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Rhythm and Motion

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Music and Motion

Theoretical Framework

- *Embodied music cognition* (Leman, 2008).
- *An ecological perspective on perception* (Gibson, 1979).
- *Motor theories of perception* (e.g. Berthoz, 2000; Liberman and Mattingly, 1985)
- *Action–Sound* couplings (Jensenius, 2007).
- *A motor-mimetic perspective* on music cognition (Godøy, 2003).
- Multimodality

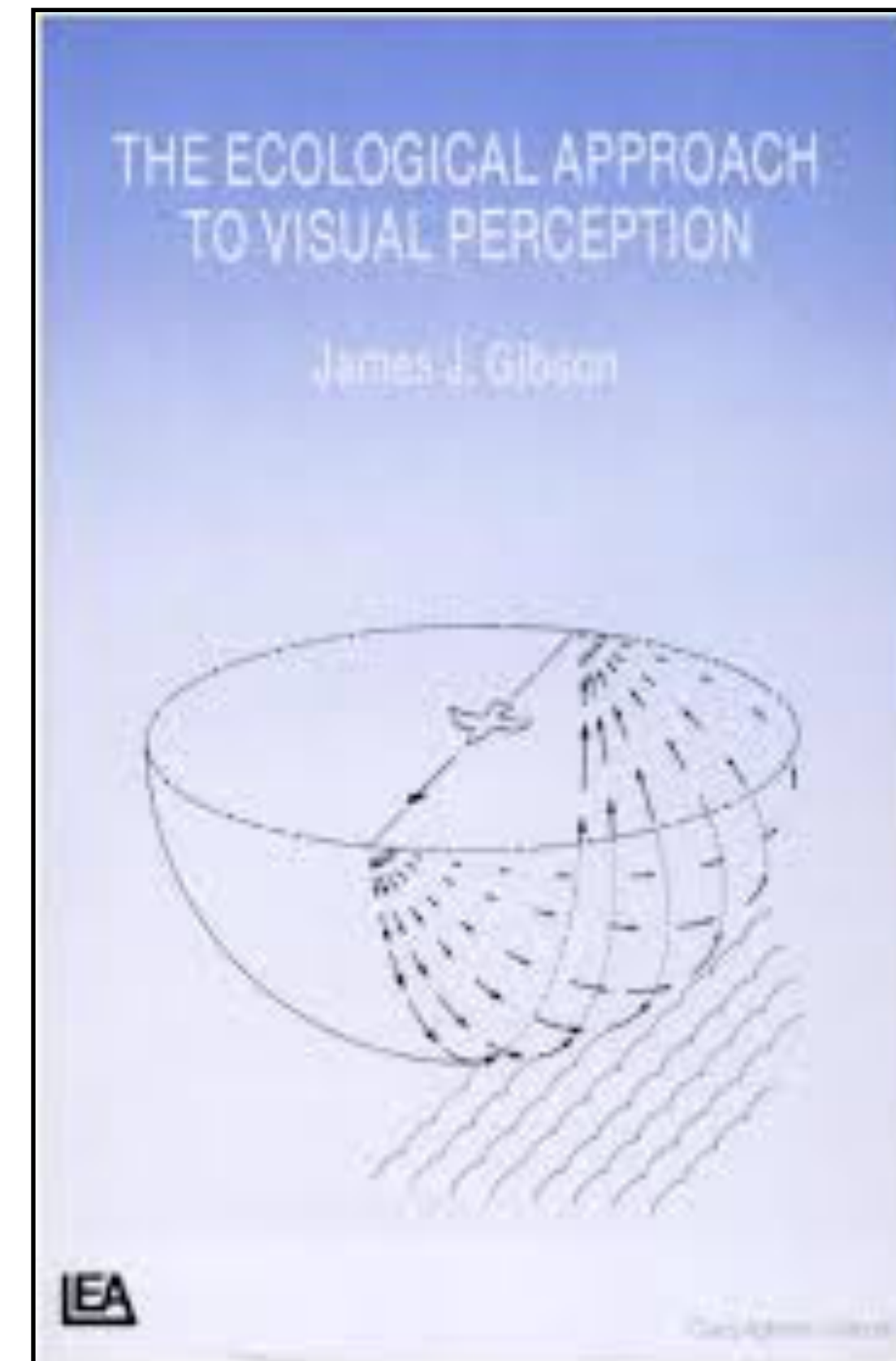
An Ecological Approach to Perception

James J. Gibson (1904–1979)

The Ecological Approach to Visual Perception
(1979)

We obtain knowledge about the world by constantly interacting with it with our bodies.

“One sees the environment not just with the eyes but with the eyes in the head on the shoulders of a body that goes about” (Gibson 1979, 222).



Affordance

- When we perceive an object, we simultaneously perceive the action that we relate to that object.
- *Affordance*: The actions that people assign to the objects that they perceive.
- An object may have multiple affordances.

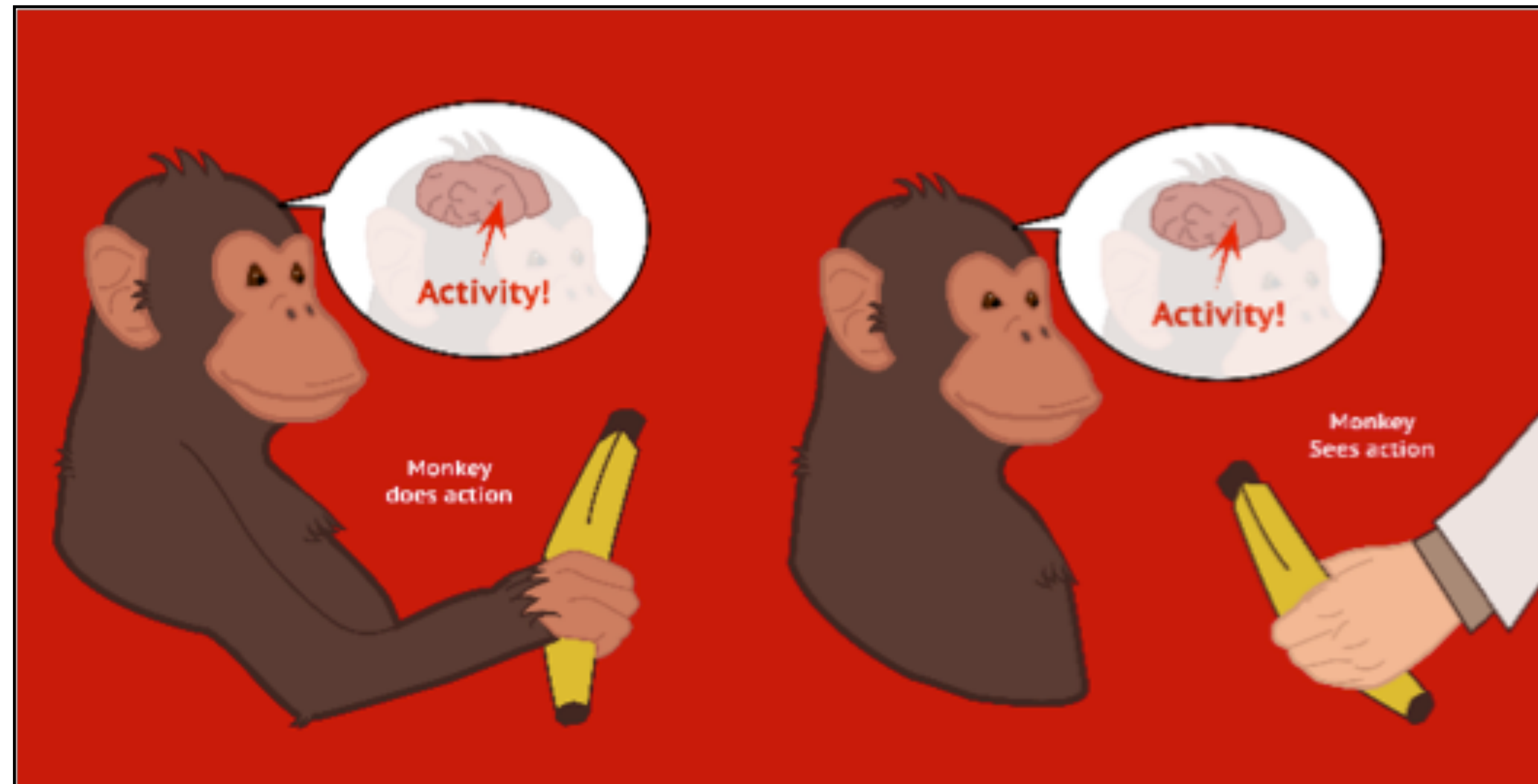
Affordance



Motor theory of perception

- When we perceive a sound, we simultaneously perceive the *source* of the sound.
- Simulation of the action that *produced the sound* (for example, Berthoz, 2000; Godøy, 2010; Liberman and Mattingly, 1985)

