done substantial research on perceptual learning processes; see, for example, Gibson & Pick 2000. For perceptual learning processes in relation to music, see Clarke 2005:22ff.
[98] Clarke 2005:22.

improve upon our ability to differentiate between subtle variations. With reference to Gibson's theories, the musicologist Björn Vickhoff describes how the sound engineer learns to "differentiate features in music [that are] unperceivable to others."[99] Two bass drum sounds that appear alike to most listeners might be quite distinct to the professional producer of dance music – moreover, one might be preferred based upon its specific perceived capacity to evoke body movement.[100] Among dancers, basic perceptual learning leads to the ability to move in synchrony with a returning rhythmic pattern, while more advanced differentiation might include the ability to hear differences in the sounds of various tracks and then translate those differences into slightly divergent movements. As one listens more, one recognizes more patterns in more complex mixes, as well as minor differences in timing or sound-related realizations.

The existence of perceptual learning processes may account for a connection between music and movement at a general level. The specific *vertical* movement patterns like head nodding and foot tapping that are often performed in connection with musical rhythm, however, demand further investigation. We recognize right away the similarity of these patterns to basic human movements like walking, running, or jumping, which rely upon quite similar patterns of contraction and relaxation of the muscles.[101] In an article from 2004 about groove in popular music, Lawrence Zbikowski "explore [s] a way to model the knowledge basic to producing and understanding musical grooves."[102] First he links basic human experiences to musical rhythm: "Our conceptions of rhythm in general, and of musical rhythm in particular, are strongly informed by the manifold regularities basic to human experience – the regular cycles of our breathing, the alternation of our limbs in walking or the repeated actions that accompany our physical work."[103] He then forms a conceptual model that comprises the basic cognitive structures of regularity, differentiation, cyclicity, and embodiment.[104] Central to Zbikowski's article is Lawrence Barsalou's theory of perceptual symbol systems, which Barsalou summarizes as follows:

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[99] Vickhoff 2008:85.
[100] Certainly the Western inclination to favour melody as the main focal point in popular music will hinder listeners' ability to differentiate among sounds that are considered to be "accompaniment."
[101] The bio-kinetics of movement and the effects of gravity and various inertial forces on the moving body might also be relevant for my discussions. See van Norden 2010. Among the topics Van Norden discusses are connections between human locomotion, dance, and tempo in music (157ff).
[102] Zbikowski 2004:273.
[103] Ibid.:277-278.
[104] Ibid.:276.

> A perceptual state can contain two components: an unconscious neural representation of physical input, and an optional conscious experience. Once a perceptual state arises, a subset of it is extracted via selective attention and stored permanently in long-term memory. On later retrievals, this perceptual memory can function symbolically, standing for referents in the world, and entering into symbol manipulation. As collections of perceptual symbols develop, they constitute the representations that underlie cognition.[105]

According to Barsalou, then, a subset of a perceptual state is stored for use later on in various cognitive processes. Zbikowski uses Barsalou's theory mainly to describe a route from embodied knowledge to an abstract understanding of rhythm. This understanding then has to be transferred *back* into bodily movement when we play an instrument or move/dance while listening to music. In the context of consideration here – a rather simple movement pattern performed by participants of a culture where music is not written down or learned systematically – it would appear more likely that movement patterns are in fact stored and retrieved directly. In this case, then, the "neural representation of physical input" not only functions symbolically but also directly informs our motor processes.

The link between rhythm in music and movement may originate early in our childhoods. Several books on music and children address prenatal sound experiences and their assumed relevance to the development of a child's musical abilities.[106] The human foetus hears rhythmic sounds like its mother's heartbeat and breathing. It also experiences movements – its own and its mother's.[107] The prenatal development of the vestibular system is likely relevant to our equation of music and movement, because it is anatomically and physiologically connected to our auditory system. Located in our inner ear, the "saccule" consists of sensory cells that communicate information about head movement to the brain. Interestingly, Jessica Phillips-Silver and Laurel Trainor have conducted studies of seven-month-old infants to see whether the metrical interpretation (duple or triple meter) of an ambiguous musical rhythm would be influenced by body movement.[108] In tandem with other studies conducted with adults, they concluded that "the strong, early-developing relation between the auditory modality and movement-

