

# Hoe maak je een luisterende machine?

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# Overzicht

- Wat is muziekcognitie?
  - Onderzoekscontext
  - Twee korte voorbeelden
- Hoe ziet een luisterende machine eruit?
  - Van kunstmatige intelligentie tot cognitiewetenschap
  - Voorbeeld: categorizatie van ritme

# Music Cognition Group

## ■ Academic context

- University of Amsterdam (UvA), Institute for Logic, Language and Computation (ILLC), Cognitive Science Center Amsterdam (CSCA)

## ■ Domain of research

- Study of music cognition, perception and performance, using theoretical, empirical and computational methods

## ■ Mission

- Arrive at a cognitive science of music, with a special focus on its temporal aspects, such as rhythm, tempo and timing



# Music Cognition Group



*Henkjan Honing*

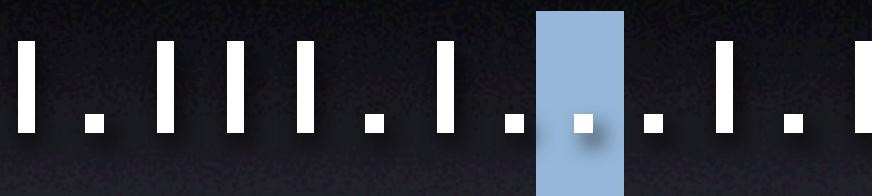
*Olivia Ladinig*

*Leigh. M. Smith*

*Bas de Haas*



# Voorbeeld ritmisch cliché



Een ‘luid’ rust

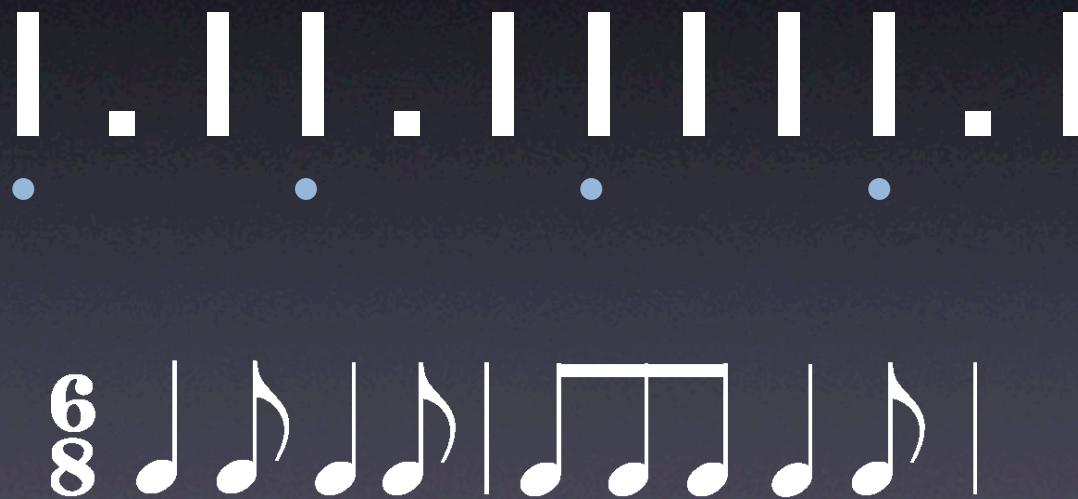


Alternatieve  
notaties van een  
*syncopē*





# Voorbeeld *beat inductie*



# Modellen van *beat inductie*

- **Symbolic** (*Longuet-Higgins, 1976*)
- **Knowledge-based** (*Mont-Reynaud et al., 1985*)
- **Control theory** (*Dannenberg et al., 1987*)
- **Connectionist** (*Desain & Honing, 1989*)
- **Complex dynamics** (*Large & Kolen, 1994*)
- ...



# Voorbeelden uit 90er jaren



Google “Beat Induction Demo” voor deze video



## Music, the food of neuroscience?

Playing, listening to and creating music involves practically every cognitive function. Robert Zatorre explains how music can teach us about speech, brain plasticity and even the origins of emotion.

We tend to consider art and culture from a humanistic or historical perspective rather than a biological one. Yet these products of human cognition must have their origin in the function and structure of the human nervous system. As such, they should be able to yield valuable scientific insights. This line of reasoning is nowhere more evident than in the contemporary interest in the neuroscience of music.

Music provides a tool to study numerous aspects of neuroscience, from motor-skill learning to emotion. Indeed, from a psychologist's point of view, listening to and producing music involves a tantalizing mix of practically every human cognitive function. Even a seemingly simple activity, such as humming a familiar tune, necessitates complex auditory pattern-processing mechanisms, attention, memory storage and retrieval, motor programming, sensory-motor integration, and so forth (Fig. 1).

Likewise, the musician does not consider music to be monolithic, but recognizes within it multiple features including

