Musical Meter as Shape: An Embodied Perspective on Metrical Trajectories and Curves

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Abstract. The perception of musical rhythm includes not only the *sonic rhythm* but also the *endogenous reference structures,* such as *meter*. Musical meter is often described and understood as points in time or durations between such points. In this chapter, I argue that musical meter also has a *shape*. I propose that we perceive and make sense of musical meter based on our previous musical experiences involving meter-related bodily motion. In other words, the meter-related motion is integral to the perceived meter—they are the same. Meter thus has a *shape* that relates to the embodied sensations of these movements. Also crucial is the notion that musical meter is conditioned by musical culture. This perspective on meter as shape is highly influenced by Godøy's *motor-mimetic perspective on music perception* and *musical shape cognition* and concurs with the multimodal approach to sonic design that acknowledges motion as intrinsic to music performance and perception.

Keywords: Musical meter · rhythm · multimodality · music culture · musical shape cognition

1 Introduction

The perception of musical rhythm involves the interaction between the *sonic rhythm* (also referred to as the *rhythmic surface* (e.g., London, 2012) and *sounding rhythm* (Honing, 2013) and the *endogenous reference structures,* such as *pulse* (also referred to as the *beat* (e.g., Honing, 2013), *regulative beat* (Nketia, 1986), *subjective beat* (Chernoff, 1979), *tactus* (London, 2012), *inner pulsation* (Kubik, 1990), and *internal beat* (Danielsen, 2006)) and *meter*. Such structures are not necessarily represented by sonic events, but instead supply an implicit framework against which one perceives them (e.g., Danielsen 2010; Haugen 2016b; London 2012). Whereas the pulse comprises a single periodicity, the meter groups or organizes that pulse. Meter consists of a minimum of two hierarchically organized periodicities on different time scales: a pulse or tactus (referent) level that is coordinated with one or more levels of organization, for example, the pulse level, an ordering of pulse beats into measures (e.g., double and triple meter), and subdivisions of the pulse (e.g., London 2012).

Meter is often described as successive time points (e.g., Lerdahl & Jackendoff, 1983) or as the durations between the points (e.g., Bengtsson, Gabrielsson, & Thorsén, 1969;

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Kvifte, 2004). In this article, I argue that meter also has a *shape*. This is not an entirely new idea. Some theorists have proposed various conceptions of meter that stress its continuous and dynamic aspects from different perspectives. Meter has, for example, been explored as composer-specific motion curves (e.g., Becking, 1928; Clynes, 1995), an underlying dynamic flow of an "away from–back to" *cycle* (Zuckerkandl, 1956), continuous pulsations of up-and-down motion trajectories (Waadeland, 2000), projection and process (Hasty, 1997), dynamic attending (e.g., Jones, 2019; Large & Jones, 1999), entrainment of attentional periodicities (London, 2012), and beat-bins (Danielsen, 2010, 2019). Fundamental to the present perspective is the conviction that meter is intrinsically related to motion, and that meter perception is influenced by people's previous embodied experiences and music-cultural background. This perspective is highly influenced by embodied music cognition (e.g., Godøy & Leman, 2010) in general and Rolf Inge Godøy's *motor-mimetic perspective on music perception* (e.g., 2003, 2006, 2010) and *musical shape cognition* (2019) in particular. It contributes to the multimodal approach to sonic design that acknowledges that motion is intrinsic to music perception.