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[105] Barsalou 1999:577–578. Barsalou contrasts his theories with "amodal symbol systems" where "perceptual states are transduced into a completely new representational system that describes these states amodally" (ibid.: 579). Here he intersects with Gibson, who also favoured a view of perception whereby information is directly interpreted from its stimulus, in contrast to a view of perception as an act of gathering, organizing, and interpreting unstructured data by our brains.
[106] See Flohr 2005 and McPherson 2006.
[107] See DeNora 2000:77 and Parncutt 2006.
[108] Phillips-Silver & Trainor 2005.

related sensory inputs is maintained in adulthood"[109] and that "musical rhythm patterns elicit movement, that movement of the body can influence auditory perception of the metrical structure of rhythm, and that vestibular and auditory information is integrated in perception."[110] In his book on the musical lives of young children, John Flohr writes "Children are predisposed to move to the sound of music."[111] This inclination appears to be grounded in the interaction between the perception of sounds and the proprioception of body movements at early stages of human development.[112]

Lily Chen-Hafteck has studied her own daughter's development of physical movement to music. In the first months of life, a lack of muscle control limits her daughter's ability to exhibit any bodily interaction with music, but between seven and twelve months she begins to move, mainly to the beat. Infants start to perform up-and-down movements with the torso and feet (while lying on the floor) as soon as they are able to, and in line with Chen-Hafteck's observation, rhythmic music with a definite beat can intensify or interact with such movements. She further reports that by thirteen months her daughter "walked and bounced in standing position to the music."[113] Such activities demonstrate that vertical movement patterns might well have roots in early childhood and already comprise likely affordances to rhythm in music. In cultures where dance and movement to music is prevalent, music/movement relations would probably develop even faster.

A wide variety of individual participants appear in a typical club environment, however. They all have different bodies with different predispositions for moving to the music. How are consistent vertical movement patterns then spread throughout such a culture? What mechanisms are significant for activating them?

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[109] Philips-Silver & Trainor 2007:543.
[110] Philips-Silver & Trainor 2008:100.
[111] Flohr 2005:98.
[112] It should be noted that because a mother's movements and vocal sounds (singing, talking, dancing, playing an instrument), as well as the sounds from outside, communicate a specific cultural context, this stage/process of human development should not be considered "universal." Middleton writes: "Modern genetic theory insists that the question of whether 'nature' or 'nurture' has priority is in principle not susceptible of resolution; this is because it is impossible to find, or to conceive of finding, even the smallest, the most embryonic bit of human nature which is not already nurtured" (Middleton 1993:178).
[113] Chen-Hafteck 2004:3. The pleasure children derive from bouncing, jumping and swinging may also have a biological basis. Hodges writes: "The cerebellum is directly linked to the limbic system, specifically a region of the hypothalamus known as the pleasure center. The result is that body movement brings pleasure" (Hodges 1996:44).

MOTOR ACTIVATION

People have an inclination to imitate movements made by others. The recent discovery of "mirror neurons" reveals that motor networks used to perform a certain action are partly triggered by the act of observing someone else performing it.[114] This discovery applies also to sound stimuli. In 2003 the neuroscientist Christian Keysers and his colleagues identified audiovisual mirror neurons that discharged regardless of whether the subjects (monkeys) performed, heard, or saw a specific sound-related action.[115] Istvan Molnar-Szakacs and Katie Overy explain how mirror neurons may apply to music listening:

> The experience of music thus involves the perception of purposeful, intentional and organized sequences of motor acts as the cause of temporally synchronous auditory information. Thus, according to the simulation mechanism implemented by the human mirror neuron system, a similar or equivalent motor network is engaged by someone listening to singing/drumming as the motor network engaged by the actual singer/drummer; from the large-scale movements of different notes to the tiny, subtle movements of different timbres.[116]

When we hear someone playing an instrument, then, our mirror neurons will activate parts of the motor system in our brains and thus evoke experiences of movement as if we were actually playing too. This hypothesis is central to the theoretical framework for motor-mimetic processes in the perception of music.[117] Rolf Inge Godøy emphasizes further the embodied relationship and close connection between perception and action as well as our multimodal manner of perception: "The idea of gestural affordances of musical sound initially rests on the assumption that musical sound is a transducer of *source-information*, meaning both the actions that go into producing the sound . . . and the material properties of the sound source."[118] The movements (or gestures) required to produce sounds on an instrument are viewed as a source for a meaningful experience of "sound as movement" for the listener. More precisely, the musical sound evokes our awareness of the instrument as a source for producing it.[119]

