

# **SOUND ANALYSIS AND MOVEMENT ANALYSIS**

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# Why would one might want to study movements in relation to sound?

- To understand how musicians control the sound (motor control)
- To understand how musicians synchronize (timing)
- To understand movements in response to musical sounds
- To understand how visual information influence perceived performance (timbre, expression...)



# Plan for today's lecture

- Some examples of studies of instrumentalists' motor control
- More in-depth: Two studies of preparatory movements and control in drumming

BREAK

- Movements in response to music: DISCUSSION EXERCISE
- Motion information affecting perception



# Challenges for analyzing music performance (in general)

- Comparing between performers and performances
  - Great individual differences!
- Reproducibility vs. ecological settings

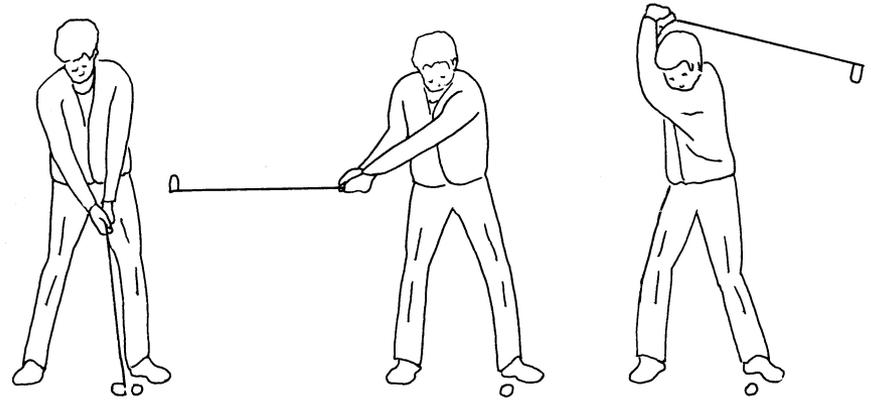


# **Instrumentalists' movements to control timing and sound parameters**



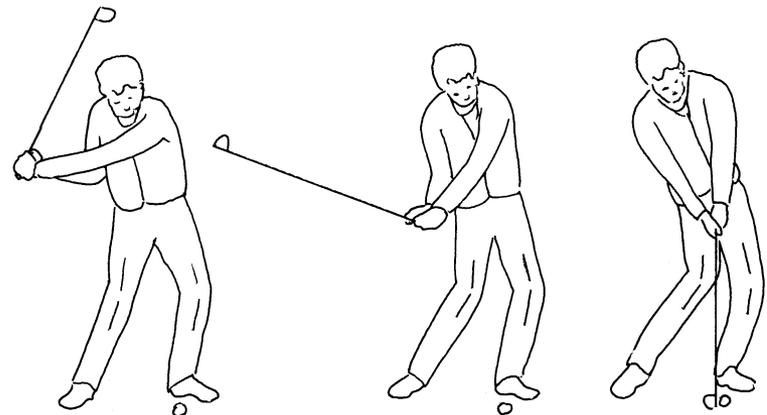
# Musicians' movements: Communication as goal

The evaluation of music performance differs from that of many other types of skilled performance (e.g. in sports). Not so much about speed or getting the most points.

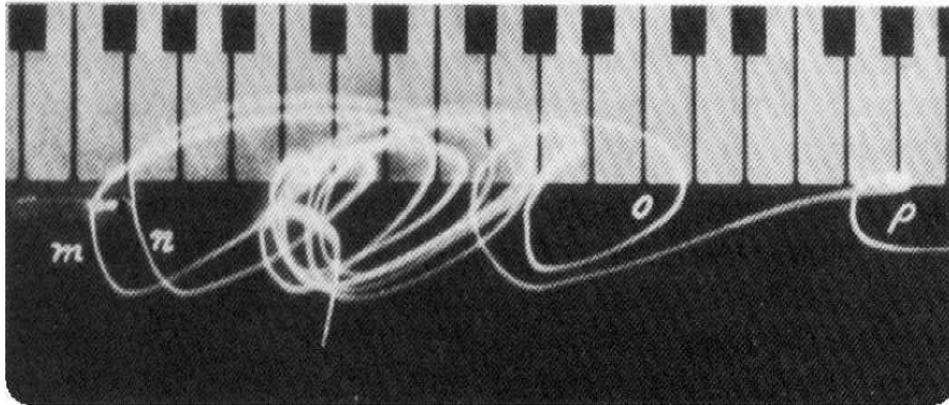


Focus is typically on the resulting sound rather than the movement per se.

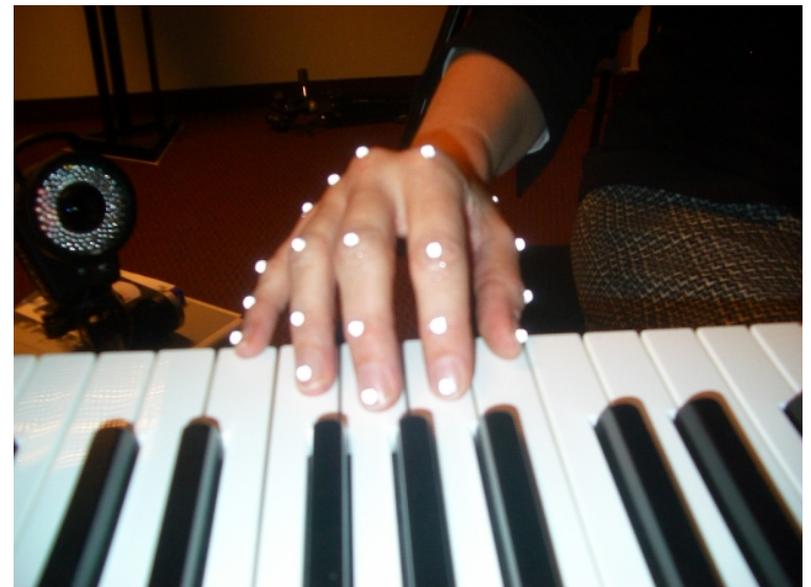
Also, the movements are normally performed under a (strict) time constraint: the tempo



## Sound-producing gestures in piano

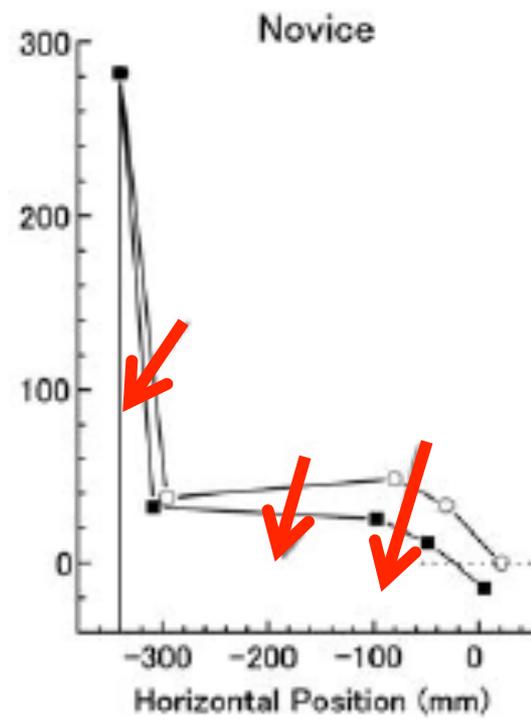
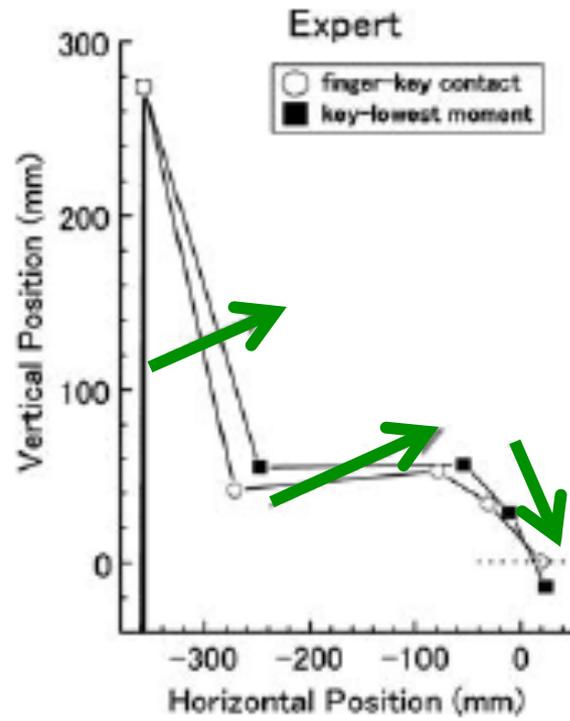
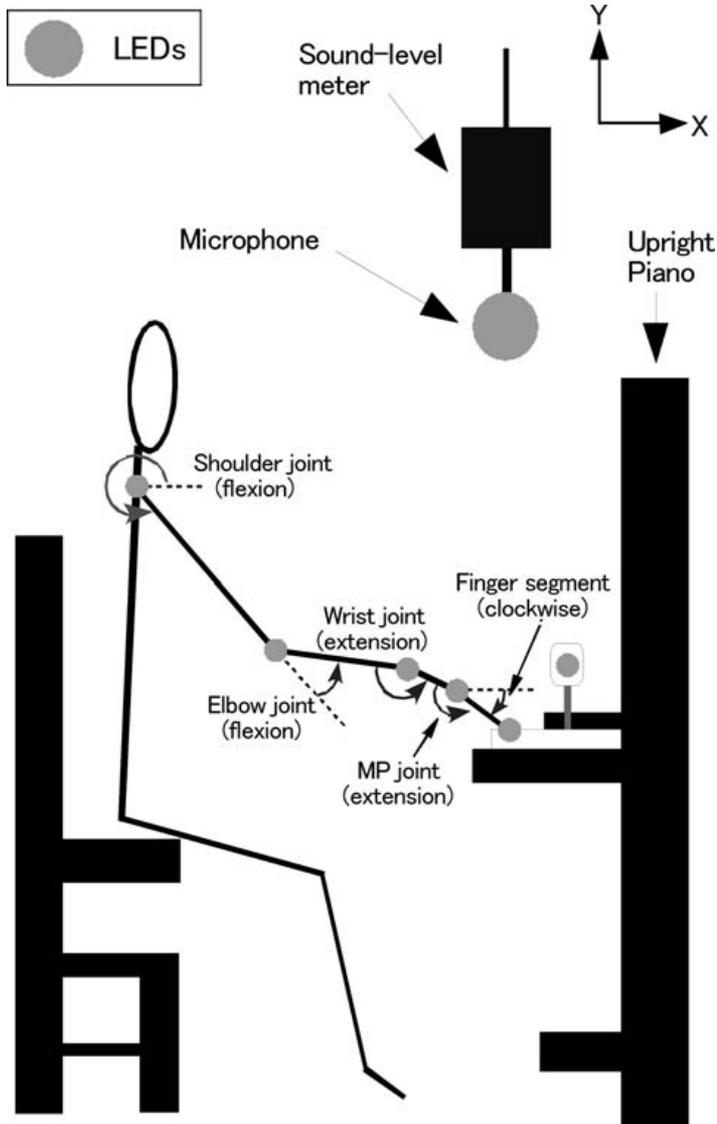


Continuous circling movement  
of the hand in a Chopin etude  
(Ortmann, 1929).

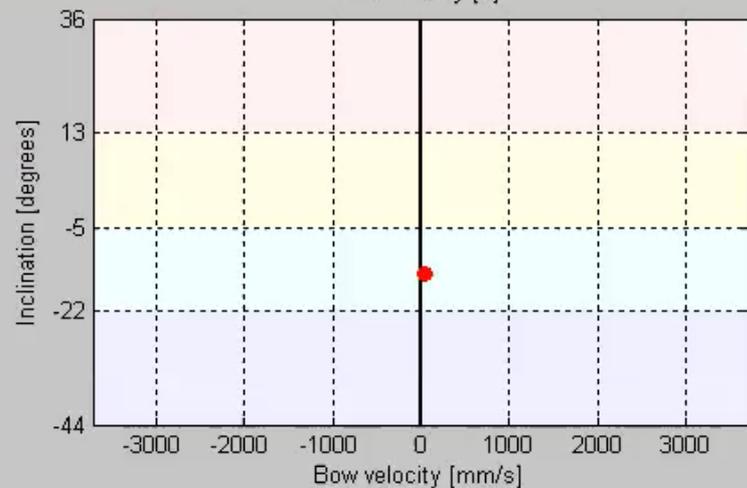
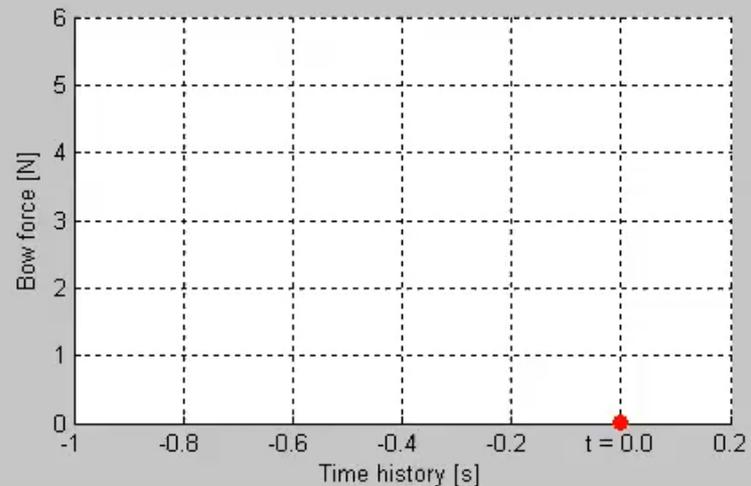
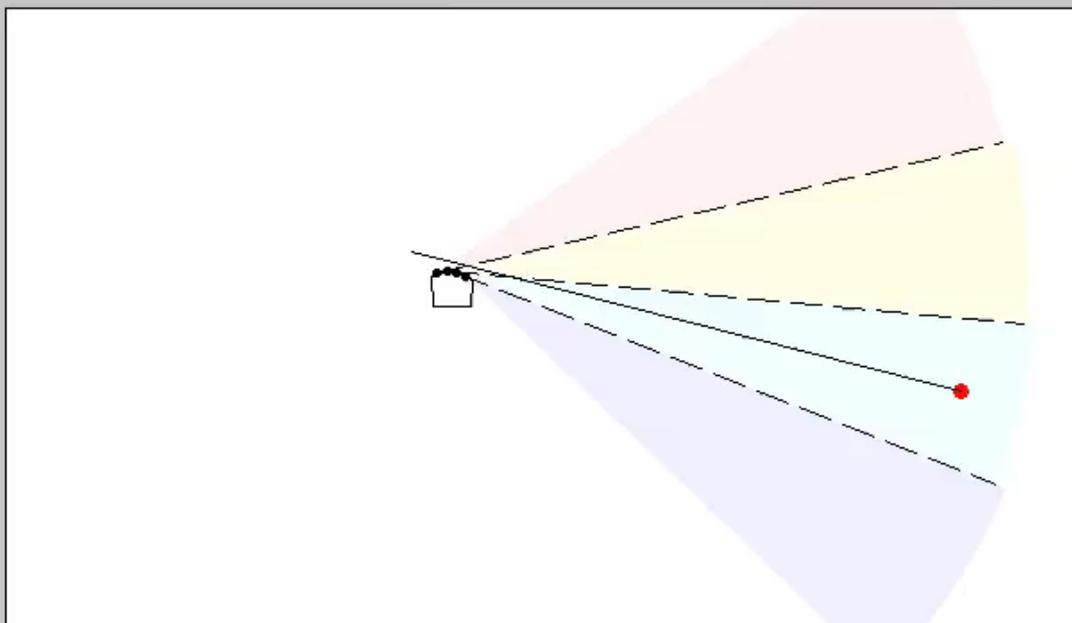
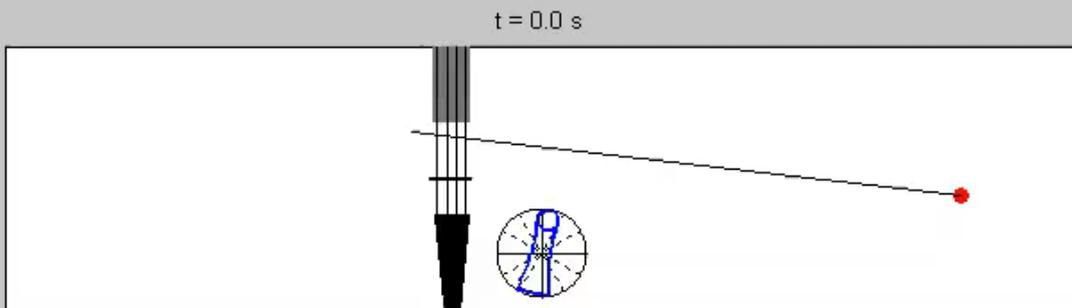


