

PERFORMANCE ISSUES AND STRATEGIES

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Network Sound and Data

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Delay is Disruptive for Synchronization

Early Studies

Hirsch, *"Auditory perception of temporal order"*, 1959

3 ranges of perception:

0-20 ms: phase perception

20-100 ms: auditory patterns

100-up ms: separate auditory events

Hass (or precedence) Effect

Identical sounds with arrival times 30-40 ms:

The sound is perceived as one coming from a specific location rather than two distinct sounds.

Timing and Sync

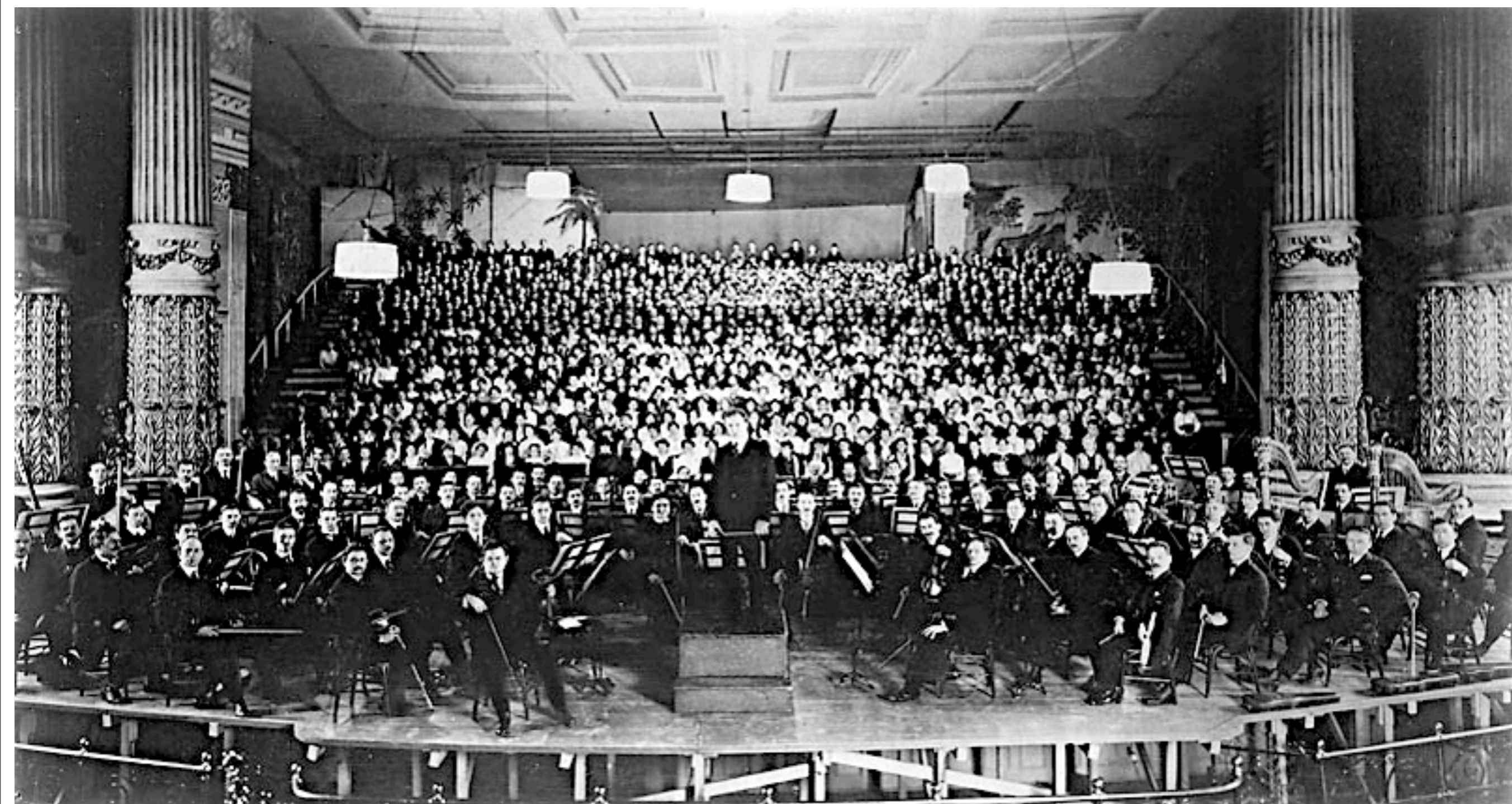
Rasch, *"Timing and synchronization in ensemble performance"*, 1988.

Tolerances in the performance of small ensembles can be as high as 50 ms on average

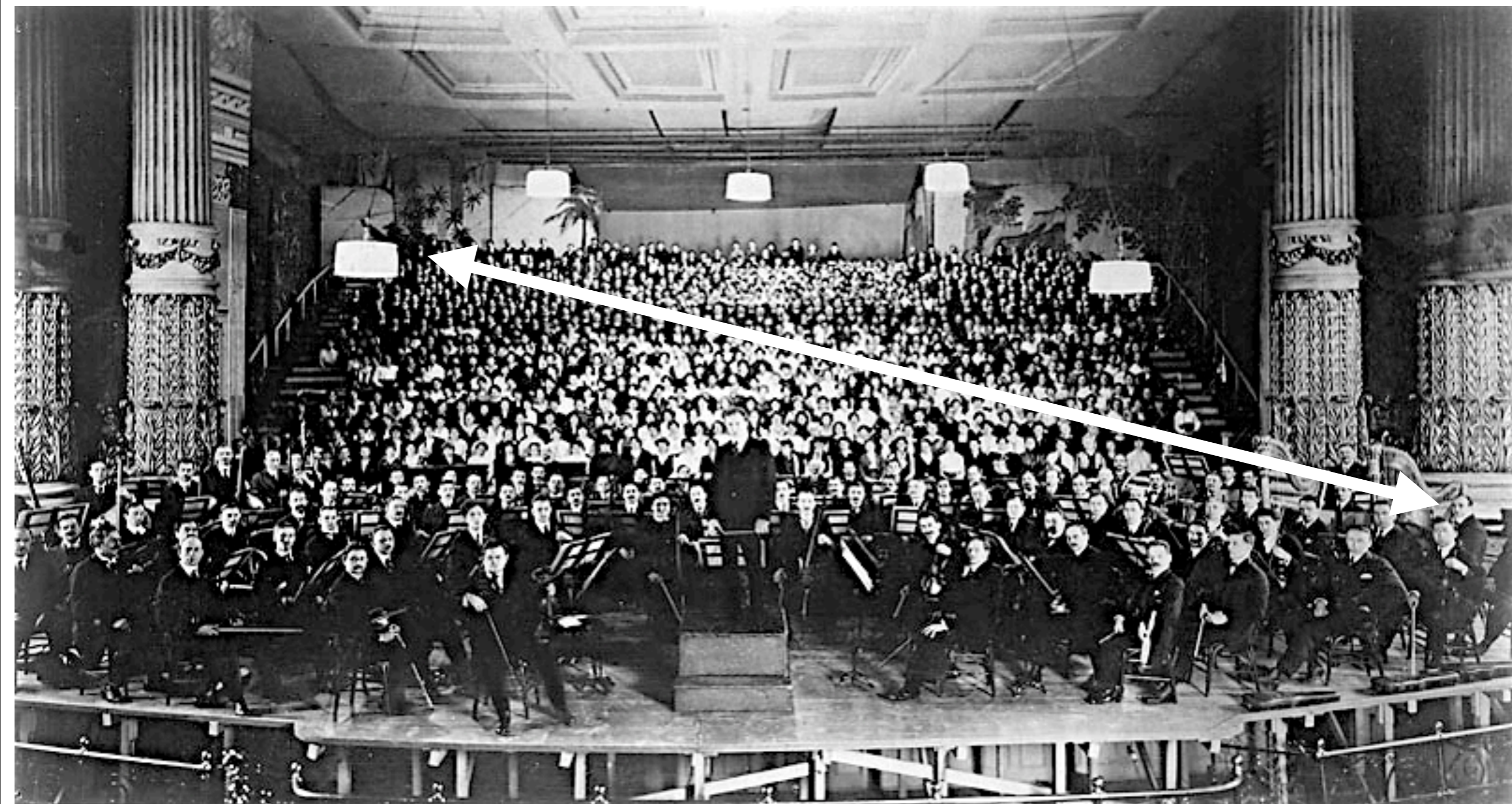
Influential Factors: Instrumental timbre, length of articulations, masking, and reverberation

Human vs. Machine

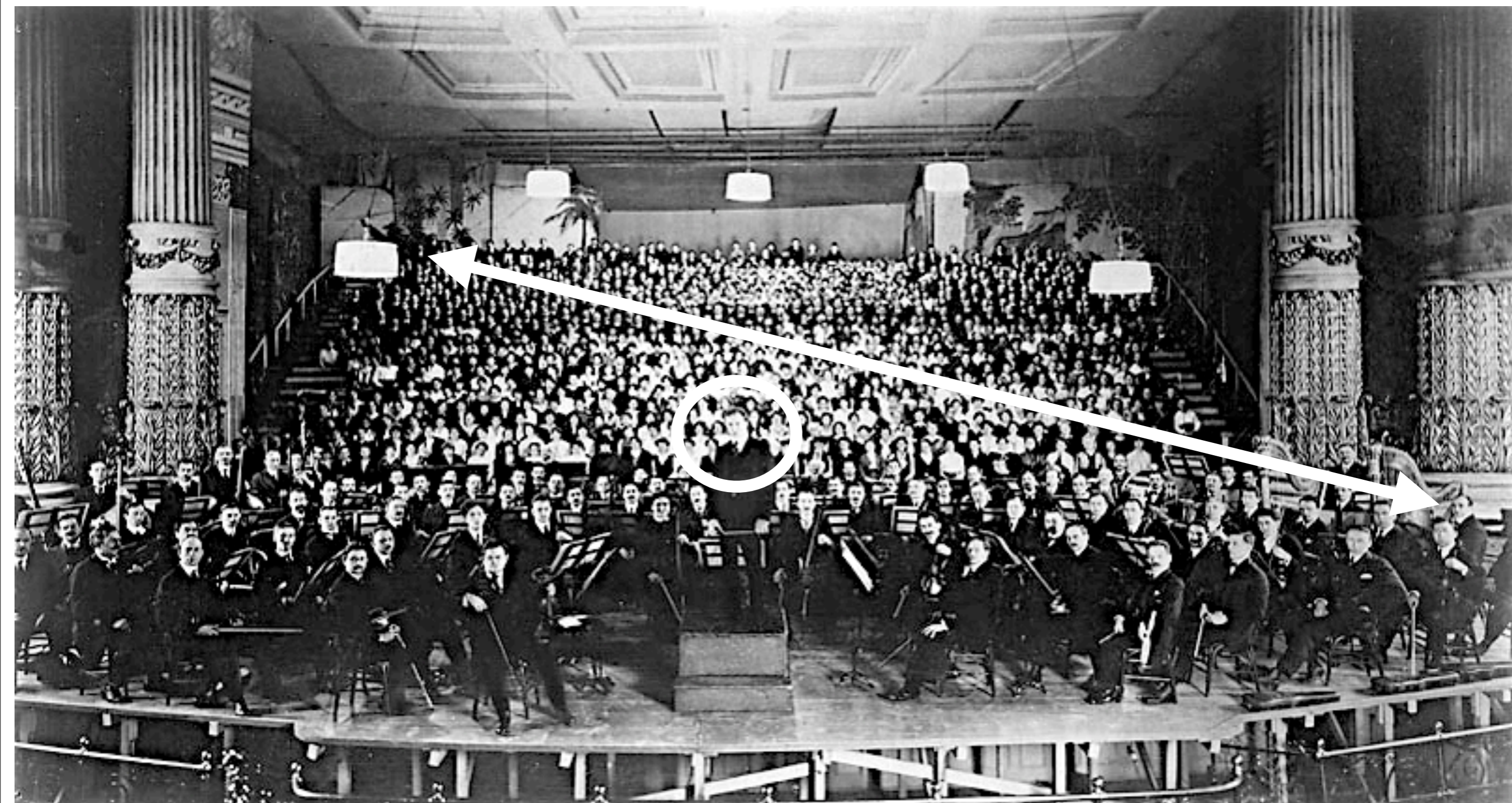
Variations on synchronization are perceived as “human like”, whereas systematic perfect synchronous performances sound more “machine like”.



+1000 musicians



+1000 musicians



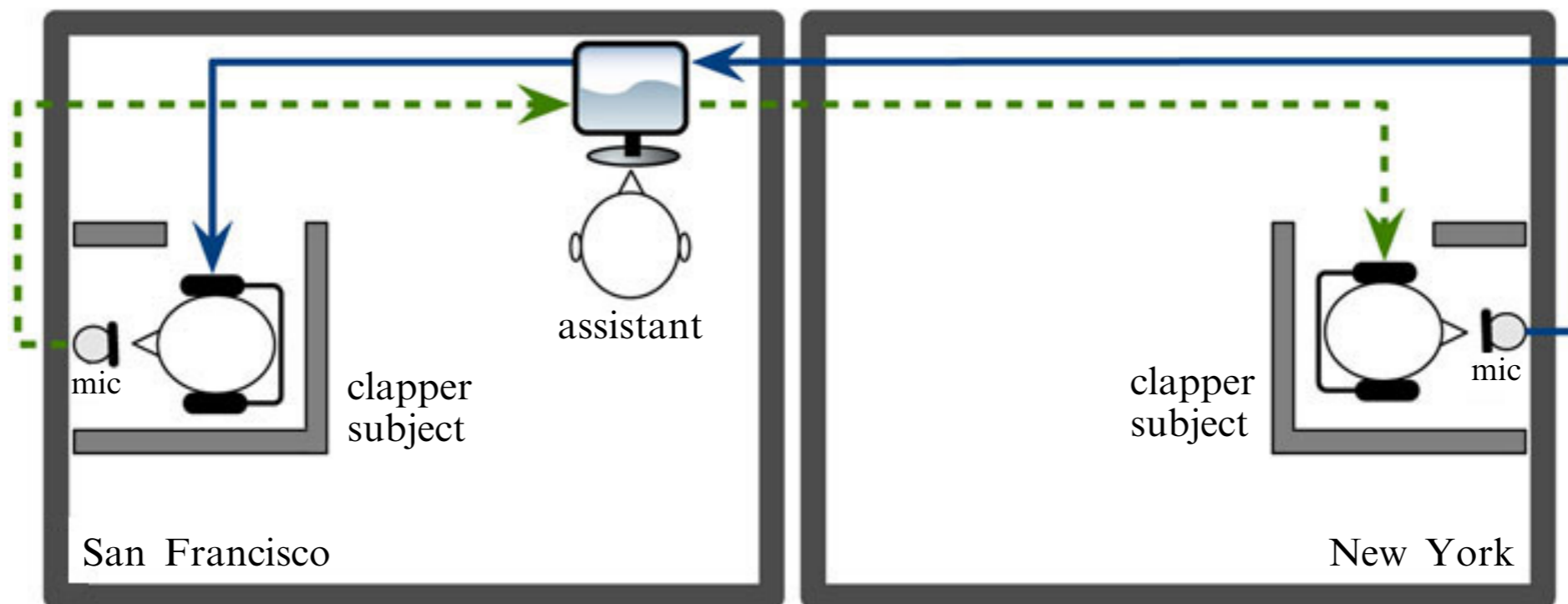
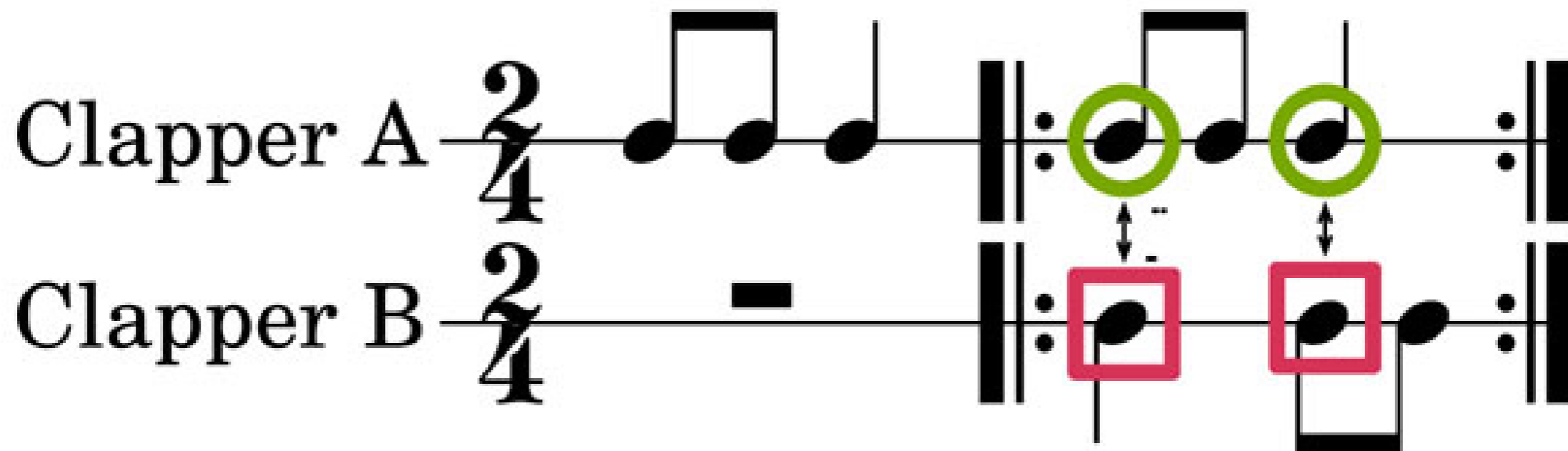
+1000 musicians