2 Music and Motion

Essential to the present view on meter is the notion that human perception is *multimodal* in nature. This refers to how we use multiple senses simultaneously when we explore our environment (e.g., Gibson, 1966). It has also been pointed out that integrating several modalities is the optimal strategy for perception since it achieves a better understanding of the world (Ernst & Bülthoff, 2004). Within this approach, perception is an active process–it is something that we *do*, and which is related to sense-making and based on previous multimodal experiences (e.g., Noë, 2004; Shapiro, 2010; Varela, Thompson, & Rosch, 2016). *Motor theories of perception*, for example, point out that sound perception includes not only auditory input but also an understanding of what we believe caused the sound–that is, the sound's *source* and/or the *action* that produced the sound (e.g., Berthoz, 2000; Laeng, Kuyateh, & Kelkar, 2021; Liberman & Mattingly, 1985). Sound perception, then, includes knowledge of *sound-source* relationships based on previous multimodal experiences. Accordingly, Gaver (1993) proposes an *ecological approach to auditory event perception* and highlights that sound is informative not only about its source but also about the materials involved and their interaction, environment, and location (direction). In the same vein, Bennett Hogg points out that sounds "do not carry meaning in and of themselves, but are the sites of complex and mediated sets of relationships between physical sounds, perceptual systems, personal associations, culturally signifying gestures, bodily and emotional responses, observed actions and reactions, and culturally learned listener expectations" (Hogg, 2011, p. 88).

Clarke (2005) proposes an ecological approach to musical meaning, highlighting perception as sense-making and noting that, when we hear a sound and recognize what produced the sound, we grasp its perceptual meaning. He then criticizes the information-processing approach, which holds that perception starts with stimulus-driven simple features that are subsequently combined into more complex structures (ib. p. 14). He refers to Gibson's (1966) concept of *direct experience* to argue that there is no need for complex processing or the interpretation of stimulus information—instead, the information

is directly specified by the structure of the environment. When we perceive a sound, for example, of piano playing, we will immediately recognize the sound as what it is, without any complex processing.

Arnie Cox focuses on the importance of mimetic behavior in music cognition. He hypothesizes that "part of how we comprehend music is by imitating, covertly or overtly, the observed sound-producing actions of performers" (Cox, 2016, p. 12). Rolf Inge Godøy suggests a *motor-mimetic perspective on music perception* (e.g., 2003, 2006, 2010, 2019). Along the lines of Pierre Schaeffer's terminology for describing sonic objects (Schaeffer, North, & Dack, 2017), Godøy suggests that the simulated sound-producing actions that we relate to the perceived musical sounds can be directly related to playing an instrument, but they can also be imitative of *sonic shapes*. In other words, we can perceive a sound as a sonic shape, including a corresponding simulated action with a similar shape. These actions and their corresponding sound shapes, he explains, usually fall into one of three main categories: *impulsive, sustained,* or *iterative.* We perceive these *action–sound shape* relationships as meaningful units due to our multimodal perception. For example, we know from experience that a sustained sound-producing action with continuous energy transfer (e.g., stroking) will produce a sustained sound, whereas an impulsive sound-producing action with a fast attack (e.g., hitting) will produce an impulsive sound (Godøy, 2011). Furthermore, we recognize similarities between sound-producing actions with a particular shape and other kinds of motion with a similar shape, as, for example, in dance and sound tracing (Godøy, Song, Nymoen, Haugen, & Jensenius, 2016). Godøy (2010) exemplifies this relationship with the barbershop scene from Charlie Chaplin's The Great Dictator. In this scene, Chaplin shaves a customer to the accompaniment of Brahms's Hungarian Dance No. 5, and his shaving motions appear to correlate perfectly with the musical sound.

Music-related motion involves not only the actions related to sound production and perception but also the gestural repertoire associated with the specific music culture in question, such as typical movement patterns or dance (e.g., Haugen, 2016b; Naveda, 2011). Here, *music culture* refers to that which arises when multiple people share a repertoire of musical concepts and practices (e.g., Baily, 1985; Blacking, 1955; Clayton, Dueck, & Leante, 2013). It includes everything that allows cultural insiders to recognize a given music genre, such as typical instruments, sonic features, phrasings, timing, ways of singing and/or playing, and signature motion patterns. This understanding of music culture takes into account that our experiences with and general exposure to music are more relevant than our geographical area as such (see also, Jacoby et al., 2020; Trehub, Becker, & Morley, 2015).