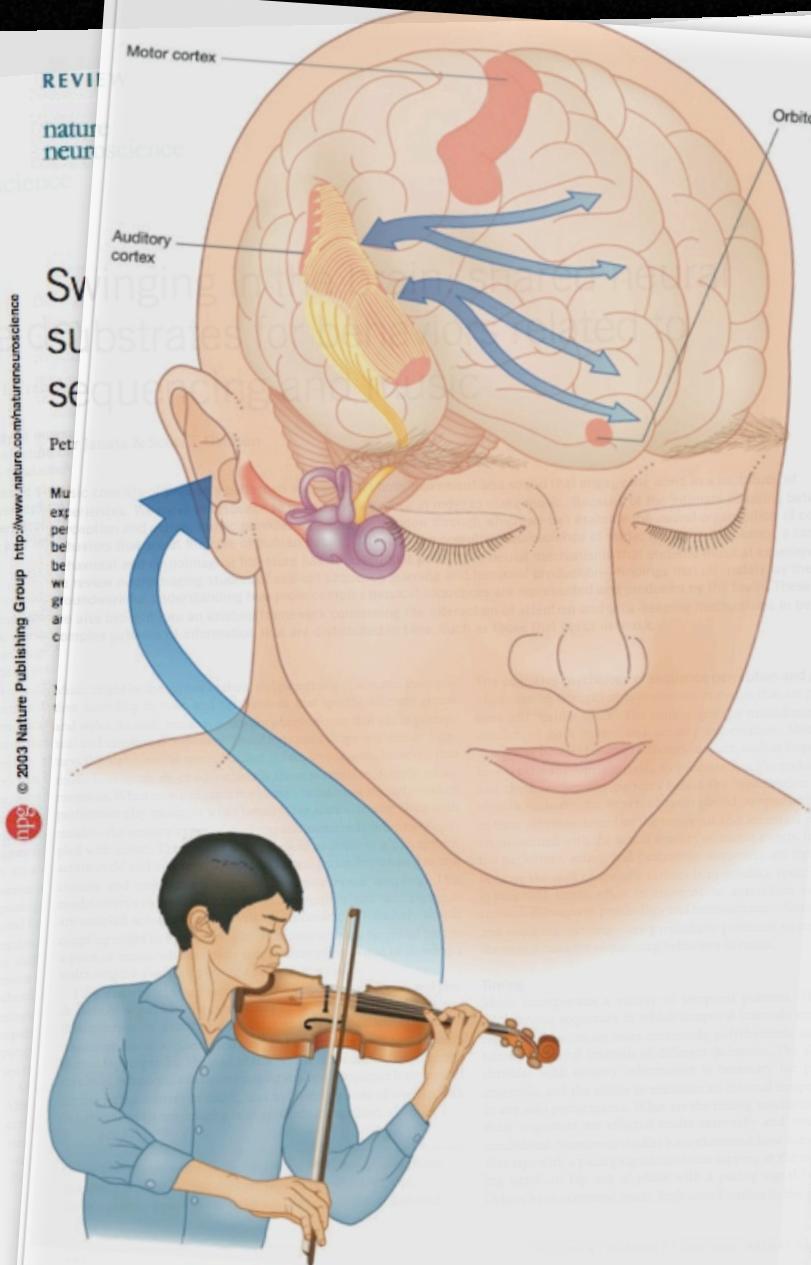


Figure 1 The processing of sound waves from a musical instrument. After being transduced into neural

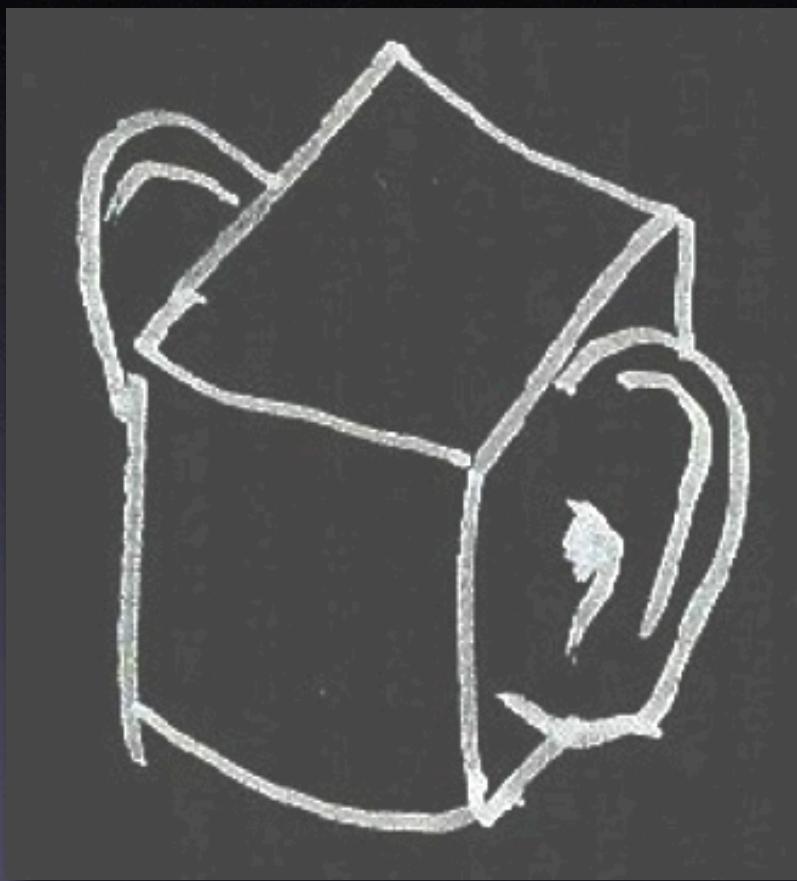


I.