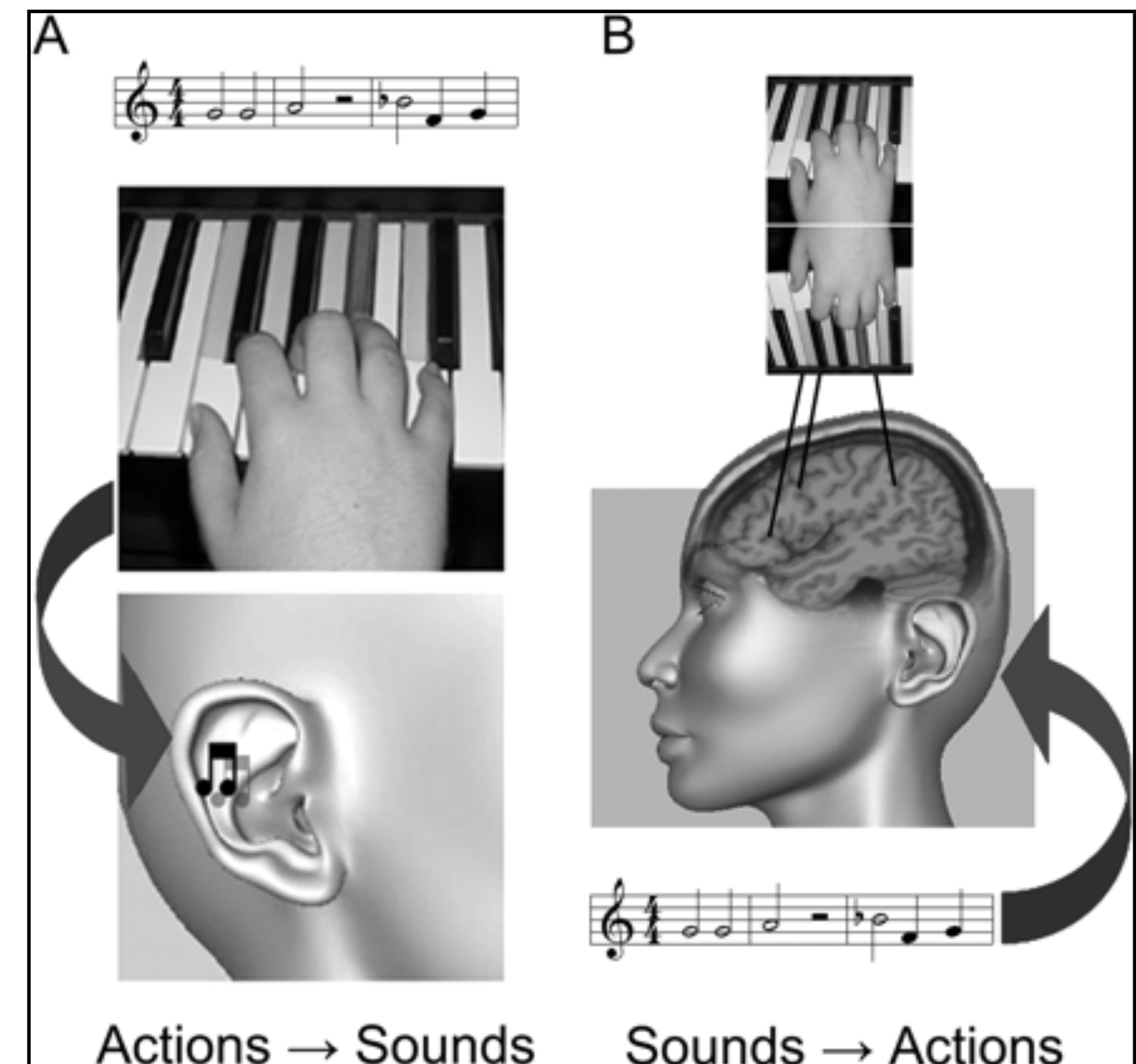
Mirror Neurons



Gallese et al. (1996)

Gestural renderings of musical sound

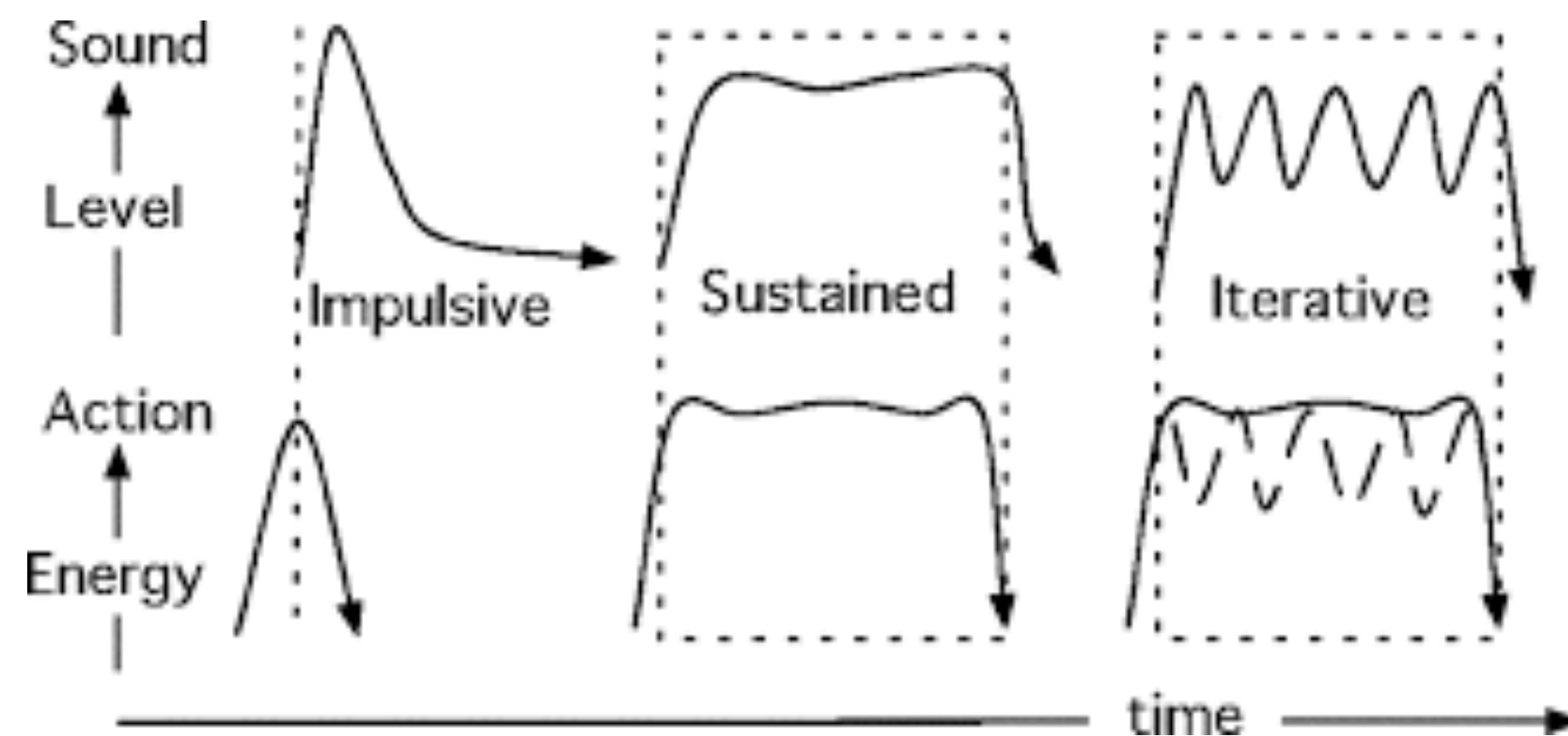
- Musical sound activate motor areas in performers' brains (Wilson and Knoblich 2005).
- Observation of silent “sound-producing” actions activate auditory areas in performers' brains (Haslinger et al. 2005).
- A *motor-mimetic* perspective on music: a relationship between simulated sound-producing actions and musical sound (Godøy 2010).



Gestural Affordances of Musical Sound (Godøy 2010)

Action–Sound:

1. Impulsiv
2. Sustained
3. Iterativ



The barber scene from Charlie Chaplin's
The Great Dictator

Multimodality

- We perceive the world around us through our senses—including sight, smell, hearing, touch, balance, and taste.
- Human perception is multimodal: all of our senses are constantly in use and work together in different ways as we experience phenomena in the world.