3 Meter-Related Motion

The close relationship between meter and motion is often highlighted in the literature. Periodic body motion such as foot tapping, body swaying, head nodding, and dance moves are often labeled "entrained" motion since it follows the perceived meter (e.g., Dahl et al., 2010; Jensenius, 2007; Merchant, Grahn, Trainor, Rohrmeier, & Fitch, 2015). Some researchers have suggested that such repetitive music-related body motions are rooted in *basic gestures*. The concept of the basic gesture can be traced back to Becking

(1928) and defined as a three-dimensional repeating motion pattern of a body part during one period of a repetitive sequence, whereby its shape will be such that the starting point and the ending point will be connected. In an exploratory study by Styns and Van Noorden (2006), people were asked to move a joystick while listening to march music, baroque string music, and a metronome, all played at a constant tempo (120 beats per minute). The analysis showed that most people synchronized their motion to the pulse of the music, but the ways in which they moved varied according to the musical content. Van Noorden (2010) later observed that the participants tended to use a limited set of movement strategies or basic gestures. Visualizations of the participants' motion patterns in space revealed motion patterns shaped like "raindrops", "figure-eights", and "bananas."

Basic gestures have also been investigated in music and dance research. Naveda and Leman highlighted the intimate relationship between music and dance in many music genres and noted that repetitive motion patterns in these dance styles are commonly synchronized with the musical meter (Naveda, 2011; Naveda & Leman, 2009, 2010). They then suggested that such repetitive dance patterns are based on spatiotemporal reference frames or basic gestures. They developed a method through which metrical points derived from the musical sound could be projected onto basic gestures extracted from repetitive motion in the corresponding dance (Leman & Naveda, 2010), then used it to compare basic gestures in performed samba and Charleston dance. The basic gestures were obtained from motion-capture recordings of repetitive motion using the hand, torso, head, and foot in the dances. They observed that certain motion forms (for example, round and arc-like) and periodicities related to different metrical levels.

Several ethnomusicological studies have argued that in music cultures where music and dance have evolved together under mutual influence, the meter must be understood in relation to the musicians' and dancers' bodies. Bengtsson (1974), for example, points out that, in such genres, the underlying meter may be both conditioned by the dance *and* intrinsic to the music, even when the music is detached from the actual dancing. In a study of Brazilian drum patterns, Kubik (1990) explains that the percussionists' "inner pulsation" is often not present in the sound, but is often visible in the performers' and dancers' body motion. Agawu (2003) points out that, in many genres in West and Central Africa, there is an interaction between specific periodic sonic rhythms, often referred to as *time-lines* (*topoi* in Agawu's (2003) terminology), and the meter. In many time-line genres, the music and the dance took shape together, and the pulse in performance is often expressed by the dancers' feet. For cultural insiders, then, the perception of a standard pattern, or time-line, will instinctively and spontaneously incorporate either the actual dancers' feet or an image of their motion. People unfamiliar with the music genre's intrinsic way of moving may perceive and understand its sonic rhythm patterns differently (Agawu, 2003; Naveda, 2011).

Scandinavian folk music is yet another tradition featuring an intimate relationship between music and dance, and scholars often highlight that meter in this music should be understood in relation to the periodic motion in the corresponding dances (e.g., Bakka, 1978; Blom, 1981; Omholt, 2009). Norwegian anthropologist and ethnomusicologist Jan-Petter Blom (1927–2021), for example, was interested in this correspondence and

highlighted the influence of music culture on rhythm production and perception. Accordingly, he proposed a *motor theory of rhythm* to capture that "culture-specific movement styles of a social group represent shared kinaesthetic experiences embedded in its musical forms of expression, thus constituting the implicit and shared background knowledge from which socially appropriate rhythmic actions/reactions are generated" (Blom, 2006, p. 79). Blom also emphasized that musical meter should be understood in relation to any corresponding dance and, in the case of Scandinavian folk music and dance, to the vertical motion pattern of the dancers' center of gravity in particular (see, e.g., Blom, 1981, 1993, 2006). Blom observed that the vertical motion of the dancers' center of gravity, caused by bending and stretching the hips, knees, ankles, and joints of the feet, seemed to follow a regular up-and-down pattern that he called the dancers' *libration pattern* or *libration curves*. He noted that this pattern was repeated in each measure regardless of the different steps and tunings in the dance. The execution of the libration patterns in terms of the number of oscillations, position of turning points, and overall shape are considered style-specific and directly linked to the musical meter (Blom, 1981).