# Hoe ziet een luisterende machine eruit?



# Black box model



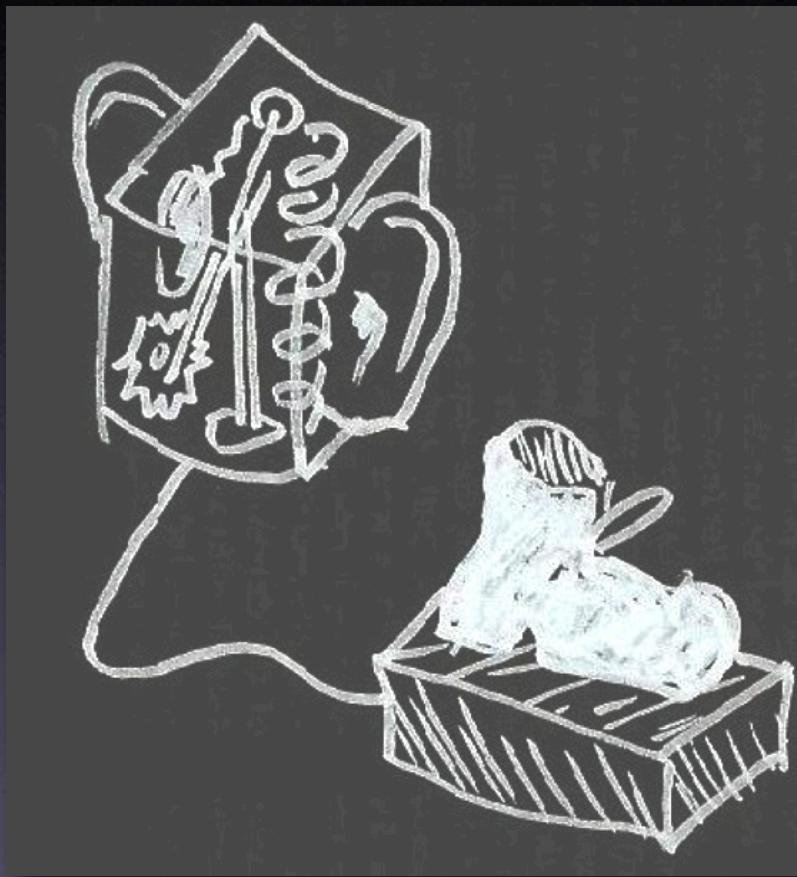


# Transparent model





# Model with overt behavior





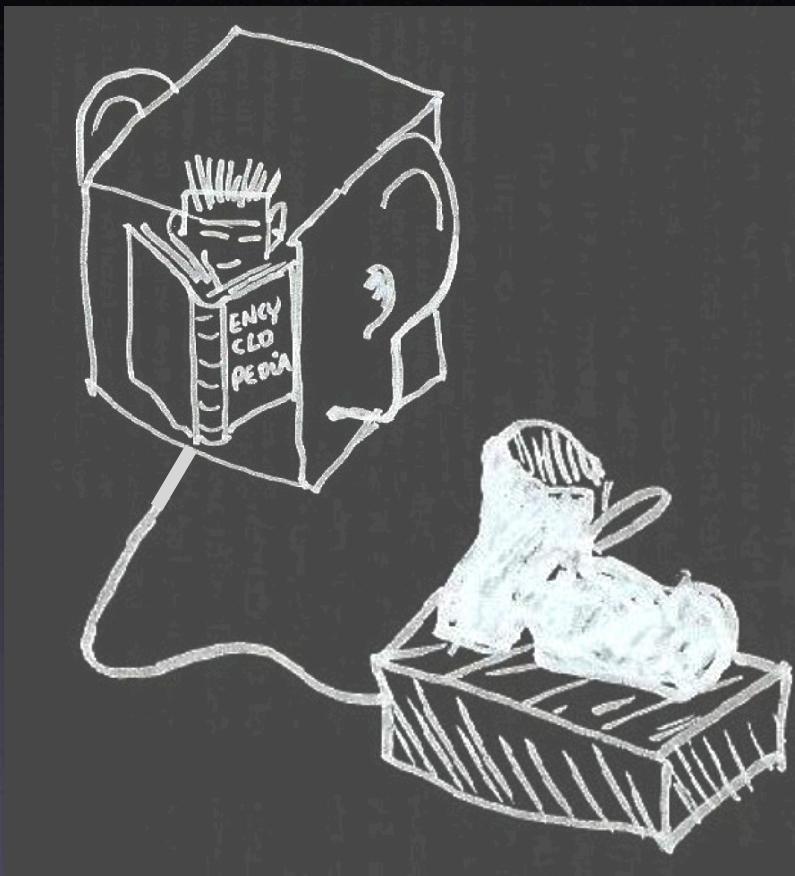
# Pachet's Continuator



Google “Continuator Turing Test” voor deze video



# Too good a model?







2.

Hoe maken we het  
onderscheid tussen  
ritme en timing?

# Rhythmic categorization

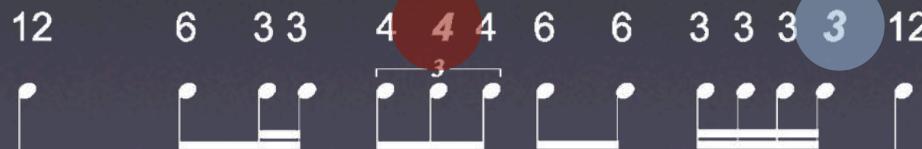
**a**

Performance (*time interval in seconds*)