Pianists may benefit from  
tactile feedback for timing  
(Goebel & Palmer, 2008)

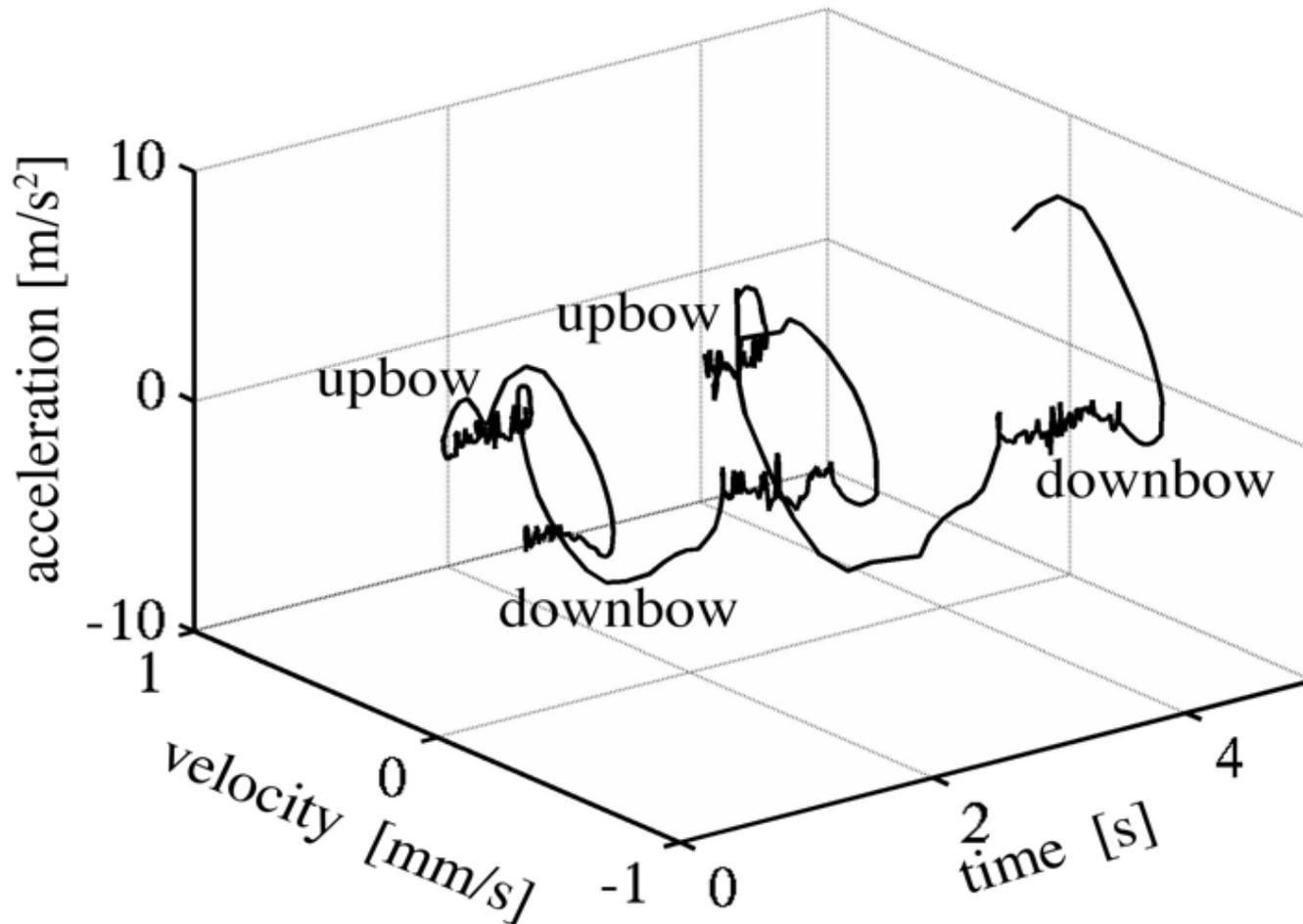
# Biomechanical study of pianists' sound control (two simultaneous notes).



# Movement and force measurement in violin playing

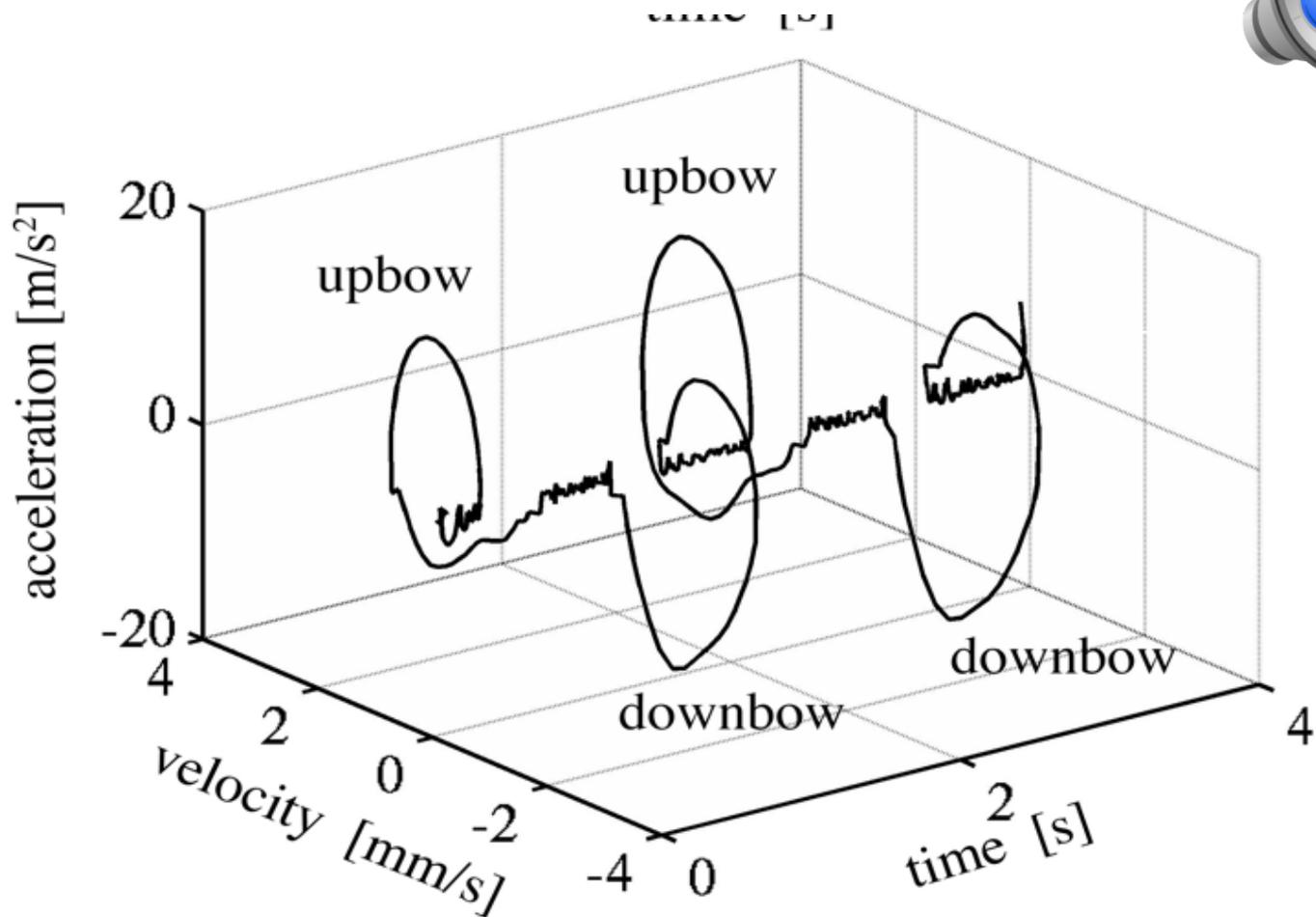


# Bowing: Détaché ("separated")



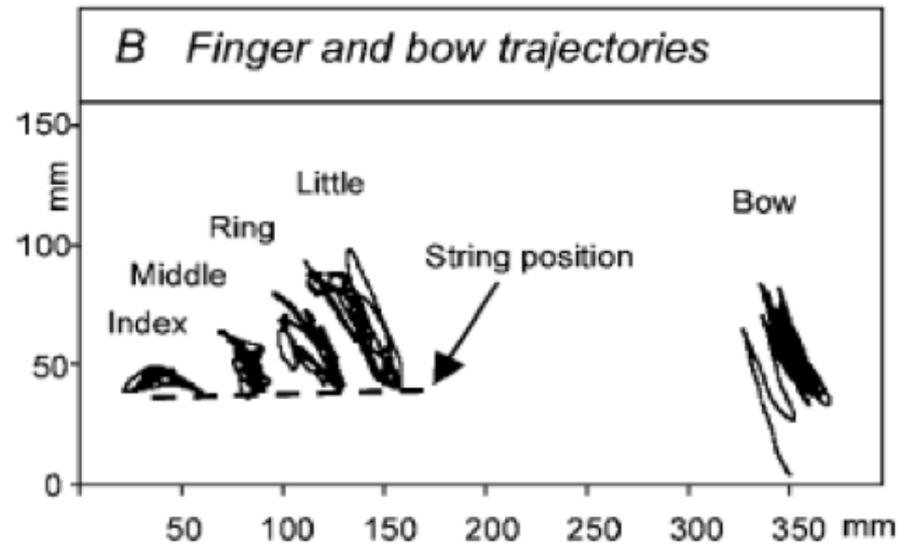
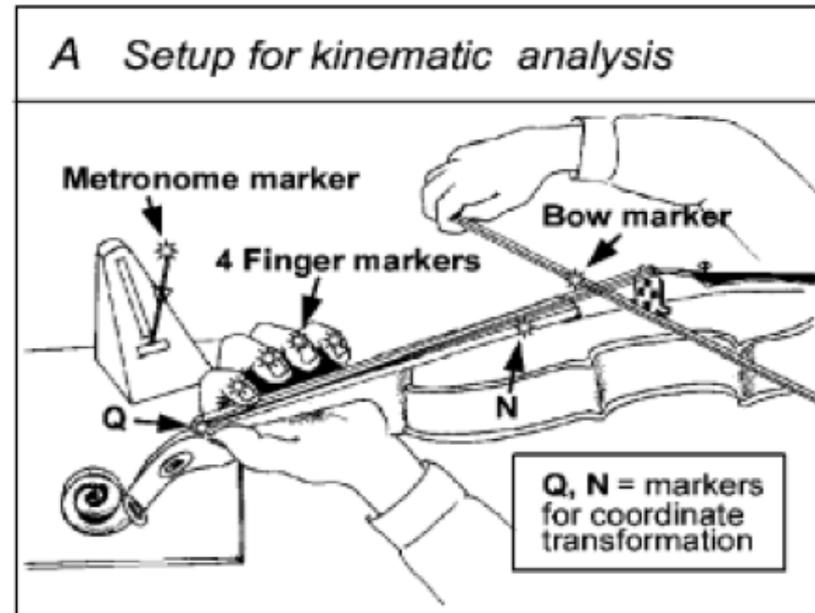
(Bild: Rasamimanana & Bevilacqua; Ton:Young)

# Bowing: Martelé ("hammered")

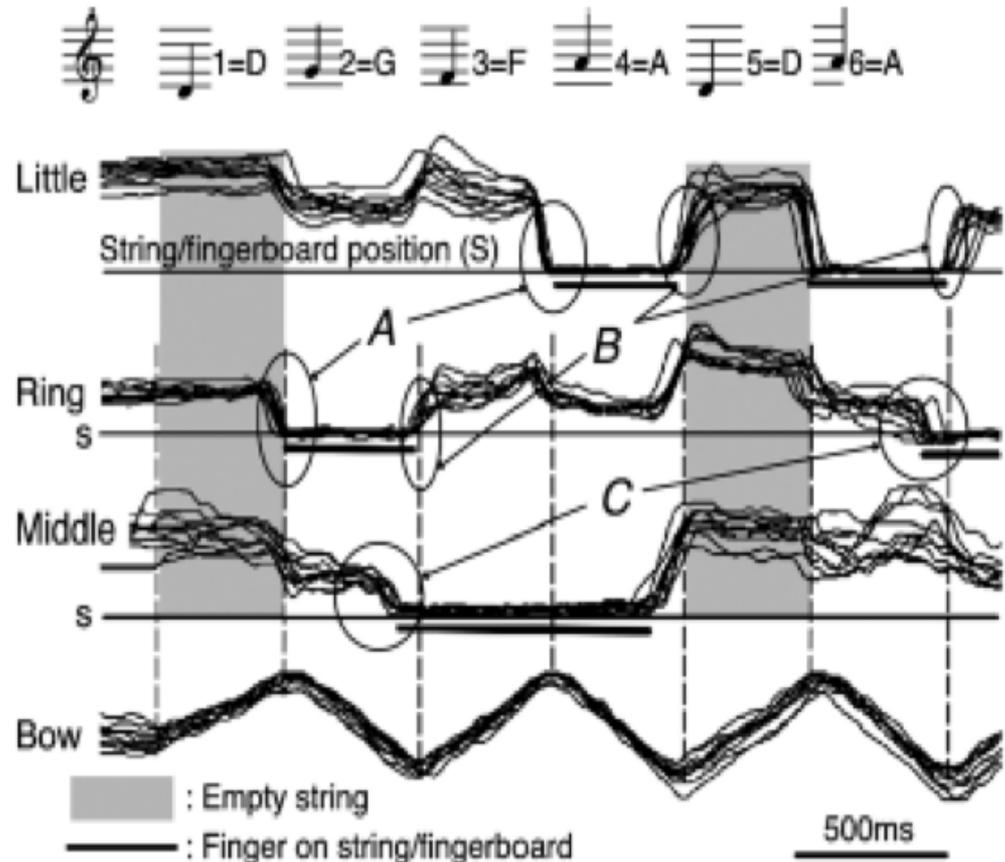


(Bild: Rasamimanana & Bevilacqua; Ton:Young)

# Preparation in violin playing

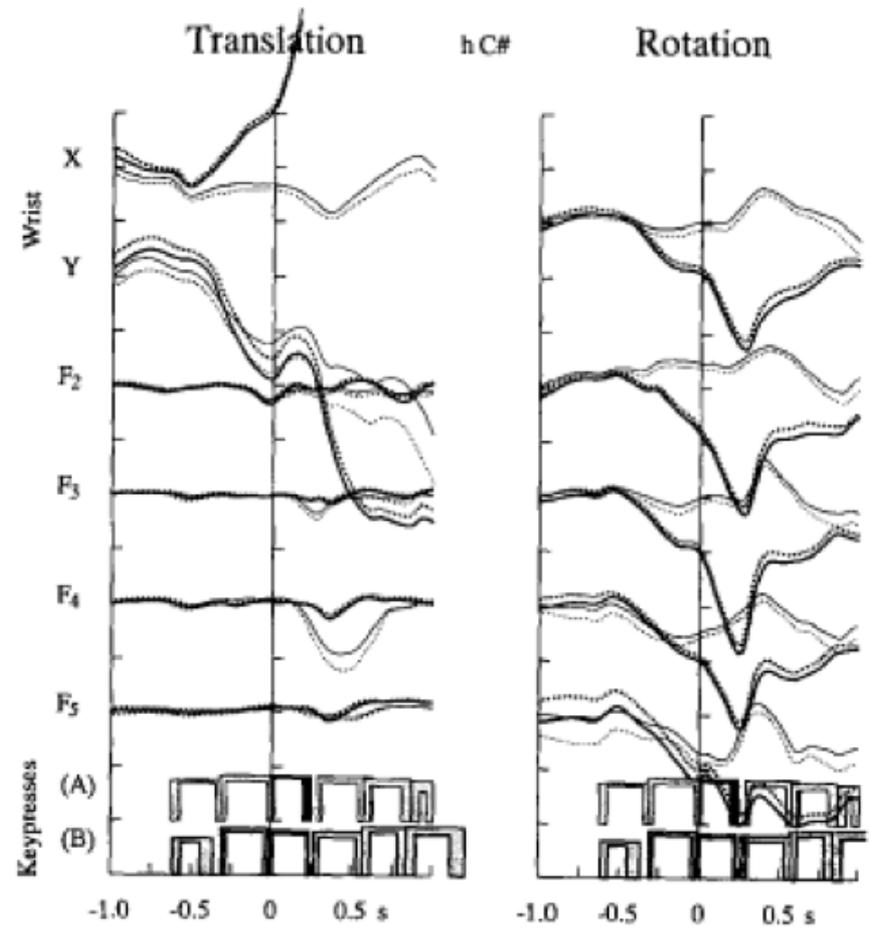


# Preparation in violin playing



- A: Serial: actionfinger down controls timing and pitch*
- B: Serial: finger-lift controls timing only*
- C: Parallel & Anticipation: actionfinger controls pitch, not timing*