Compared to a concert situation, where musicians are visually present, a club environment usually lacks the visual stimuli of relevant source information. But the

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[114] See Rizzolatti & Craighero 2004.
[115] Keysers et al. 2003.
[116] Molnar-Szakacs et al. 2006:236.
[117] The term "motor-mimetic" was introduced by Rolf Inge Godøy (2001). He and his colleagues use the term "musical gesture" to denote a combination of sound and movement that affords meaning. See Godøy & Leman 2010.
[118] Godøy 2010:106; emphasis in the original.
[119] In an experiment on "air piano," Godøy and his colleagues investigated how the instrument provided source information to respondents of different knowledge levels. They found a fairly clear correspondence between the participants' movements and the actions that were actually needed to produce the sounds on the instrument, though obviously the experts were able to imitate this more closely (Godøy et al. 2006).

effect of mirror neurons could still be active on a visual level, because clubgoers *watch each other:* when someone sees someone else nodding her head or tapping her feet, motor regions for performing these actions may be activated. Many DJs move a lot while they work, providing another potential visual source for vertical movement patterns.[120] Furthermore, according to studies of dance-related motor simulation, this correspondence or imitation is more likely regarding actions with which we have real physical experience.[121] Thus body movements that are already common to a culture will readily recur within it.[122]

To what extent do the musical sounds of electronic dance music serve as a "transducer of source-information"? Even though the club environment is almost devoid of traditional visual musical sources, listeners may draw on related experiences with musical and other sound-producing sources. Depending upon a listener's knowledge of acoustic drumming, for example, the poumtchak sounds might evoke the action of playing the drums. The four-to-the-floor bass drum pattern is produced with a regular downward movement of the foot on a pedal, one that corresponds perfectly with straightforward (non-drumming) foot tapping. On a more general level, drum sounds may evoke the action of hitting a batter-head with a downward strike. Knowledge of the actual production processes of electronic dance music, however, may counteract this particular motor-mimetic action because the drums are usually programmed (or played on a MIDI-keyboard) rather than played "live," and they are recognizable as such.

Musicologist Arnie Cox emphasizes the embodied human experience involved in how we make sense of sounds. He believes that we unconsciously compare "sounds we hear with the sounds we have made ourselves,"[123] and that we imitate these sounds (actually or virtually) when we listen to music. Since all humans have a voice box, he sees the voice as vital to these acts of imitation, and it would seem logical that an active use of the voice in making sounds is also relevant to how we experience dance music. The "human beatbox" (the production of rhythmic sounds with the mouth) is a

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[120] Vertical movement patterns probably also derive from the auxiliary movements of musicians, which audiences pick up through motor-mimetic processes. By watching musicians playing rhythmic patterns while moving their heads, upper bodies, or feet, spectators adopt the same vertical movement patterns and gradually transfer them to listening scenarios. Musicians are at times also spectators as well and may transfer performance-related movements to the activities of listening or dancing.

[121] Calvo-Merino et al. 2005 and 2006; Cross et al. 2006.

[122] Leen De Bruyn and colleagues conducted an experiment with children and adolescents who were dancing to music that compared a situation in which they could see each other with one in which they could not. It demonstrated that both intensity of movements and mean synchronization to the beat were greater in the former situation, which indicates the significance of social interaction when dancing and moving to music (De Bruyn et al. 2009).

[123] Cox 1999:59.

widespread hip-hop phenomenon that may have influenced musical participation in adjacent music cultures. Vertical movement patterns could be affected or even activated by a vocal imitation of the sounds of the poumtchak pattern. However, in order to explain why the poumtchak pattern works so well in this regard, we must look to other mechanisms.