perception ↓ ↑ performance

**b**

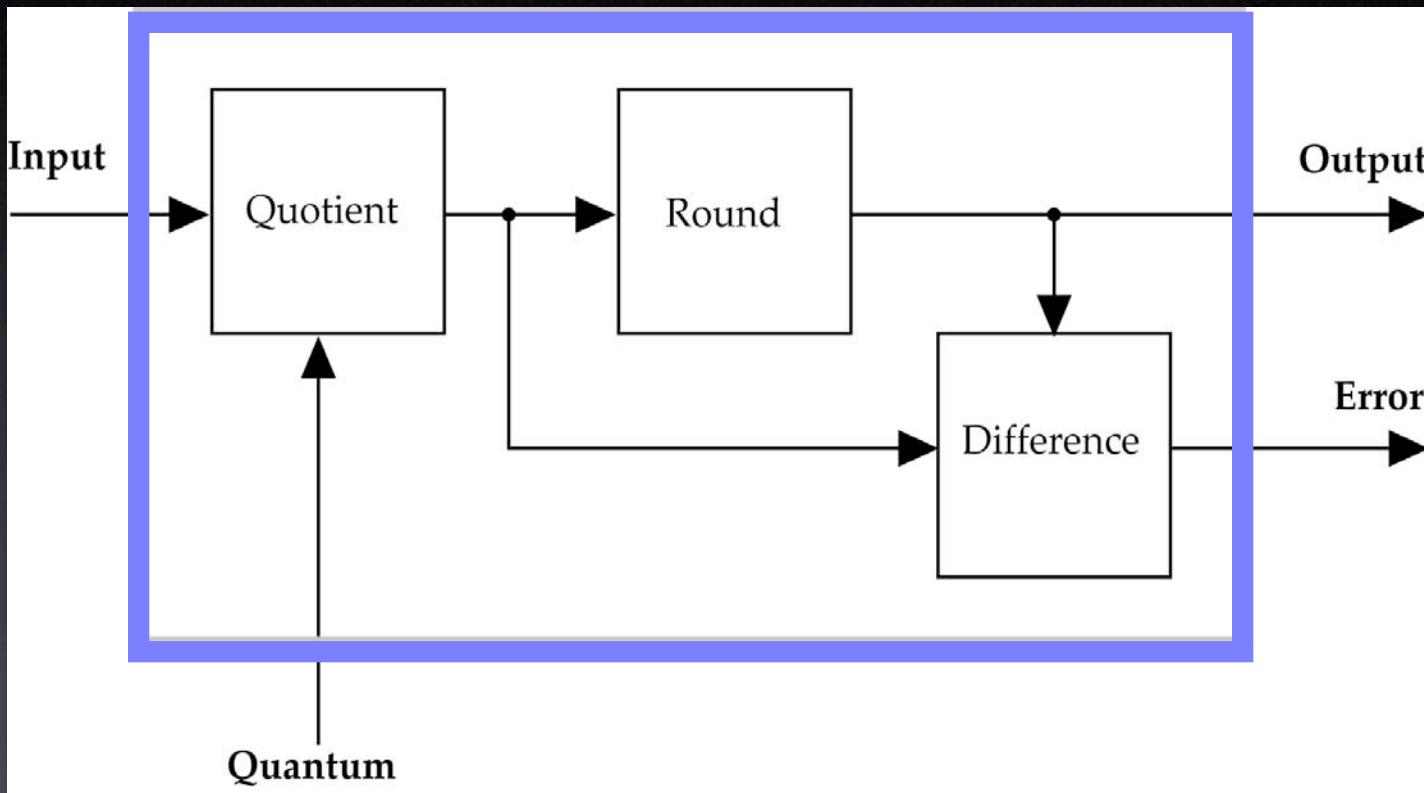


Score (*time interval categories*)