# Preparation in piano playing

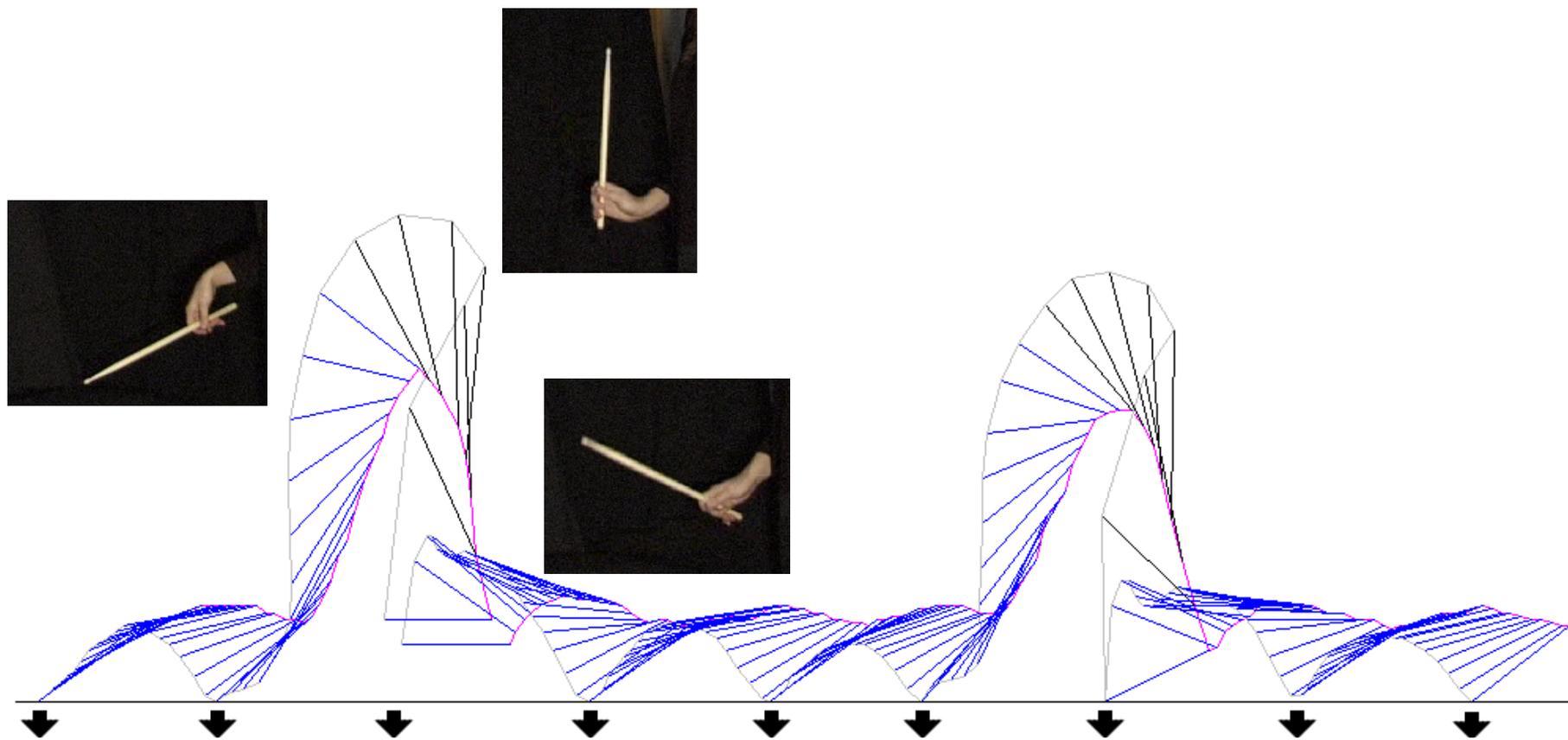


Preparations before "thumb under" can be as early as 500ms before.

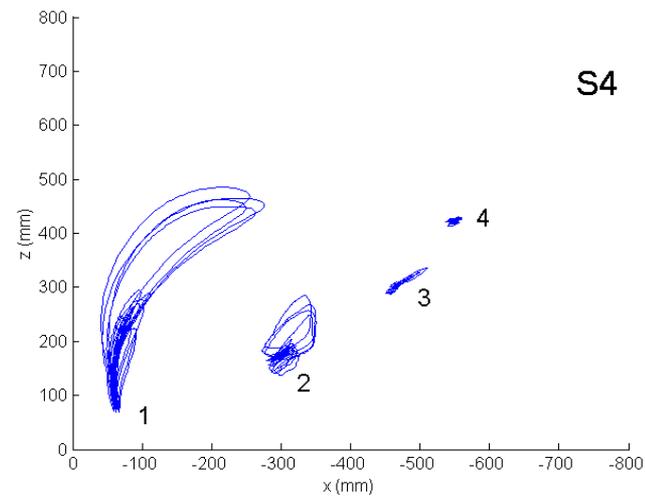
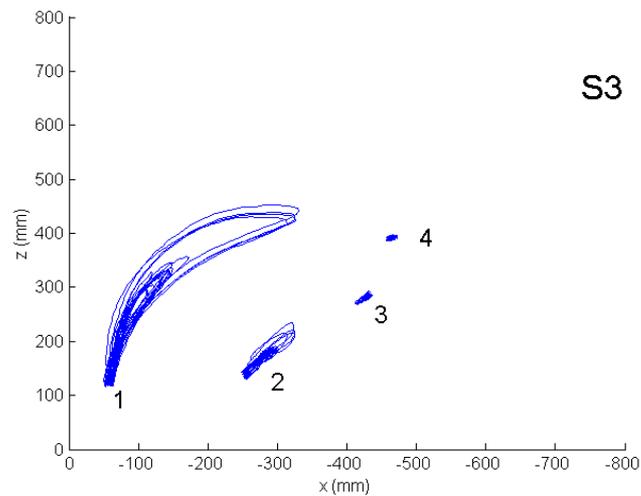
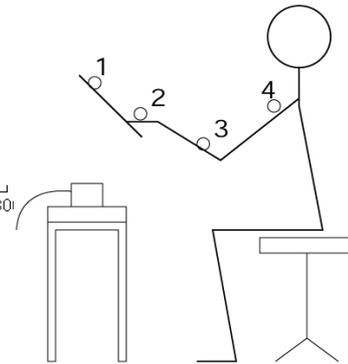
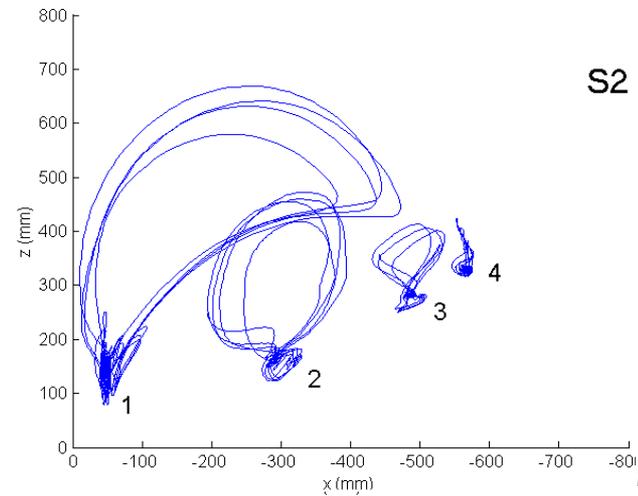
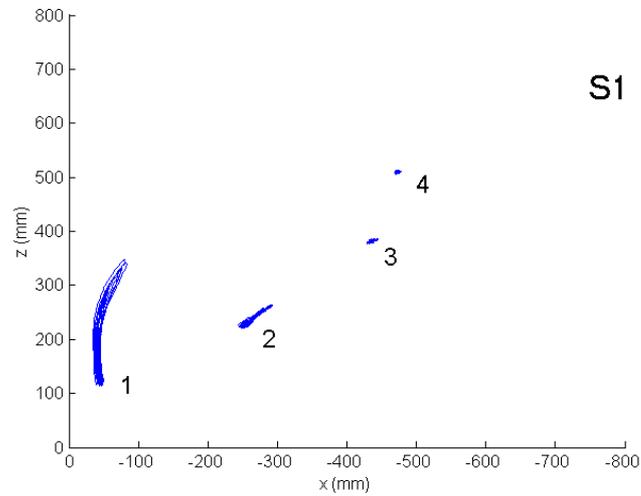
(Engel, Flanders & Soechting, 1997)



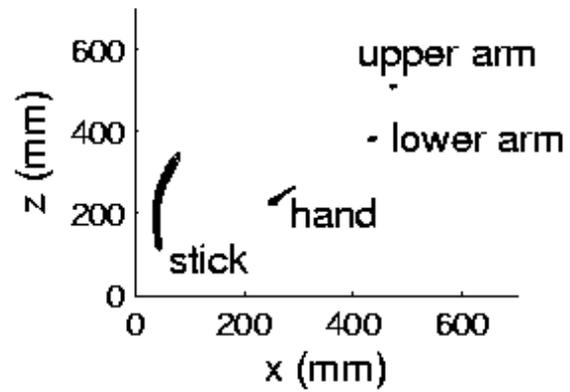
# Preparation in drumming: Stick movements for accented and unaccented drum strokes



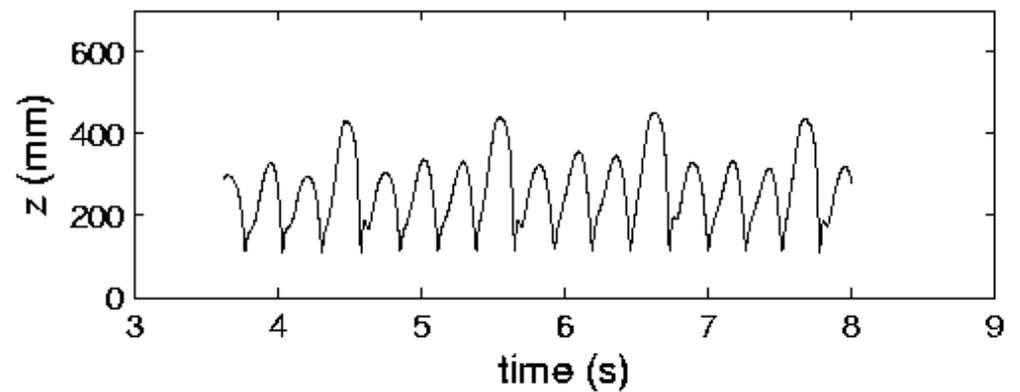
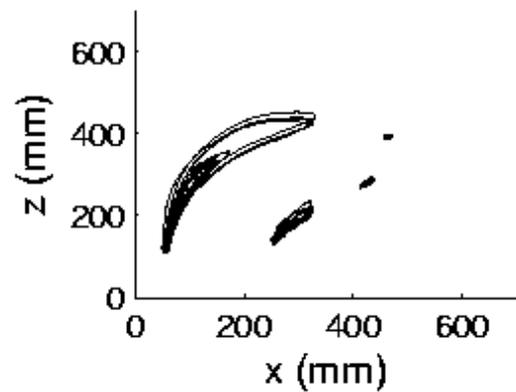
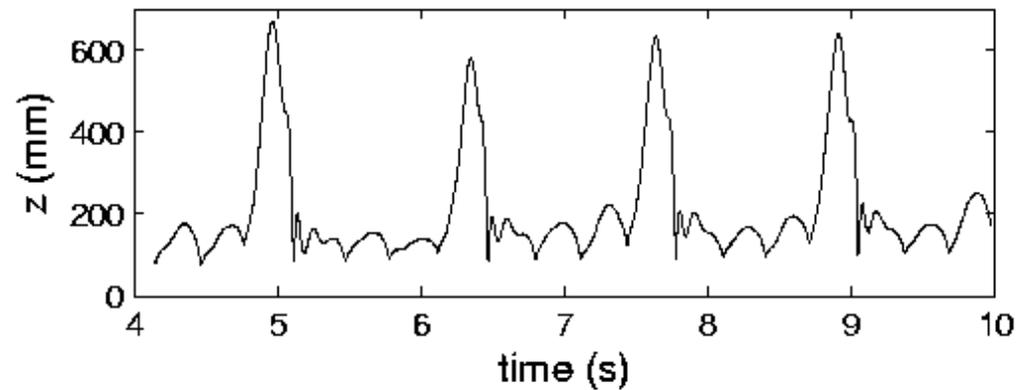
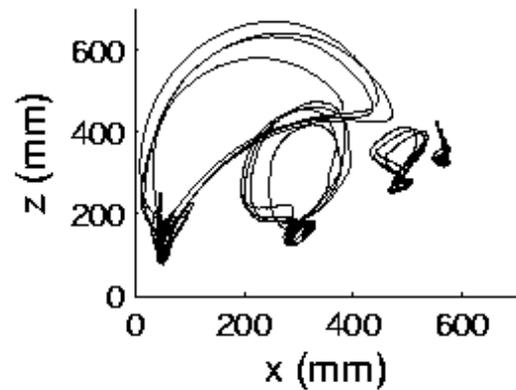
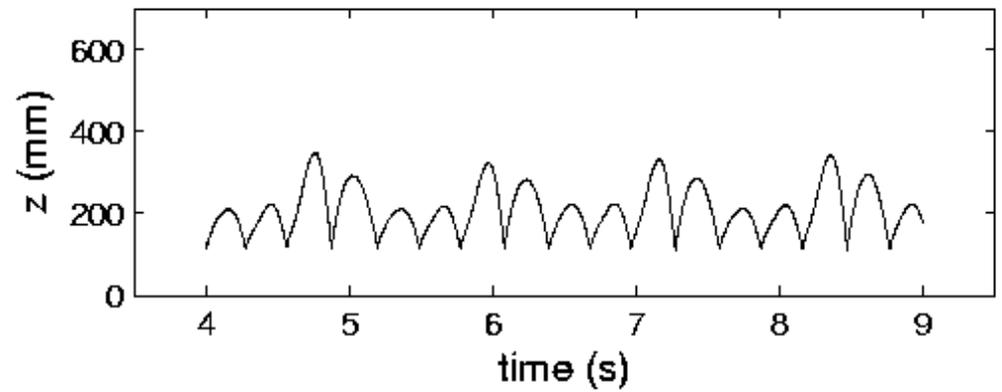
# Movement trajectories of four drummers