As mentioned earlier, the steady stream of sounds in the poumtchak pattern provides many critical points of attention. In accordance with Mari Riess Jones's theories of dynamic attending these critical points can drive bodily oscillations in our distribution of attentional energy. To what extent do such bodily oscillations also equate with the activation of motor commands? Daniel Schneck and Dorita Berger describe correspondences between rhythmic pulse and muscle activation:

> Rhythmic pulsation embodies a consistent symmetrical balance of energy output, of fall and rebound . . . of tension and relaxation. Rhythmic vibration in music involves the same steady stream of force–rest–force–rest, of systematic strong and weak impulses, of alternating *flexion* (contraction), *release* (relaxation), and *extension* as in the case for paired and coupled muscular behavior.[124]

A symmetrical rhythmical balance obviously happens in music to varying degrees (when it exists at all), but the poumtchak pattern is an extreme example of such balance, with its specific sounds for both downbeats and upbeats. It communicates an unambiguous rhythmic structure that allows the listener to easily determine the main pulse and convert it to a movement pattern. But, as Schneck and Berger imply, might the rhythmic pulse also activate the muscle commands directly? When a vertical movement pattern is synchronized with the poumtchak pattern in the music, there is powerful correspondence between the alternating sounds and the contractions and relaxations of the muscles (force-rest-force-rest). The movements in either direction are supported by a unique sound, which means that there is a direct relationship between sounds and movements.[125] The extensive use of the poumtchak pattern also in aerobic mixes further indicates its connection to muscle activation. As pointed out by one of the informants of Sophie Belcher's study of aerobic classes, music with a simple strong beat made him/her work out harder.[126] This may be because the oscillation of attentional energy initiated by the steady stream of critical points in the rhythmic pattern also causes oscillations in

[124] Schneck & Berger 2006:139.
[125] A simple experiment to test sound's significance for movement is to compare (1) a side-to-side or up-and-down head movement accompanied by a tic-toc-tic-toc with (2) the same movement accompanied by only tic–tic– (same tempo, but without the toc in between).
[126] See quotation on page 102. DeNora 2000:101.

muscular behaviour – the external rhythm (in the music) drives the internal rhythm (in the body), not only in terms of perception but also in terms of actual rhythmic movement of the body.

VERTICALITY IN MUSIC

But why down on the downbeat and up on the upbeat? Here I will pursue the idea that motor schemas are formed through our perceived understanding of verticality in music – of high and low, up and down, above and below, and ascending and descending.[127] This will clarify the link between low-frequency and high-frequency sounds and the low and high positions in a vertical movement pattern.

Sound waves, of course, do not actually move up or down in physical space with the pitch we are experiencing, as Arnie Cox points out: "Verticality is not inherent in music (let alone in its notational representation); it is not *there* to be observed (heard) in the music, but it is instead a product of logical, metaphoric conceptualization."[128] Or as Björn Vickhoff adds: "Although there are no obvious directions of melody movement, most listeners feel directions in music. When the melody is moving 'upwards' or 'downwards' you get a feeling of spatial direction."[129] Such processes of conceptualization have been addressed by cognitive semantics.[130] In *Philosophy in the Flesh* from 1999, linguist George Lakoff and philosopher Mark Johnson employ the concept of "primary metaphors" (as opposed to "complex metaphors") to illustrate the basic connection that exists between abstract and literal expressions.[131] Primary metaphors are metaphors that have been incorporated into our worldview so thoroughly that we no longer see them as metaphors. They are based on correlations between expressions and embodied experiences and are, according to Lakoff and Johnson, fundamental to all thinking regarding subjective experience and judgement:

> We do not have a choice as to whether to acquire and use primary metaphor. Just by functioning normally in the world, we automatically and unconsciously acquire and use a vast number of such metaphors. Those metaphors are realized in our brains *physically* and

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[127] I use the simple plural form "schemas" instead of the standard form "schemata".
[128] Cox 1999:50; emphasis in the original.
[129] Vickhoff 2008:52.
[130] See Lakoff & Johnson 1980 and 1999, and Johnson 1987. Also see Echard 1999, Aksnes 2001 and 2002, Larson 2002, and Gur 2008 for analyses drawing upon the Lakoff-Johnson theory of metaphor as related to meaning in music.
[131] The distinction was introduced by Joe Grady, who used "primitive" and "compound" in an article from 1996 (Grady et al. 1996) before settling upon "primary" and "complex."