The need for a Conductor

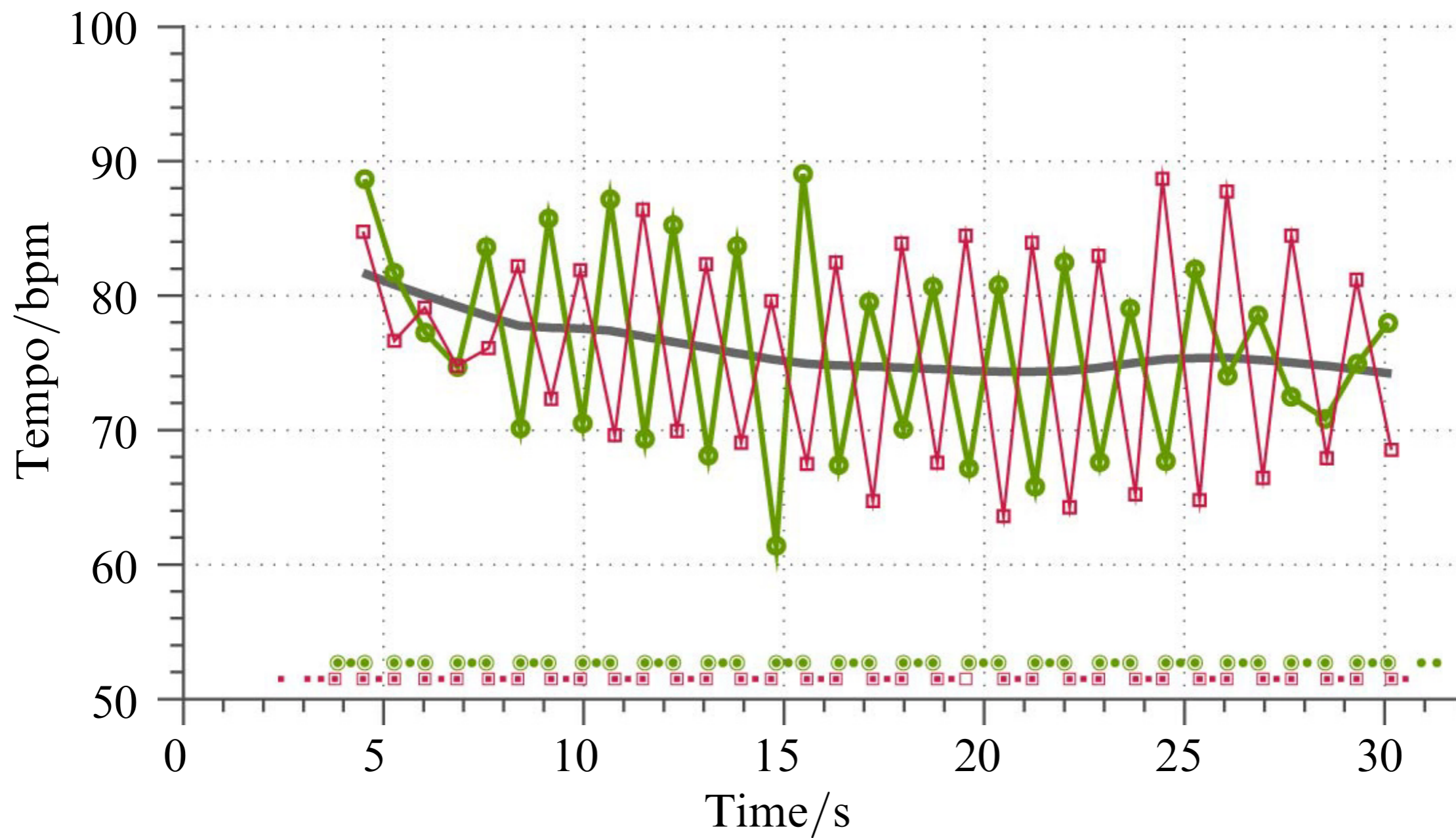
As ensembles grow in number and physical size, asynchronization also grows.

At a certain point the presence of a conductor becomes necessary to maintain synchronization for larger ensembles.