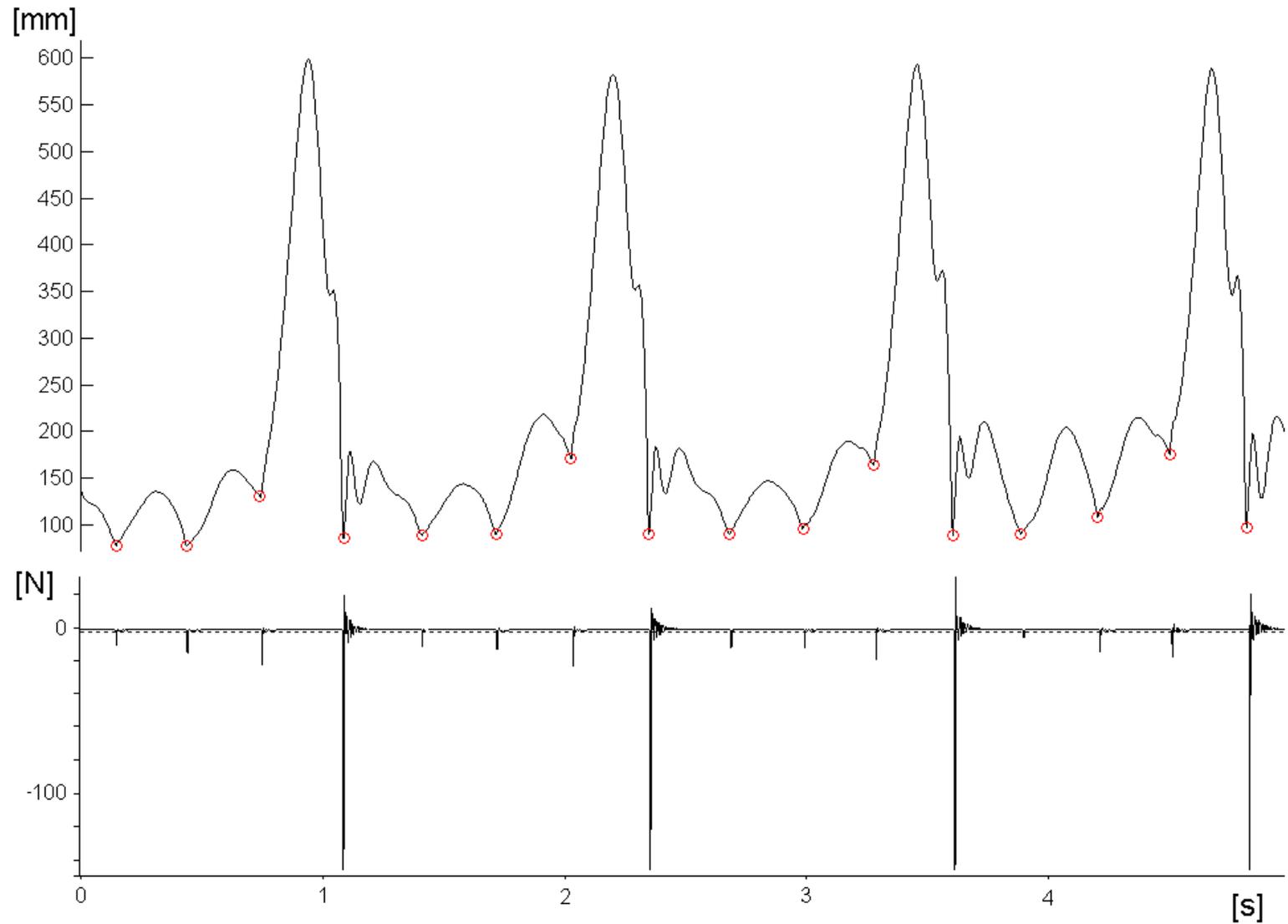
trajectories



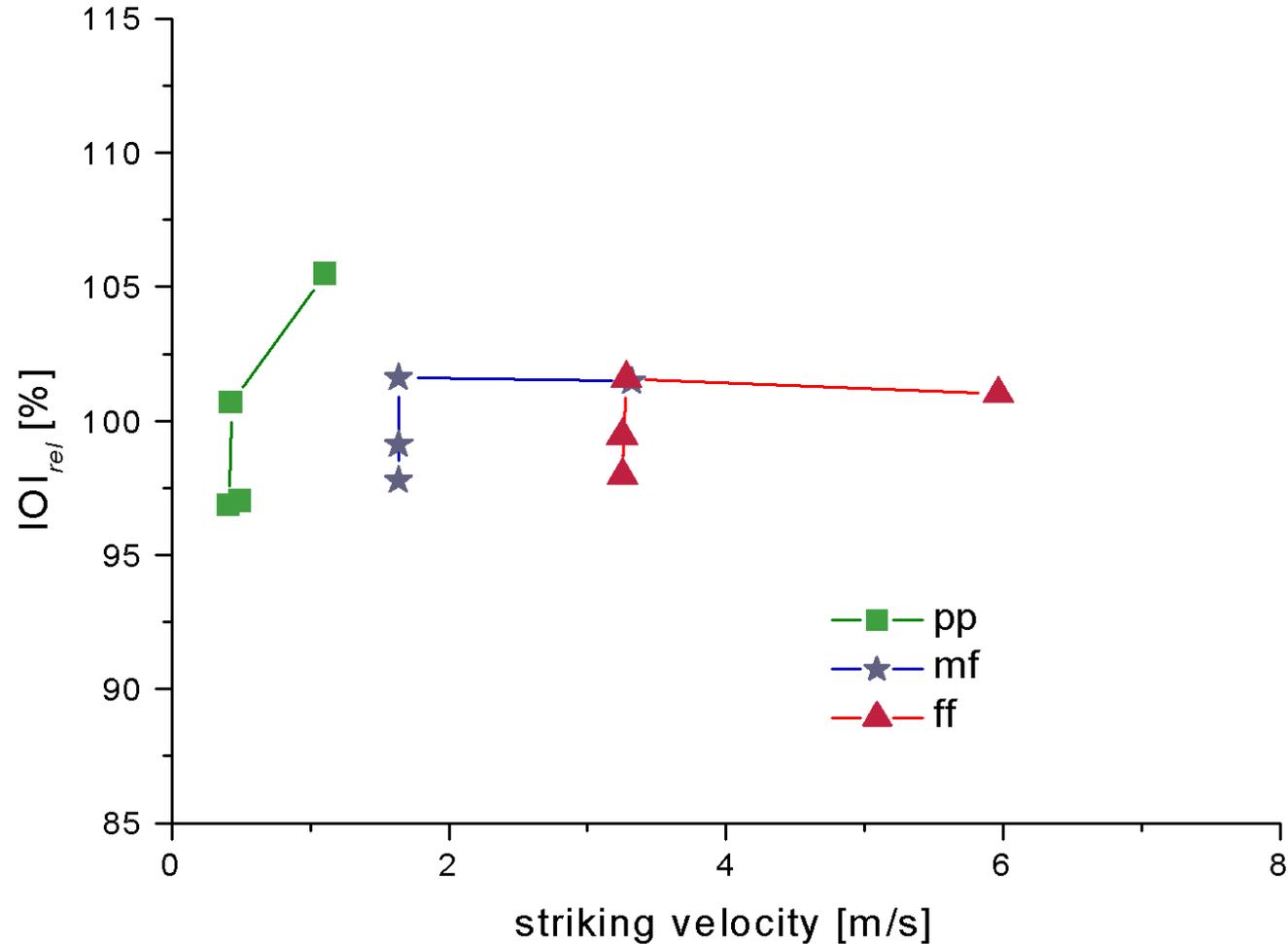
vertical stick displacement



# Producing force from acceleration



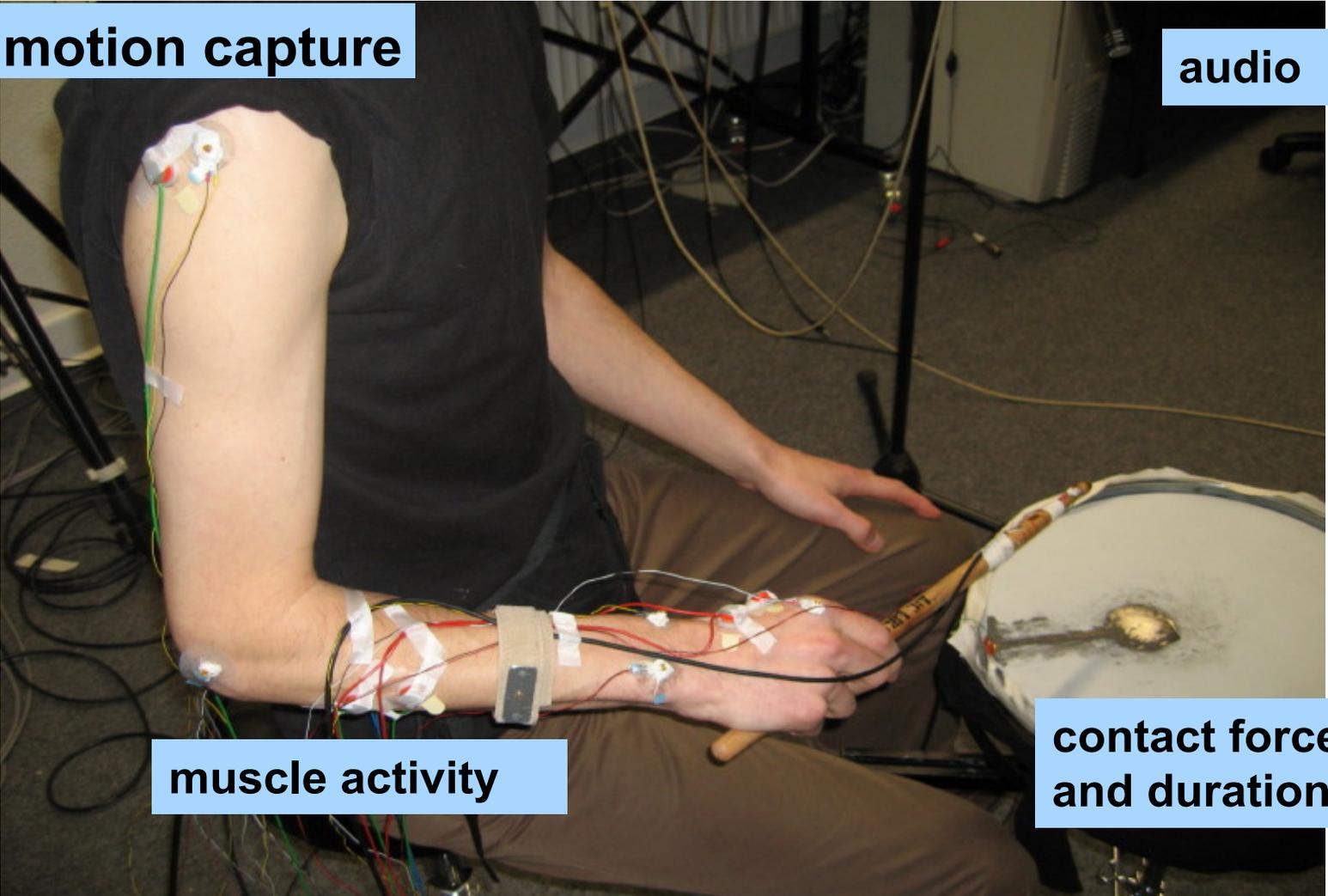
# Striking velocity and relative timing (inter-onset intervals)



# Measuring movement and sound in drumming

**motion capture**

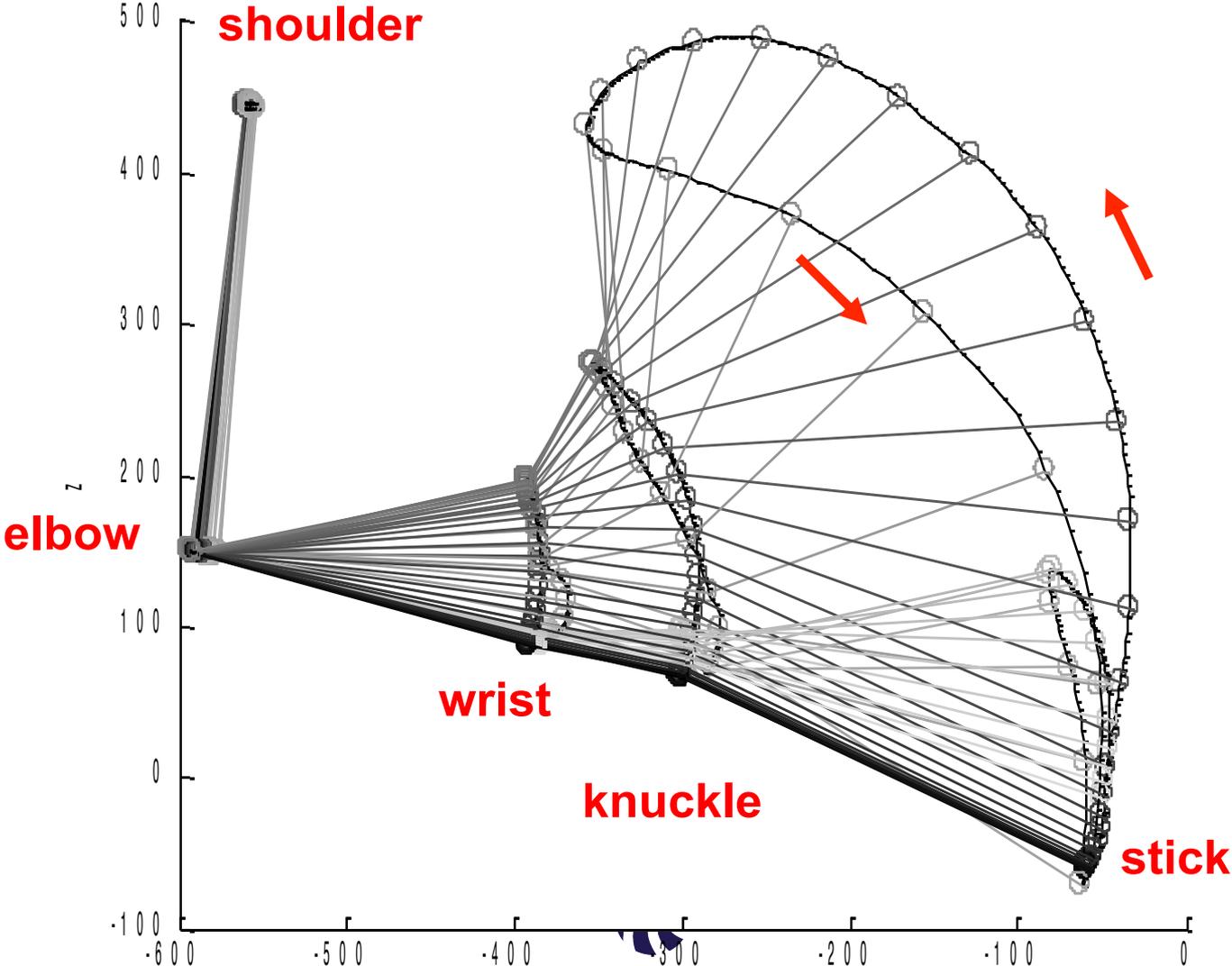
**audio**



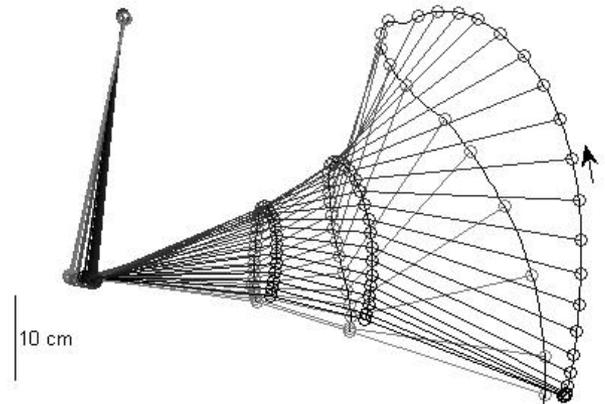
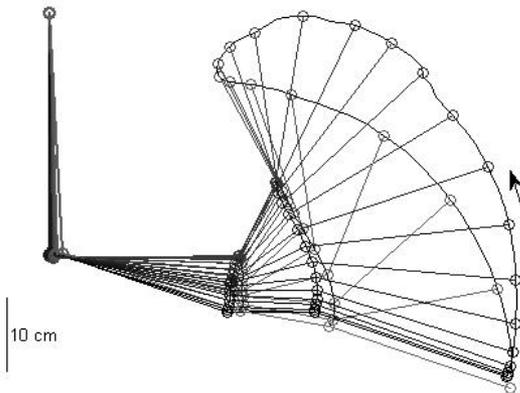
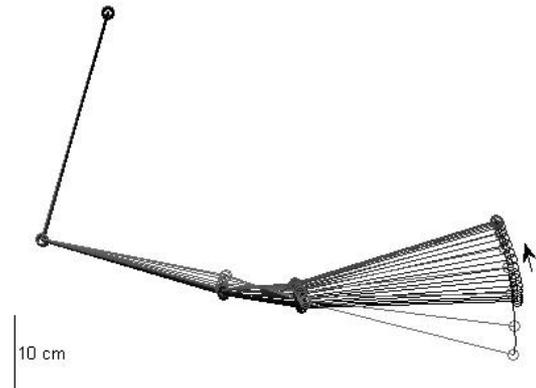
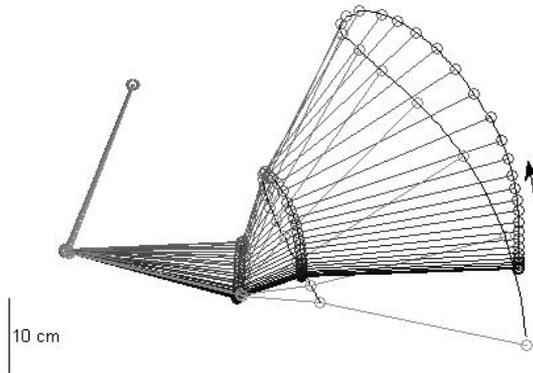
**muscle activity**