# 3. Is dit te formaliseren?

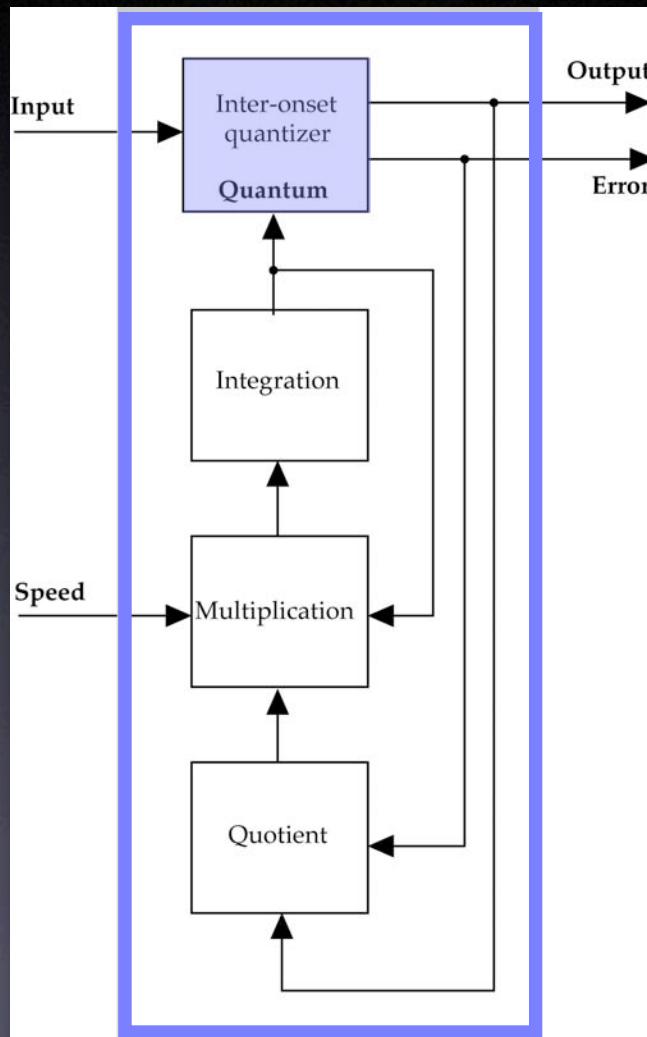


# Inter-onset quantizer



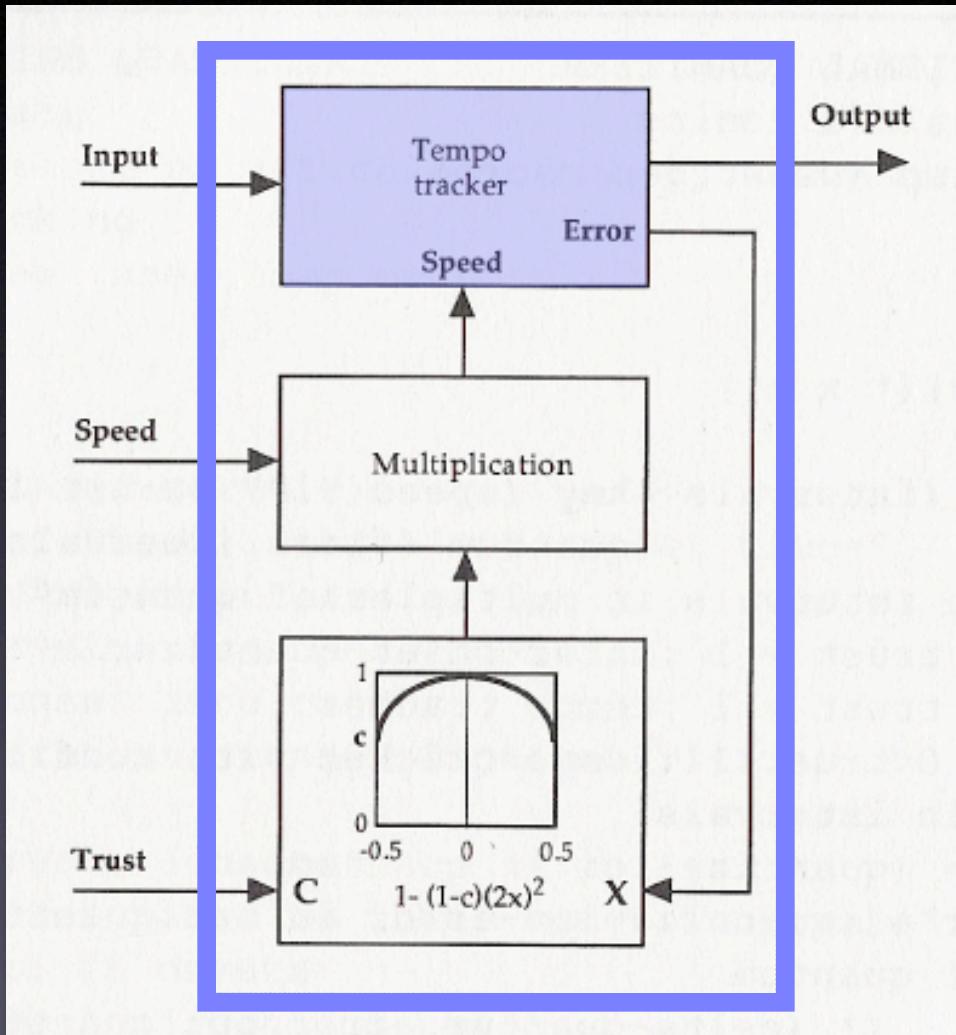


# Tempo tracker

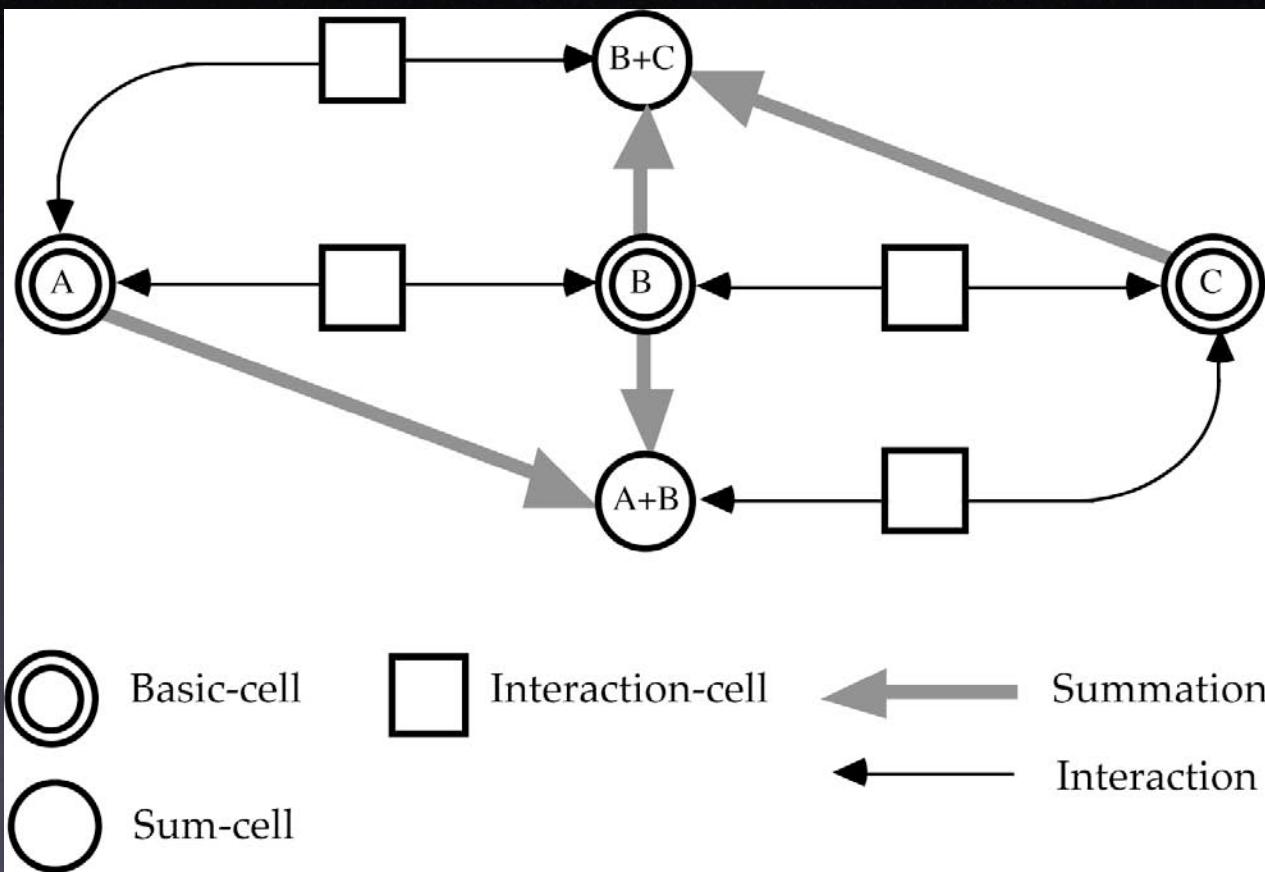


(Desain & Honing, 1992)