Musical rhythm

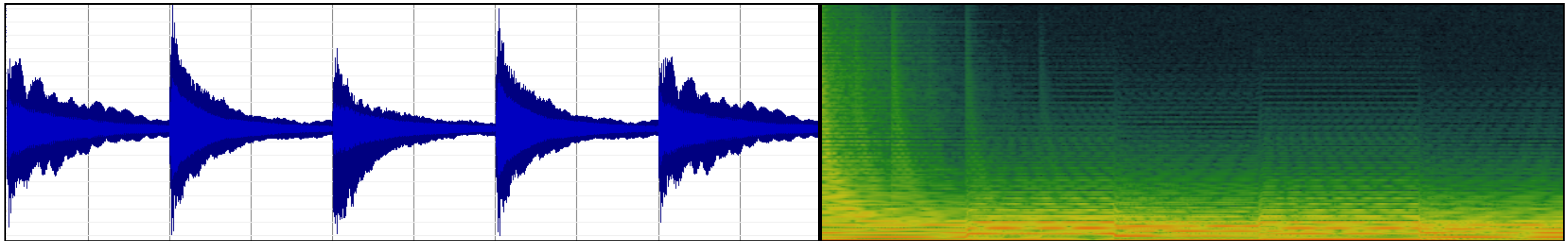
- Our perception of rhythm involves not only the processing of sonic input but also the actions we relate to it.
- These actions can be directly sound producing (Godøy et al., 2006), or they can be mental simulations related to sonic objects (Godøy, 2003, 2006).
- Rhythm is intrinsically related to motion.



Rytme

The occurrence of two or more *events* within the span of one's short-term memory.

Event describes a perceptible change in an acoustic environment (Snyder, 2000, p. 159).



Time domain

Frequency domain

Rhythm

The shortest interval that we can hear or perform as an element of rhythmic figure is about 100 ms

The upper limit is around 5 to 6 seconds

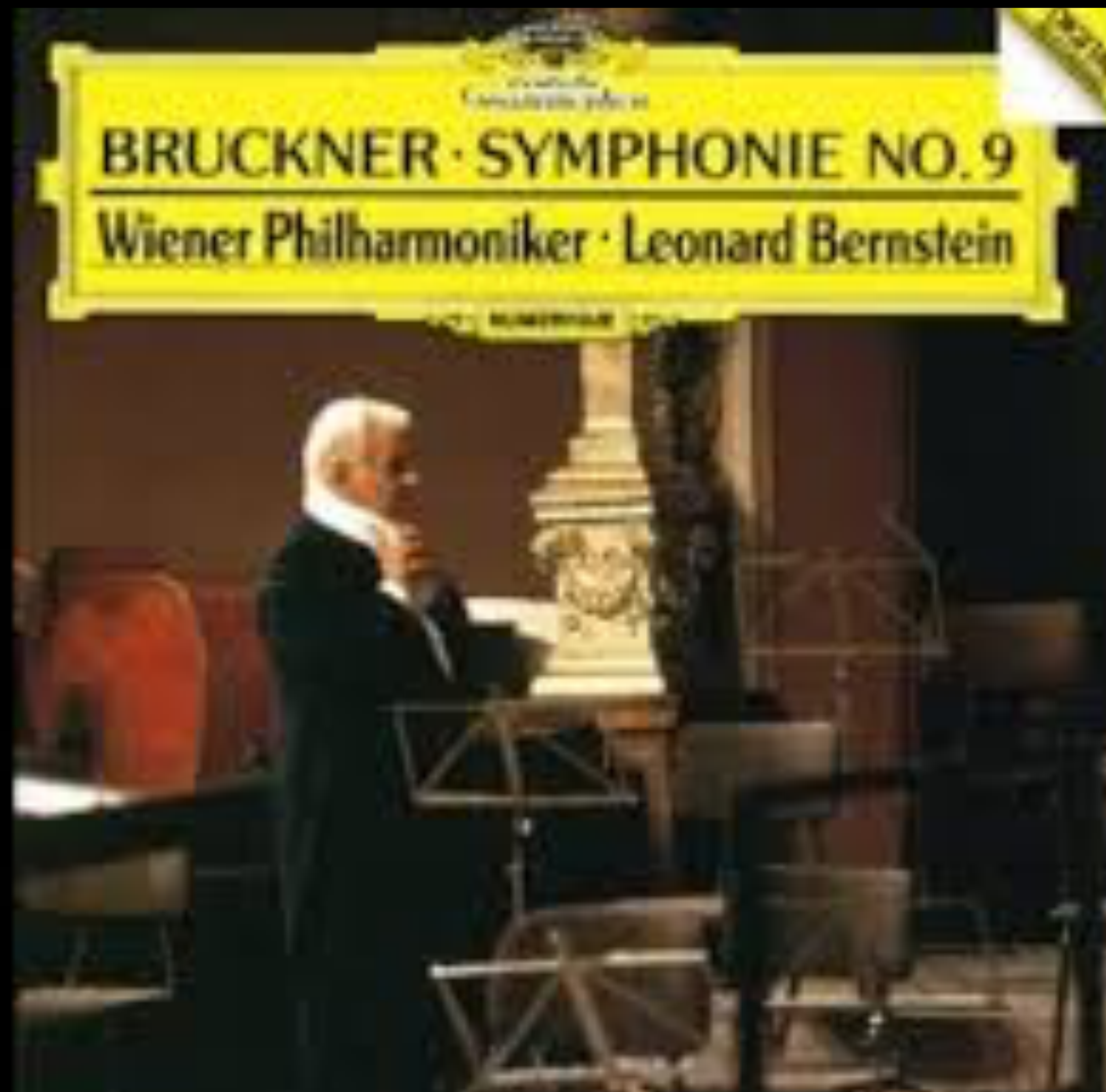


< 100 milliseconds, we tend to fuse them into one event.

> six seconds apart are perceived as unrelated.

Rhythm

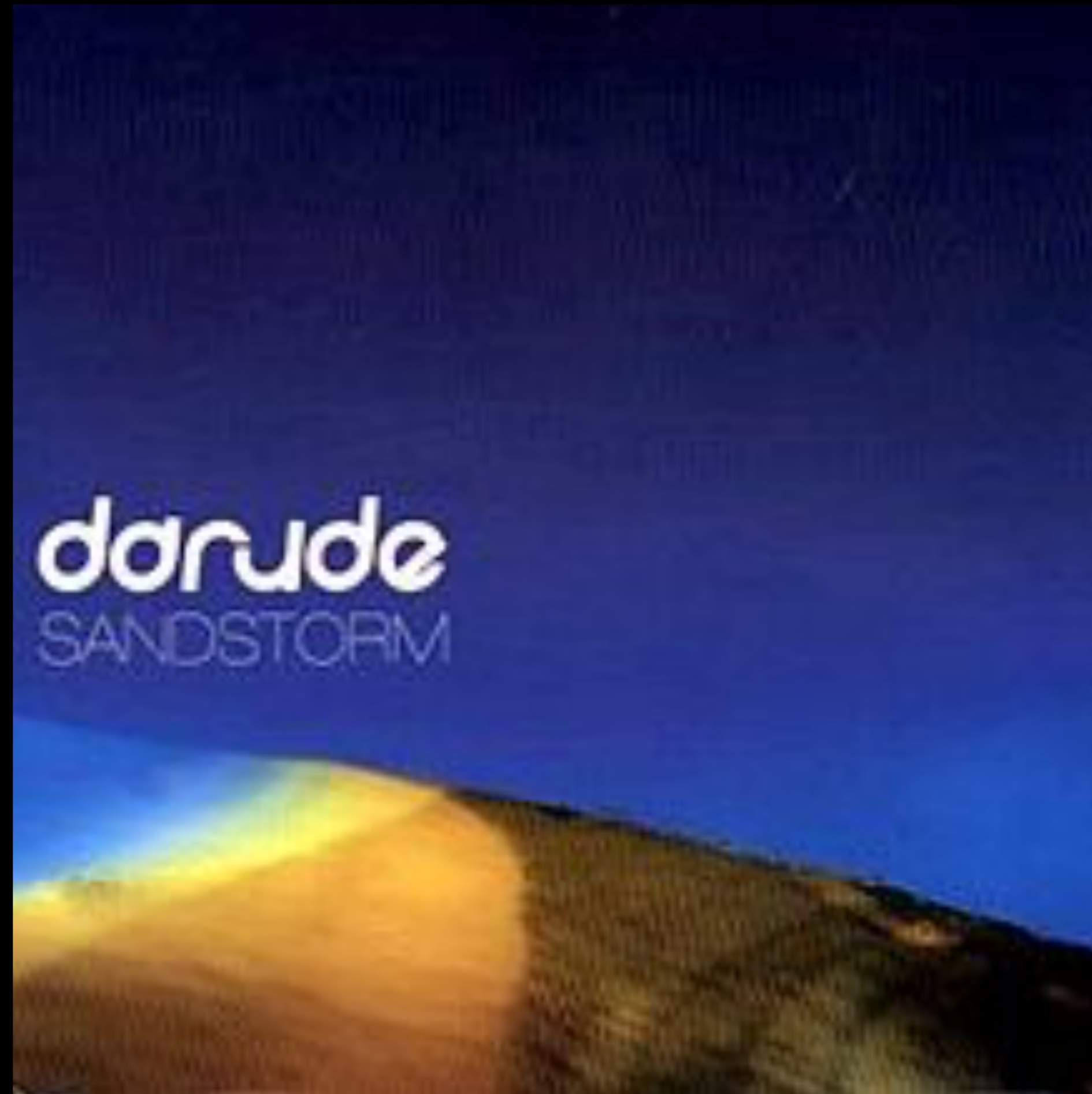




Bruckner. Symphony no. 9.