**contact force and duration**

# Motion capture data for a single *mf* stroke



# Same task, different movement strategies.



Single, stroke at mf



# Dealing with the rebound

- The rebound from the surface can be incorporated in, and be an aid for, the preparation for the nextcoming stroke.
- Necessary in order to play some fast patterns (e.g. rolls)
- Strategies like the “Moeller stroke” also utilizes the rebound
- Accelerating the stick over a longer runway makes louder playing possible.
- ...but if the next stroke is to be softly played the rebound may need to be controlled

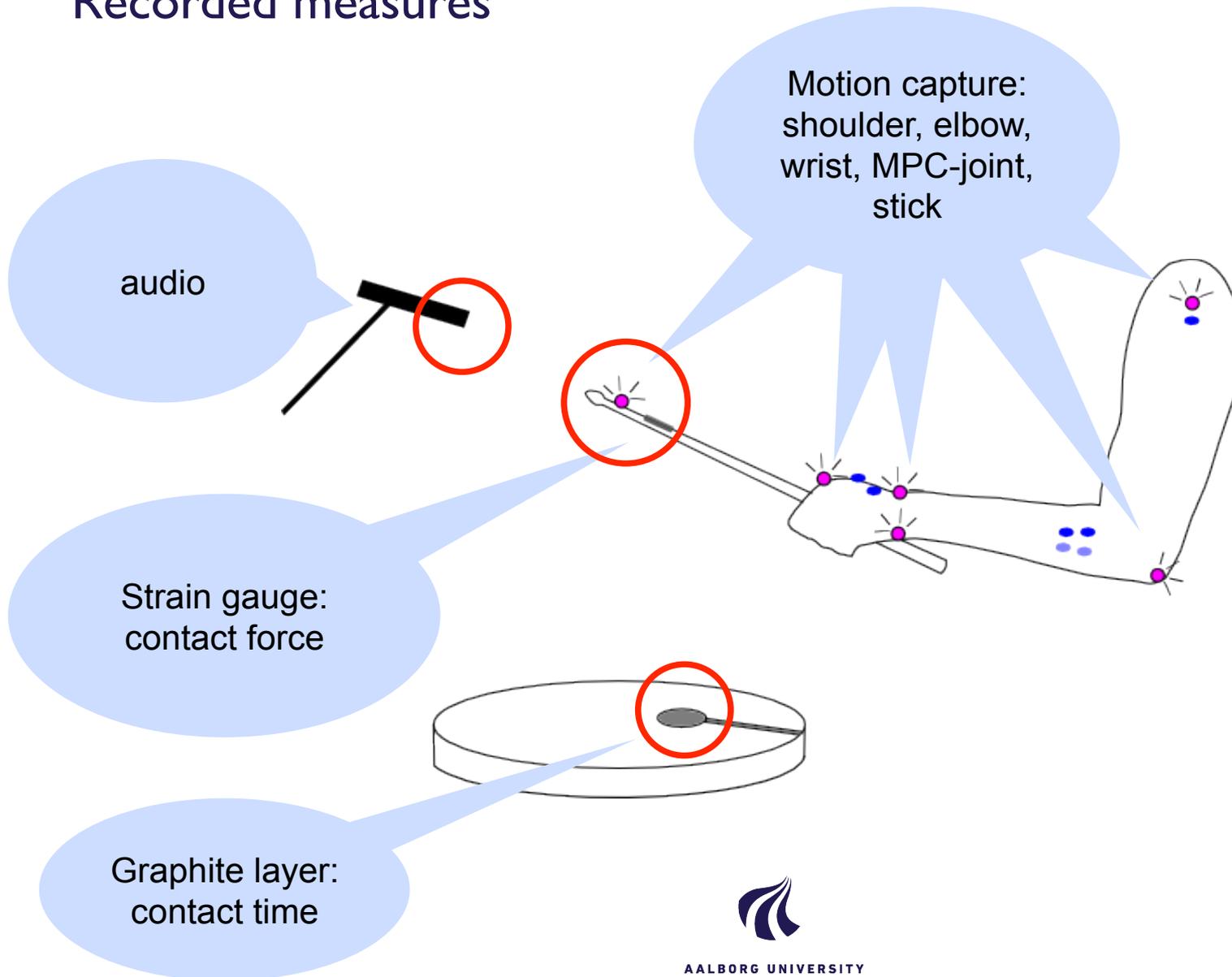


# How does controlling the rebound affect the sound?

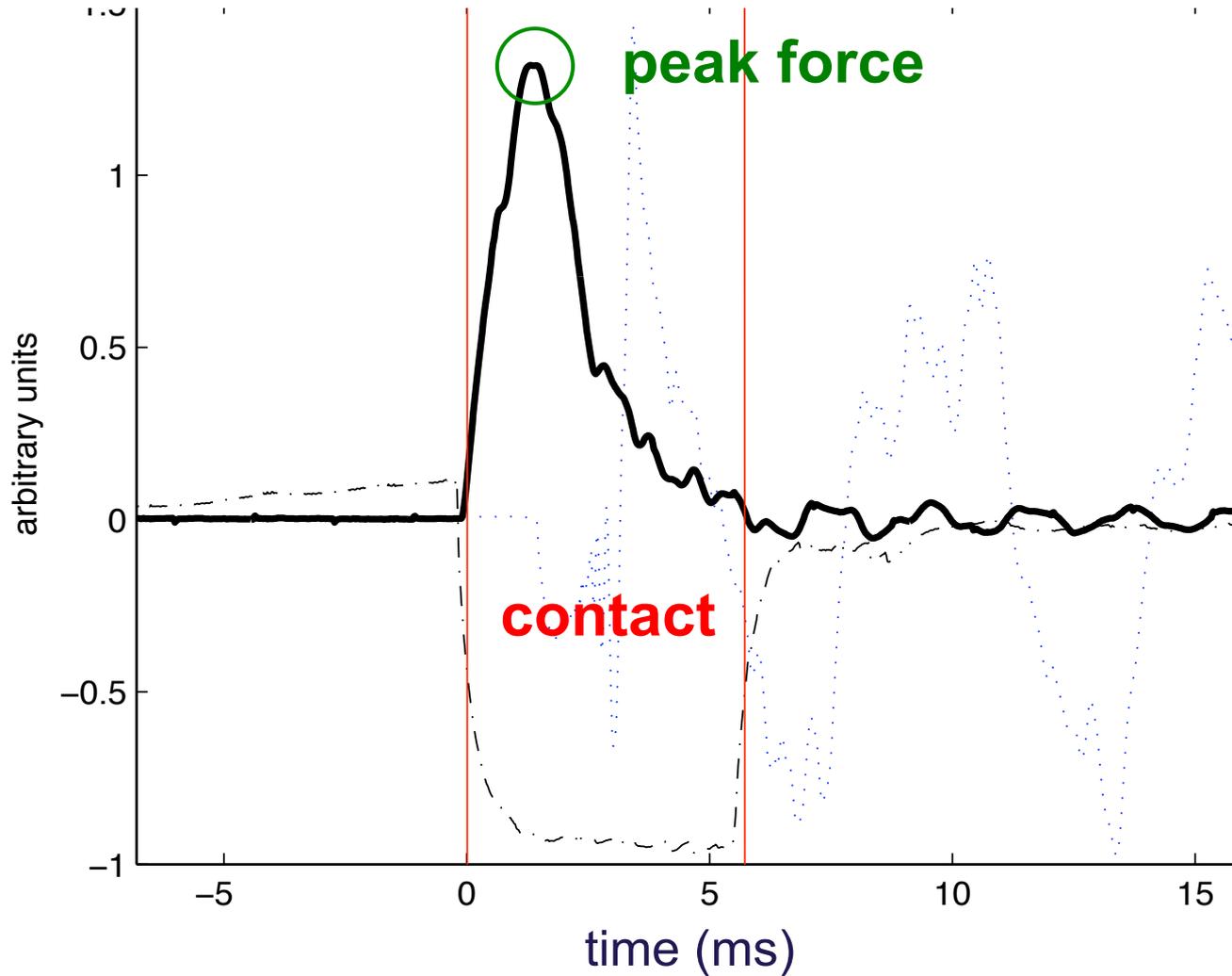
- Separated single *mf* strokes
  - allowed to ring out
- “Normal”
  - play as normal, relaxed, stick free to rebound
- “Controlled”
  - stop stick as close as possible to the drumhead directly after stroke



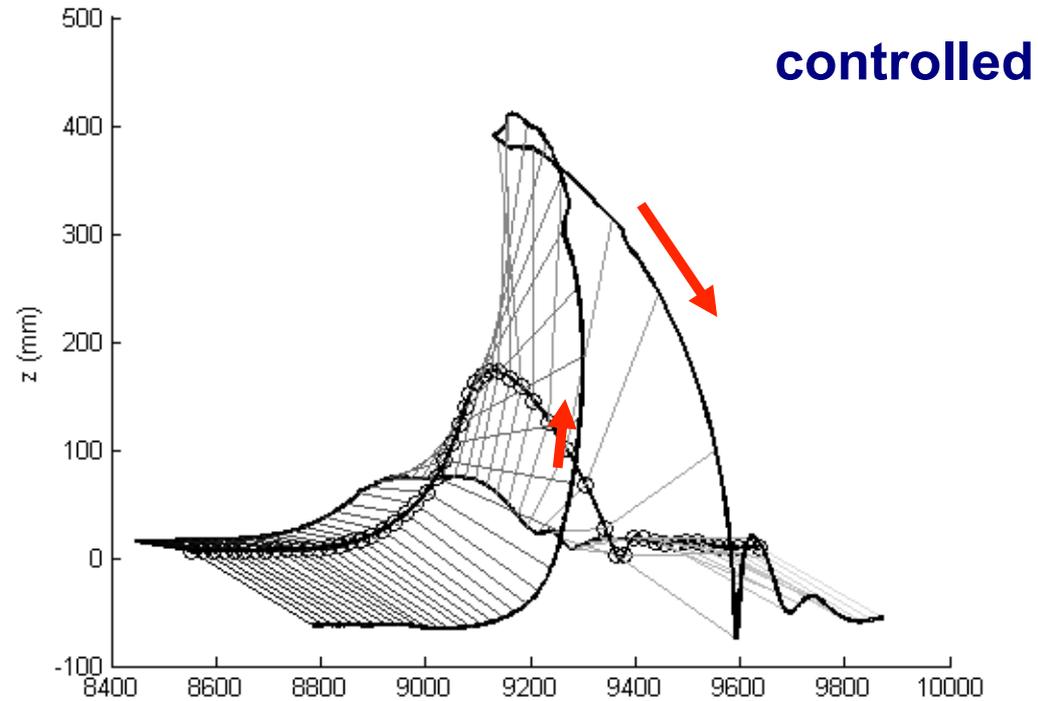
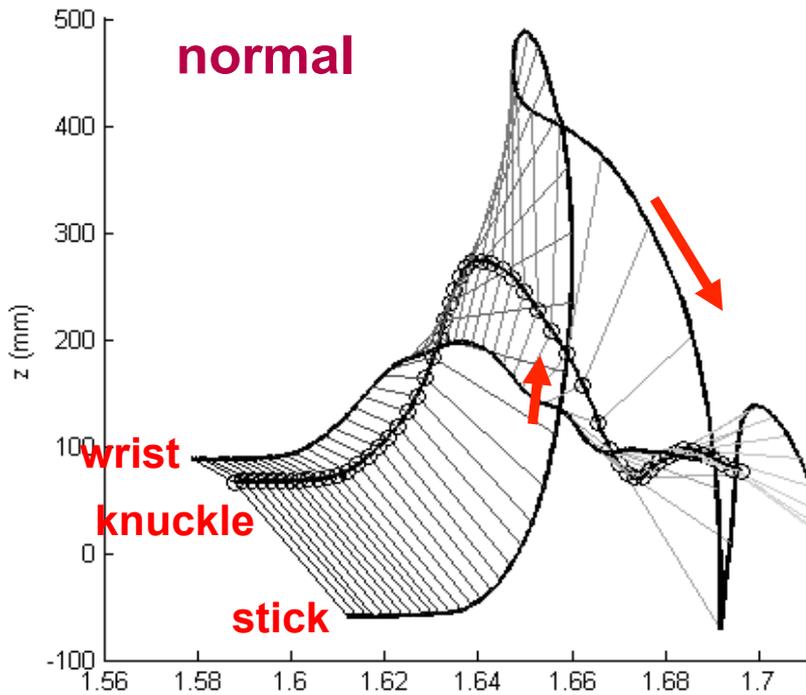
# Recorded measures