> are mostly beyond our control. They are a consequence of the nature of our brains, our bodies, and the world we inhabit.[132]

With reference to Christopher Johnson's "theory of conflation,"[133] Lakoff and Johnson then describe how primary metaphors are formed: "For young children, subjective (nonsensorimotor) experiences and judgments, on the one hand, and sensorimotor experiences, on the other, are so regularly conflated—undifferentiated in experience—that for a time children do not distinguish between the two when they occur together."[134] Lakoff and Johnson use the example of the subjective experience of affection and the sensory experience of warmth through being held.[135] Even when children eventually develop the ability to differentiate between them, they will preserve associations from one domain (the "source domain") to the other (the "target domain"). Thus "affection" and "warmth" will be connected, and in relation to affective meaning, "warmth" may be used where no actual (literal) high temperature is present. Similarly, metaphors are linked to movements: when we use "falling" metaphorically in the phrase "falling asleep," the downward movement is projected upon the transition from consciousness to unconsciousness. Yet we have not "fallen" anywhere.

Verticality underpins our understanding of music as well, though the adverbs "up" and "down" and the adjectives "high" and "low" imply nonexistent spatial orientations there.[136] According to Lakoff and Johnson such parallels "arise from the fact that we have bodies of the sort we have and that they function as they do in our physical environment."[137] Motor schemas and image schemas are parts of the conceptual structure we form through sensorimotor experience and visual perception. Bob Snyder describes schemas as "memory structures created by generalizations made across seemingly similar

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[132] Lakoff & Johnson 1999:59, emphasis in the original.
[133] Johnson 1999.
[134] Lakoff & Johnson 1999:46.
[135] Loc. cit.
[136] My eldest daughter at the age of six already had ideas of "up" and "down" in music, even though she was not familiar with notation. If I asked her to sing a "high" note, she tended to stretch her upper body so as to reach "up" to the pitch, and vice versa. These movements may point to the fact that it is easier (and therefore more natural) to lift the head/upper body and stretch the throat to make "higher" pitches; on the other hand, perhaps my daughter had already adapted to the metaphoric understanding of verticality in music. Zbikowski confirms that "low" sounds resonate in our chests while "high" sounds do not (they seem instead to be located nearer to our heads); Zbikowski 1998:3.9. On the question of the universality of verticality in music Zbikowski also remarks upon how other languages characterize pitch relations differently: "Greek music theorists of antiquity spoke not of 'high' and 'low' but of 'sharpness' and 'heaviness'; in Bali and Java pitches are not 'high' and 'low' but 'small' and 'large'; and among the Suyá of the Amazon basin, pitches are not 'high' and 'low' but 'young' and 'old'" (Zbikowski 1998:3.5). See Cox 1999:31ff for further discussion of the various cultural sources of vertical relations.
[137] Lakoff & Johnson 1980:14.

situations in the environment."[138] These affect perception and shape actions. In the same way that we use image schemas as points of departure for producing images when we are told stories, we use motor schemas to form motor commands when listening, dancing, conducting, singing, or playing an instrument. A motor schema related to tempo in music will support a correspondence between fast rhythms and rapid body movements; a motor schema related to verticality in music will encourage vertical movements in response to pitch. This latter motor schema has been shaped through our encounter with sources of verticality in music. Cox refers to ten such sources that possess both literal and metaphoric features:

> Of the ten sources of verticality, three are based on literal vertical relations—(1) verticality in staff notation, (2) verticality in vocal experience, and (3) the propagation of sound waves—and seven are based on metaphoric verticality—(4) "higher" and "lower" frequencies, (5) the "higher" and "lower" perceived loudness levels of high and low notes, (6) the "higher" and "lower" amounts of air used for high and low notes, (7) the "higher" and "lower" magnitudes of effort needed for high and low notes, (8) the "higher" and "lower" degrees of tension in producing high and low notes, (9) the association of "high" levels of emotional intensity and pitch at climaxes, and (10) the metaphoric state-locations of tones in pitch space.[139]

Several of these sources are mainly corporeally experienced and do not have to trigger any explicit knowledge before helping us to form motor schemas. In a culture where music is written (as notation) and actively learned, verticality in music likely arises from a mixture of rational *and* corporeal knowledge. Presumably the participants in the main survey presented in the preceding chapter are to some extent familiar with notation, possess at least some vocal experience, and recognize the concept of "high" and "low" frequencies. Music students are undoubtedly more accustomed to notation and the conventions surrounding singing and playing instruments than clubgoers are as well. Still, a producer of dance music, it should be noted, constantly confronts the notion of "high" and "low" frequencies. The sound systems in clubs are usually organized with separate subwoofers and tweeters that are situated vertically, so that "low" sounds come from the speaker beneath the one that produces "high" sounds.[140] The loud volume level in clubs also intensifies how sounds resonate in our body. Low-frequency sound waves have a greater impact than high-frequency waves in how they are felt most noticeably in

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[138] Snyder 2000:102.