Emperor, Live 2006. "The Loss and Curse of Revenge"



Darude, 1999. "Sandstorm." *Before the Storm*.

"Drum roll": (1) 110 ms (2) 55 ms

Rhythm



Flam:

- Jazz drumming (Iyer 2002)
- Samba drumming (Gerischer 2003)
- Djembe drumming (Polak, 2010)



Rainer Polak, *Rhythmic Feel as Meter*, Video Sample 1

Music: Drissa Kone Ensemble. Title: Manjanin

Video: R. Polak (Bamako: 2006)

Copyright: Music Theory Online (2010)

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Rhythm

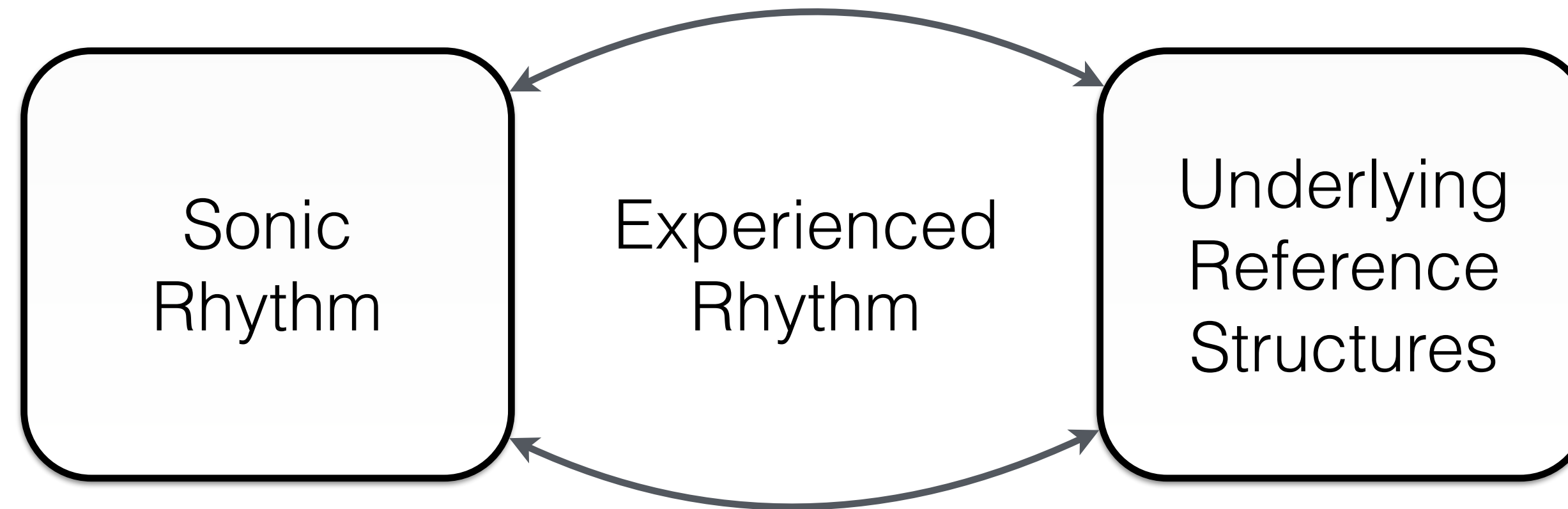
The shortest interval that we can hear or perform as an element of rhythmic figure is about 100 ms

The upper limit is around 5 to 6 seconds



- Dependent on task and context
- Individual differences

Musical rhythm



The experience of musical rhythm includes the interactions between perceived sonic rhythms and underlying reference structures.



Changing sonic rhythm patterns alternate the main pulse between a “fast” interpretation and a “half-tempo” interpretation (Danielsen 2015).

Destiny’s Child (2001). “Nasty Girl”. *Survivor*.

Experienced rhythm and body motion

- *Motor-mimetic perspective on music perception* (Godøy, 2003).
- Body motions related to underlying reference structures: foot tapping, body swaying, head nodding, and dance.
- Both the *perceived sonic rhythm* and the *underlying reference structures* incorporate an understanding of body motion.