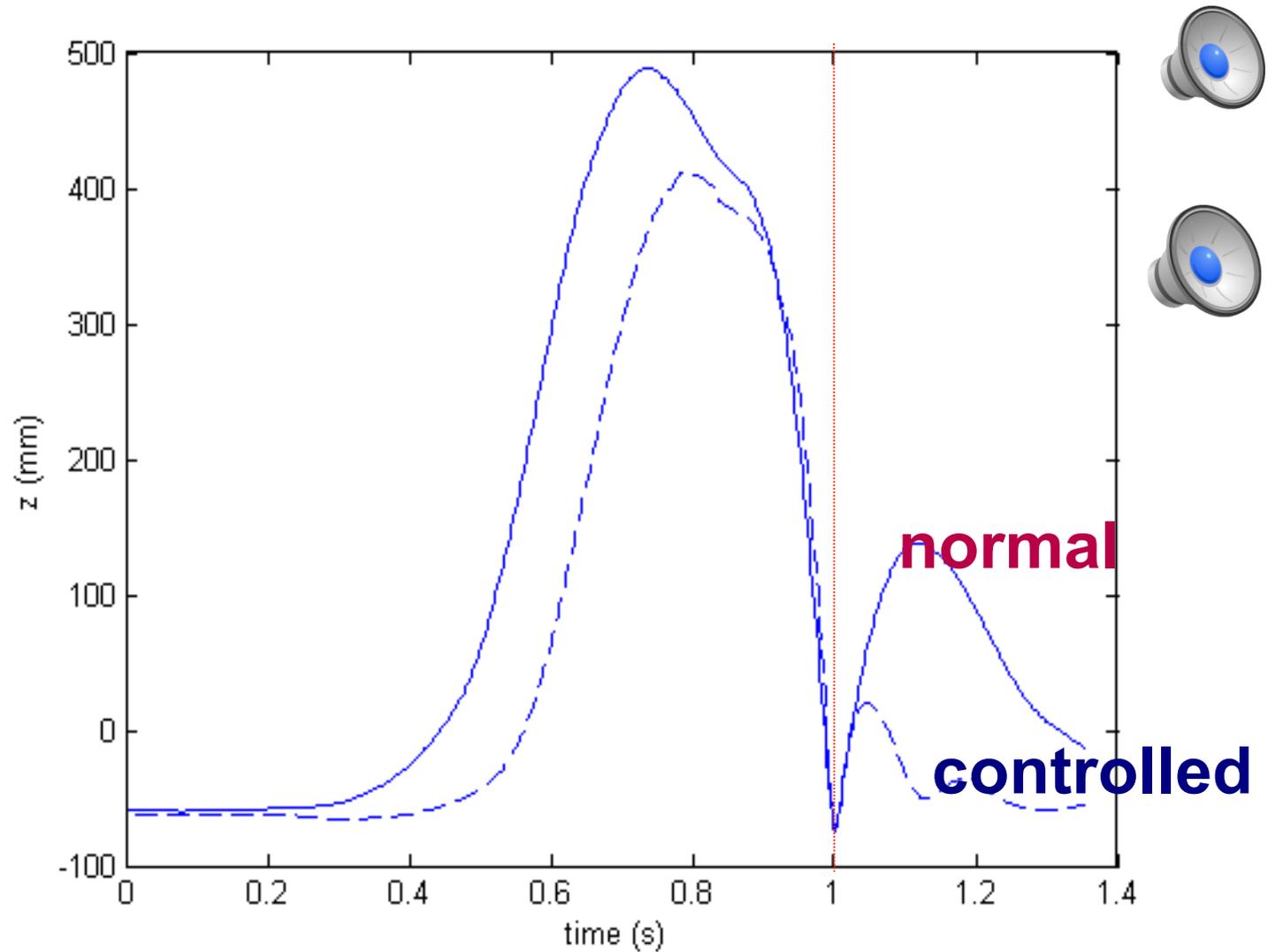
# Measurement of force and contact time



# “Normal” and “Controlled” strokes

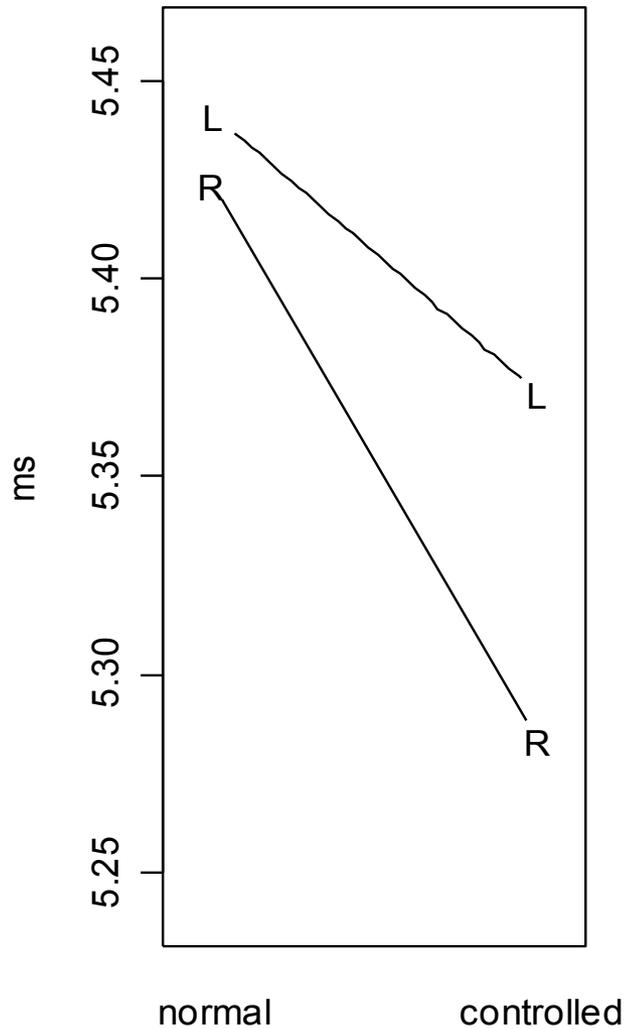


# Vertical displacement of stick marker

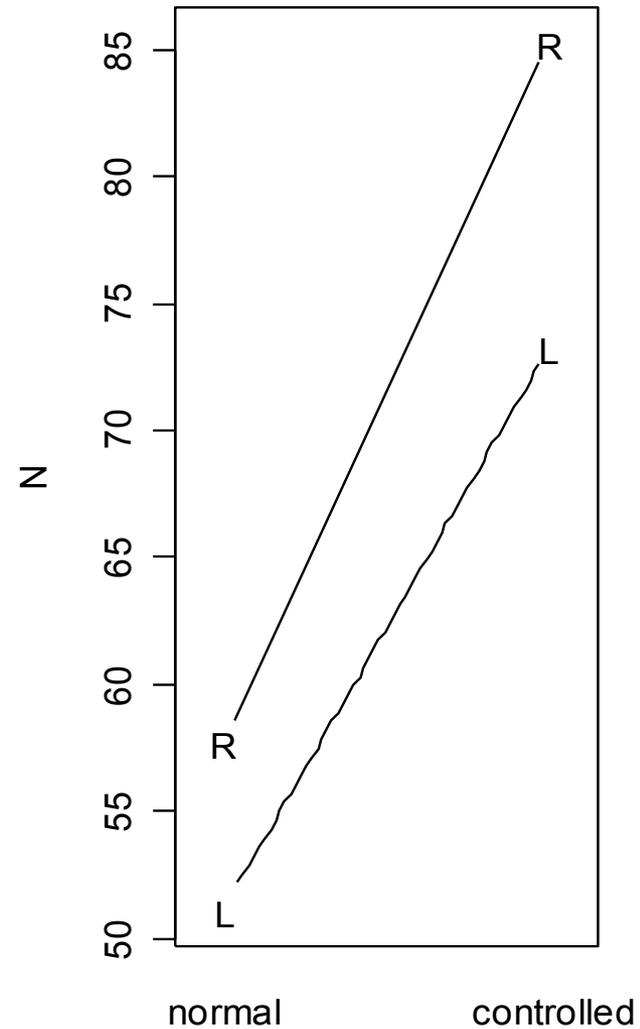


# Contact force and duration for normal and controlled strokes

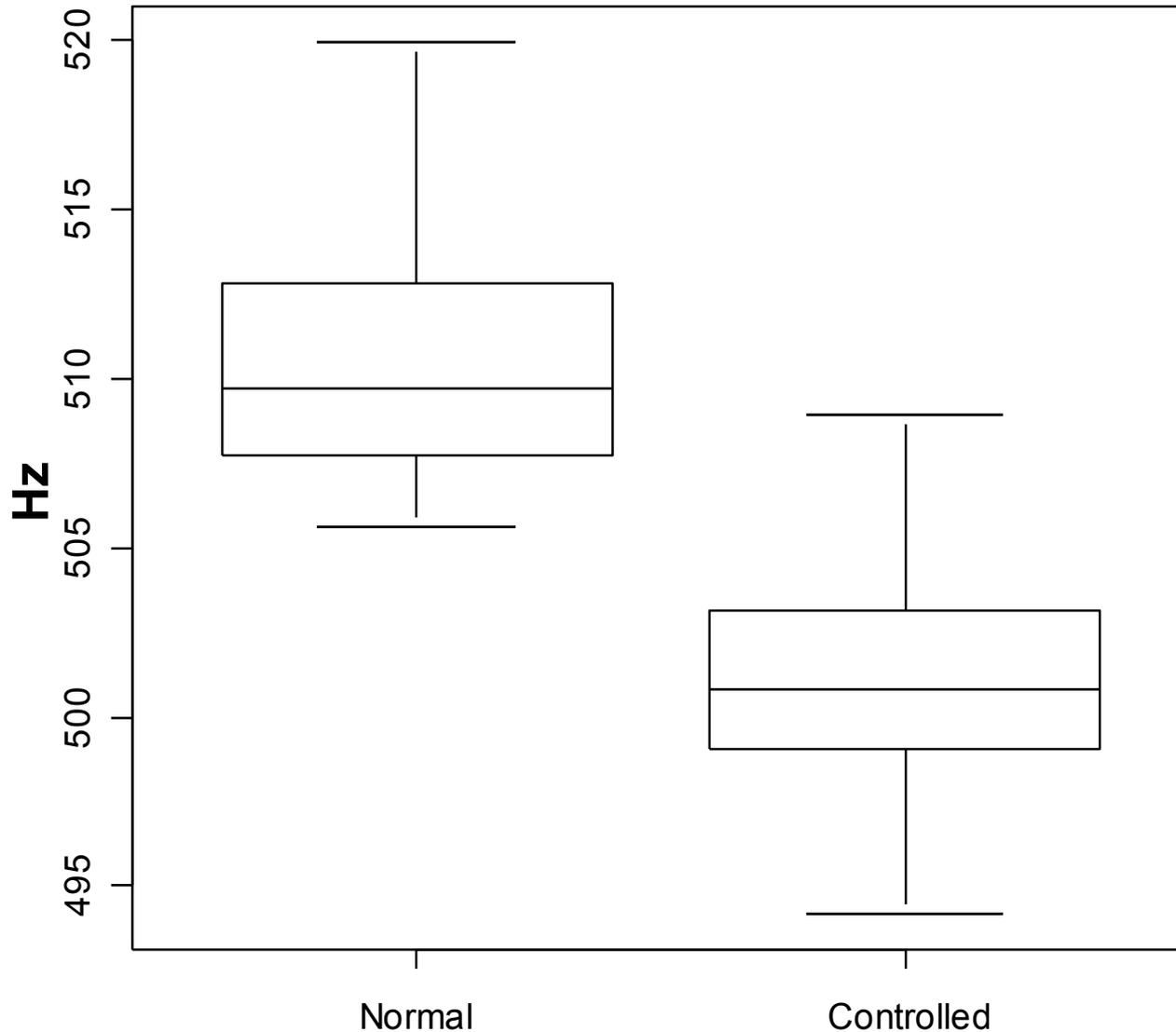
**contact duration**



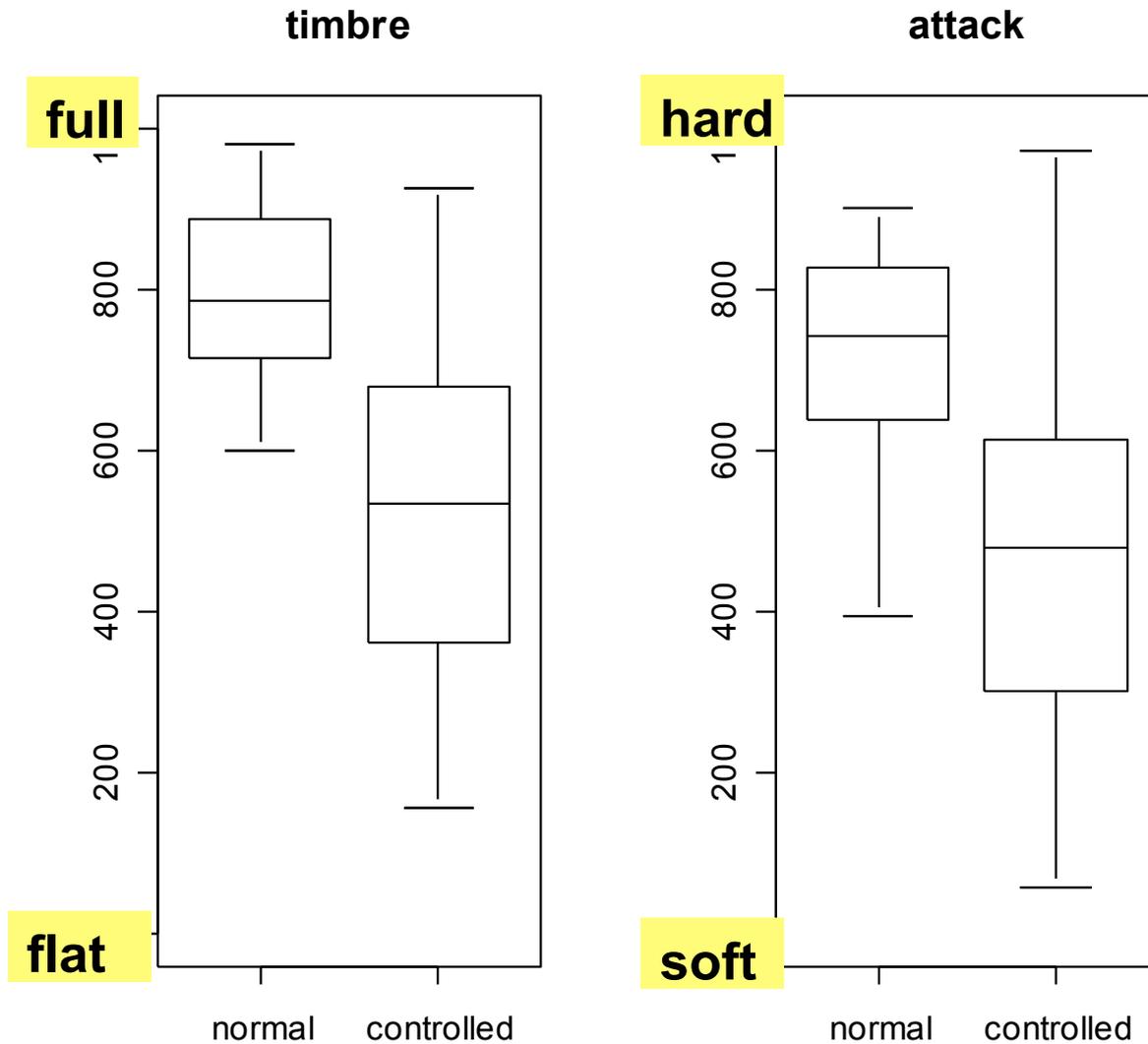
**peak force**



# Spectral centroid (considering 16-1000 Hz)



# Ratings for timbre and attack: results



Learning to play

Playing for fun

beginner

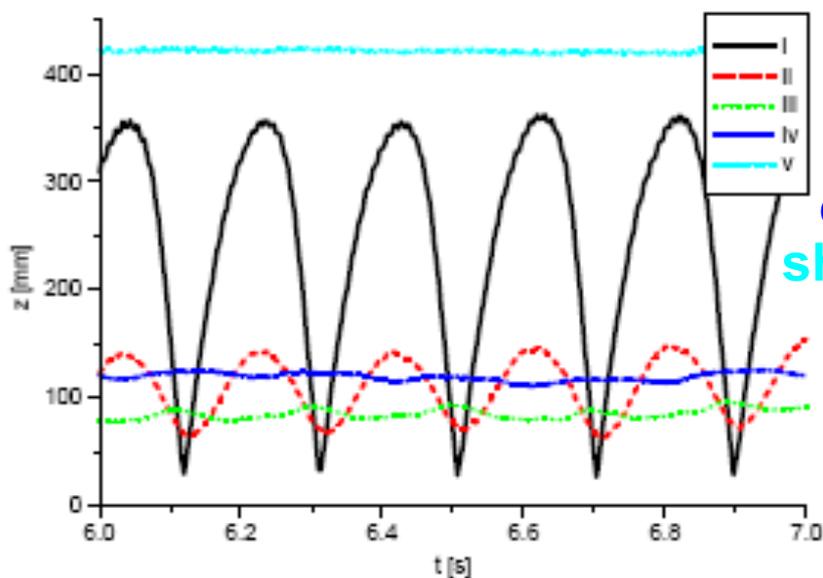
Professional



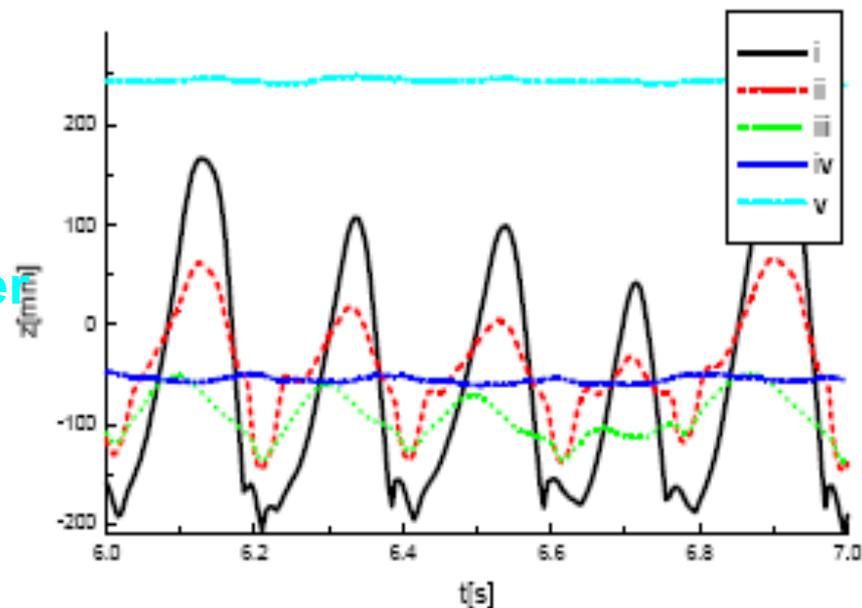
Drop out

# Expert and novice differences

## Motion trajectories, forte, IOI=200ms



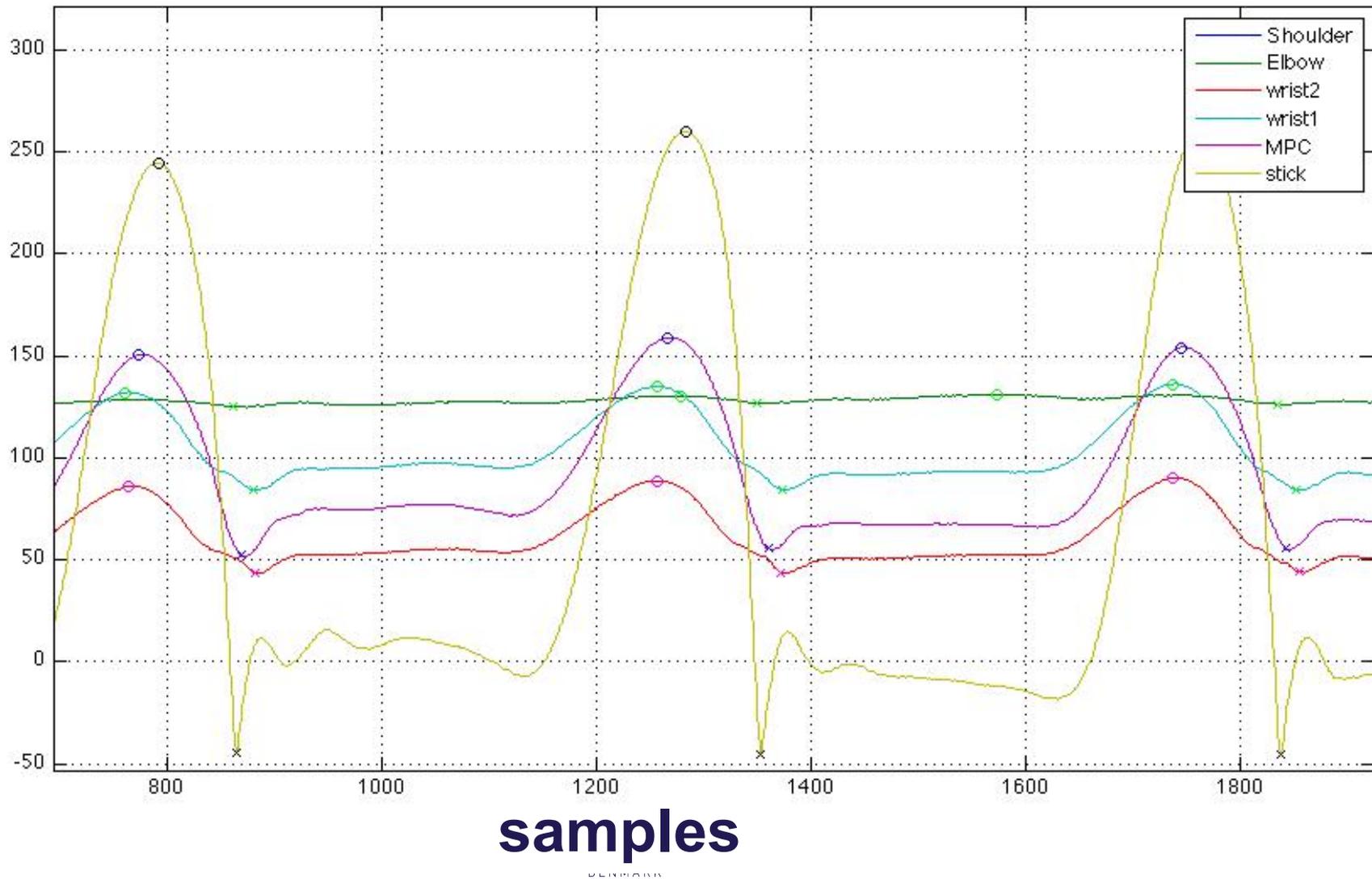
Professional



non-drummer

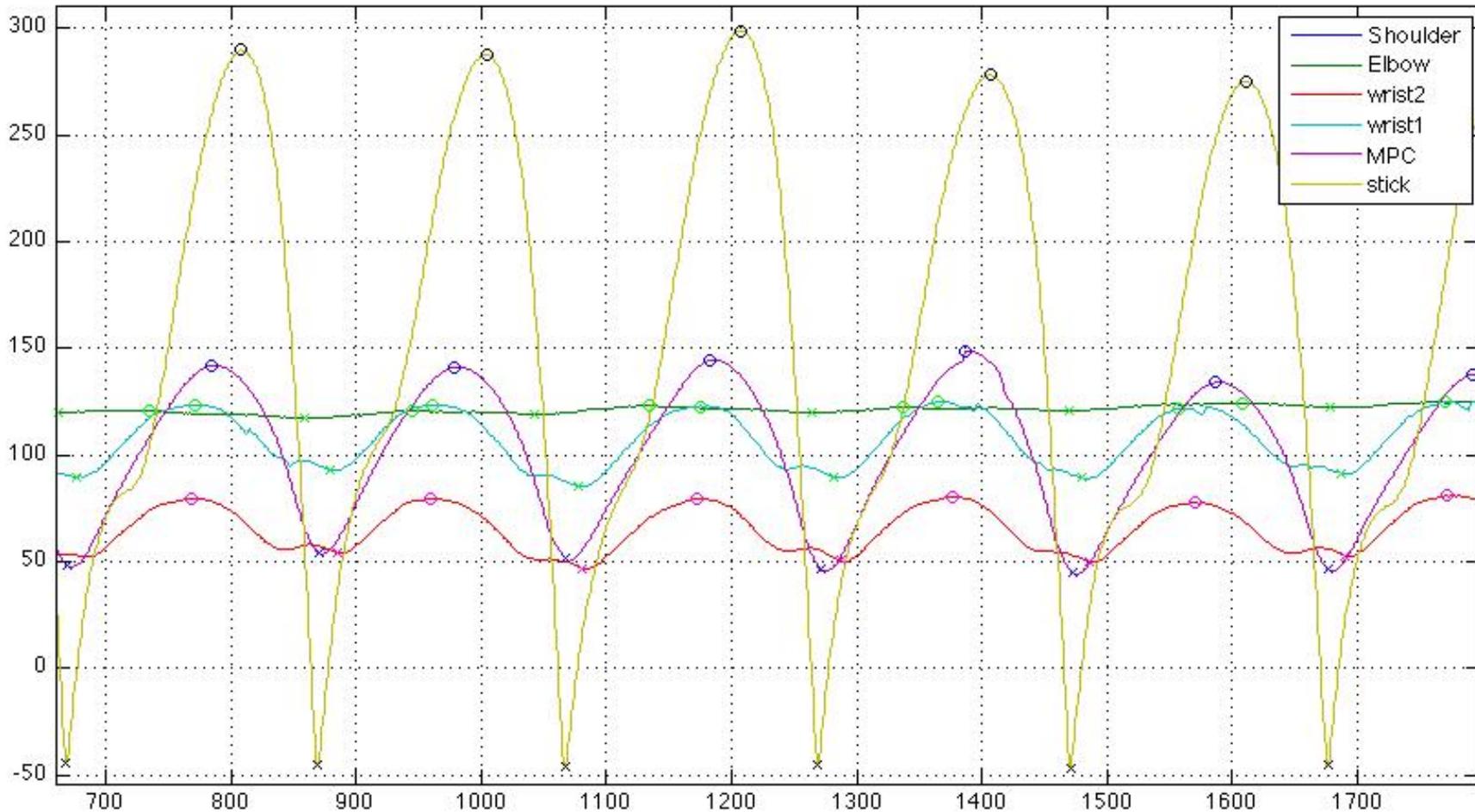
# Part3 50 bpm, mf

mm



# Part3 120 bpm, mf

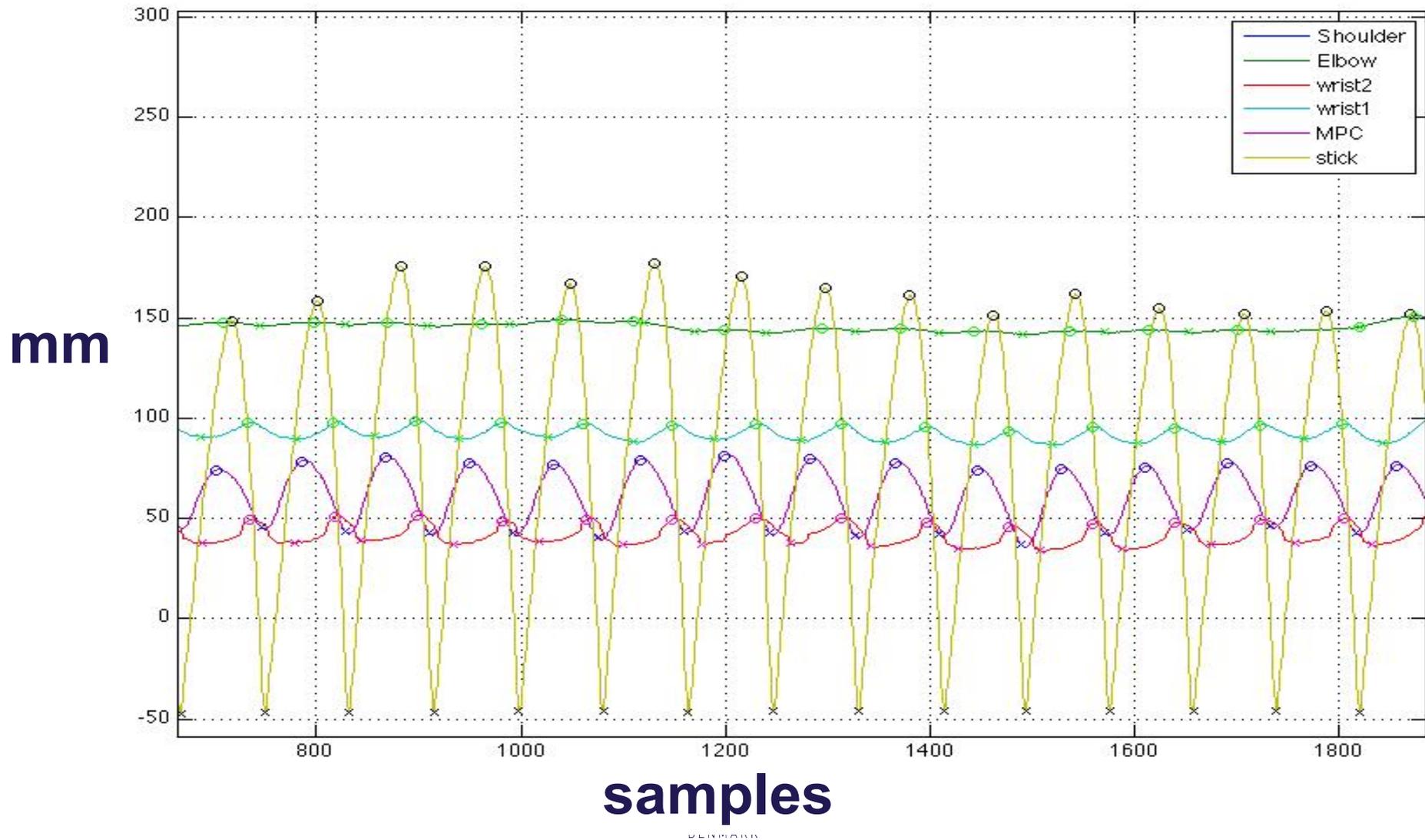
mm



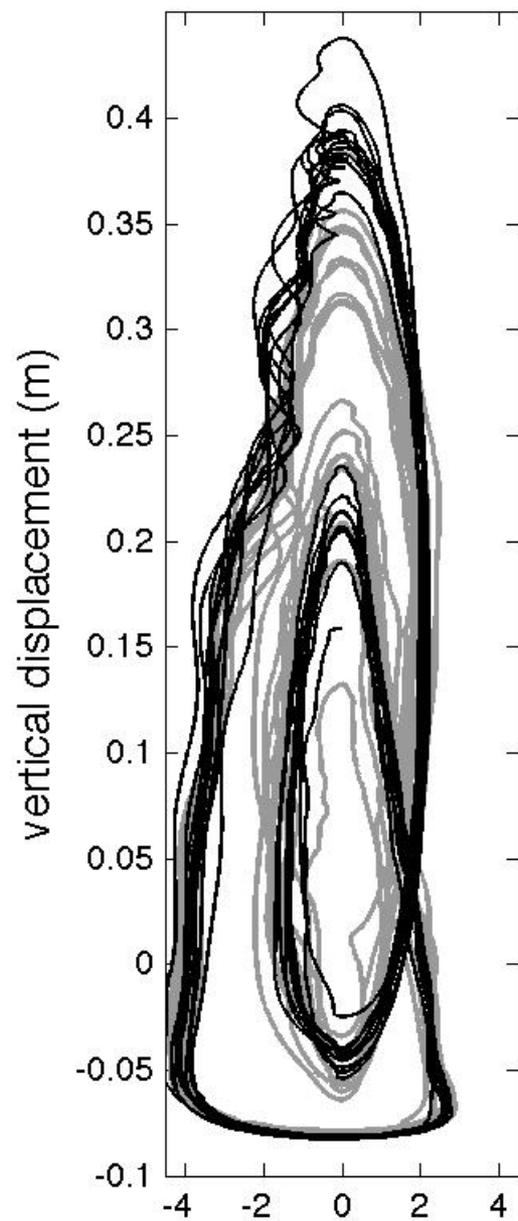
samples

DENMARK

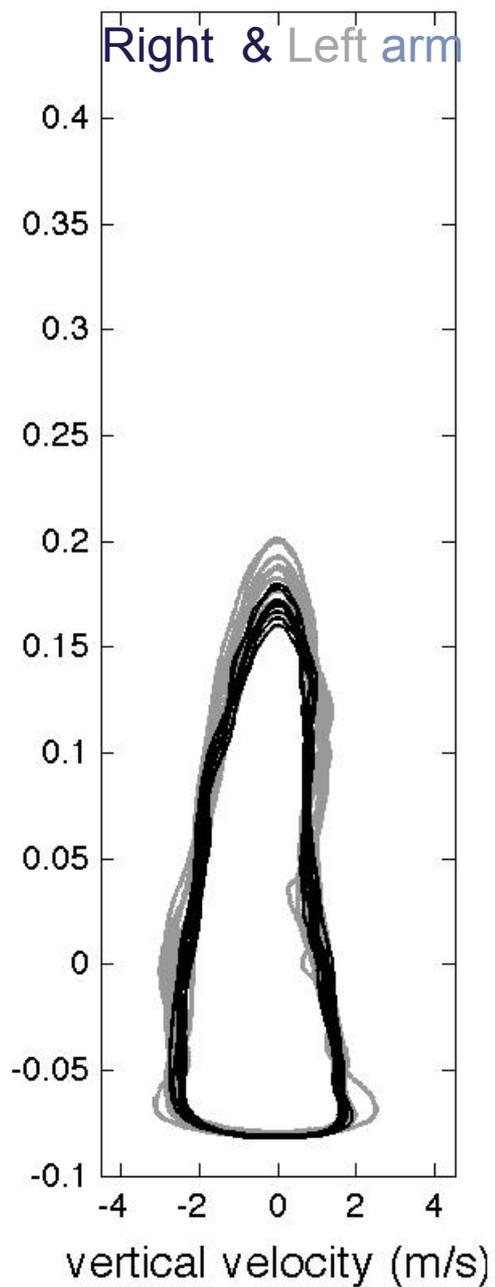
# Part3 300 bpm, mf



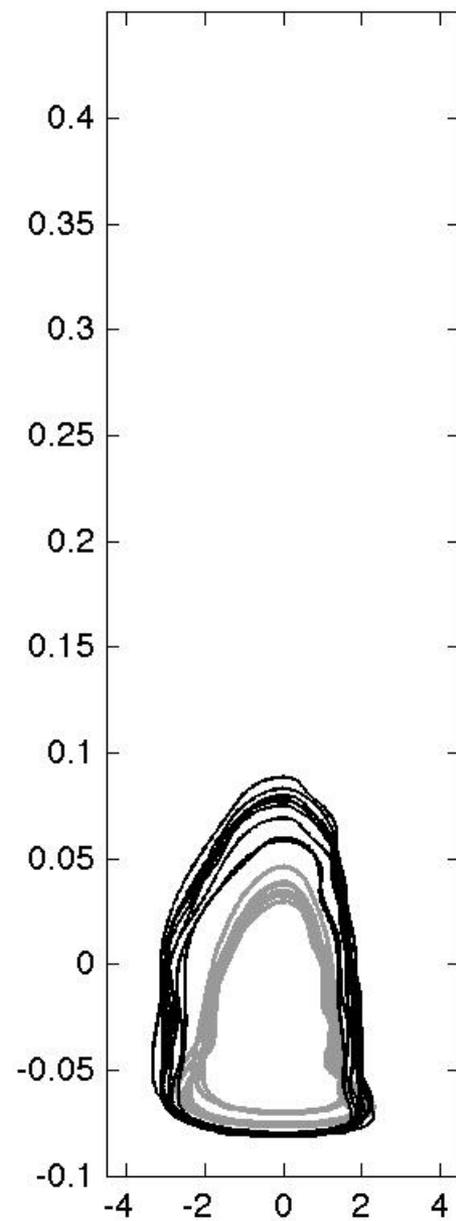
50 bpm



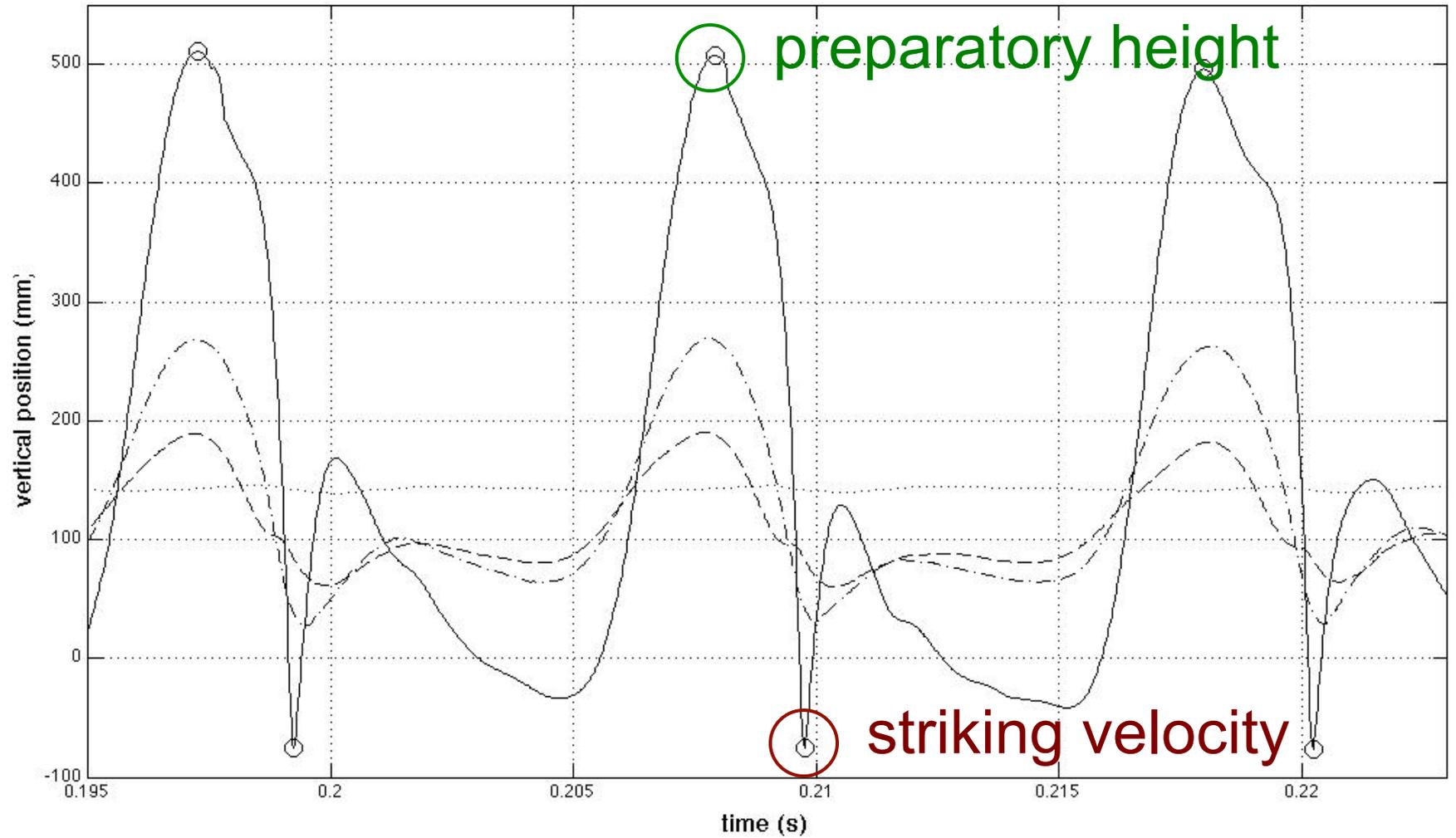
120 bpm



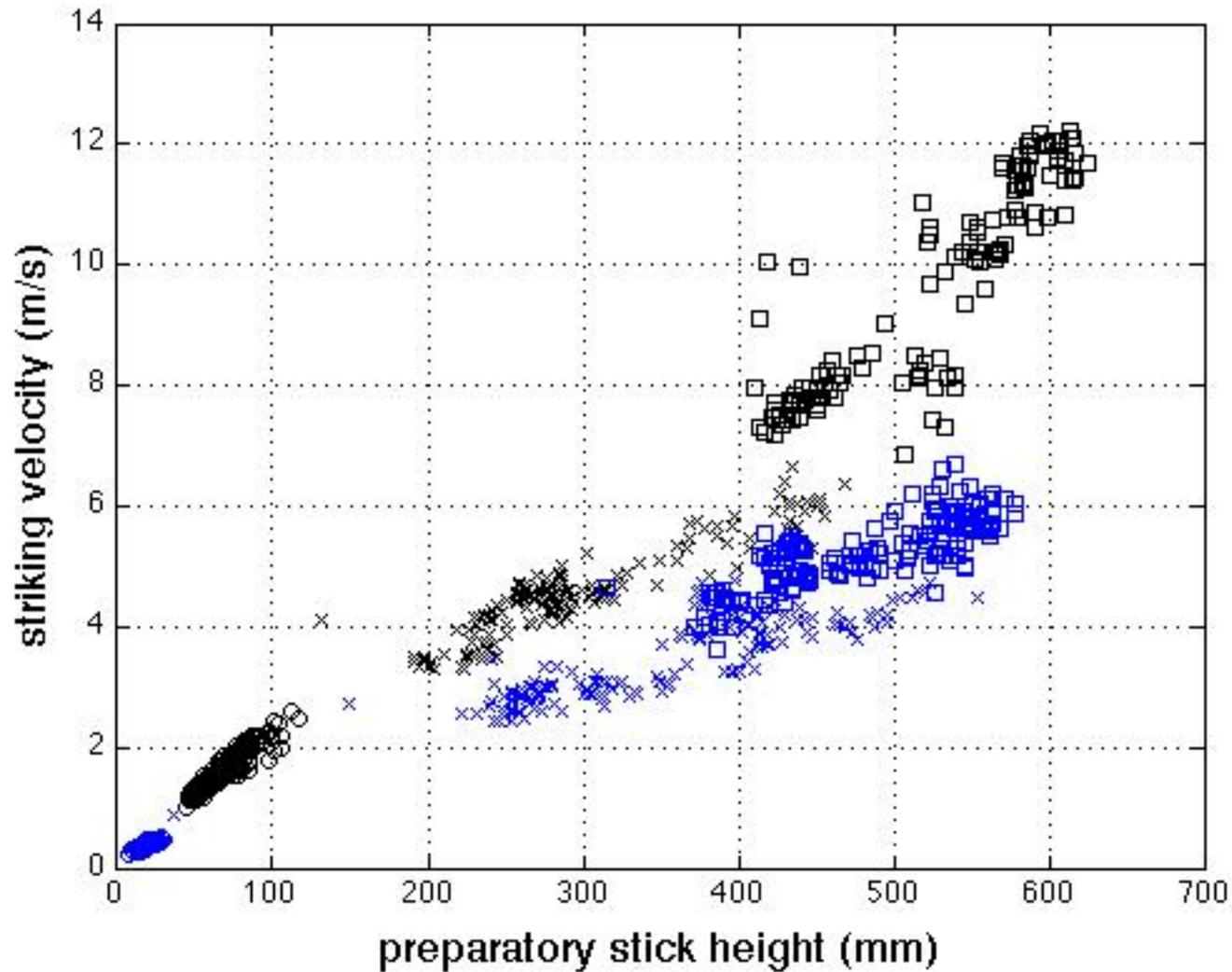
300 bpm