4 Toward a Theory of Meter as Shape

Crucial to the perspective on meter as shape proposed in this chapter, is the conviction that meter is intrinsically related to motion, and that meter perception is influenced by personal experience and music culture. Fundamental to it, as well, is an understanding of the experienced rhythm as an interaction between the sonic rhythm and the meter—something I will unpack further below.

As pointed out in the introduction, the experienced rhythm includes not only the perception of sonic events but also endogenous reference structures such as meter. Central to the present perspective is the insight that the *experienced rhythm* emerges via an *interaction* between the sonic rhythm and the meter (see Fig. 1). Note that, in this case, the *experienced rhythm* does not refer to the perceived sound alone but rather to *both* the sonic rhythm and the meter simultaneously. From this perspective, the meter is not derived from the sonic rhythm; instead, the sonic rhythm and the meter are mutually dependent. As a result, we experience the sonic rhythm and the meter not as discrete entities but as aspects of the experienced rhythm. I would argue, then, that musical meter is also learned in this context—that is, during musical *sonic rhythm–meter* interactions. Meter perception is influenced by the sonic rhythm–meter interactions to which we are most often exposed and with which we are most familiar, based on our previous musical experiences and music-cultural backgrounds. This conviction is also in line with Kvifte's (2007) *pattern-recognition* concept, which highlights the importance of the perceiver's knowledge and experience in metrical interpretation, and London's (2012) concept of metric *recognition*, which claims that, in meter perception in familiar music genres, one matches the sonic rhythm against a repertoire of well-known rhythmic/metric templates (London, 2012, p. 67).

Moreover, I argue that meter-related motion, such as foot tapping, body swaying, head nodding, and repetitive dance moves, are not only externalizations of a perceived meter but also the way in which we both learn and shape that meter during musical experiences. In parallel with Godøy's aforementioned *motor-mimetic perspective on*

music perception (2003, 2006, 2010), which suggests that we make sense of perceived sounds based on our previous experience with how sounds are produced–that is, action–sound relationships, I propose that a *meter–motion shape* relationship is implicated in meter perception. I suggest we do not perceive the meter as one thing and meter-related motion as something else. Instead, we understand meter–motion relationships as meaningful wholes due to previous musical experiences involving meter-related bodily motion. Meter thus has a *shape* that includes sensations of what it feels like to move the body in space in a particular manner—for example, in relation to gravity and/or qualitative motion features such as weight and flow (see, e.g., Laban, 1960, on effort). Once the meter is acquired, one does not need to see or perform its intrinsic periodic body motion shape to perceive it. It is inherent in the perceived meter, either overtly or covertly.

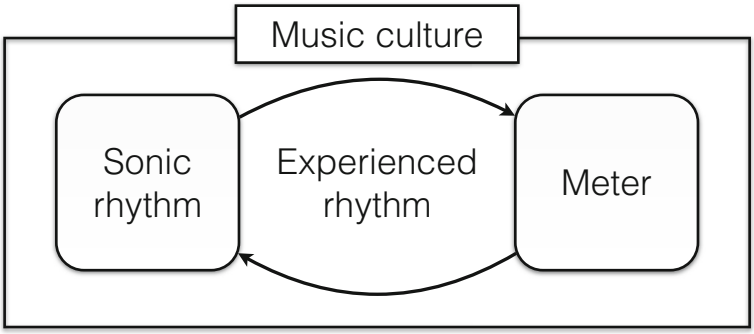

Fig. 1. An illustration of *experienced rhythm* as an interaction between the perceived *sonic rhythm* and *meter*, influenced by music culture.