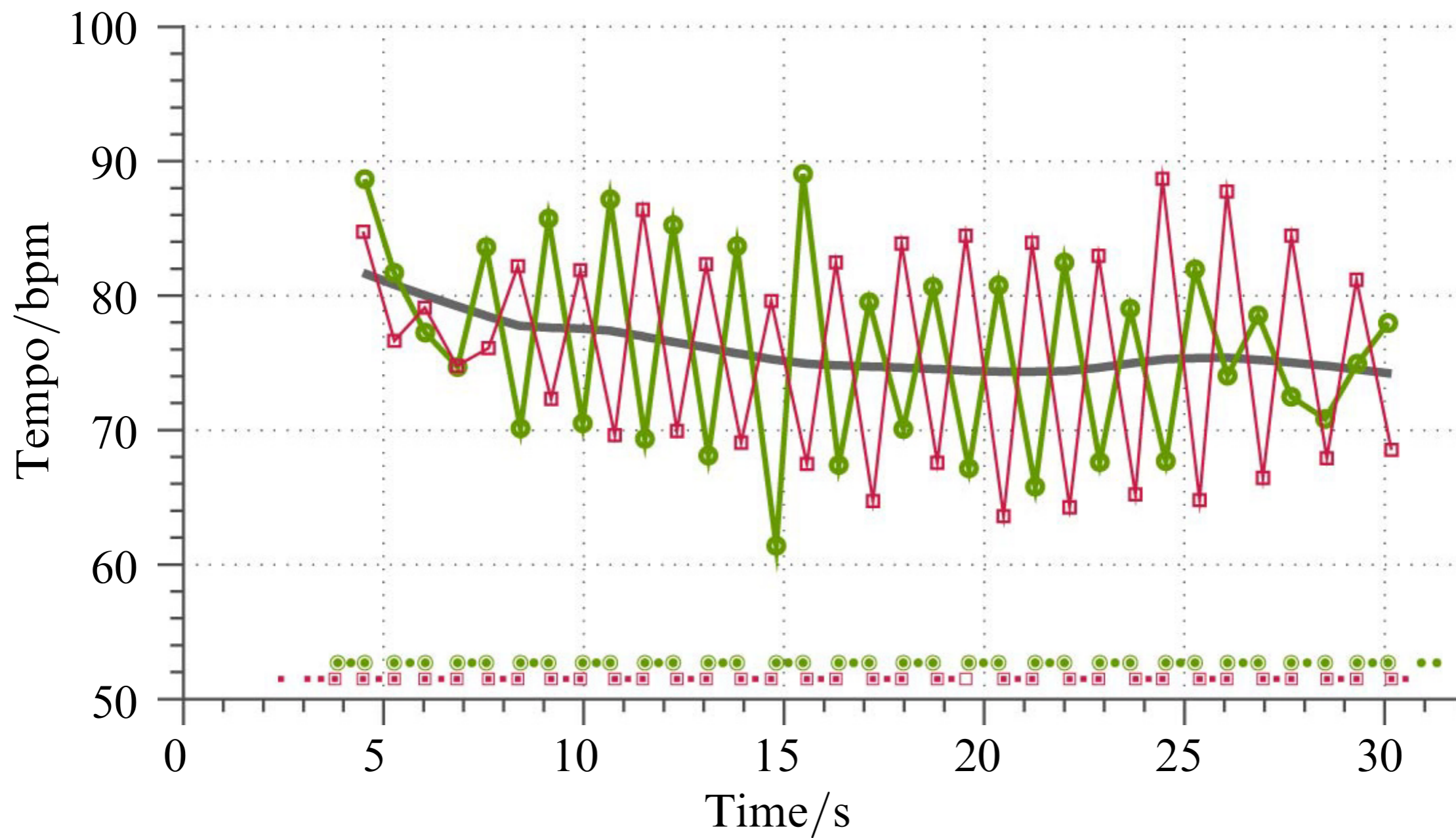
The Clapping Experiment



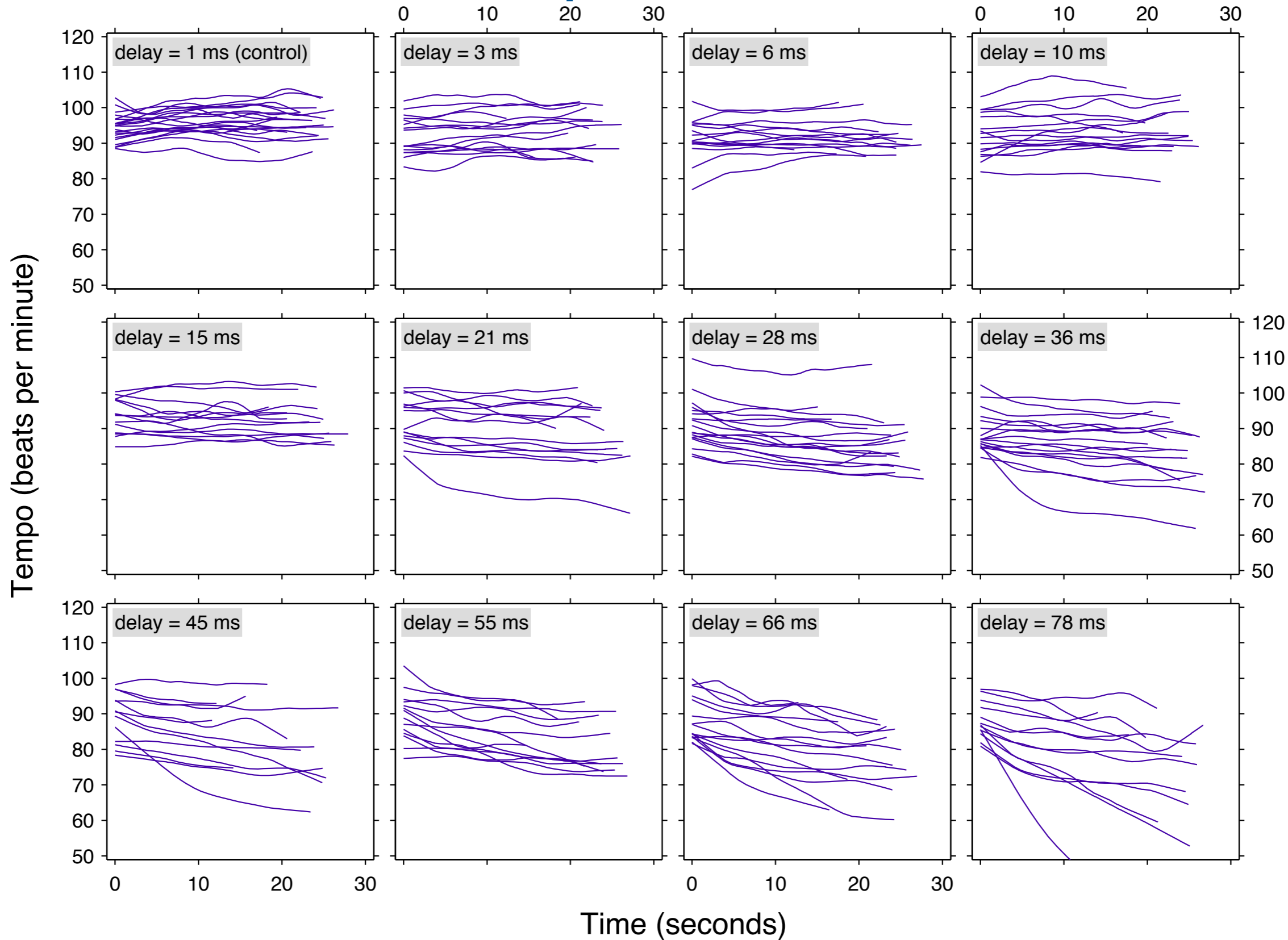
Example at 66ms



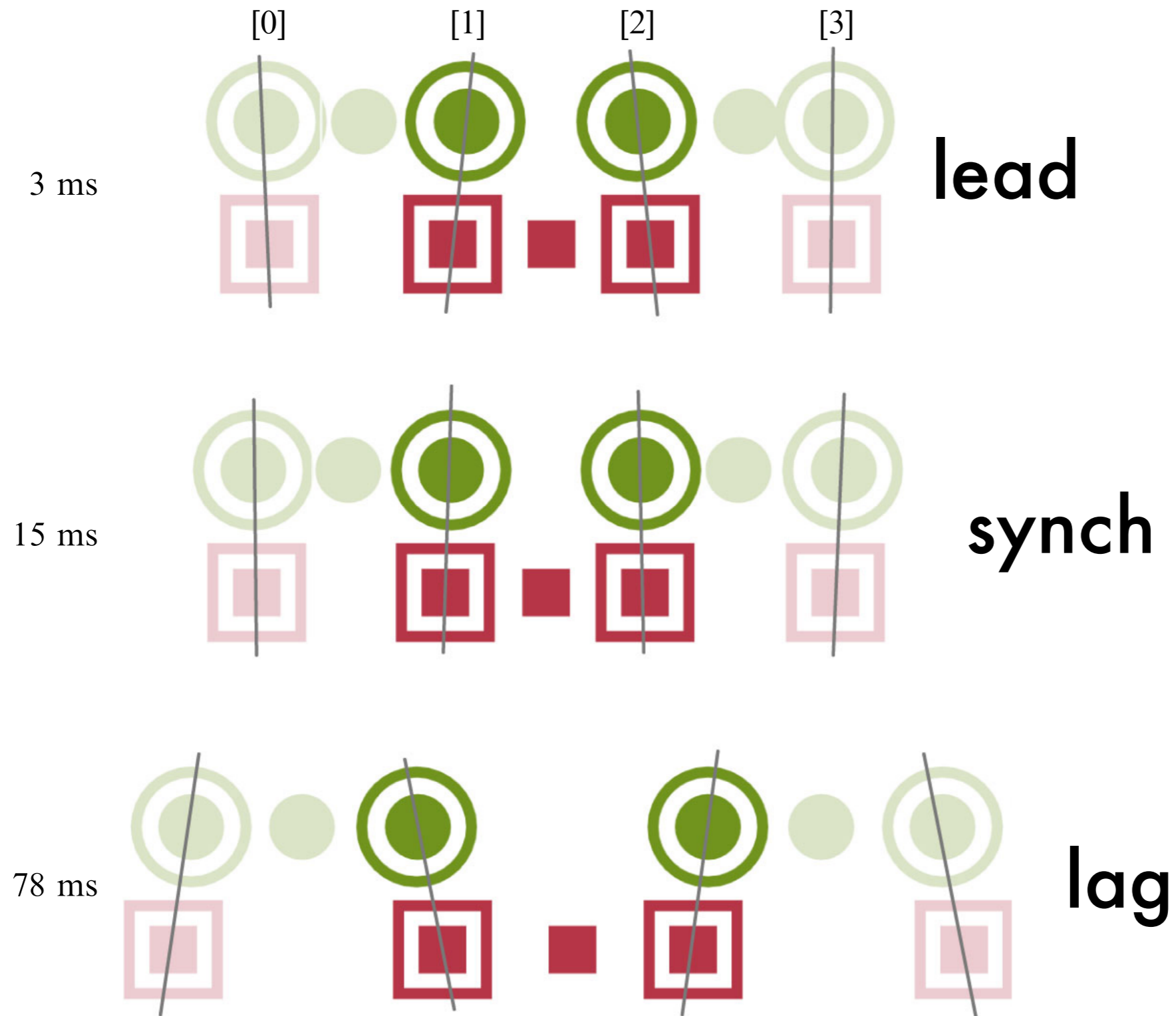
Example at 66ms



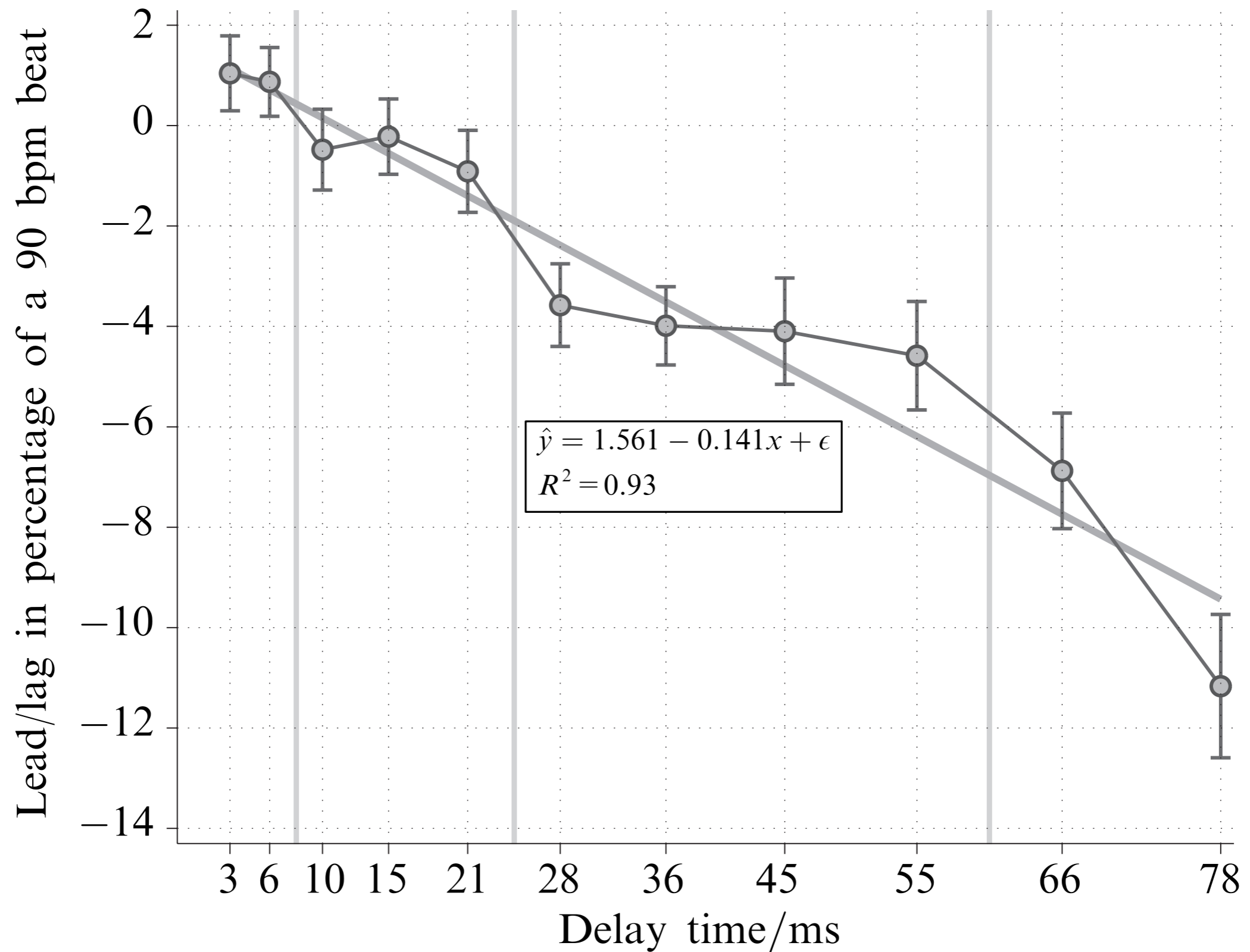
Tempo Curves



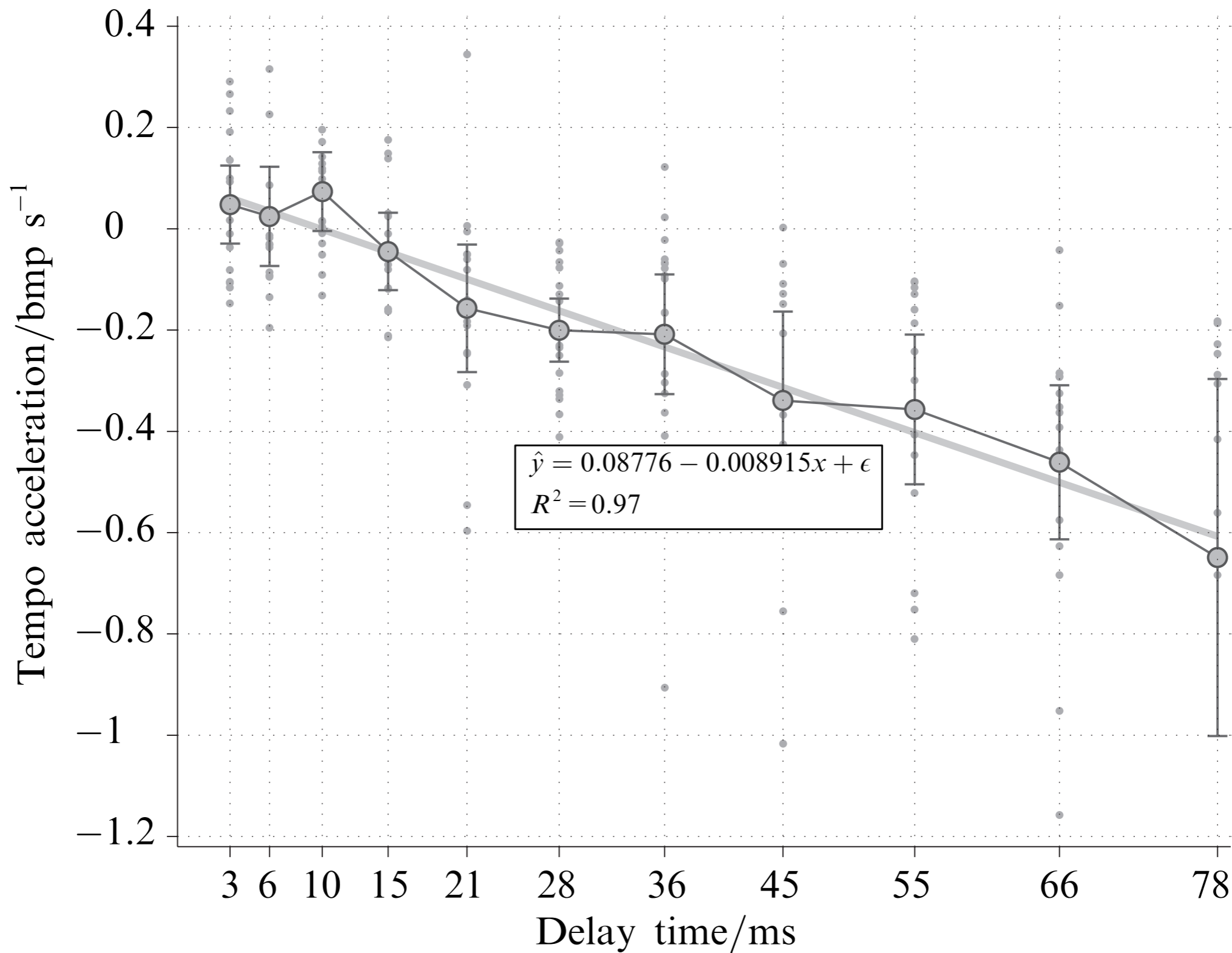
Lead/Lag Synchronization



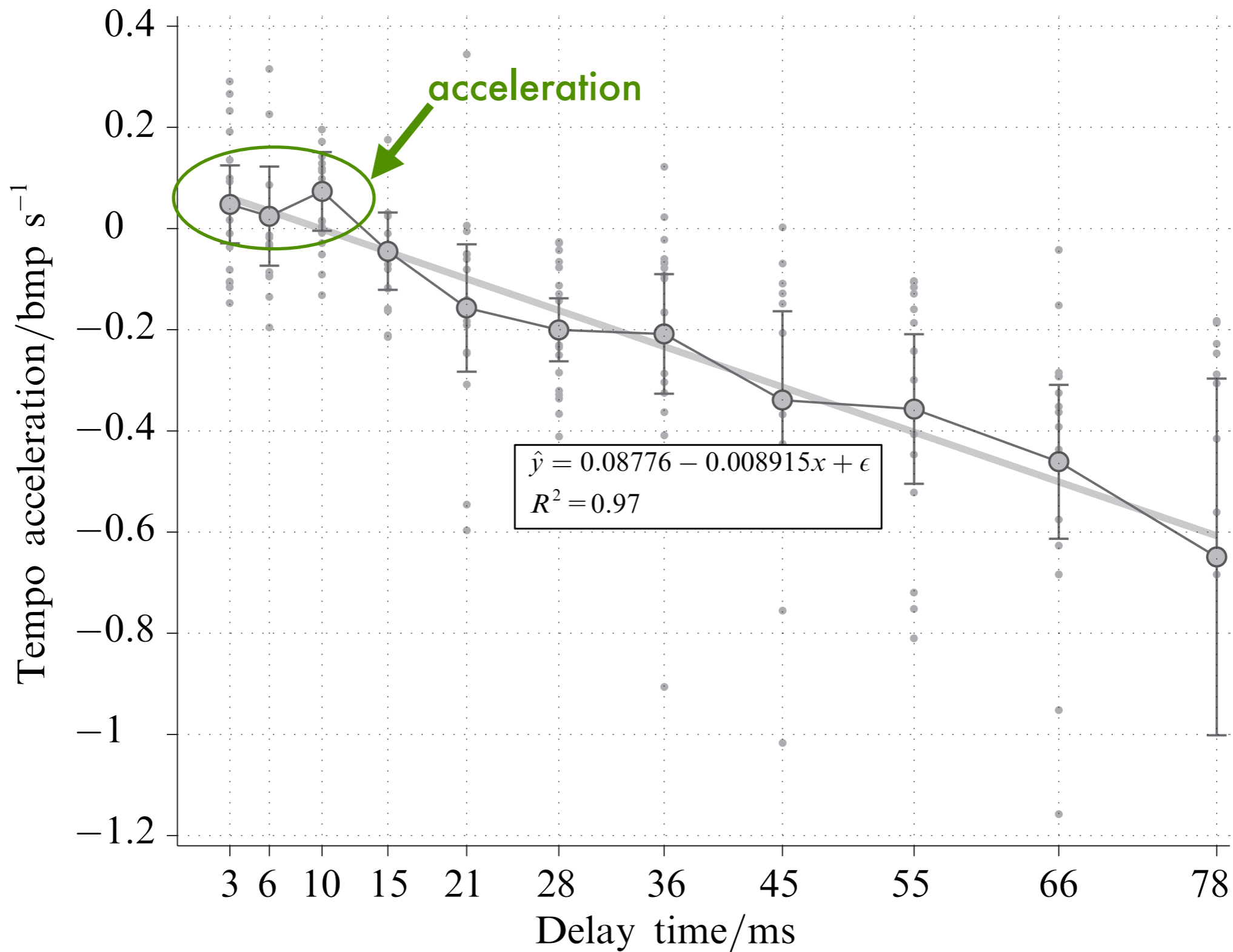
Lead/lag vs. Delay



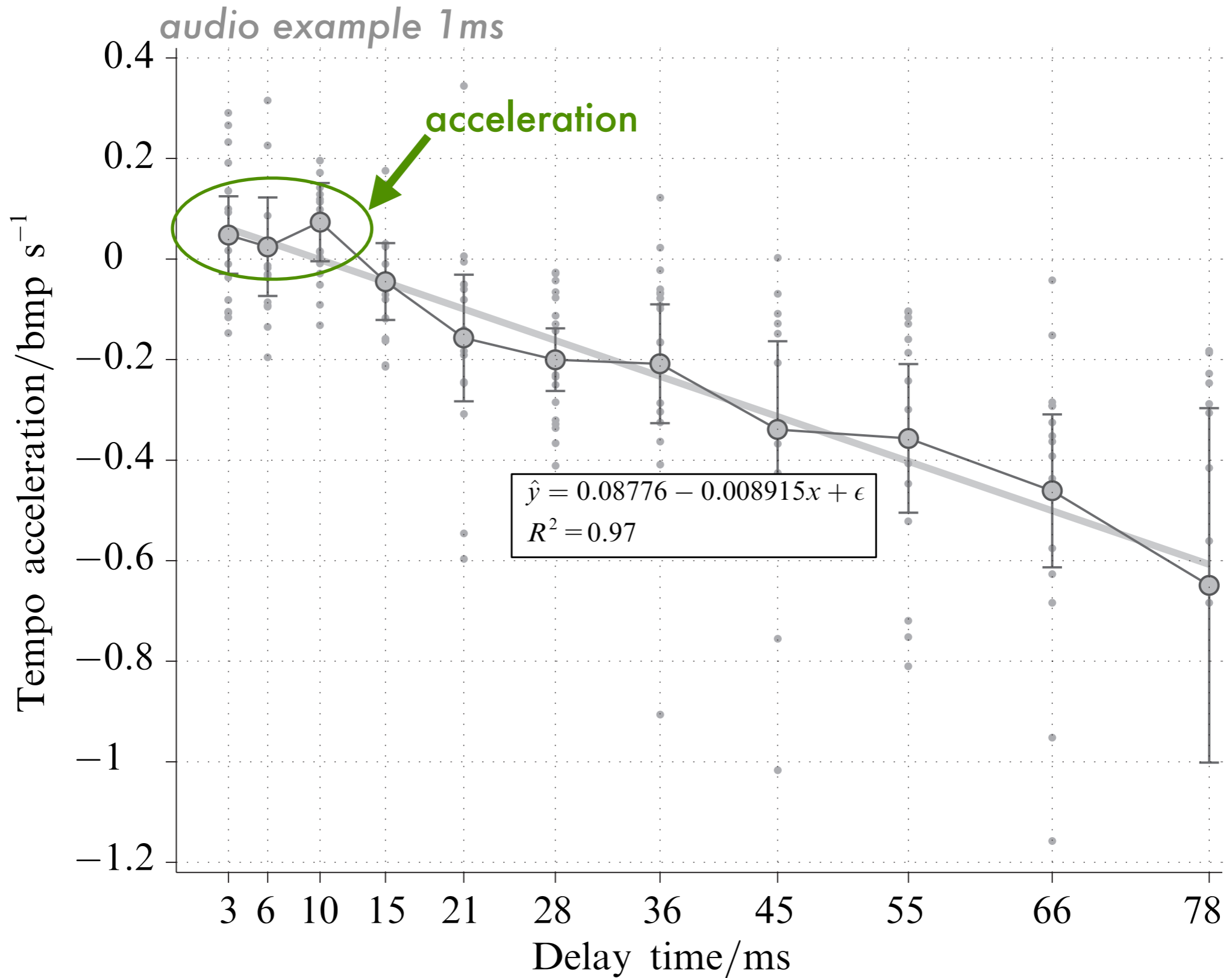
Acceleration



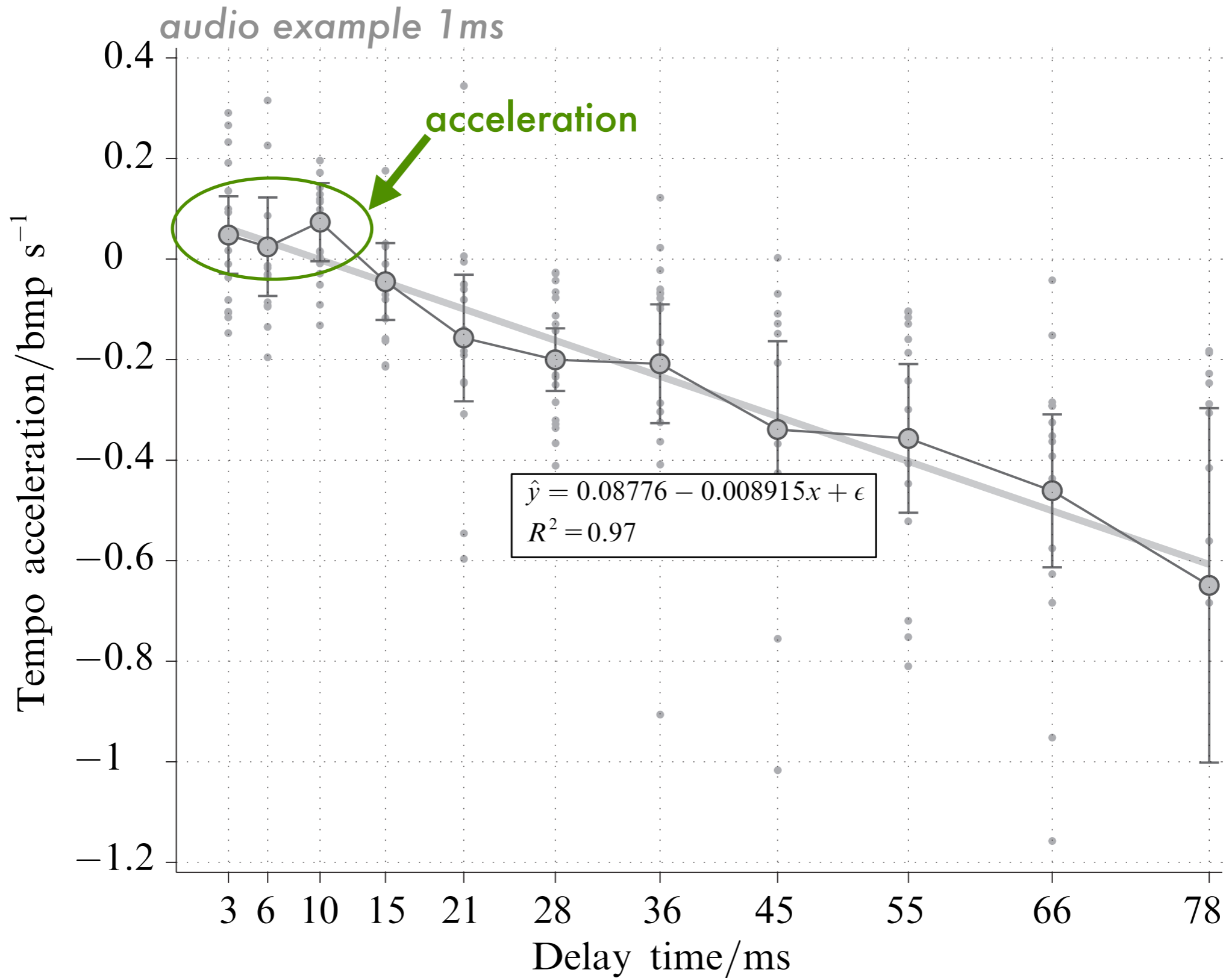
Acceleration



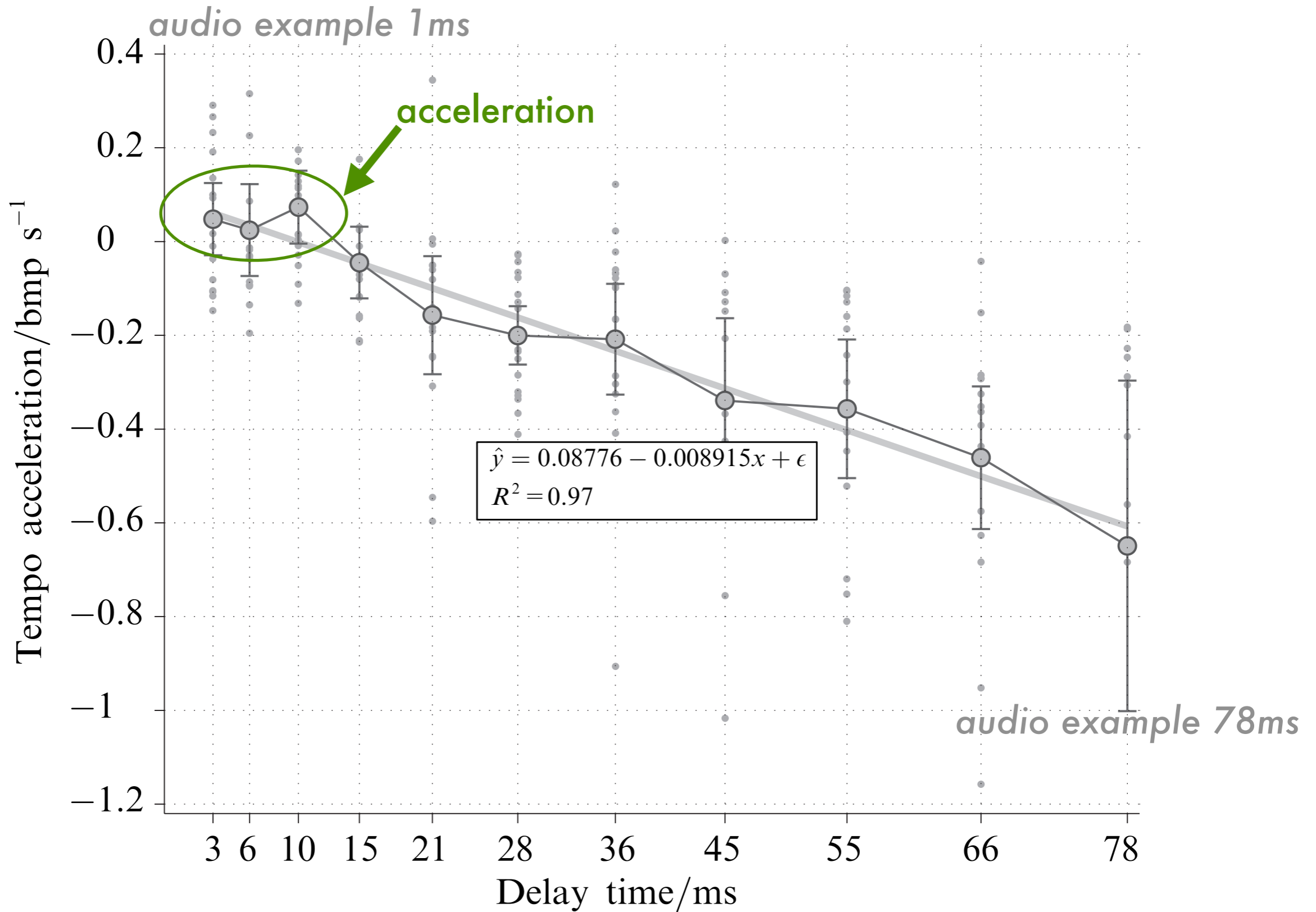
Acceleration



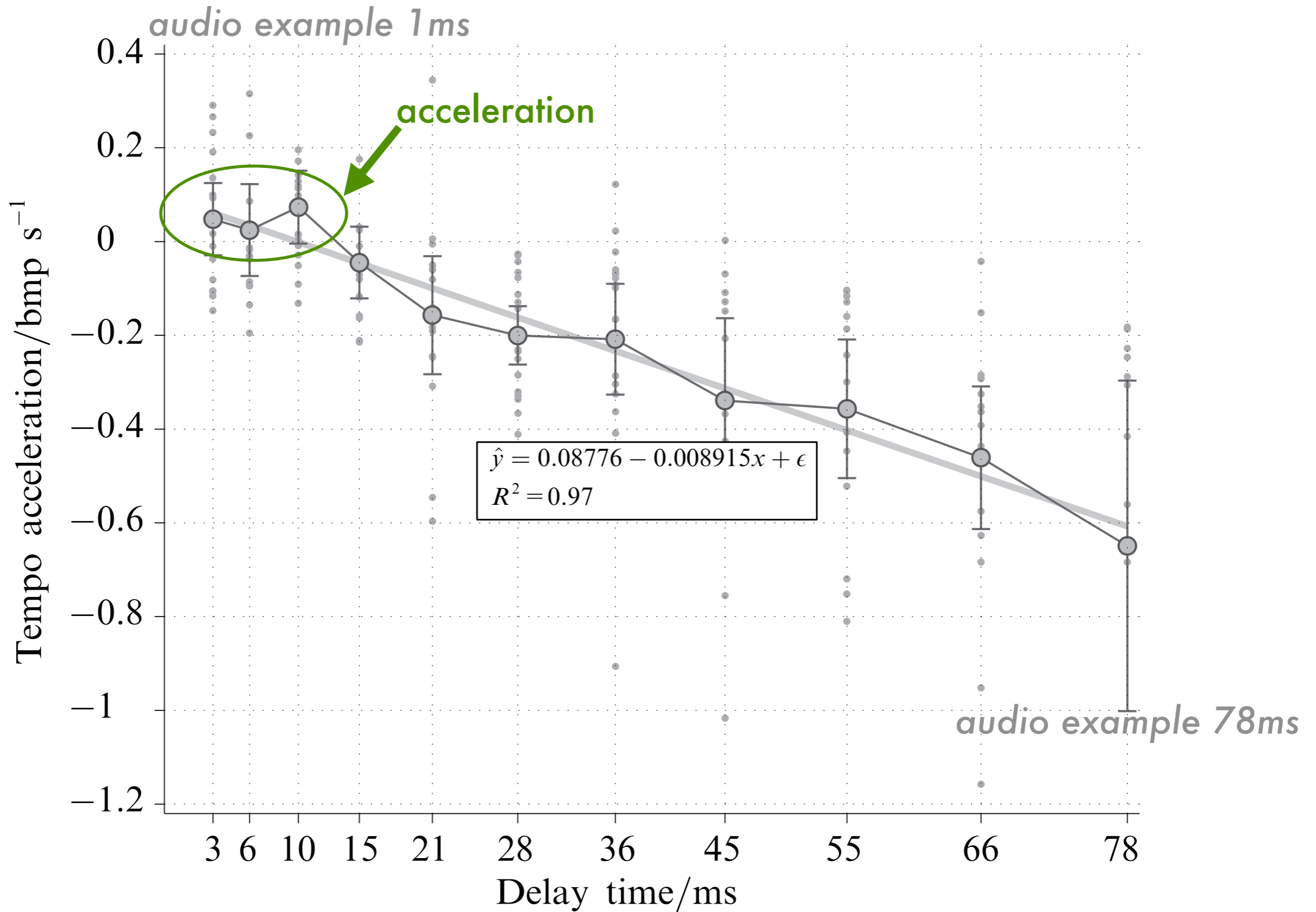
Acceleration



Acceleration



Acceleration



Sound Events Perception

Echoes

Frequency

Sound Events Perception

Echoes

Frequency

Propagation Speeds

Sound Events Perception

Echoes

Frequency

Propagation Speeds

Water

Sound Events Perception

Echoes

Frequency

Propagation Speeds

Water



Air

Sound Events Perception

Echoes

Frequency

Propagation Speeds

Water



Air