Pulse

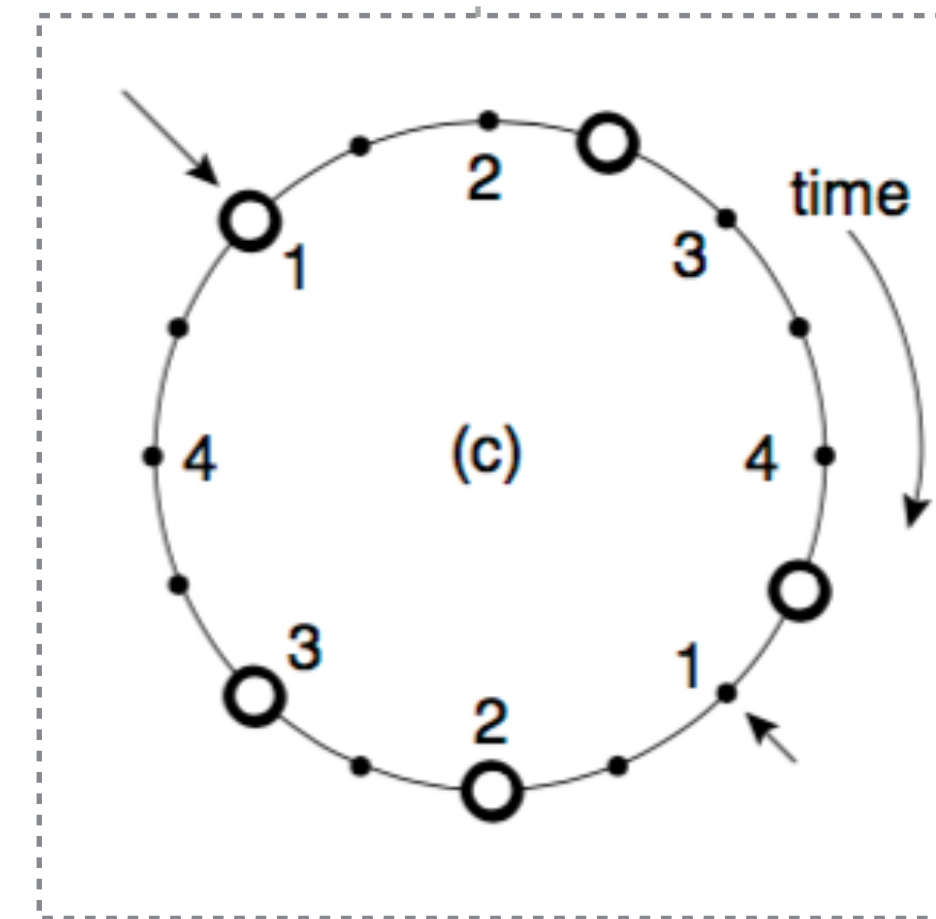
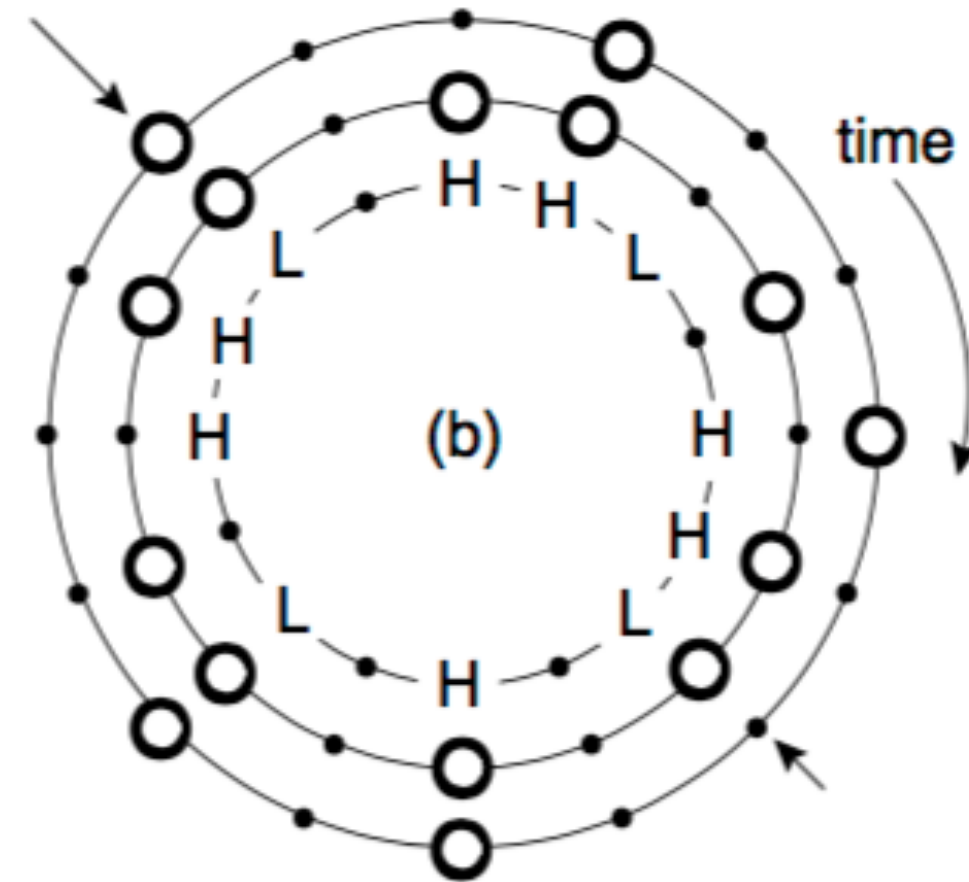
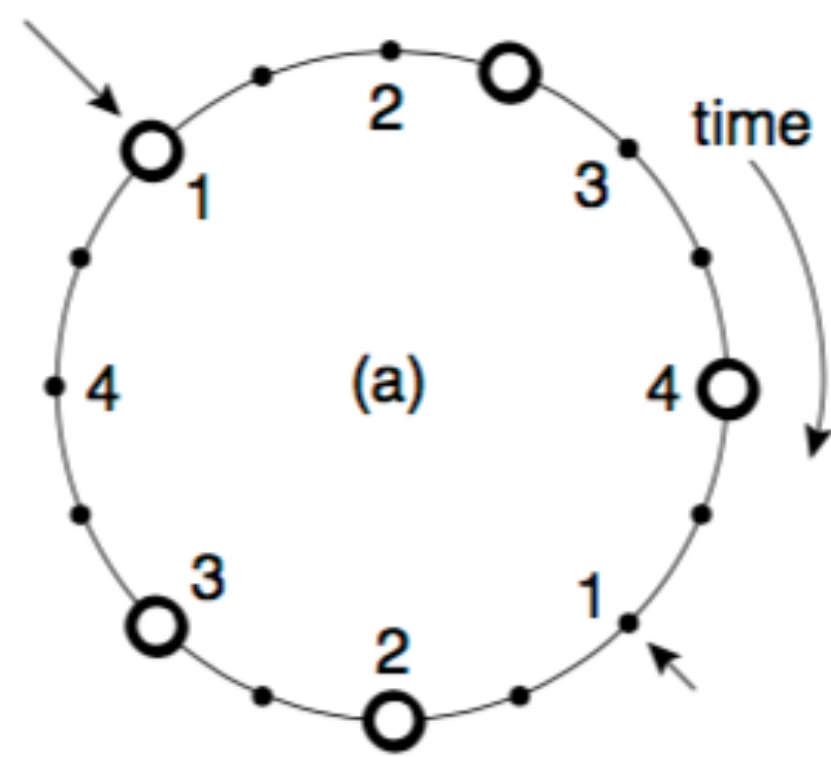
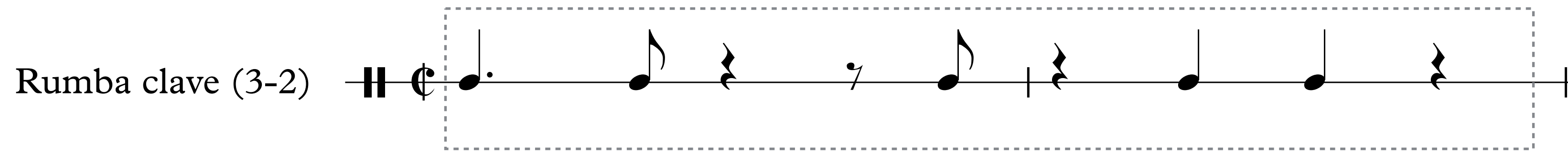
- Fundamental reference level for the perception of rhythm.
- ‘Tactus’, ‘internal beat’, ‘subjective beat’, or ‘regulative beat.’
- The duration between sonic events in the music may change, but the pulse is unchanged.
- Can be represented by sonic events, but not necessarily. The pulse does not need to be sounded in order to be experienced.
- The pulse level cannot always be directly measured in the sound signal (Sethares, 2007; Honing, 2013)

Time line

- ‘Standard rhythms’: Genre-specific rhythmic patterns that identifies the pulse, though it is not aligned with it.
- West and Central African dances: The pulse is indicated by “time lines,” and visible in the corresponding dance (Agawu 2003).
- Brazilian drum patterns: The pulse is not in the musical sound, but in the musicians’ and the dancers’ body motion (Kubik 1990).

Time line

Afro-Cuban Rumba (*guaguancó*):



(Sethares 2007, p.62)

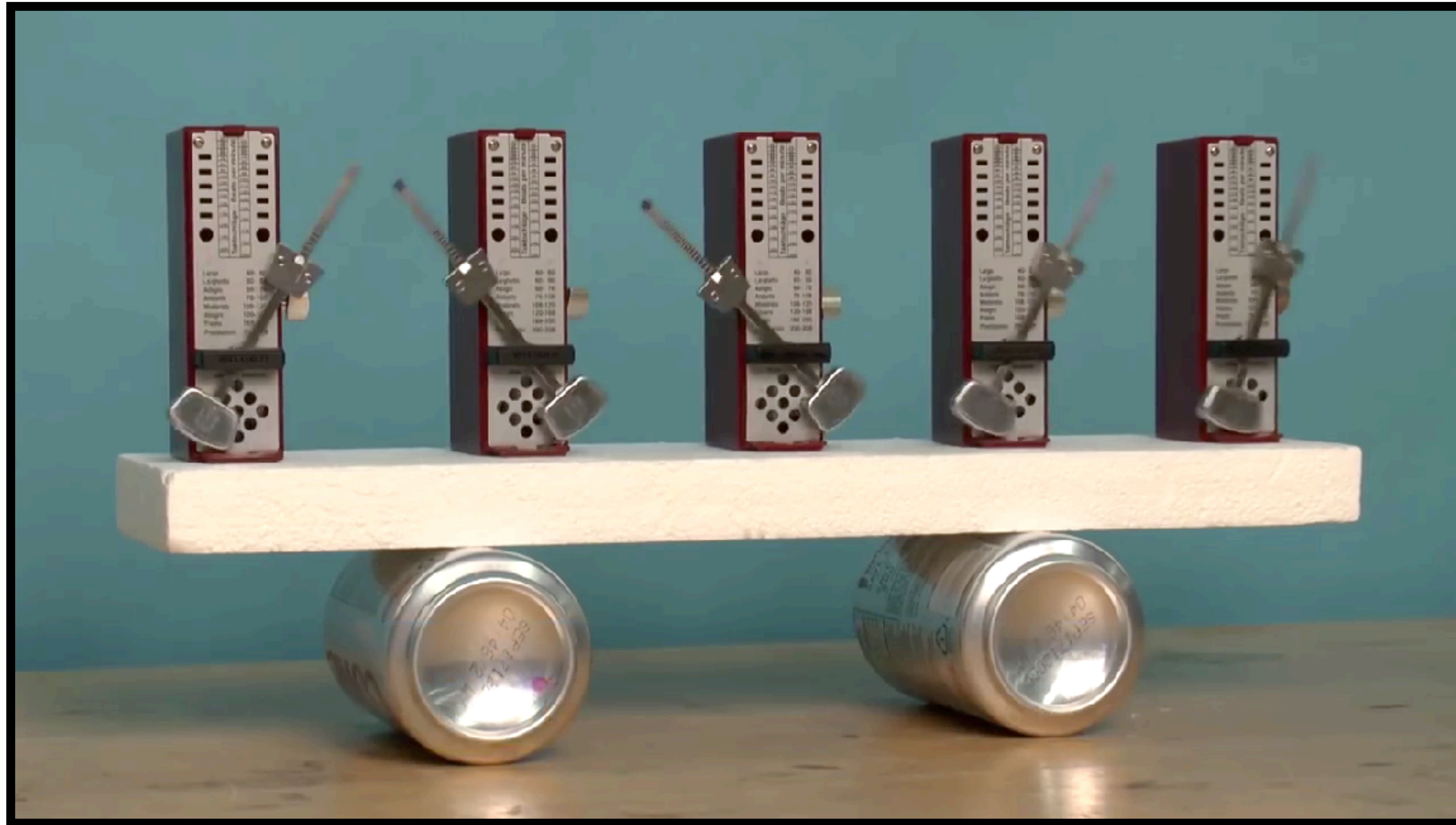
viaDanza



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Entrainment



Entrainment

In a musical context

Entrained body motion

- Foot tapping
- Head nodding
- Body swaying
- Dancing

Three levels of entrainment

1. *Intra-individual*: takes place within a person. *The dynamic attending theory.*
2. *Inter-individual*: between individuals in a group.
3. *Inter-group*: between different groups.