As stated above, like action–sound shape relationships in sound perception, I propose that meter–motion shape relationships in meter perception are conditioned by previous experiences. However, since musical sound and the motion associated with it differs considerably among genres and music cultures, and musical meter always occurs in musical contexts, metrical shapes are dependent on *music culture*—how one usually moves—and also by each person's embodied experience with the culture's meter-related motion. I will refer to those meters spontaneously perceived by cultural insiders as *culture-specific meters*. This is not to say that this culture-specific meter is the only perceivable meter possible but rather that it, including its shape, is likely to be quite consistent among the people conversant with the music culture in question. A familiar music genre will automatically evoke the culture-specific metrical shape. An unfamiliar music genre with an unfamiliar metrical shape might be experienced within a metrical-gestural framework with which the perceiver is familiar—that is, with a familiar metrical shape. To learn to know a new metrical shape, then, one has to acquire some embodied knowledge of the meter in question. I also suggest that perceived metrical shapes are not necessarily fixed but can vary during a musical performance—for example, due to a perceived stylistic change in the middle of the piece.

5 Metrical Shapes in Norwegian Folk Music and Dance

The aforementioned Scandinavian folk music and dance genres are interesting examples of the importance of culture-specific embodied metrical shapes in music performance and perception. In this final section, I will exemplify the present perspective on meter as shape via the Norwegian folk music genre telespringar. Springar tunes are among the older types of Norwegian folk dances, and telespringar is a springar from the region of Telemark in Norway, performed by couples. It can be sung or played on several traditional instruments but is most often played on a Hardanger fiddle. Telespringar is normally notated in triple meter, but it is commonly understood by cultural insiders that the beats are of uneven duration—what is often referred to as asymmetrical triple meter—and follow a long–medium–short duration pattern (e.g., Blom, 1981; Groven, 1971; Kvifte, 1999). Telespringar derives from oral traditions, and its music and dance developed together under conditions of mutual influence. The intimate relationship between music and dance is often emphasized in rhythm studies of telespringar and, in particular, when it comes to meter. As previously mentioned, it has been suggested that meter in these genres should be understood in relation to performers' periodic motion, and, specifically, the fiddler's foot stamping, which is integrated into this tradition of playing, but also the vertical motion pattern of the dancers' center of gravity in the corresponding dance (e.g., Blom 1981; Kaminsky 2014; Kvifte 2007).

To investigate the meter-related body motion in telespringar, I carried out a motion capture study involving three experienced telespringar performers: a fiddler playing the Hardanger fiddle and a dance couple (Haugen, 2016a, 2017). The presence of an asymmetrical beat-duration pattern was supported by the analysis that revealed that the musician's integrated foot stamping followed a very regular long–medium–short pattern (Fig. 2b). The analysis of the dancers' periodic vertical motion also showed a very regular motion pattern at a beat level that consisted of a small "valley-shaped" down–up motion during the long beat 1, a deeper down–up motion during the medium-long beat 2, and a small up–down motion during the short beat 3 (Fig. 2a).

Interestingly, telespringar dancers do not refer to beat durations. For example, when they teach telespringar dance, they do not talk about a long–medium–short pattern but rather a heavy–heavier–light pattern (Omholt, 2011). This "weight" pattern seems to correspond well to this curve, since the deepest "valley-shaped" beat 2 might feel "heavier" than beat 1, and beat 3, which has a small up–down motion, might feel light. And it is not only the dancers but also the musicians who refer to the beat in terms of felt weight. In a recent study by Mats Johansson (2022), where he interviewed folk musicians about timing-sound interactions in traditional Scandinavian fiddle music, the musicians explained how the integrated foot tapping influences their playing in terms related to force or weight, describing the foot stamping as "heavy" and "light," and even explaining that some beats should be played with an "upwards" feeling.

The notion that insiders experience telespringar meter as patterns of force and/or weight was also supported by the motion capture study (Haugen, 2017), wherein the musician's acceleration curves based on foot stamping revealed a high–higher–low pattern (Fig. 2c). This pattern indicates that more power is put into the first two foot stamps than into the third, resulting in a strong–stronger–weak pattern, which seems to correspond well to the dancers' heavy–heavier–light pattern.