Digital Networks (*Chafe 2000*)

Sound Events Perception

Echoes

Frequency

Propagation Speeds

Water



Air



Digital Networks *(Chafe 2000)*



Sound Events Perception

Echoes

Frequency

Propagation Speeds

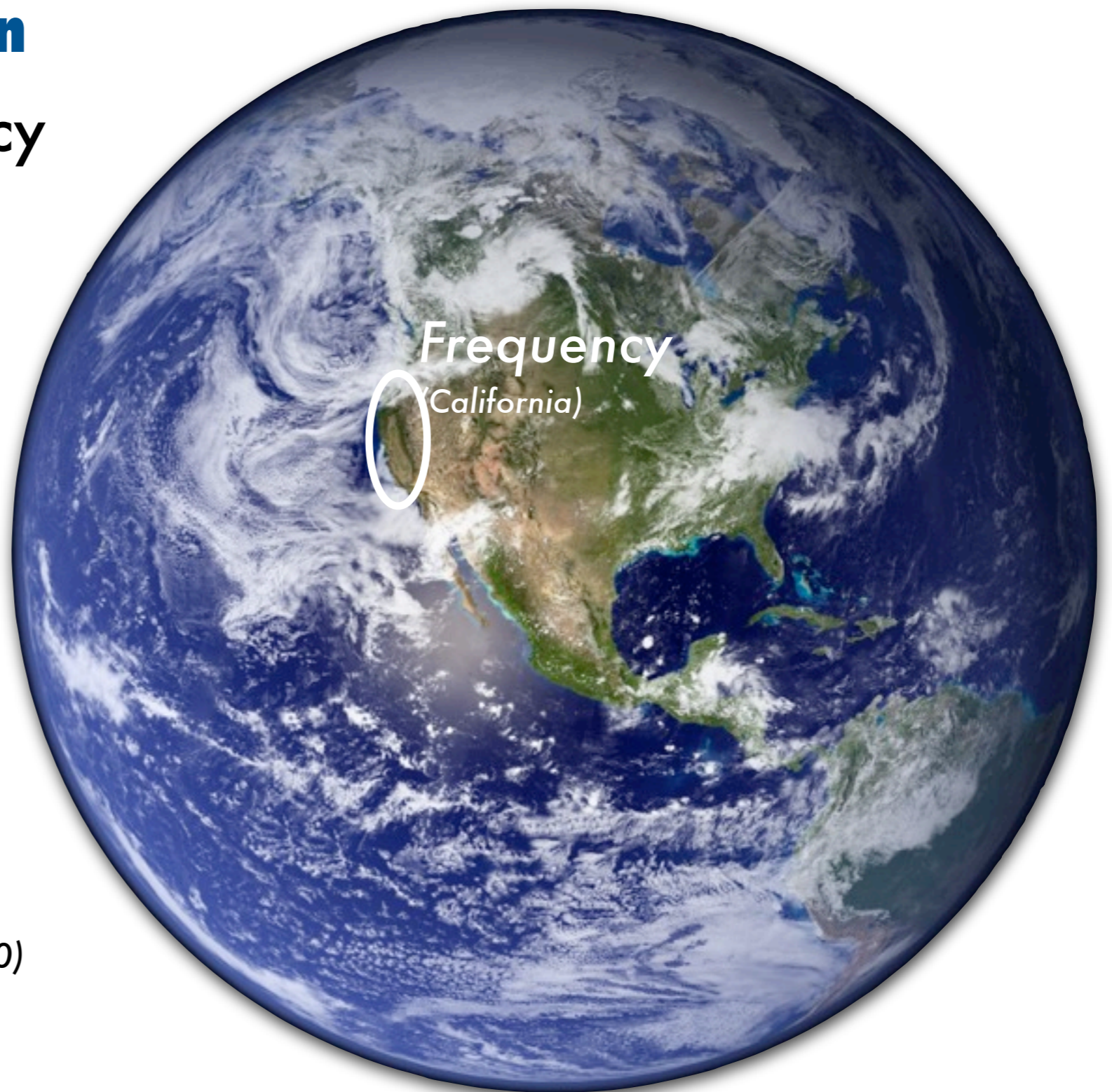
Water



Air



Digital Networks *(Chafe 2000)*



Sound Events Perception

Echoes

Frequency

Propagation Speeds

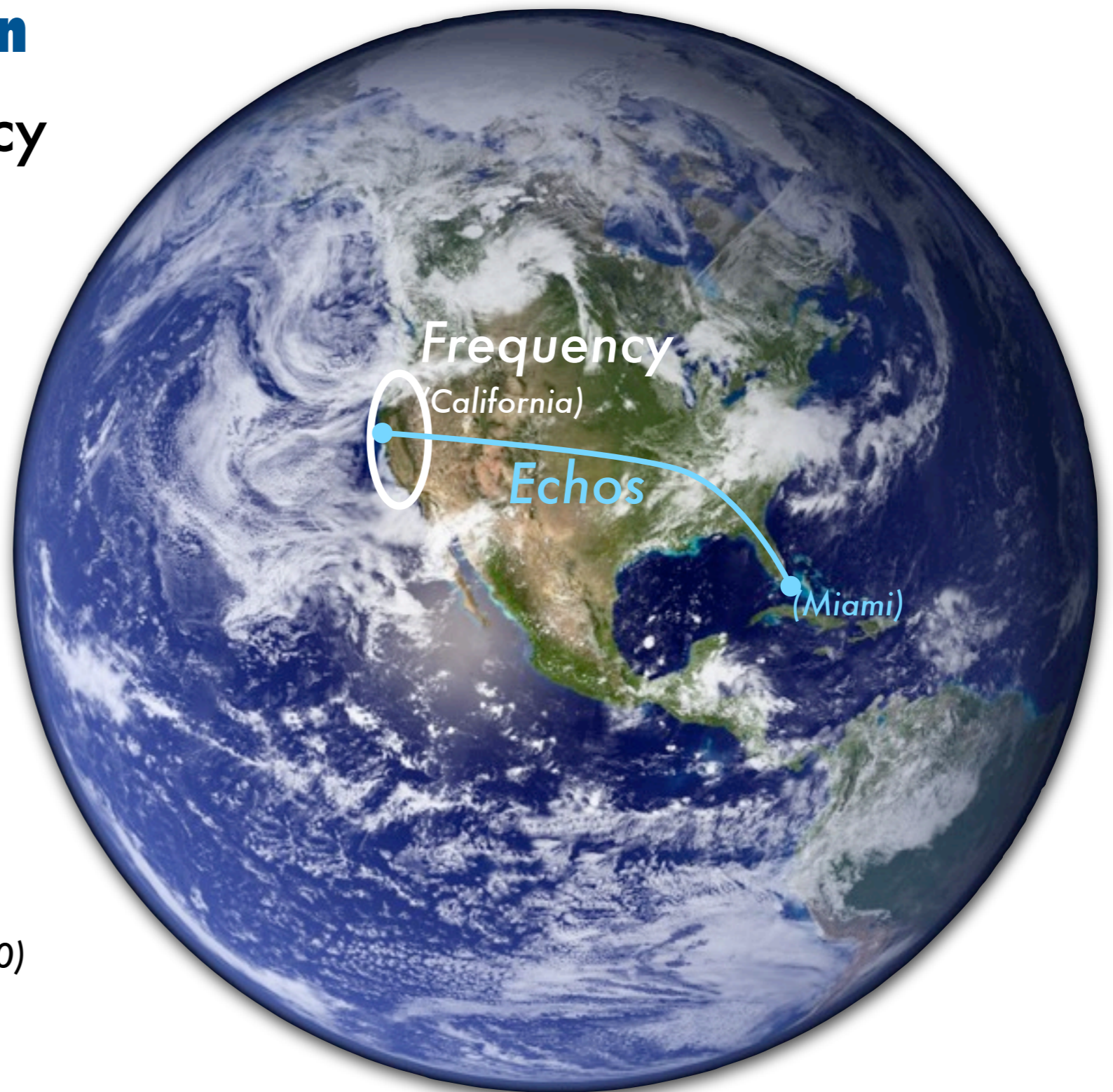
Water



Air



Digital Networks *(Chafe 2000)*



Distant-Dependent Strategies

Distant-Dependent Strategies

Echoes

Delay Effects

Distributed Rhythmic Patterns

Synchronization

Distant-Dependent Strategies

Echoes

Delay Effects

Distributed Rhythmic Patterns

Synchronization

Frequency

Physical Models

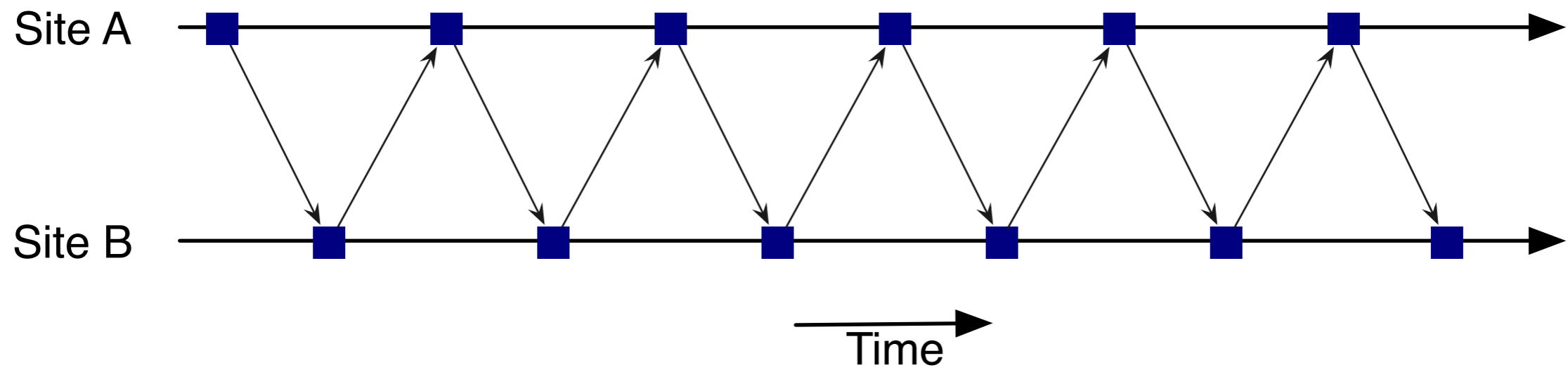
Quality of Service

Distributed Rhythmic Patterns

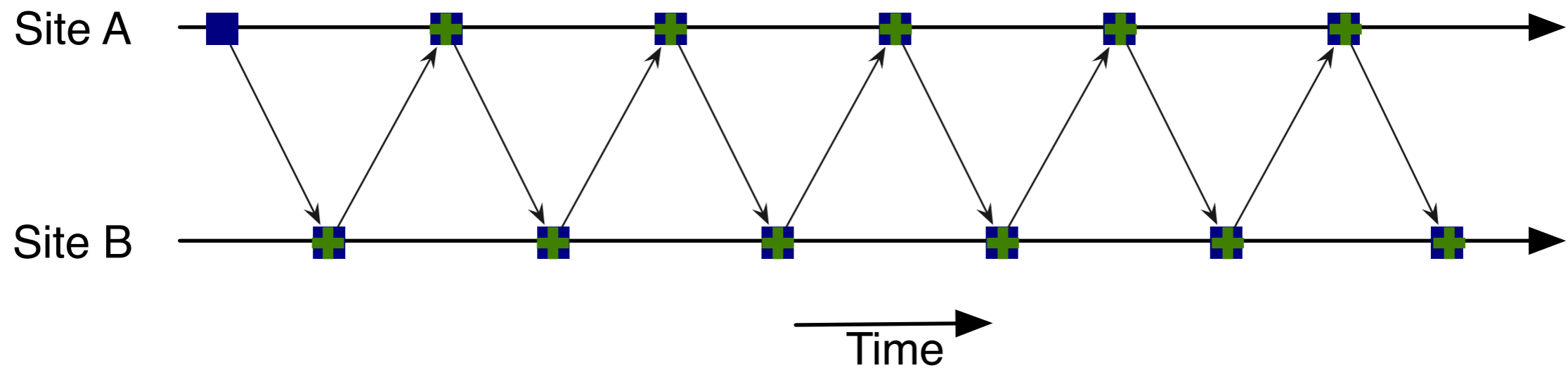
Distributed Rhythmic Patterns

Patterns that emerge as part of the *natural* behavior of *time-delayed* signals in network performance