## Vertical displacement vs time at 50 bpm



# Striking velocity vs preparatory height



□ forte  
X mezzoforte  
O piano

Participant 1  
Participant 2

# Moving to music



# Discussion

Read:

Burger B, Thompson MR, Luck G, Saarikallio S and Toiviainen P (2013) Influences of rhythm- and timbre-related musical features on characteristics of music-induced movement. *Front. Psychol.* **4**:183. doi: 10.3389/fpsyg.2013.00183

[http://www.frontiersin.org/Auditory\\_Cognitive\\_Neuroscience/10.3389/fpsyg.2013.00183/abstract](http://www.frontiersin.org/Auditory_Cognitive_Neuroscience/10.3389/fpsyg.2013.00183/abstract)

- What measures of musical and movement features have been used?
- What is the rationale for using them?
- Discuss the experimental setup and data treatment.
- What critique do you have?



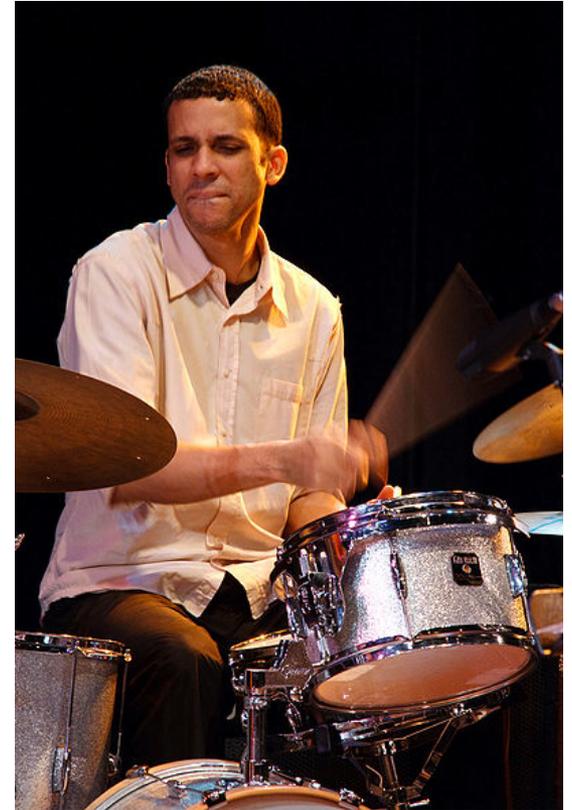
# Type of movements in music performance



Ancillary,  
sound-accompanying,  
and communicative

Sound-producing

Sound-modifying

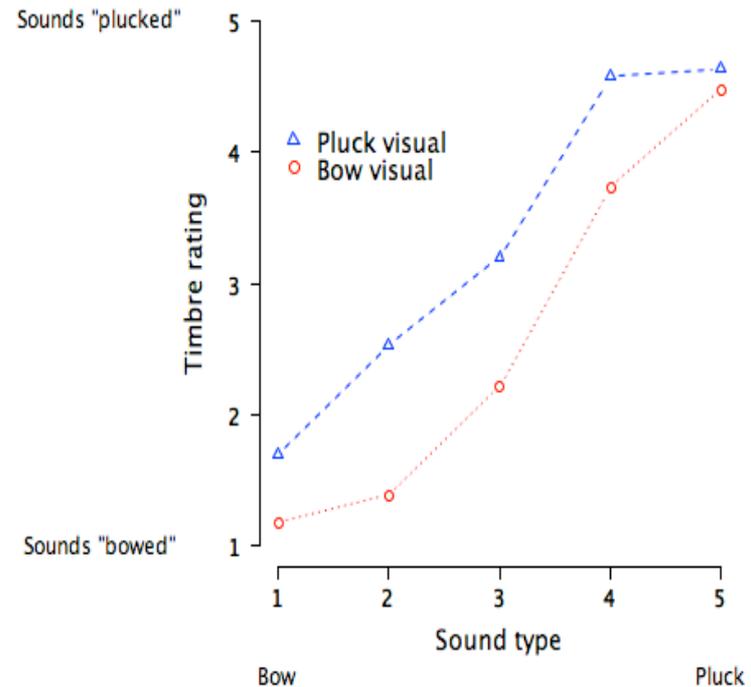


(Godøy & Leman 2010)



# Visual information affects how a sound is perceived

- McGurk-effect (McGurk & McDonald, 1976)
- Large clapping motions judged louder (Rosenblum & Fowler 1992).
- Bowed or plucked visual affected judgement of timbre (Saldaña & Rosenblum 1993).