[139] Cox 1999:18–19. Some of these sources are based on the experience of singing or playing certain instruments and are blended with other metaphoric associations of "high" and "low," especially greater or lesser quantities/magnitudes ("more = up, less = down") (Lakoff & Johnson 1980:15).

[140] This vertical placement has little specific impact upon low frequencies, but high frequencies are generally more directional, so tweeters are often placed at ear height. See Rossing et al. 2002: chap. 24.

boneless body regions like the abdomen, which is obviously below our ears (and eyes), thereby contributing to the physical realization of a "low" frequency.[141]

Sensorimotor experiences are important to both image schemas and motor schemas. The alternation of "low" and "high" is not as obviously "vertical" as a continuous pitch movement either up or down, but in relation to a vertical movement pattern, the structural parallel is pivotal. The bass drum sound evokes the "low" position of verticality, while the hi-hat sound evokes the "high" position. While theories of motor-mimetic processes view musical sound as a "transducer of *source-information,*"[142] it may also be a transducer of *verticality-information,* from music to spatial orientation. The information that is part of the alternating "low" and "high" in the poumtchak pattern is thereby transduced to analogous up-and-down movements.[143]

Head nodding, upper-body bouncing, foot tapping and similar vertical movement patterns are also performed in response to music with other rhythm patterns, but certain features seem to make the poumtchak pattern especially effective in evoking them.

1. *The steady stream of reference points (critical points of attention) using specific sounds to mark out the downbeats (the bass drum) and upbeats (the hi-hat) of a basic rhythmic structure.* The alternating pattern of bass drum and hi-hat sounds not only marks out the rhythmic pulse but communicates the basic rhythmic structure very clearly. This steady stream of reference points makes it easy to achieve synchronization of attentional energy and motor commands.

2. *The regular alternation of the low-frequency bass drum sound and the high-frequency hi-hat sound.* These alternating sounds offer the listener a musical verticality that can be mapped directly onto the "down" and "up" positions in a vertical movement pattern. When a motor schema of up and down is mapped onto the "up" and "down" in music, the "low" bass drum and the "high" hi-hat can be experienced as literally generating "up" and "down" movements.

3. *The interaction of these two features.* In the figure below, an undulating line is drawn onto a sonogram of the poumtchak pattern. The bass drum sounds are the four dark areas

[141] The bio-kinetics of movement and the effects of gravity and various inertial forces on the moving body might also be relevant for my discussion. See van Norden 2010.
[142] Godøy 2010:106; emphasis in the original.
[143] Descending pitch movements are common features in the bass drum sounds created for electronic dance music tracks; see chapter 8.

at the lower part of the sonogram, while the hi-hat sounds are the four pillars between them. The positioning of the sounds in the sonogram emphasizes their vertical relation, and the metric grid on top displays the rhythmic structure of downbeats and upbeats. The undulating line illustrates a vertical movement pattern but might also indicate oscillatory processes such as the distribution of attentional energy (where both the peaks and the troughs indicate peaks of attentional energy) and muscle commands (where the peaks and troughs indicate contractions and relaxations of the muscles).

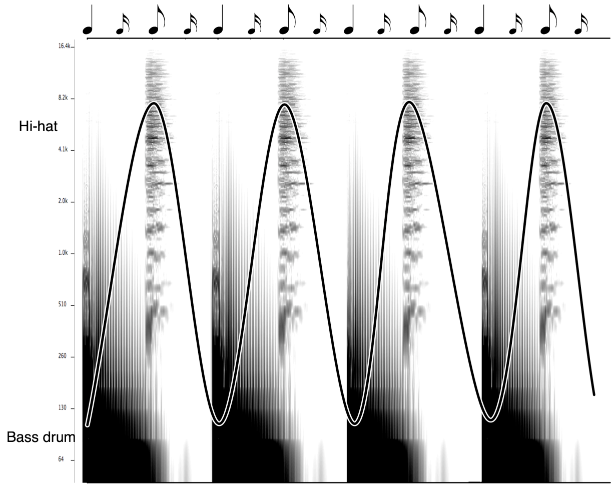

Figure 4.5: A sonogram of a poumtchak pattern (from Daft Punk's *Phœnix*, 1996, 0:15–0:17) in a grid showing the metric structure with an undulating line illustrating a possible movement pattern and/or oscillations in bodily processes such as the distribution of attentional energy or muscle commands.