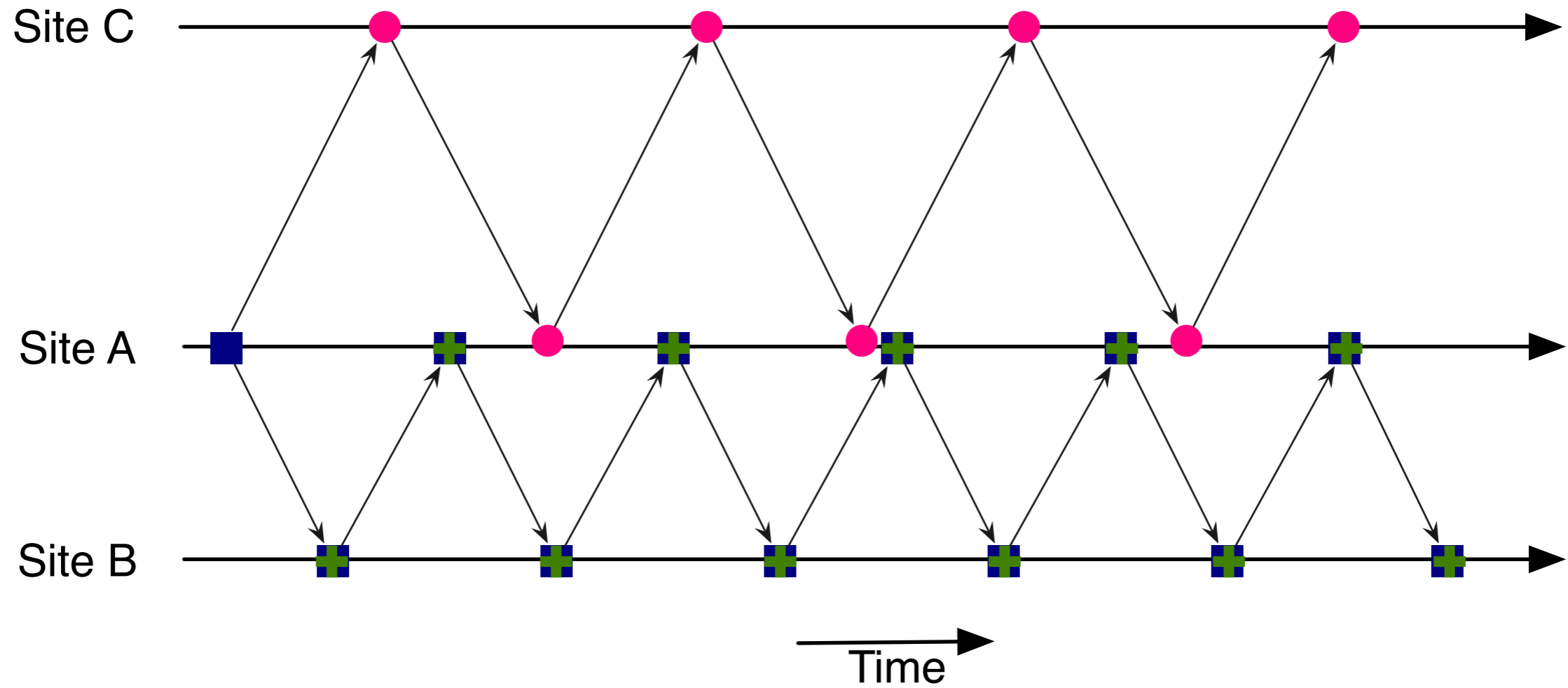
Feedback Locking



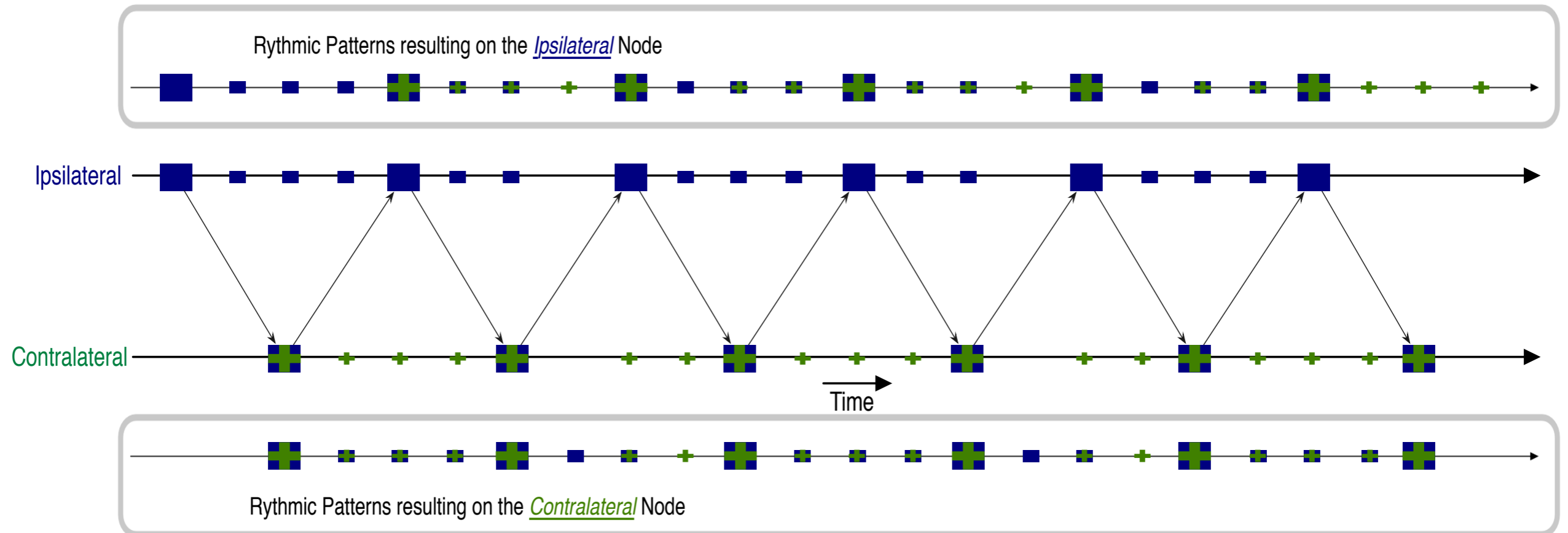
Feedback Locking



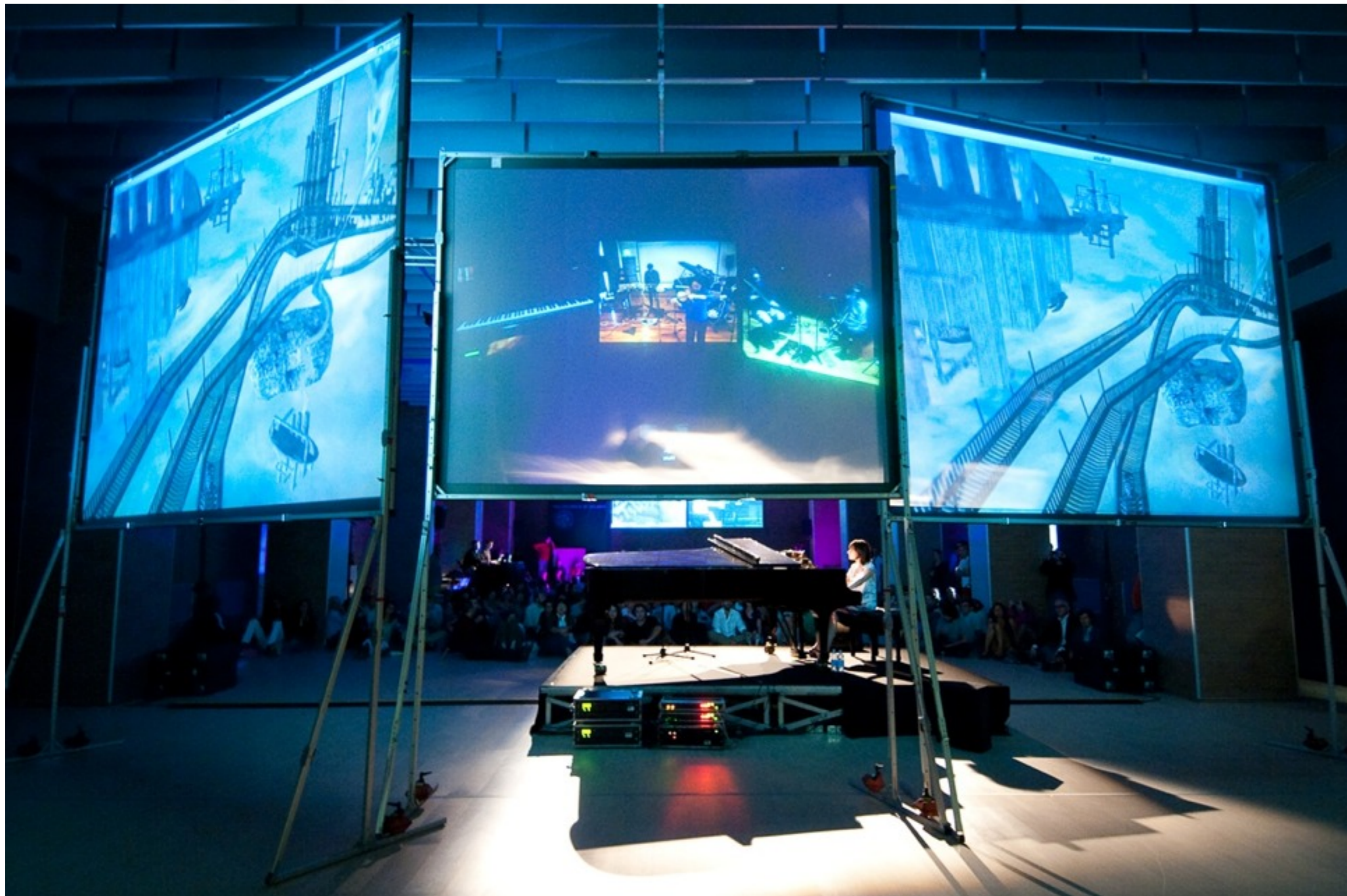
Feedback Locking



Feedback Locking in Detail



Terry Riley's In C - Milan's MiTo Festival (Sept. 2009)



in C.

© 1964
Terry Riley
© 1989
Celestial Harmonies

in C.

Musical score for 'In C' by Terry Riley, measures 1-21. The score is written in treble clef and consists of 21 numbered measures. The notation includes various rhythmic patterns and melodic lines.

From Riley's Performance Instructions:

“One of the joys of *In C* is the interaction of the players in polyrhythmic combinations that spontaneously arise between patterns.”

Musical score for 'In C' by Terry Riley, measures 36-53. The score is written in treble clef and consists of 18 numbered measures. The notation includes various rhythmic patterns and melodic lines.

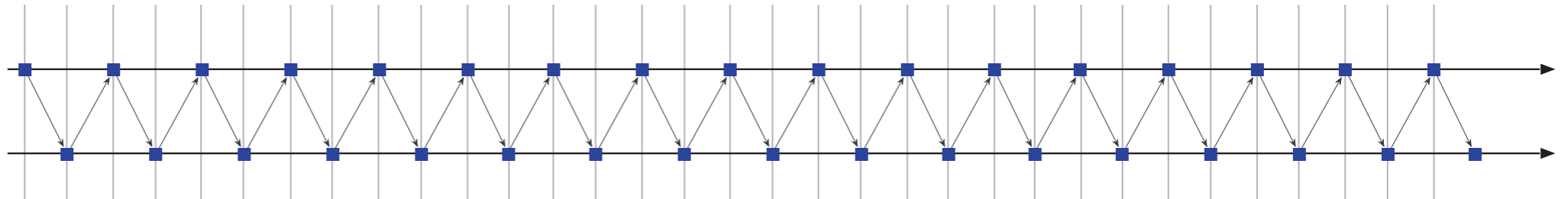
© 1964
Terry Riley
© 1989
Celestial Harmonies

Terry Riley's In C - Stanford/Beijing (April 2008)

Hidden Audio
Channel
Metronome

Stanford

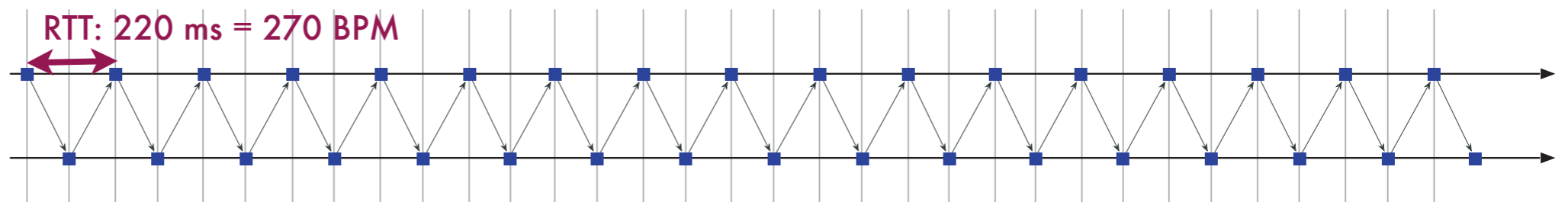
Beijing



Terry Riley's In C - Stanford/Beijing (April 2008)

Hidden Audio
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Metronome

Stanford
Beijing



Terry Riley's In C - Stanford/Beijing (April 2008)

Beijing



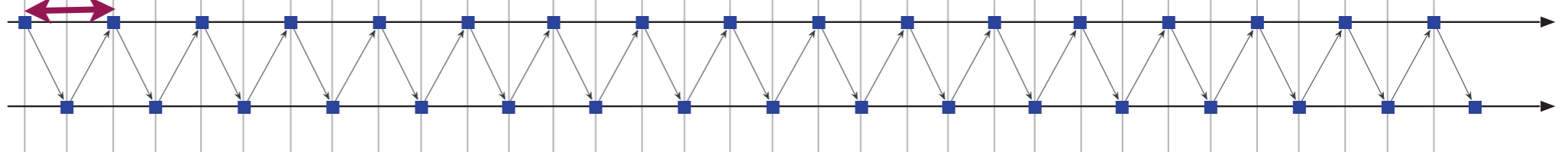
Stanford



RTT: 220 ms = 270 BPM

Hidden Audio Channel Metronome

Stanford
Beijing



Terry Riley's In C - Stanford/Beijing (April 2008)

Beijing



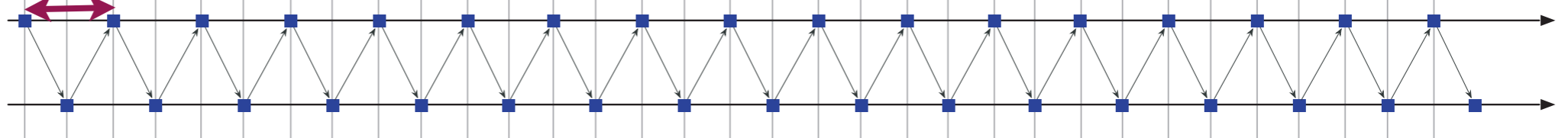
Stanford



RTT: 220 ms = 270 BPM

Hidden Audio Channel Metronome

Stanford
Beijing



Beijing



Stanford



Terry Riley's In C - Stanford/Beijing (April 2008)

Beijing



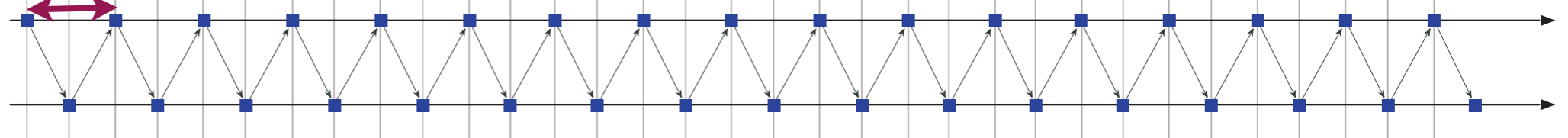
Stanford



RTT: 220 ms = 270 BPM

Hidden Audio Channel Metronome

Stanford
Beijing



Beijing



Stanford



Terry Riley's In C - Stanford/Beijing (April 2008)