(Clayton, 2012)

2



Tempo

Duration

Inter Onset Intervals (IOI)

Milliseconds (ms)

Frequency

Metronome (M.M.)

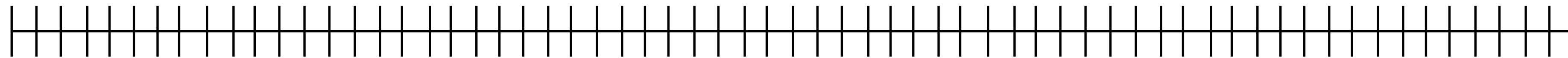
Beats per minute (bpm)

1000 ms (1 sec)

60 bpm

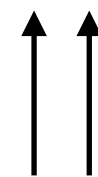


one minute



1 2 3 4

..... 57 58 59 60



Tempo

- Limits for tempo:
 - Lower limit: 200–300 msec (300–200 bpm)
 - Upper limit: 2000 msec (30 bpm)

Tempo

BPM	Tempo Comment
30	Too slow to be useful
42	Very slow
60	Moderately slow
80	Moderate
120	Moderately fast
168	Very fast
240	Too fast to be useful

Peter Westergaard (1975) in London (2012, s. 28)

1966
MILES DAVIS
• FOUR • & MORE
RECORDED LIVE IN CONCERT



Miles Davies, 1966. “So What.” “*Four*” & *More*.

Piano solo
Mean tempo: 319 bpm

Fluctuations in tempo

Often an accelerando-ritardando pattern.

Three types of tempo (Gabrielsson, 1999):

1. **Mean tempo**—the average number of beats per minute across the whole piece disregarding possible variations.
2. **Main tempo**—the prevailing tempo when passages with momentarily variations are deleted.
3. **Local tempo**, which is maintained only for a short time.

Fluctuations in tempo

A musical score for Robert Schumann's *Träumerei*, Op. 15, No. 7. The score is written for piano and is divided into two systems. The first system contains measures 1 through 4, and the second system contains measures 5 through 8. The score is marked with various dynamics and performance instructions. Measure 1 is marked *Red*. Measure 2 is marked *Red*. Measure 3 is marked with an asterisk (*). Measure 4 is marked *(espr.)*. Measure 5 is marked *Red*. Measure 6 is marked *Red*. Measure 7 is marked with an asterisk (*). Measure 8 is marked *rit.* and *(espr.)*. The score also includes various musical notations such as slurs, ties, and articulation marks.

Robert Schumann's *Kinderscenen*, Op. 15, No. 7. *Träumerei*.

Intended and perceived tempo

- The local tempo distributions shifted towards faster tempi as the intended tempo increased.
- Perceivers: Most performances were judged to have slower tempi than the pianists had intended. Judged tempo corresponded to mean tempo.

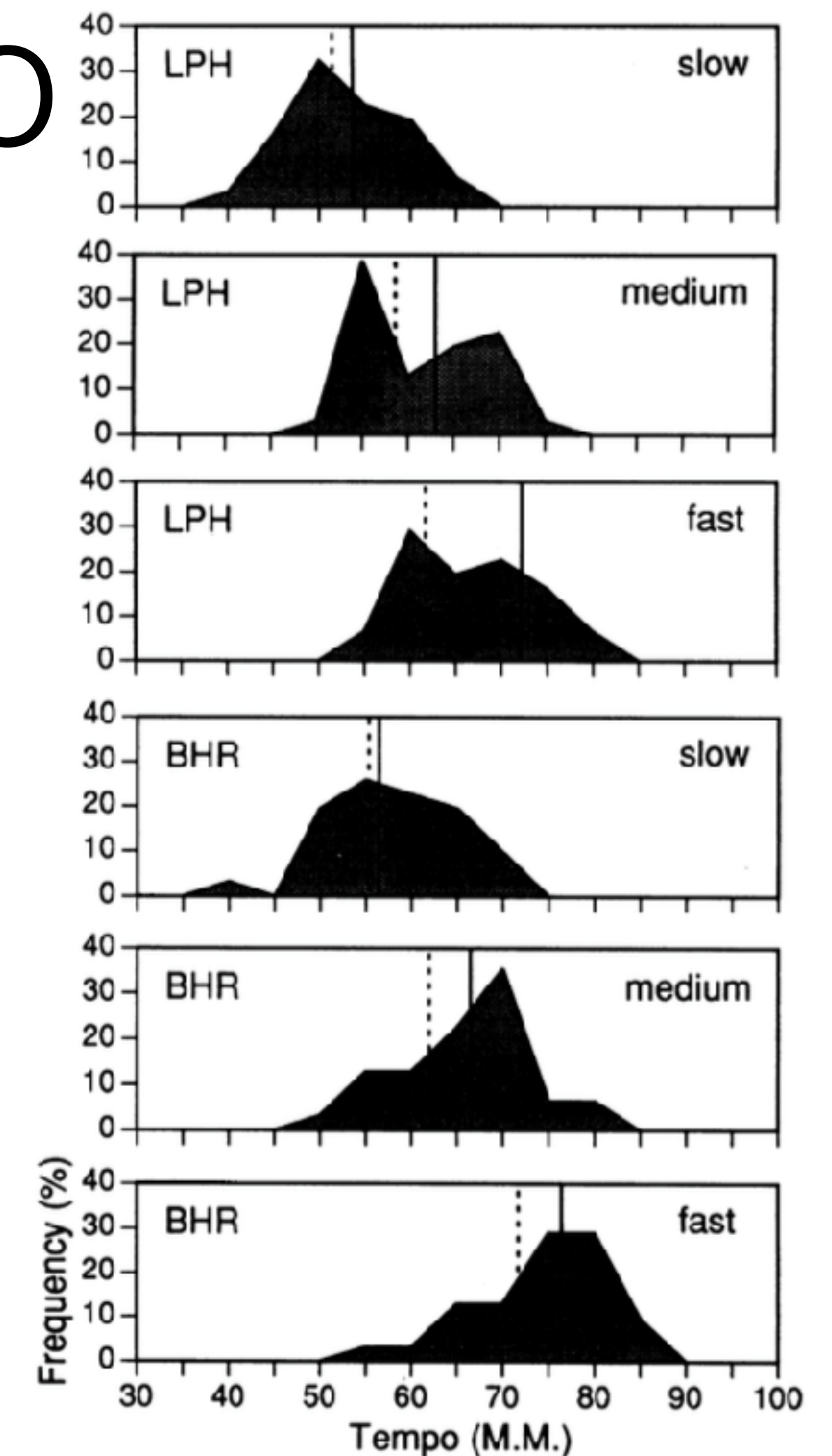


FIG. 2

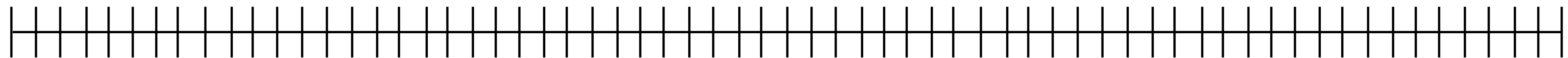
Frequency distributions of local tempi at each of three intended tempi for the two pianists, based on IOIs averaged over the three performances at each intended tempo. The bin width is 5, and frequency values are plotted at the upper limits of bins. Solid vertical lines indicate intended tempi, dotted lines judged tempi.

Preferred tempo

- Which tempi are possible and which tempi are preferred?
- Fraisse (1982): Preferred tempo corresponds to the speed of a succession of sounds that appears to be the most natural — neither too slow or too fast. Preferred tempo around 100 bpm (600 ms).
- van Noorden & Moelants (1999): Body motion (dance, foot tapping) resonate with the *preferred tempo* (pulse) in the music. The determination of the pulse strongly depends on its tempo.

Subjective accentuation

When we are presented with a series of isochronous and equivalent-sounding events, we arrange them into groups: the first event of each group is perceived as more accentuated than the others.



Subjective accentuation

- Tapping along
- Preferred groups: 1, 2, 4 and 8
- Preferred tapping tempo around 500 ms (120 bpm)



Group 2

Meter

- The *meter* could be described as an *organization of pulse beats*: when certain *pulse beats* are perceived as more accentuated than the others.
- Metrical accents are mental constructs that do not necessarily coincide with the pattern of accentuation in the sound (for example, a back beat groove).
- “Meter is thus more than a response to invariant features of the musical stimulus” (London, 2012, p. 13).
- One compares the perceived sonic rhythm to “a repertoire of well-known rhythmic/metric templates” (London, 2012, p. 67).