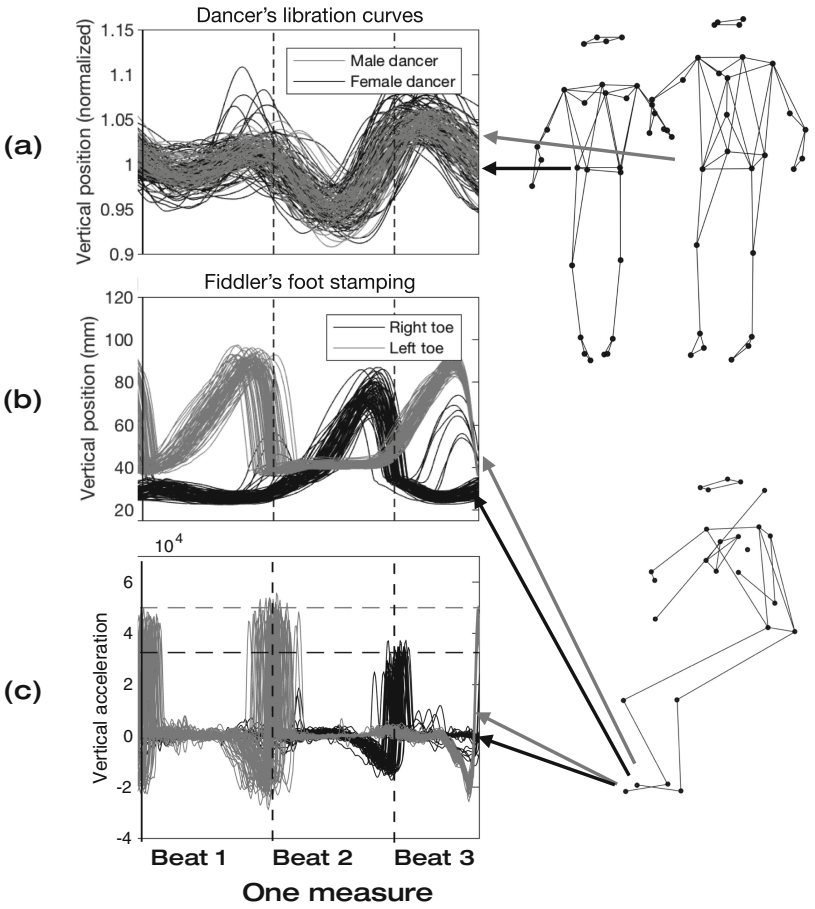

Fig. 2. Plots showing (a) the vertical position of the dancers' hips (libration curves), (b) the vertical position of the fiddler's foot stamping, and (c) the vertical acceleration of the fiddler's foot stamping. All three are chunked into segments of one measure and plotted on the same graph.

The analysis above suggests that all of the performers shared an understanding of the music's metrical shape, which seems to relate to the traditional ways of moving in the particular genre. I suggest that these motion patterns are integral to the culture-specific meter in telespringar. In other words, the meter includes not only points in time but also a shape that relates to the embodied sensations of these motion patterns. In that case, we can assume that people unfamiliar with the motion intrinsic to telespringar music might experience its rhythm differently from cultural insiders.

6 Concluding Remarks

In this chapter, I have presented a perspective on musical meter that highlights the intimate relationship between meter and motion. I suggest that meter is essentially learned and shaped through periodic body motion in musical contexts. Namely, the perceived

meter and the corresponding meter-related motion are intrinsically related—they are the same. It follows from this that meter is continuous and has a shape that relates to the embodied sensations of these movements. In other words, I propose that meter perception includes meter–motion shape relationships. This approach is highly inspired by Godøy's (e.g., 2003, 2006, 2010, 2019) motor-mimetic perspective on music perception. It also contributes to the multimodal approach to sonic design, emphasizing the embodied aspects of rhythm production and perception in music, including those intrinsic to meter. I also highlight that meter is conditioned by a person's music-cultural background and embodied experience with the music culture's meter-related motion. It also suggests that individuals with different embodied experiences will perceive the musical meter, and consequently the rhythm, differently. This perspective implies an acknowledgment of the crucial role of embodied knowledge in musical experiences in general. If we have some embodied experience with the gestural repertoire commonly associated with a particular music genre, including its meter-related motion, we might gain a deeper understanding of the music as such.

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