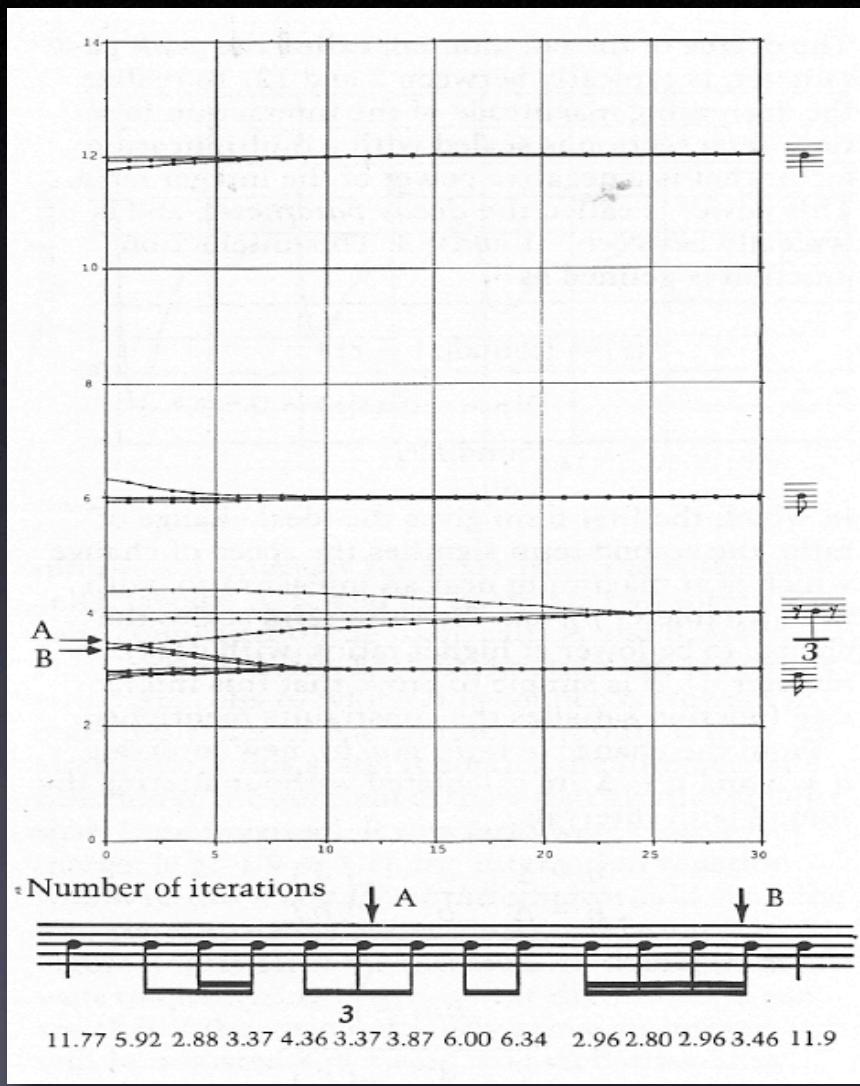
# Tempo tracker with confidence



# Connectionist quantizer



# Iteration state diagram

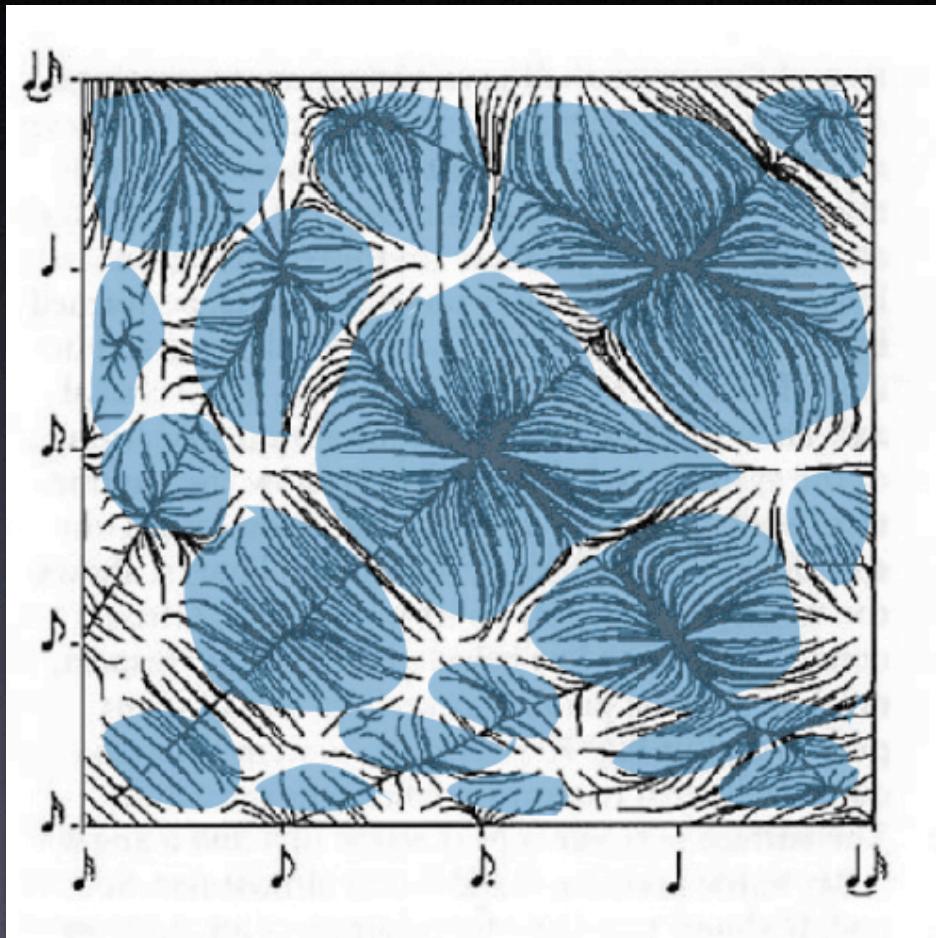


4.

# Wat voorspellen deze modellen?



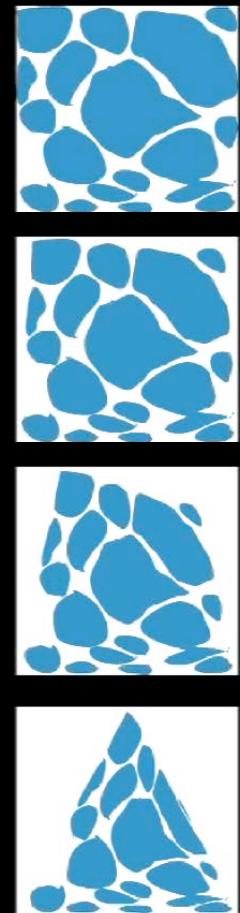
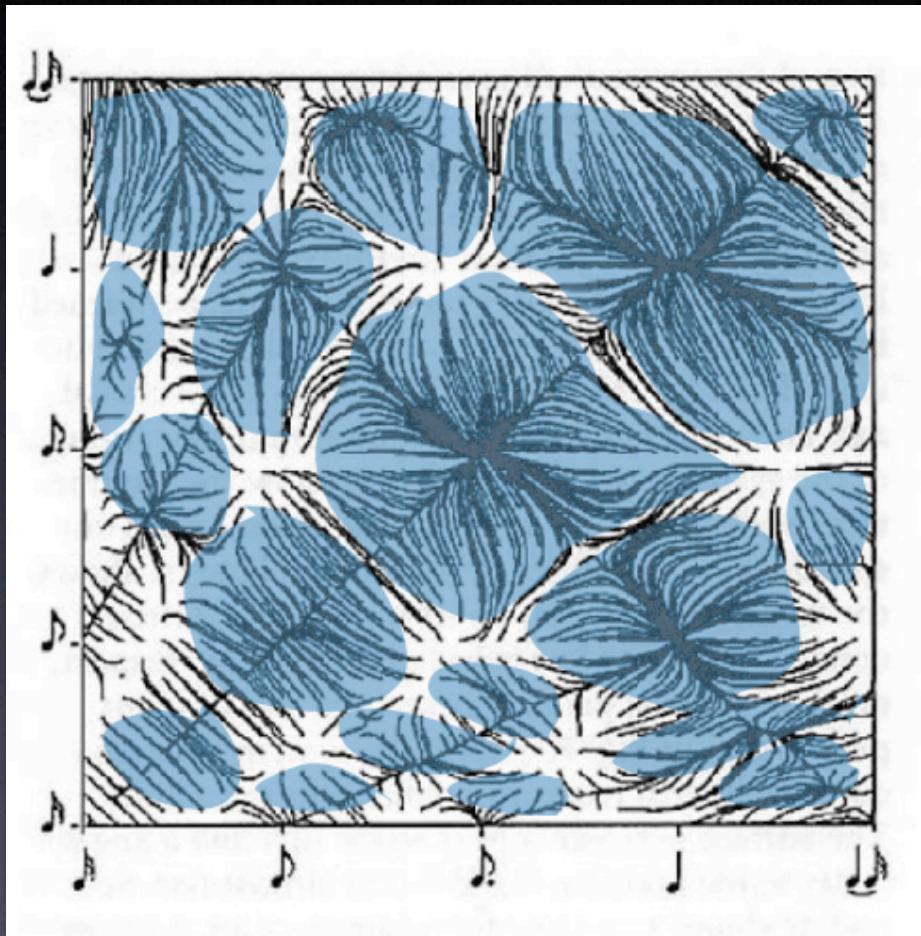
# Rhythm space