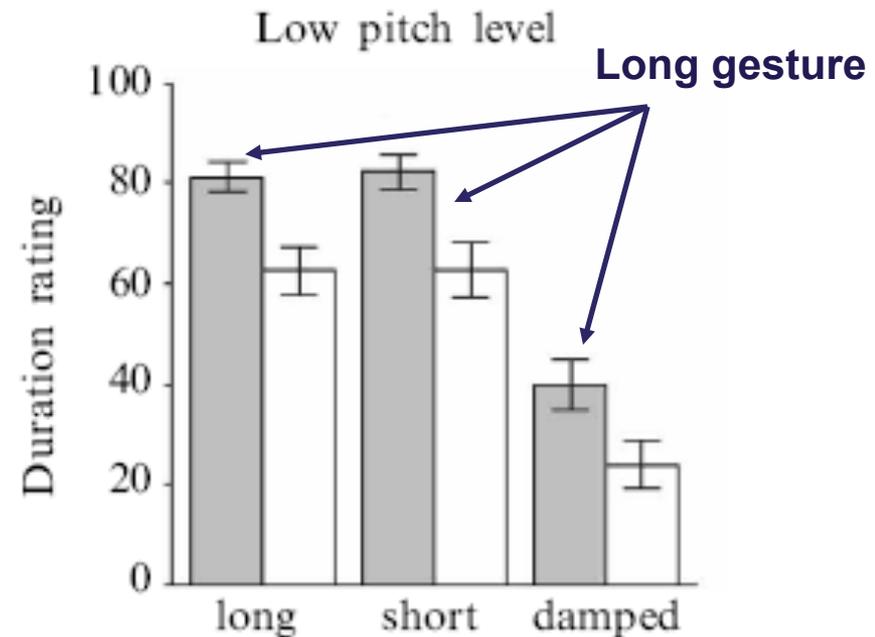


(Read Schutz, 2008, Empirical Musicology Review)

# Perceived note length affected by visual movement information



“Long” and “short” strokes played on marimba shown to affect listeners rating of the duration of the tone.



# Visual information influence ratings of expression and interest (Broughton & Stevens, 2008)

- Expressive and interest ratings of marimba performances (“projected” or “deadpan” ) higher for audio-visual stimuli than audio
- *When congruent*, expressive gestures can help performer communicate intent to audience



# Visual information affect visual ratings on musical structure (Wanderley et al, 2005)

- Clarinet players shifted movement onset with respect to score.
- Anticipating or following.
- Phase shifts between audio and visual affected rated phrasing.
- Phrases rated longer if movements extended into silence.



## Taken together...

- ...this means that perception of music performance is *highly multimodal*
- ...also in the sense that the percept is more than just the sum of stimuli in the different modalities. The modalities interact!



# Spøsmål?



AALBORG UNIVERSITY  
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