Meter

People's ability to recognize meter is based on socially learned cues related to music culture, such as, for example, when someone familiar with reggae recognizes the meter in the intro of "Stir It Up" by Bob Marley (Kaminsky 2014).



Bob Marley & the Wailers (1973).
"Stir It Up". *Catch a Fire*.

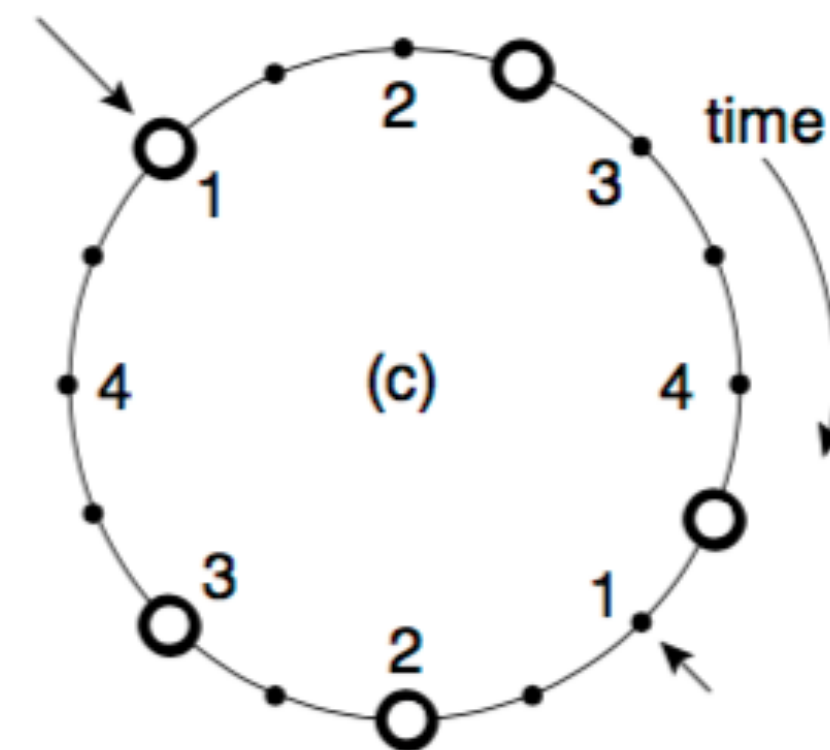
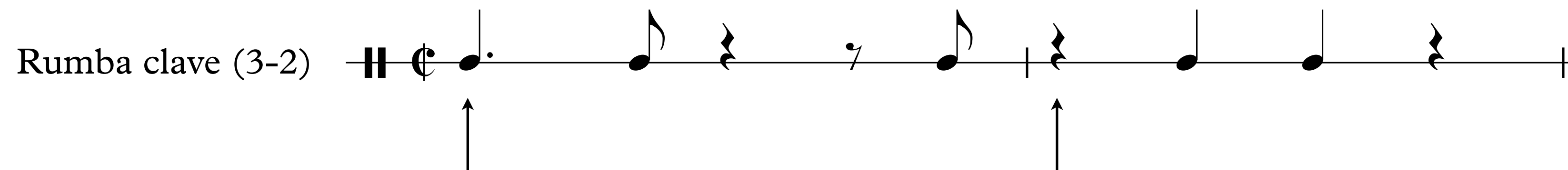
Ambiguity and meter

- *Metric malleability*: music that can be experienced in multiple metrical contexts (London, 2012:99).
- “Turning the beat around”: an initial rhythm pattern with prominent sonic events at a given pulse level shifts as the beats between the pulses become more prominent (Butler 2006).

Time lines

Afro-Cubansk Rumba (*guaguancó*)

"Mamá no quiere que yo juegue a la pelota"





Underworld (1999). "Cups". *Beaucoup Fish*.

Ambiguity and meter

- *Metric malleability*: music that can be experienced in multiple metrical contexts (London, 2012:99).
- “Turning the beat around”: an initial rhythm pattern with prominent sonic events at a given pulse level shifts as the beats between the pulses become more prominent (Butler 2006).
- Music in 6/8 can be perceived as having either three or two underlying beats.



“Waltz for Debby/Monicas Vals” (1966).
Bill Evans (p) , Eddie Gomez (b) , Alex Riel (ds).

6/8

I

Musical staff I in 6/8 time. The staff contains a sequence of notes: quarter, eighth, quarter, eighth, quarter, eighth, quarter, eighth, quarter, eighth. The first, third, fifth, and seventh notes are circled in red. Below the staff, the numbers 3, 3, 3, and 3 are placed under the circled notes, indicating a triplet of eighth notes for each.

II

Musical staff II in 6/8 time. The staff contains a sequence of notes: quarter, quarter, eighth, quarter, eighth, quarter, eighth, quarter, eighth, quarter, eighth. The first, second, fourth, sixth, eighth, and tenth notes are circled in red. Below the staff, the numbers 2, 2, 2, 2, 2, and 2 are placed under the circled notes, indicating a pair of eighth notes for each.

III

Musical staff III in 6/8 time. The staff contains a sequence of notes: quarter, eighth, quarter, eighth, quarter, eighth, quarter, eighth, quarter, eighth. The first, fourth, and seventh notes are circled in red. Below the staff, the numbers 4, 4, and 4 are placed under the circled notes, indicating a group of four eighth notes for each.

Figure-Ground

The image shows a musical exercise in 6/8 time. The melody consists of two measures, each containing a quarter note, an eighth note, a quarter note, and a quarter rest. The bass line consists of two measures, each containing a quarter note, a quarter note, a quarter note, and a quarter rest. Fingerings are indicated by numbers 1-4 below the notes.

Measure	Staff	Notes	Fingerings
1	Melody	Quarter, Eighth, Quarter, Quarter Rest	3, 2, 3
	Bass	Quarter, Quarter, Quarter, Quarter Rest	4, 2, 4
2	Melody	Quarter, Eighth, Quarter, Quarter Rest	3, 2, 3
	Bass	Quarter, Quarter, Quarter, Quarter Rest	4, 2, 4



Meter and motion

- Intimate relationship between musical meter and body motion.
- Entrainment studies: finger tapping, dance studies, and other body motion.
- Body motion does not only represents a reaction to sonic rhythmic input, but it can also facilitate the processing of temporal structures (Su and Pöppel, 2012) and improve the perception of timing, or even time keeping (Manning and Schutz, 2013).

Meter and motion

- In EDM: during metrically ambiguous musical passages in a club context, dancers *construe the meter* rather than absorb metrical information from the sound, and also that this construction occurs in and between bodies as well as in minds (Butler, 2006, p. 137).
- Phillips-Silver and Trainor (2005) found that infants who are bounced to a sonic rhythm with an ambiguous meter prefer the metrical interpretation to which they have been bounced.
- One's metrical interpretation is influenced by one's previous experiences, including pulse-related body motions.

Meter and music culture

- How we experience the meter in music also depends on our familiarity with the specific music culture.
- *Music culture*: when multiple people share a repertoire of musical concepts and practices.
- For example, in a music culture that draws upon *time lines*, the standard 6/8 bell pattern will immediately evoke its intended meter, whereas perceivers from other music cultures might interpret it differently.

Meter, motion, and music culture

- In musical cultures where music and dance have evolved together, it has been suggested that meter should be understood in relation to the corresponding dance.
- The underlying reference structure may be both conditioned by the dance and also intrinsic to the music.