Notions of verticality, which are embedded in our understanding of musical rhythm (downbeat/upbeat), form clear expectations about which sounds are appropriate in what positions in a rhythmic structure. If the bass drum sound is associated with "heaviness" and the hi-hat with "lightness," this leads to notions of accented and unaccented beats and ultimately to assumptions regarding the overall metric structure.[144] It may be difficult to pinpoint which of these features is at stake when a correspondence between the poumtchak pattern and a vertical movement pattern occurs. However, the fact that their combination and interaction is likely to increase the chances of such an occurrence seems to be beyond doubt.

[144] After I posed a question concerning the poumtchak pattern and its corresponding movements on djforums.com in June 2007, a discussion started between two DJs about sounds and verticality versus rhythmic structure in determining up-and-down dance movements: see webpage 4.1.

Summary

In this chapter I have presented and discussed various theoretical contributions towards the elucidation of the correspondence between the musical poumtchak pattern and a vertical movement pattern. I have discussed how the poumtchak pattern contains impulses for synchronized movements and, moreover, how its conveyed verticality leads to expectations about direction of movement.

In the realm of attention and perception processes, James J. Gibson's theories of ecological perception, and his term "affordance," suggest ways in which a musical pattern might capture our attention. Gibson proposes that the "affordances" of the environment guide our perception and direct our attention to what is relevant in specific situations. If the poumtchak pattern affords movements in a club environment – that is, it is relevant because we can move to it – then we attend to it.

Mari Riess Jones's works on entrainment and the ways in which we attend to music offer a theoretical explanation for how a "driven rhythm" – a responding oscillation of attentiveness in the listener, may align itself with the "driving rhythm" of the music. She claims that certain critical points in the music demand our attention and, in turn, encourage the forming of expectations regarding when such critical points are likely to reoccur. The poumtchak pattern has a steady stream of reference points that would work as these critical points in the distribution of attentional energy, in turn facilitating the synchronization between musical rhythms and bodily oscillations.

Gibson's theories on perceptual learning processes clarify connections between vertical movement patterns and musical rhythms. According to Gibson, we acquire connections between perception and action through individual experimentation and guided learning throughout our lives. In this way we come to code vertical movement patterns onto the input of a rhythm pattern (like the poumtchak). Lawrence Zbikowski even suggests a link between rhythm in music and basic physical human activities like walking or jumping. Correspondences between musical rhythm and body movement at early stages of a child's development strengthen this presumed link.

The prevalence of vertical movement patterns in a club environment, and the mechanisms that activate them, may be further explored using research and theories on motor-mimetic processes. Our inclination to imitate others, first of all, is supported by the discovery of "mirror neurons" – motor networks are activated not only when we perform an action, but also when we observe one. Thus motor networks related to the production of sounds on instruments may be activated when we observe or hear someone else who is playing.

The poumtchak pattern consists of a steady stream of alternating sounds that clearly communicates a rhythmic structure of downbeats and upbeats. The resemblance between rhythmic pulsation and coupled muscle behaviour facilitates a conversion of musical pulse to vertical movement patterns and reveals the link between the alternating sounds of the poumtchak pattern and the activation of muscle commands. The movement in a specific direction (down on the downbeat, up on the upbeat) must be associated with a commonly shared experience of perceived verticality in music. The metaphor theory of Lakoff and Johnson elucidates how such a notion of verticality might originate in metaphors at a basic, unconscious level, which is useful, given that verticality in music is simply a construction of our understanding (sound waves do not move up or down). Lakoff and Johnson explain how our use of metaphors is linked to sensorimotor experiences that form our understanding and shape image schemas and motor schemas. Bodily experiences of musical verticality thus contribute to motor schemas that provide a direct link between the "low" and "high" sounds of the poumtchak pattern and the "low" and "high" positions of a vertical movement pattern.

Three points stands out as especially relevant to the correspondence between the poumtchak pattern and a vertical movement pattern; (1) the steady stream of structural reference points in the music, (2) the alternation of two sounds with opposite frequency content, and (3) the interaction of these two characteristics. The poumtchak's rhythmic clarity and verticality work together to activate the proper motor commands and synchronize a vertical movement pattern with the music.