(Desain & Honing, 1989)

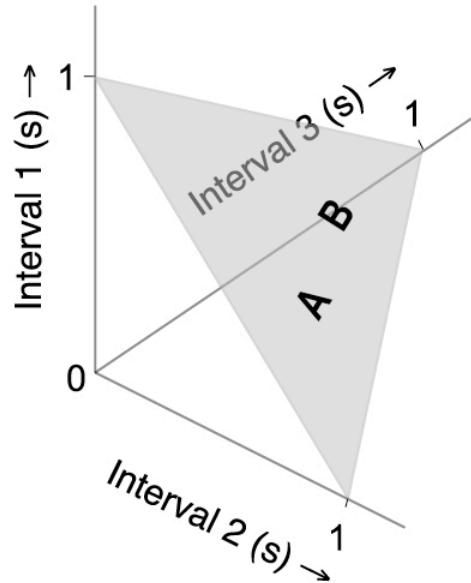


# Rhythm space

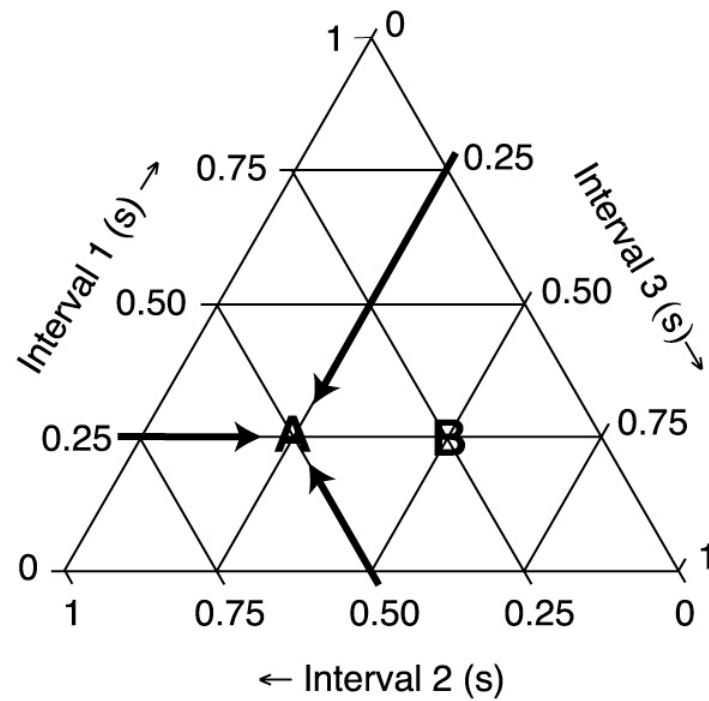


# Rhythm space

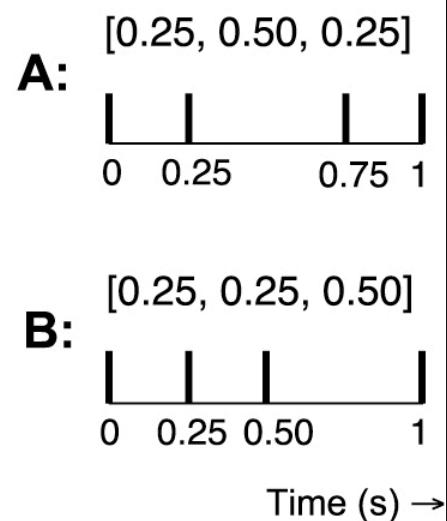
a)