Beijing



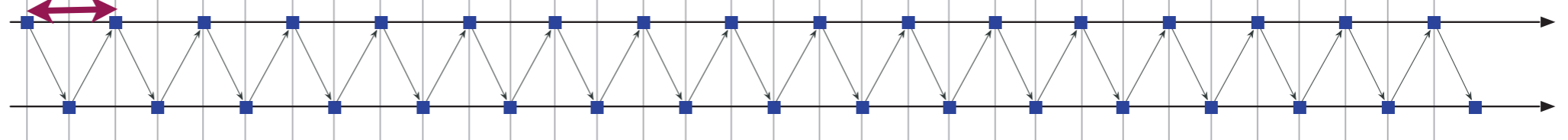
Stanford



RTT: 220 ms = 270 BPM

Hidden Audio Channel Metronome

Stanford
Beijing



Beijing

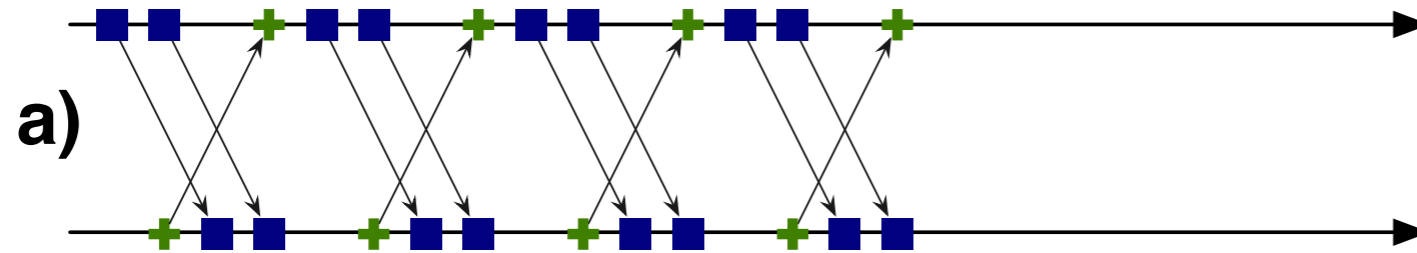


Stanford



More Patterns

Ipsilateral sound ■
Contralateral sound +

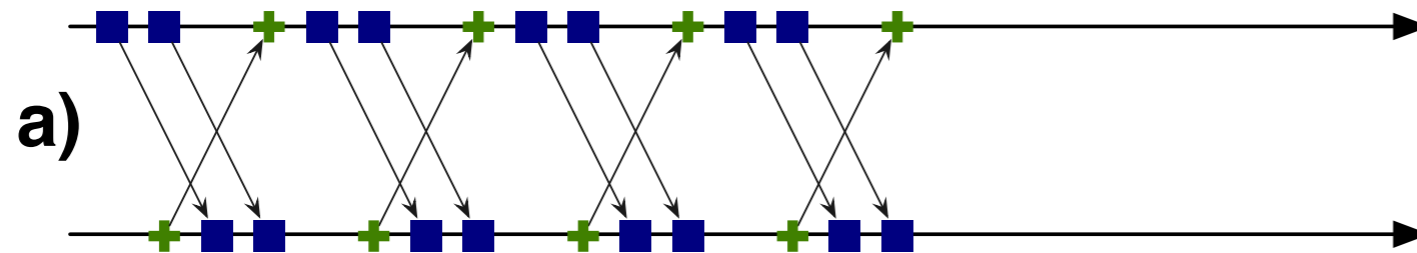


Dislocated Identical Pattern

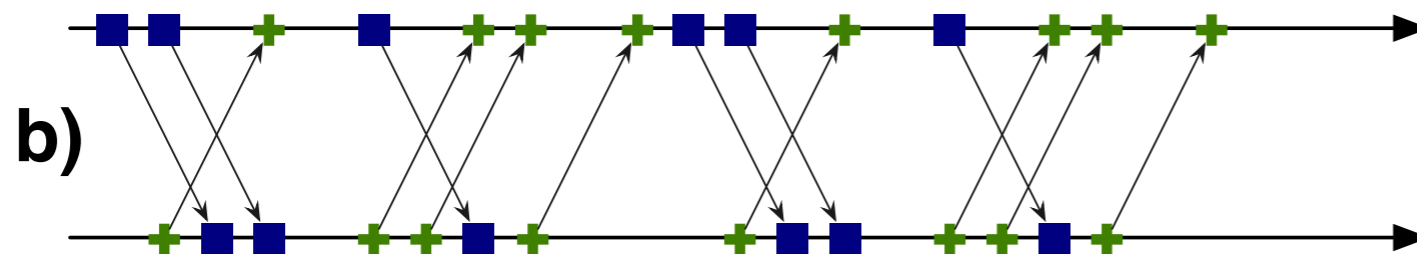
Time →

More Patterns

Ipsilateral sound ■
Contralateral sound +



Dislocated Identical Pattern

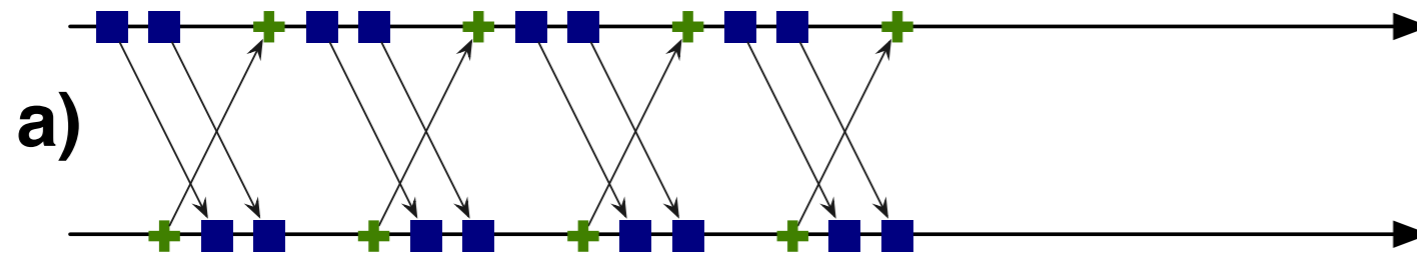


Different Patterns

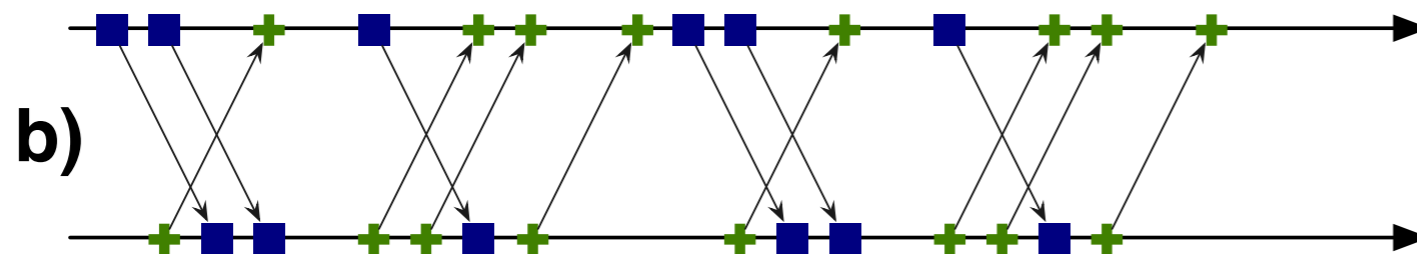
Time →

More Patterns

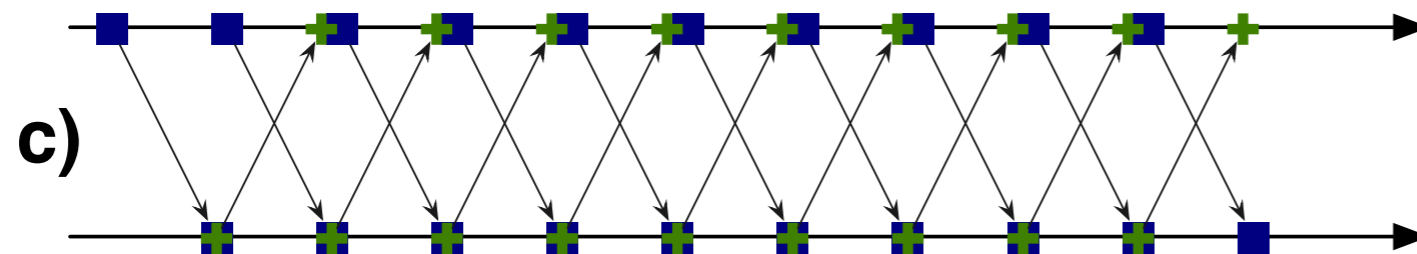
Ipsilateral sound ■
Contralateral sound +



Dislocated Identical Pattern



Different Patterns

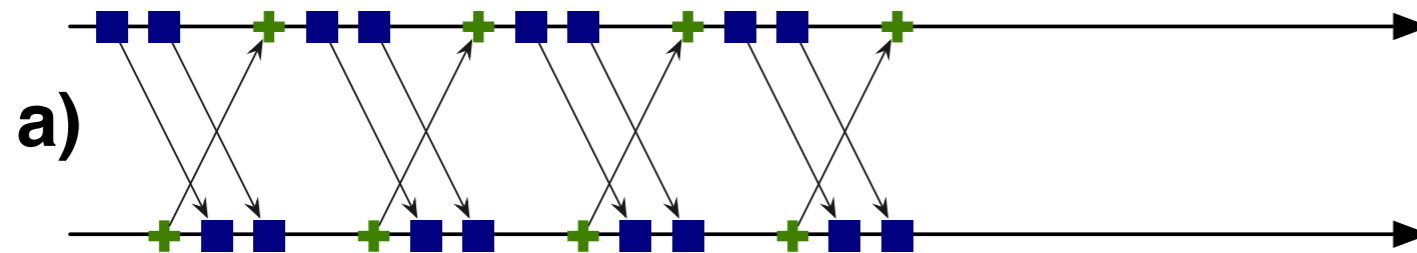


Constant Pulse

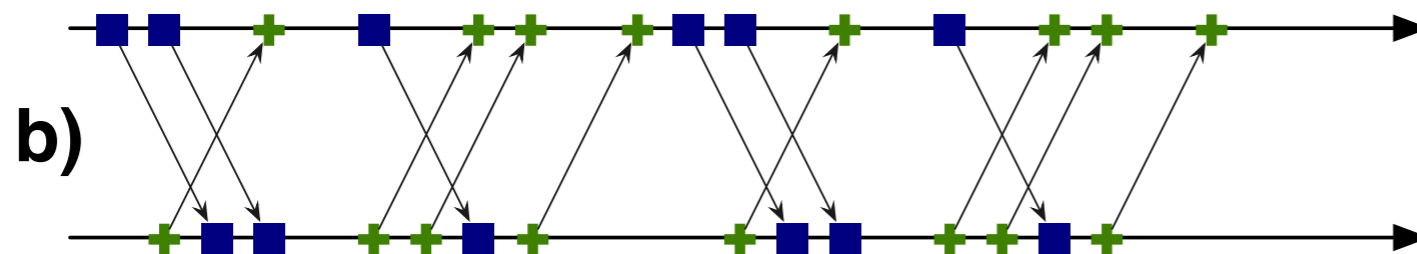
Time →

More Patterns

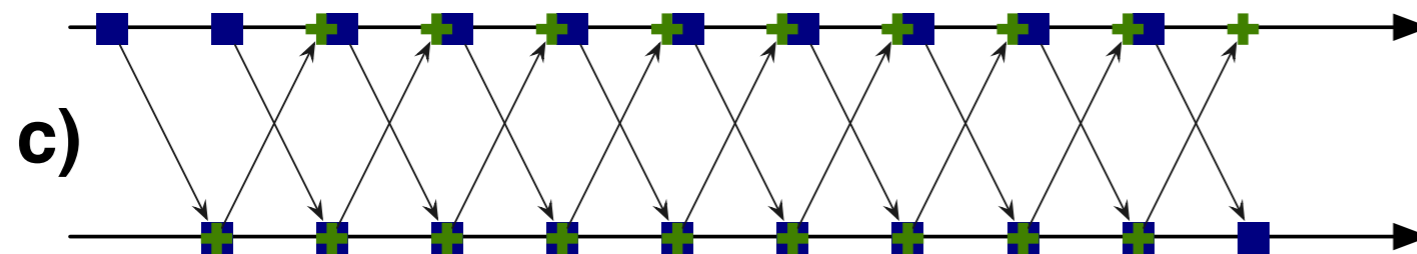
Ipsilateral sound ■
Contralateral sound +