“Music–Dance”

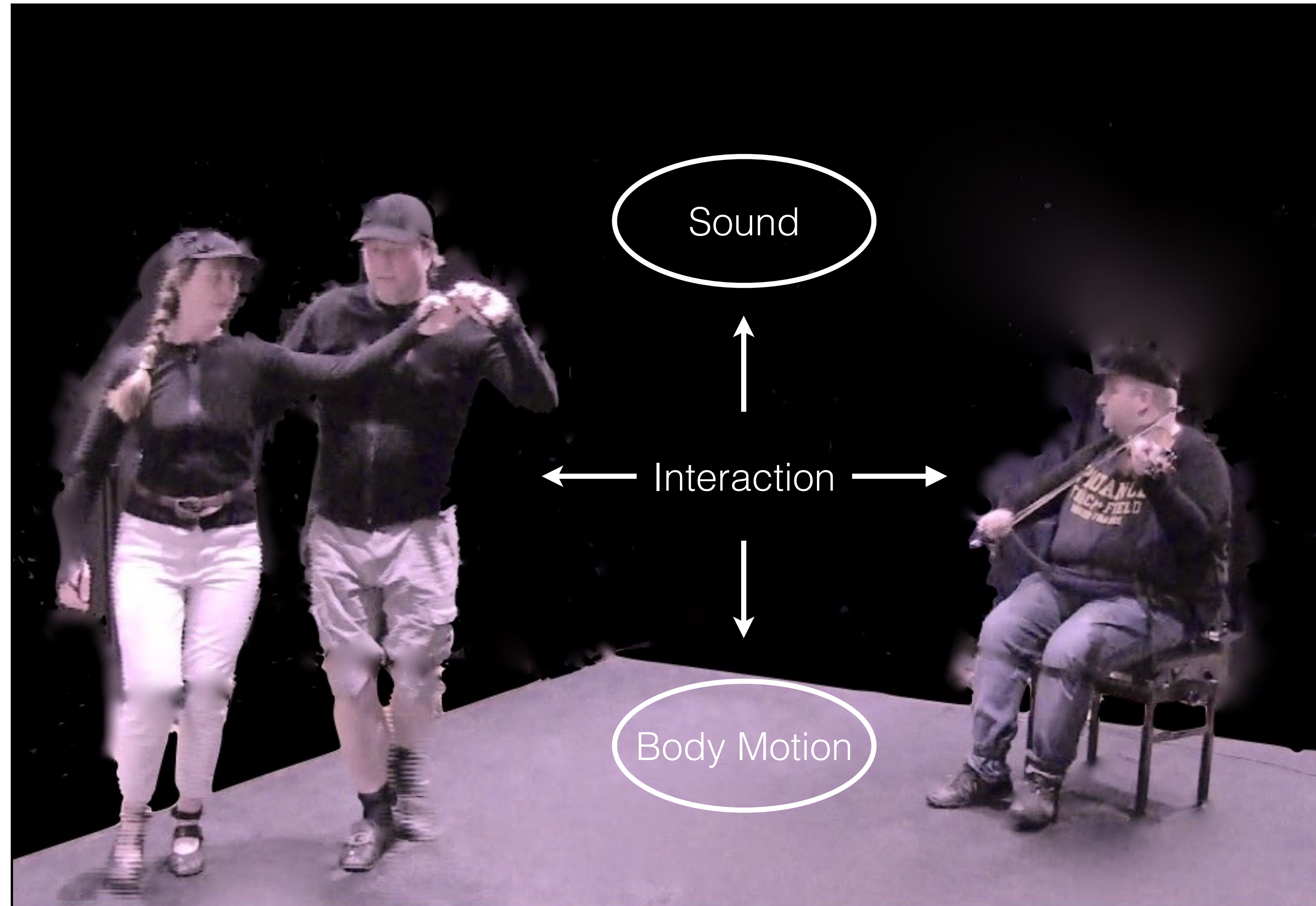
Music styles

- where the music and the dance have developed together under mutual influence.
- with an intrinsic relationship to a corresponding dance.

Music–Dance does not only refer to musical styles where music is *only* performed with the corresponding dance, but where the rhythm should be understood in relation to the corresponding dance.

(Haugen 2016)

Music–Dance performance



Gestural renderings in Music–Dance

- *A motor-mimetic perspective*: images of the motion patterns in the dance may inform the musician's playing, even when dancers are not present.
- Musicians, dancers, and perceivers may share an understanding of the underlying reference structures through commonly shaped mental images.

“Participants without the tacit knowledge of how movements are related to sonic patterns will listen, move and understand it differently.”

–Naveda 2011, p. 51

Non-Isochronous meter

- Isochronous: from Greek *isokhronos*, from *isos* 'equal' + *khronos* 'time'.
- *Non-Isochronous meters*: music styles that feature an underlying reference structure that consists of beats of uneven duration.
- Non-isochronous meters should not be viewed as deviations from an underlying isochronous pulse, but should be understood as non-isochronous in and of itself, that is, as consisting of beats with uneven duration.

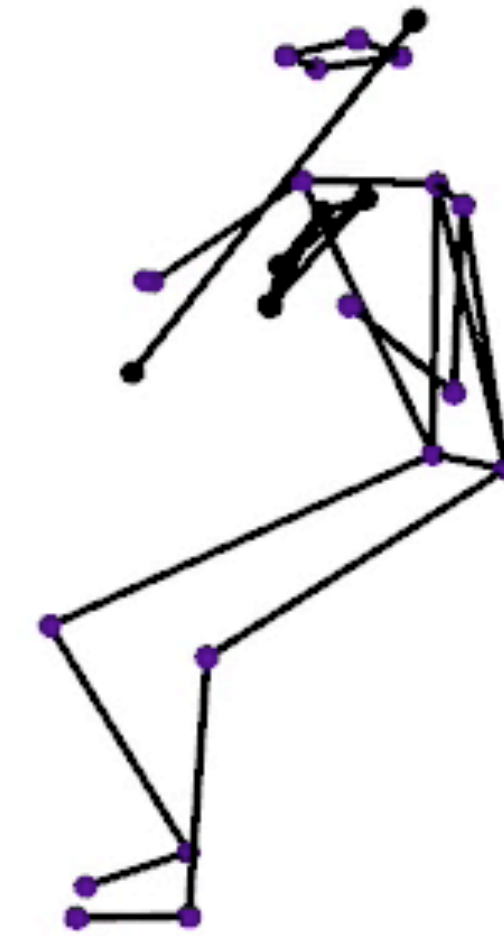
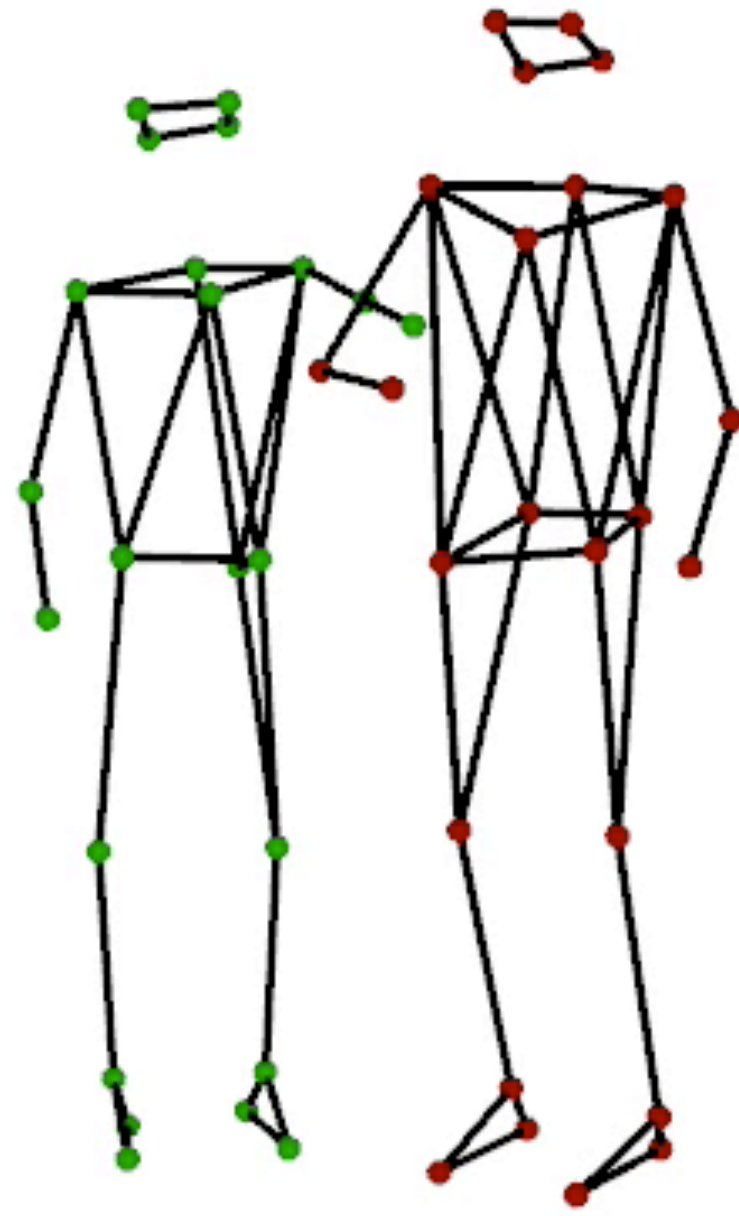
Samba

- 2/4 meter
- Non-isochronous metrical subdivisions at the level of sixteenth notes: the fourth sixteenth note in a beat is longer in duration.

Telespringar

- 3/4 meter
- *Asymmetrical meter*, the three beats in a measure are of uneven duration: long–*medium*–*short*.

Telespringar



Summary

- Embodied music cognition
- Rhythm
- Underlying reference structures (pulse, meter) and tempo
- Entrainment
- Meter and motion
- Music culture
- Non-isochronous meter
- Music–Dance

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