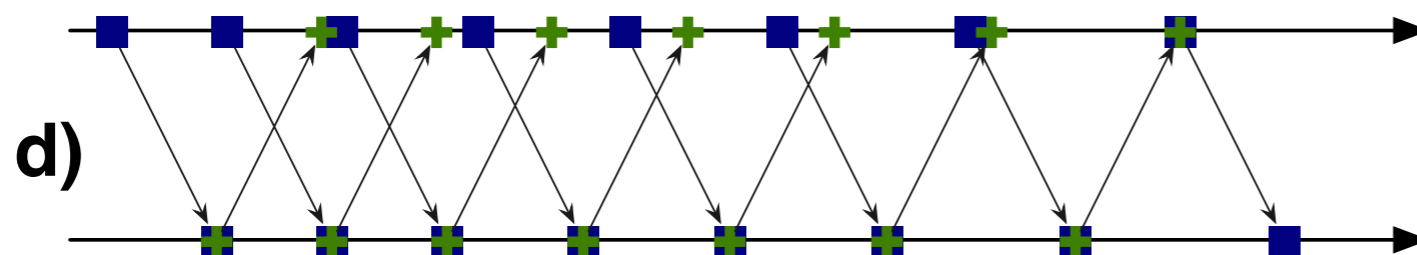
Dislocated Identical Pattern



Different Patterns



Constant Pulse

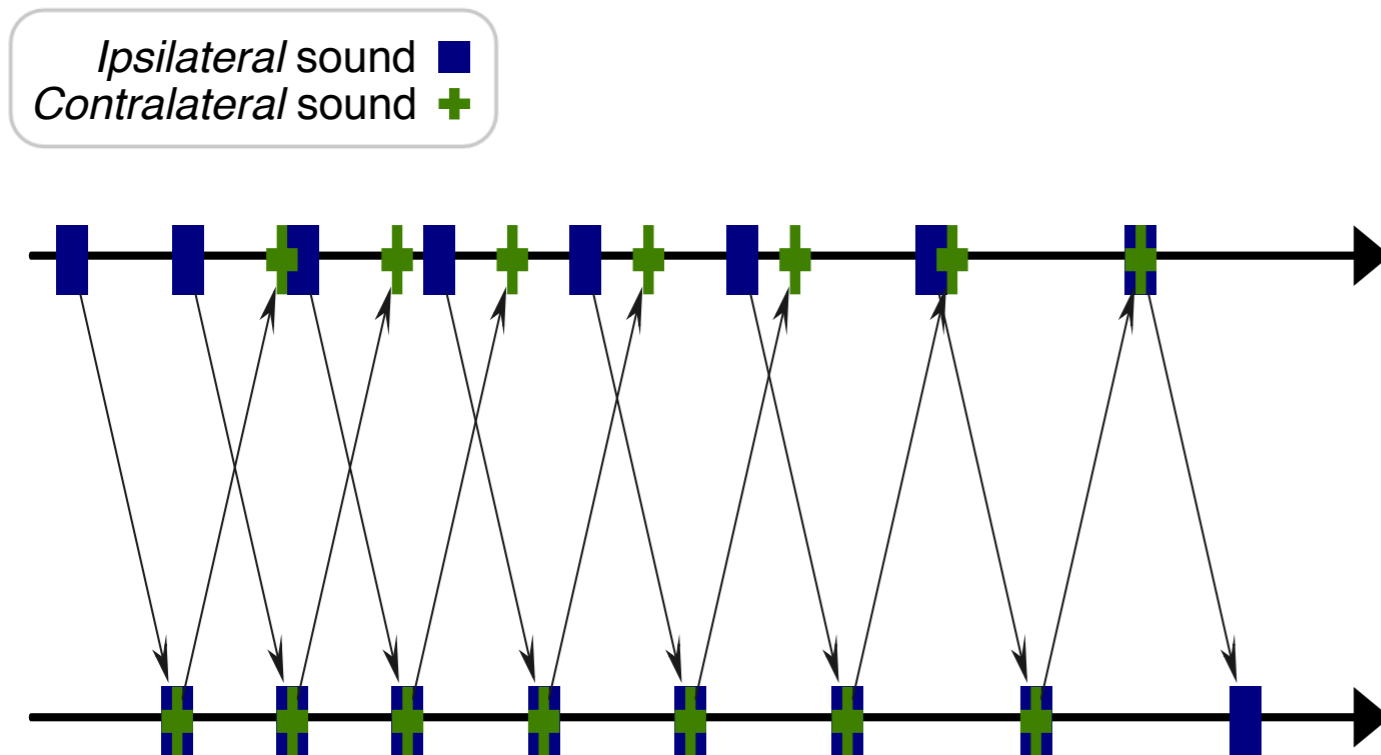


Ritardando and Phasing

Time →

How does it sound

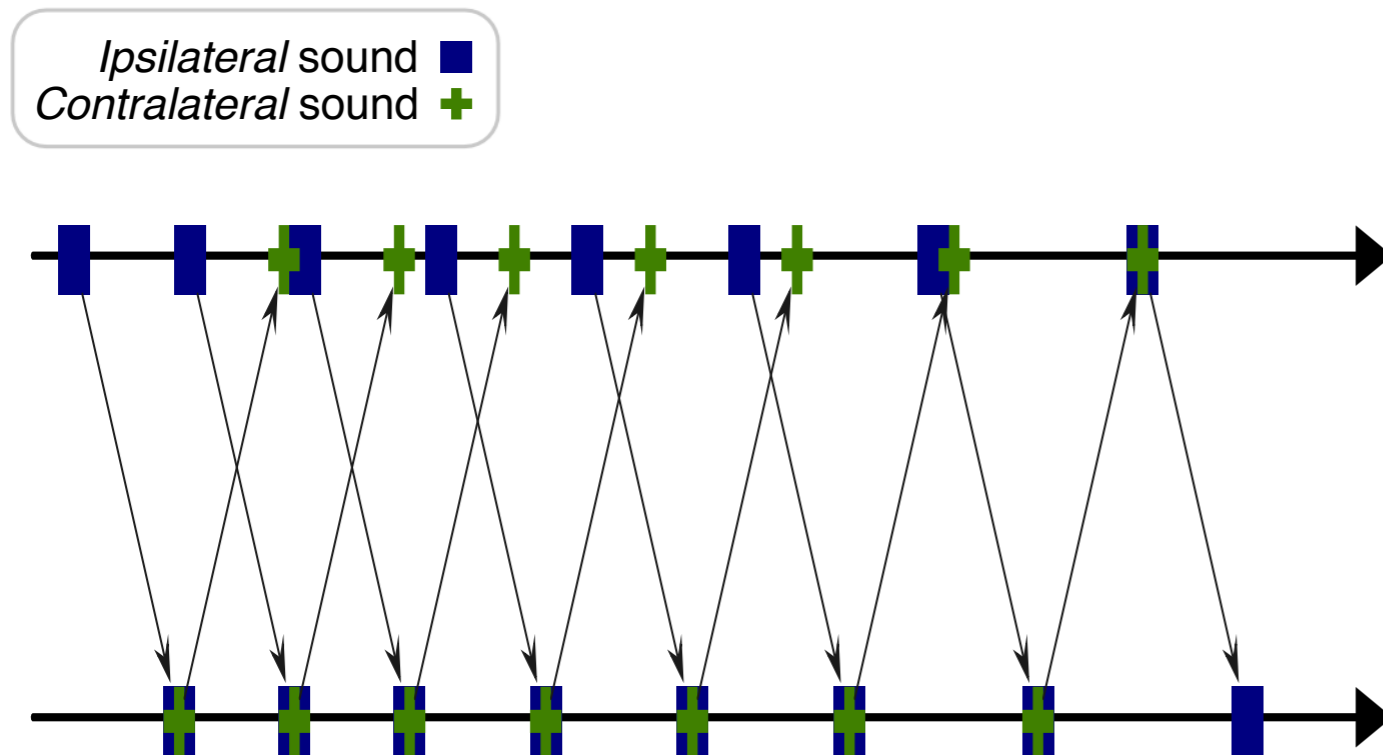
One-Way Delay



How does it sound

One-Way Delay

200 ms

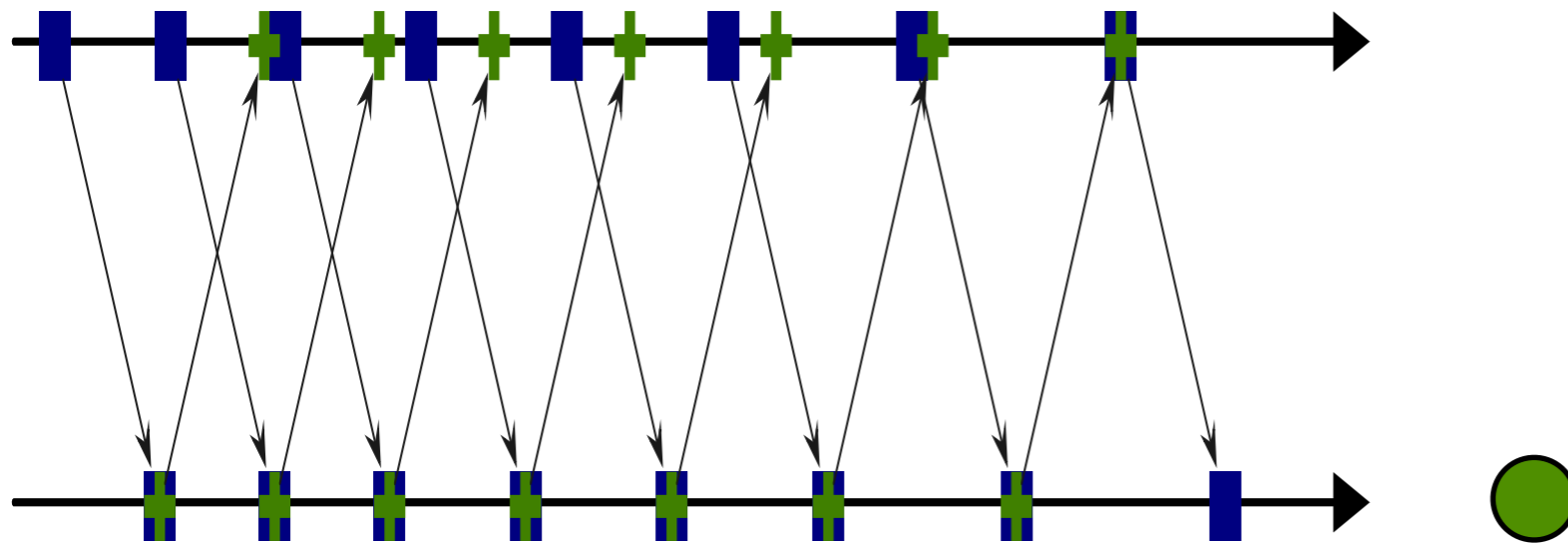


How does it sound

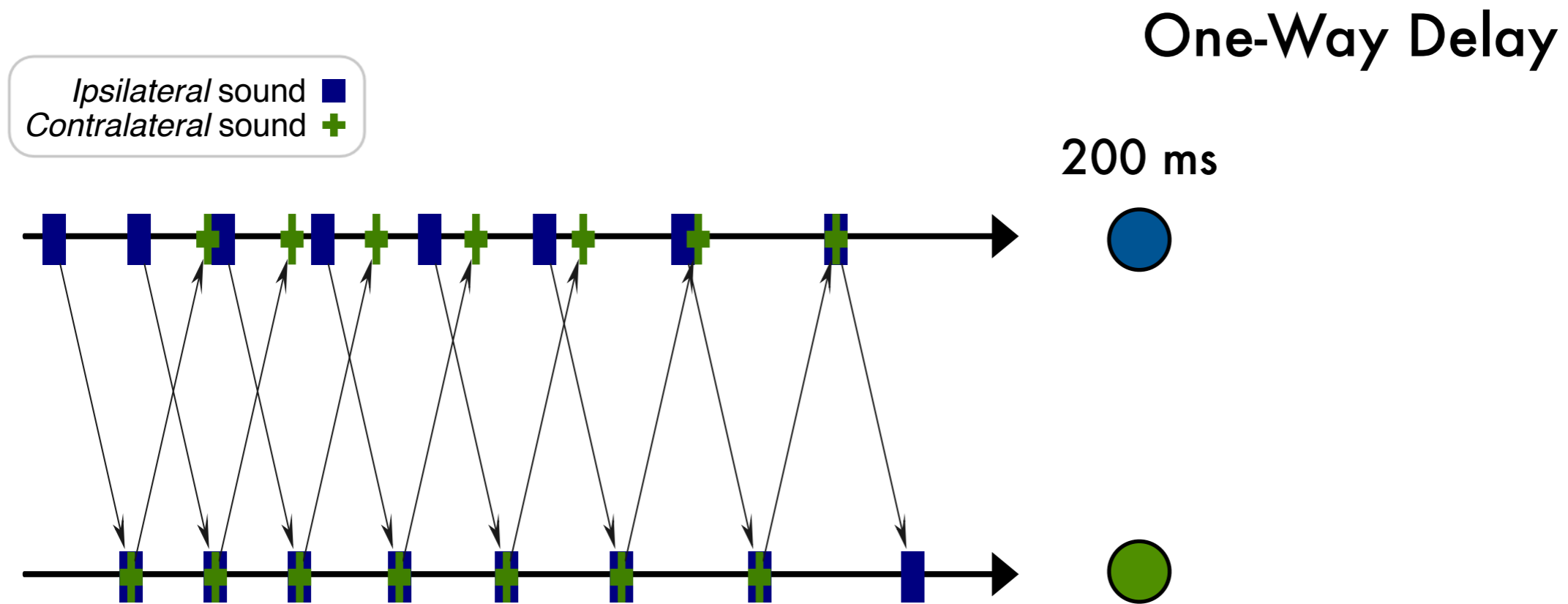
Ipsilateral sound ■
Contralateral sound +

One-Way Delay

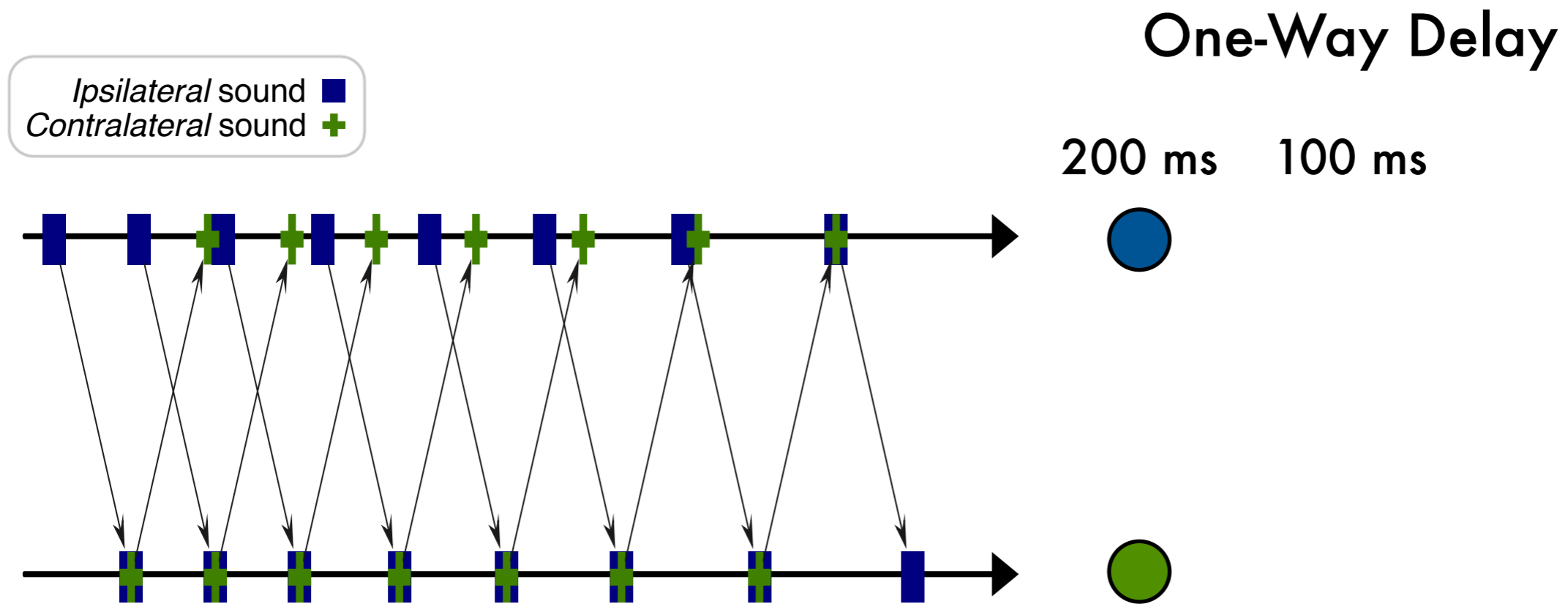
200 ms



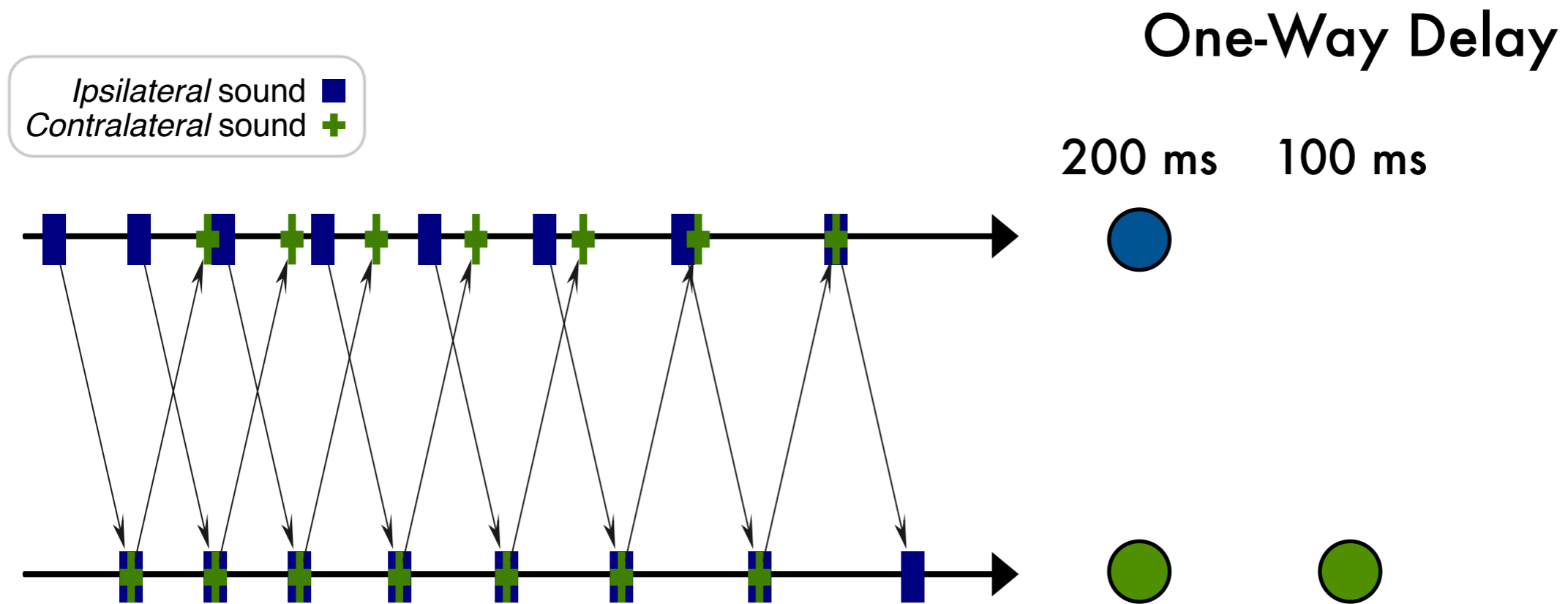
How does it sound



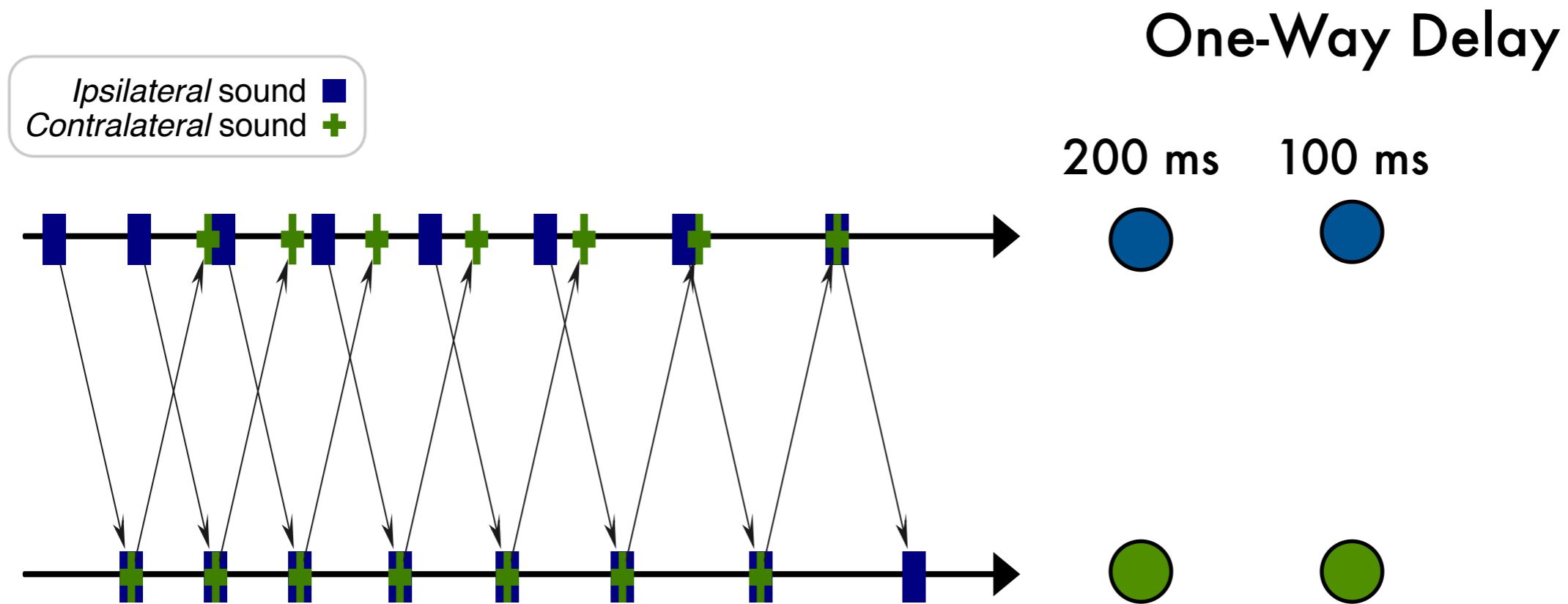
How does it sound



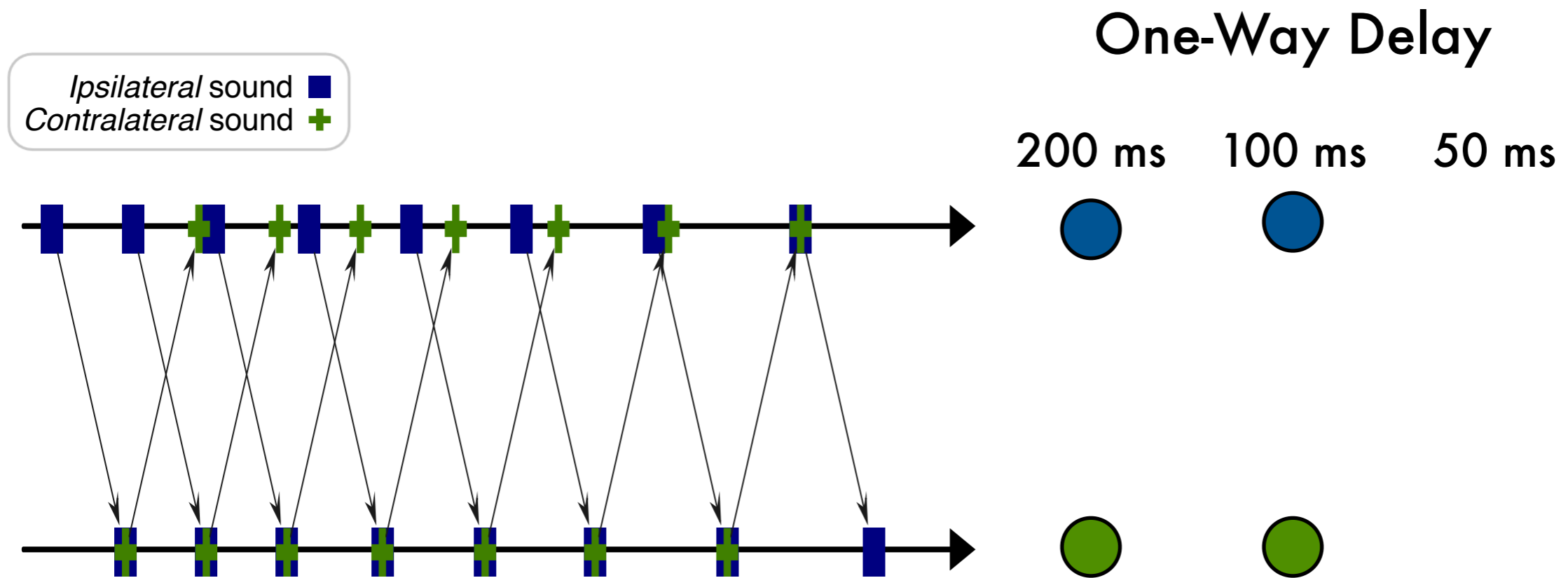
How does it sound



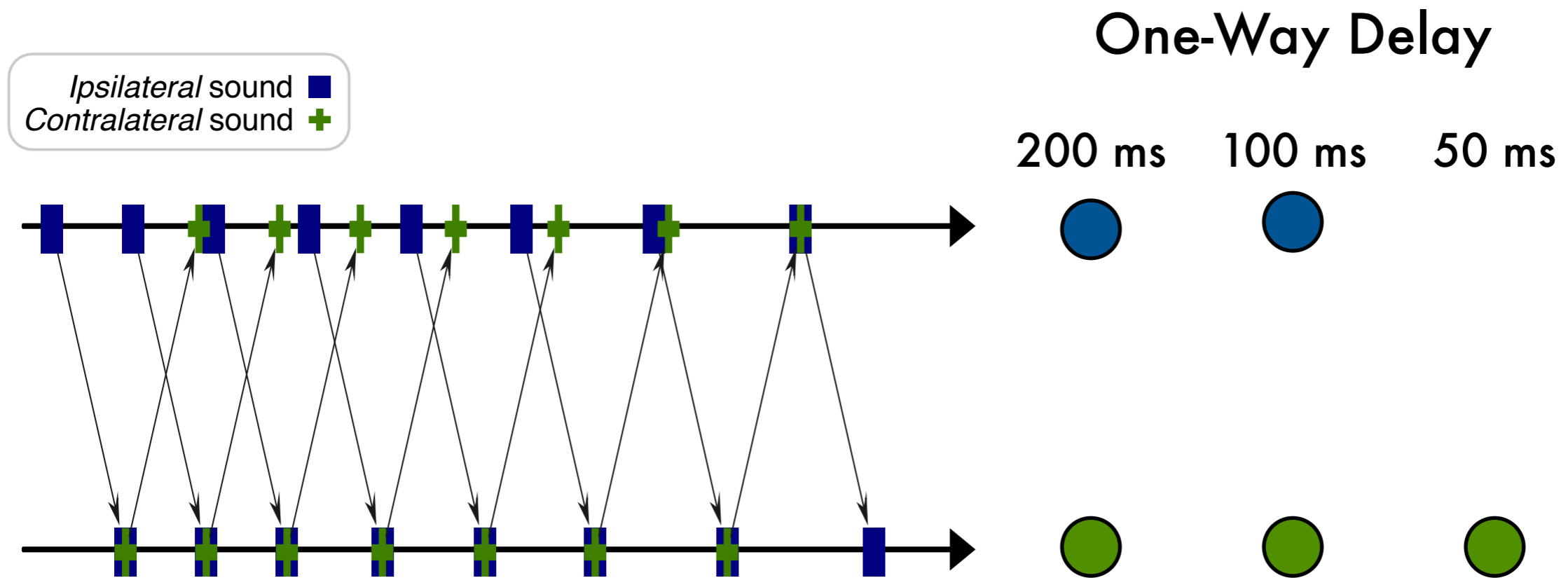
How does it sound



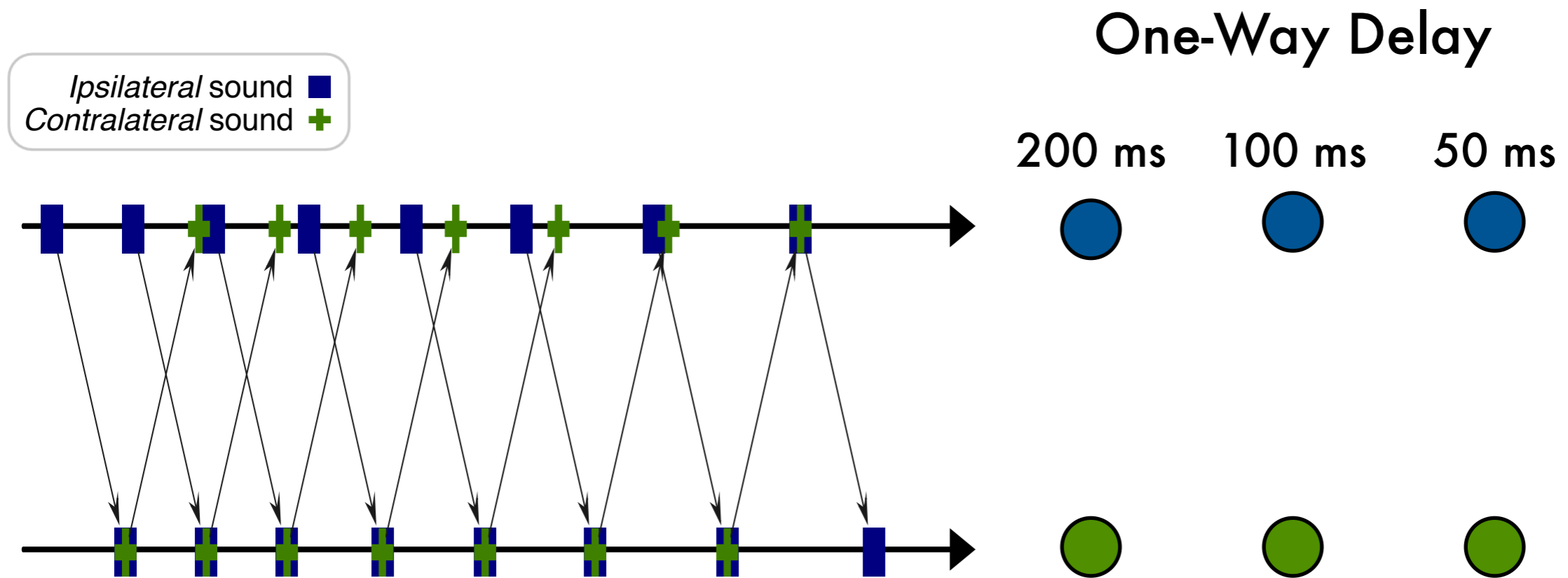
How does it sound



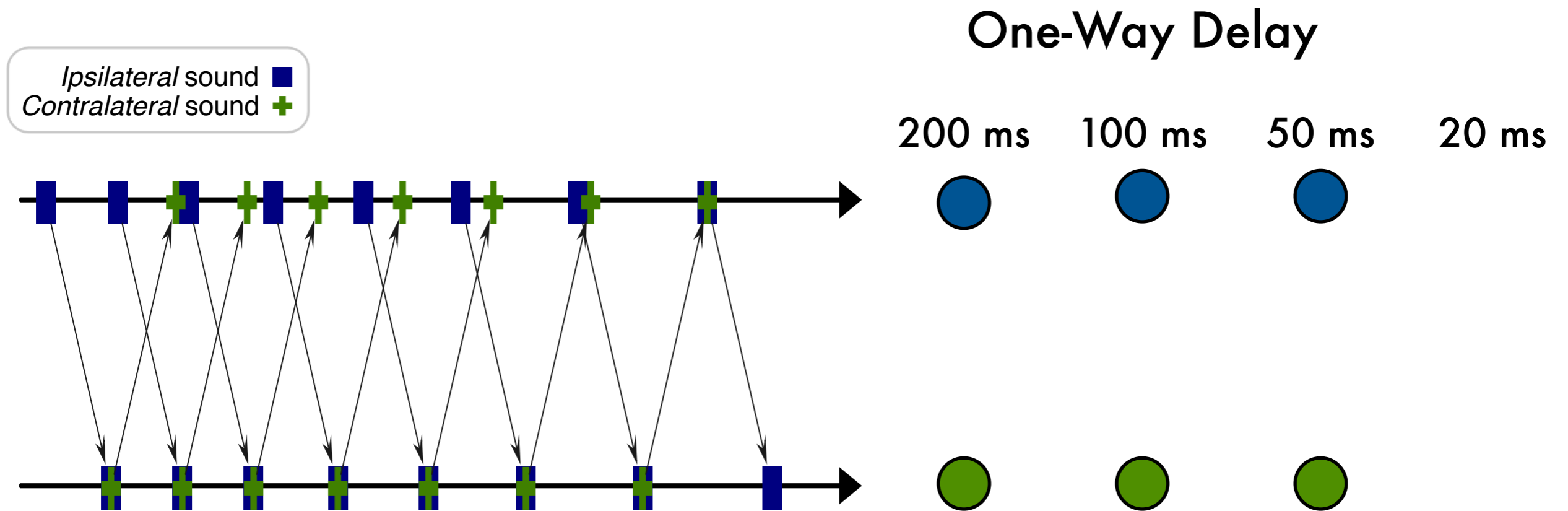
How does it sound



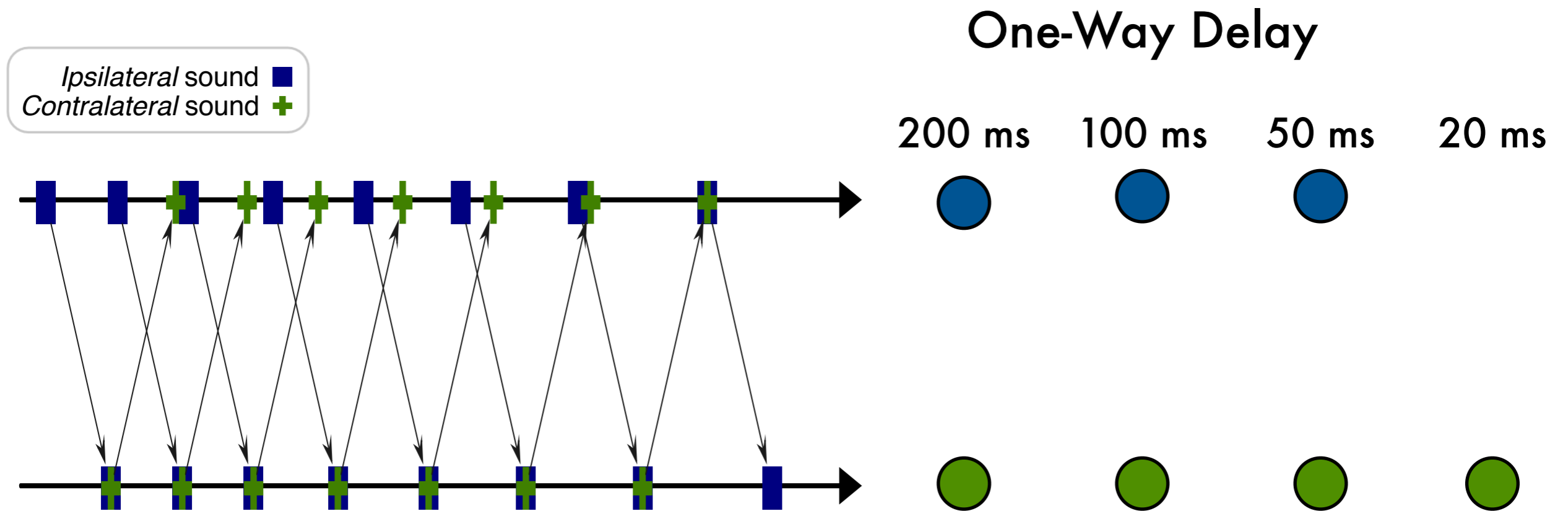
How does it sound



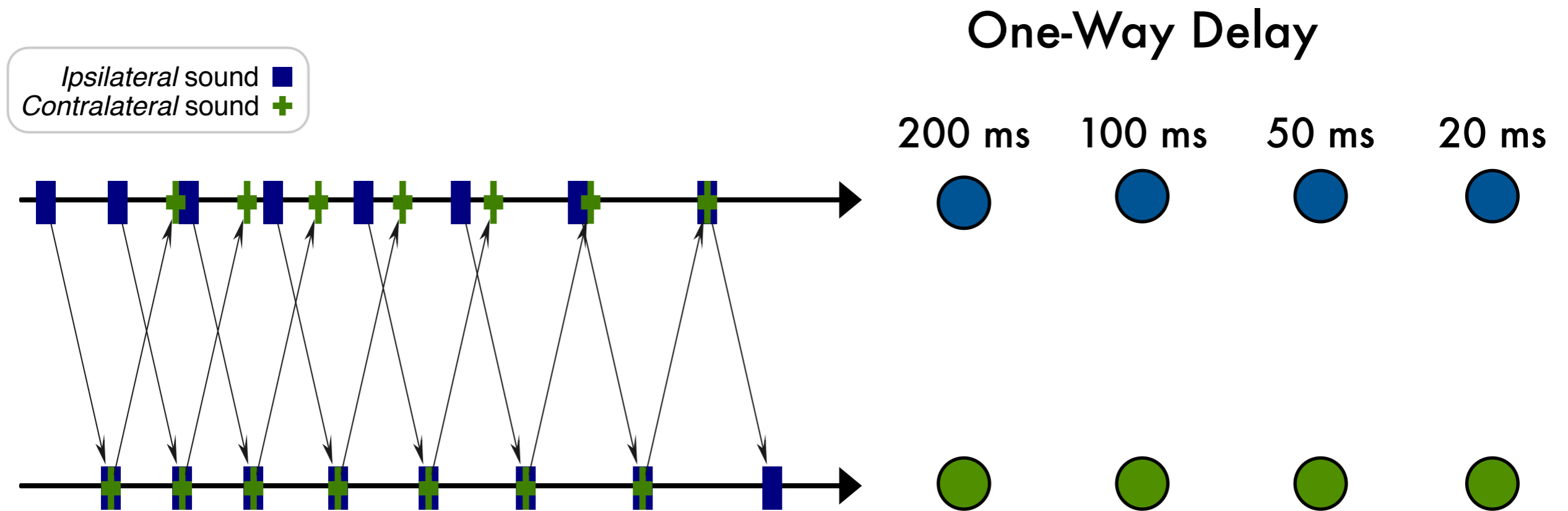
How does it sound



How does it sound



How does it sound



NET:DISTURBANCES (ICMC, August 2008)

Concert in Belfast + CCRMA



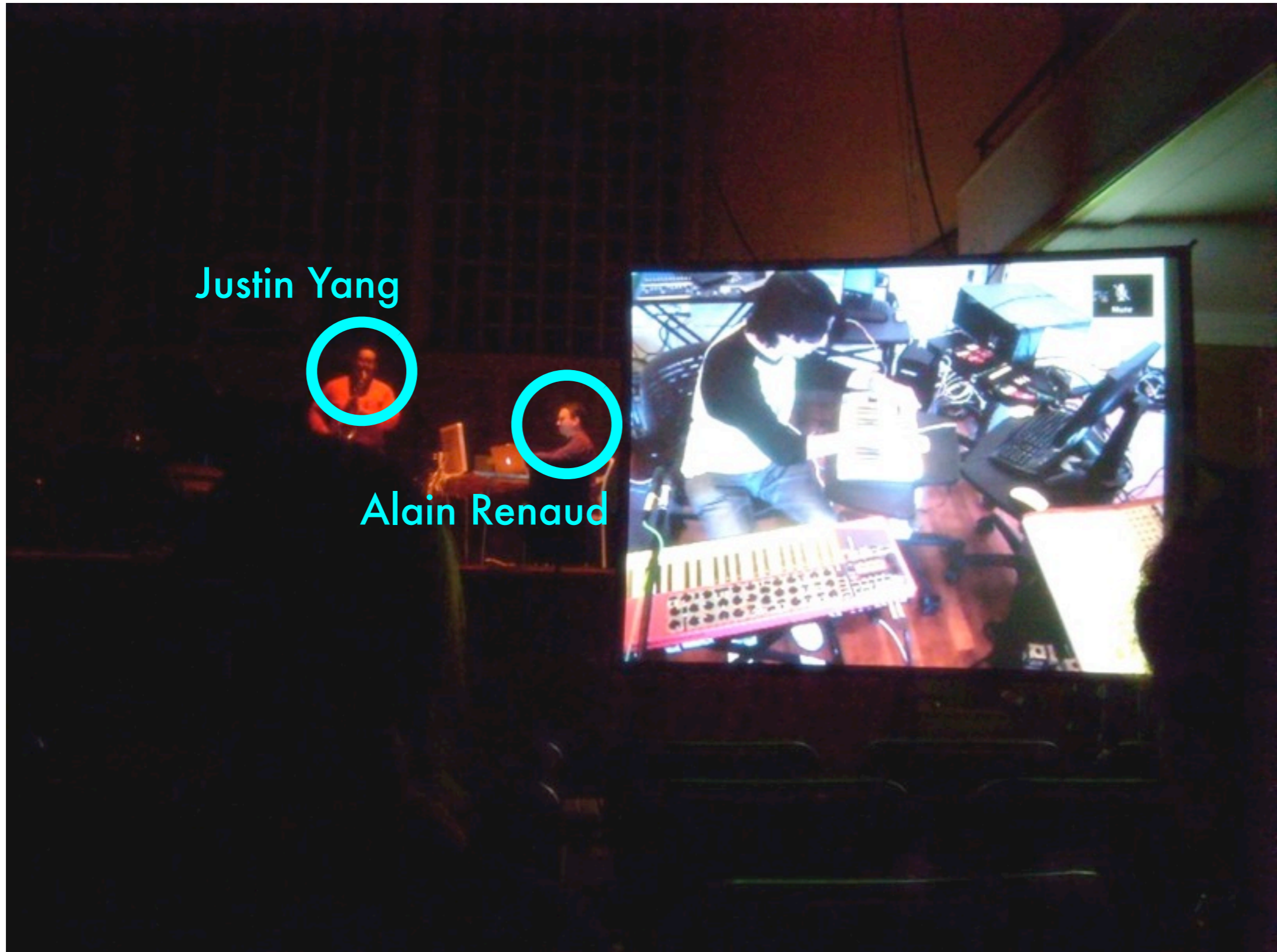
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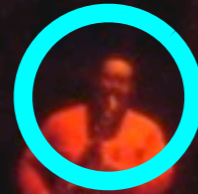


NET:DISTURBANCES (ICMC, August 2008)

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Justin Yang



Alain Renaud

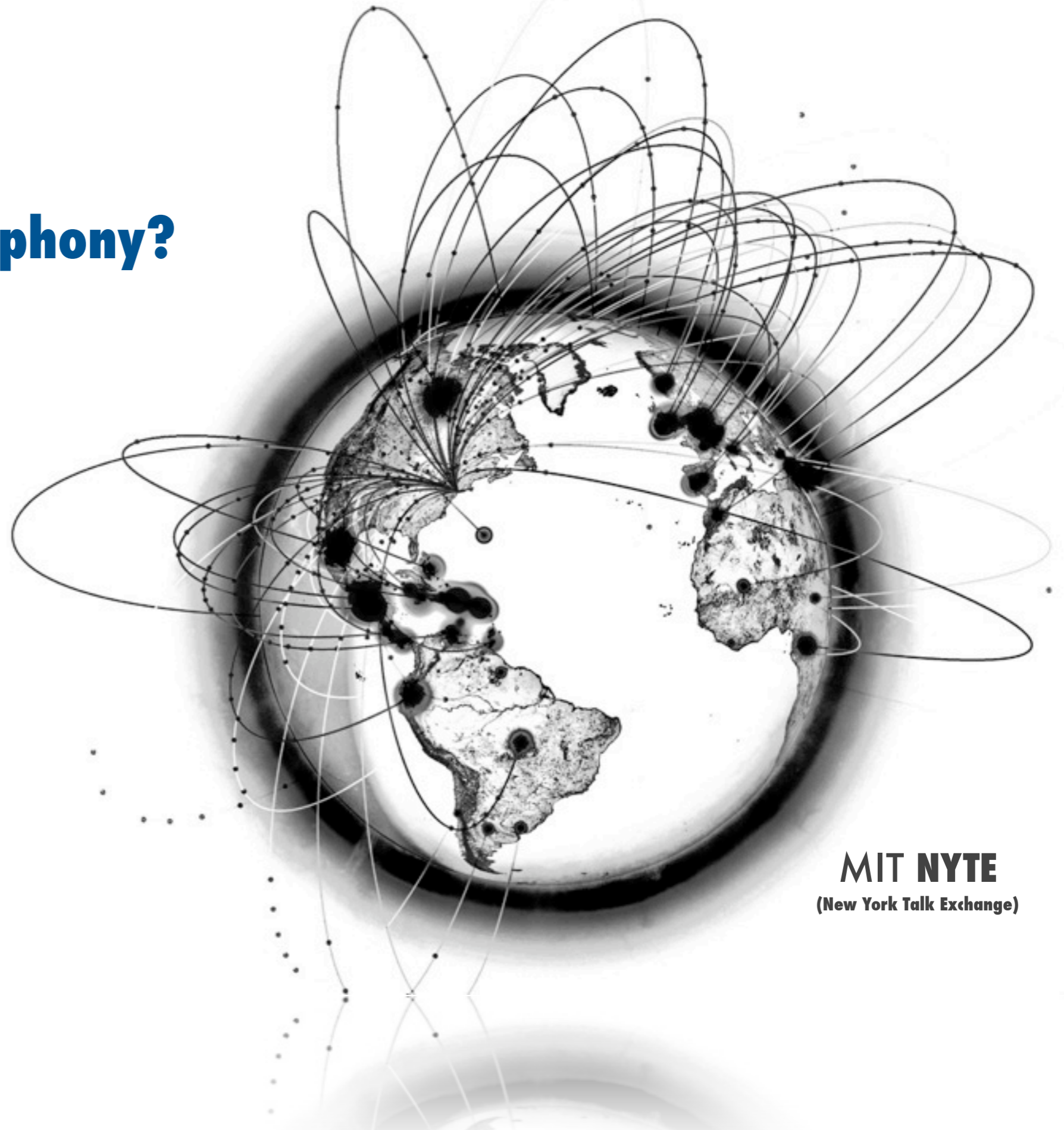
NET:DISTURBANCES (ICMC, August 2008)

Concert in Belfast + CCRMA



Global Network Symphony?

Global Network Symphony?



MIT NYTE
(New York Talk Exchange)

More Info

- Chris Chafe, Juan-Pablo Cáceres and Michael Gurevich. "Temporal Separation in Music Ensembles." *Perception*, 2010.
- Juan-Pablo Cáceres, Robert Hamilton, Deepak Iyer, Chris Chafe, and Ge Wang. "To the edge with china: Explorations in network performance." In ARTECH 2008
- Juan-Pablo Cáceres and Alain B. Renaud. "Playing the network: the use of time delays as musical devices." In Proceedings of International Computer Music Conference