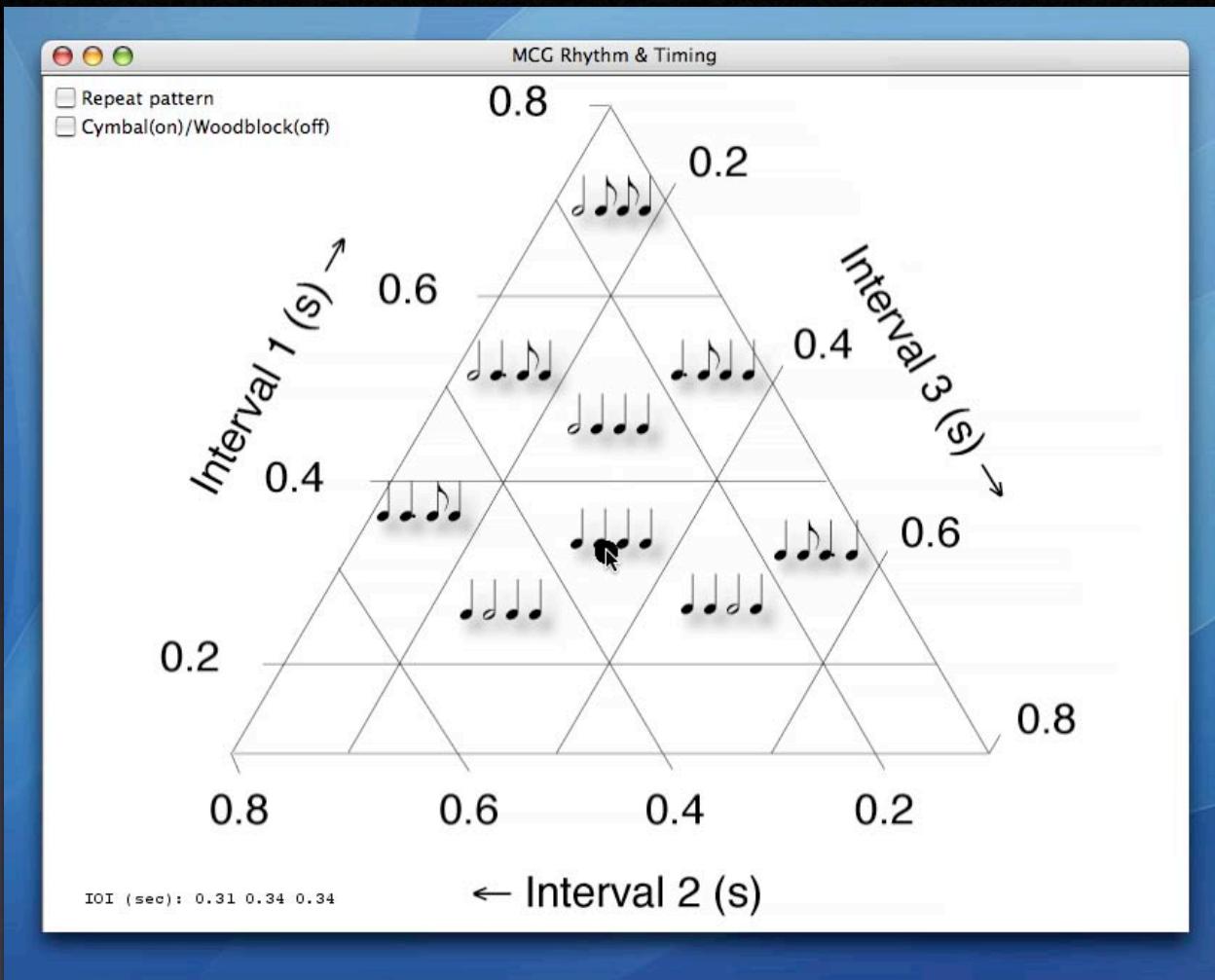
b)



c)



# Rhythm space

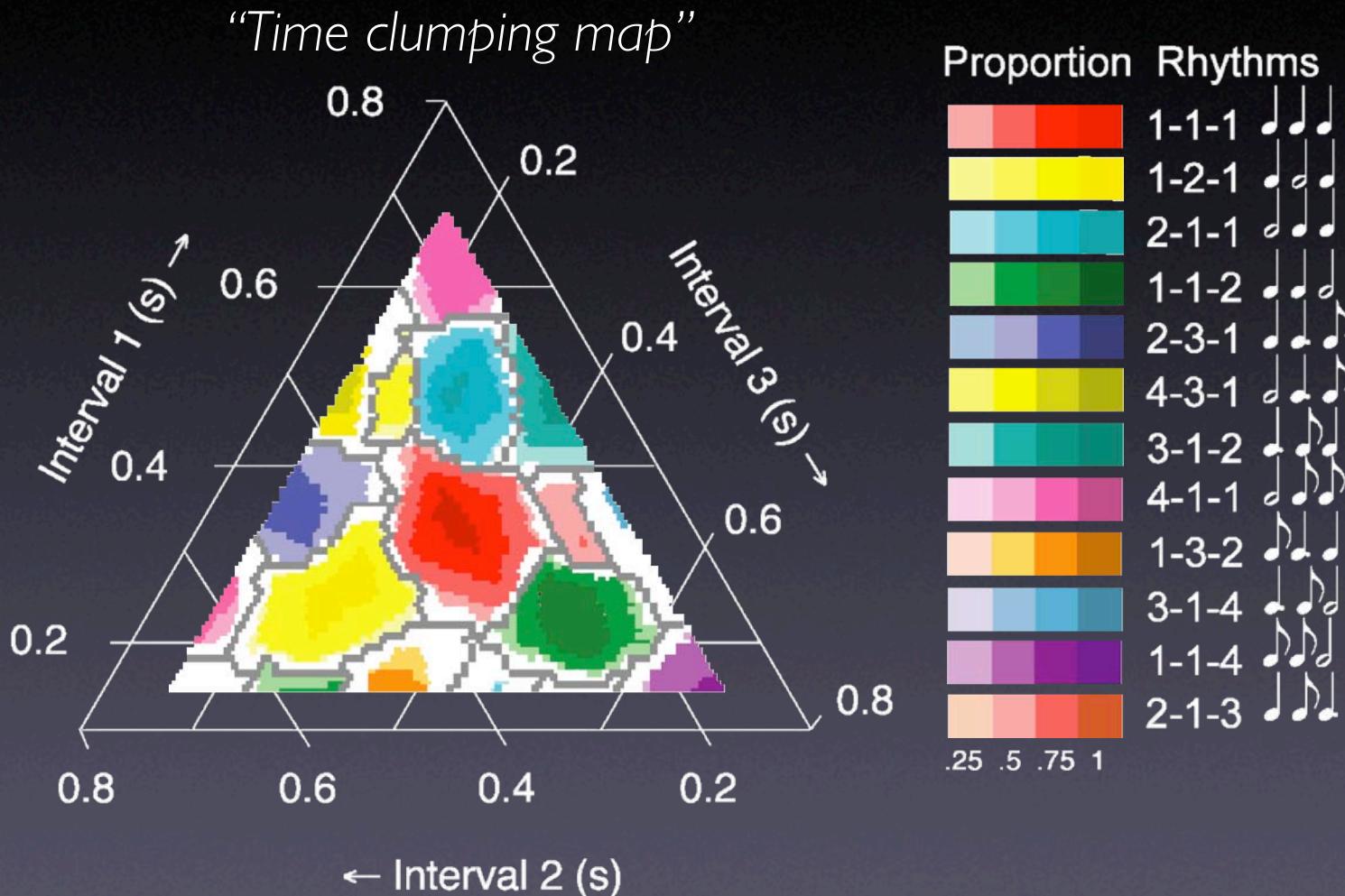




5.

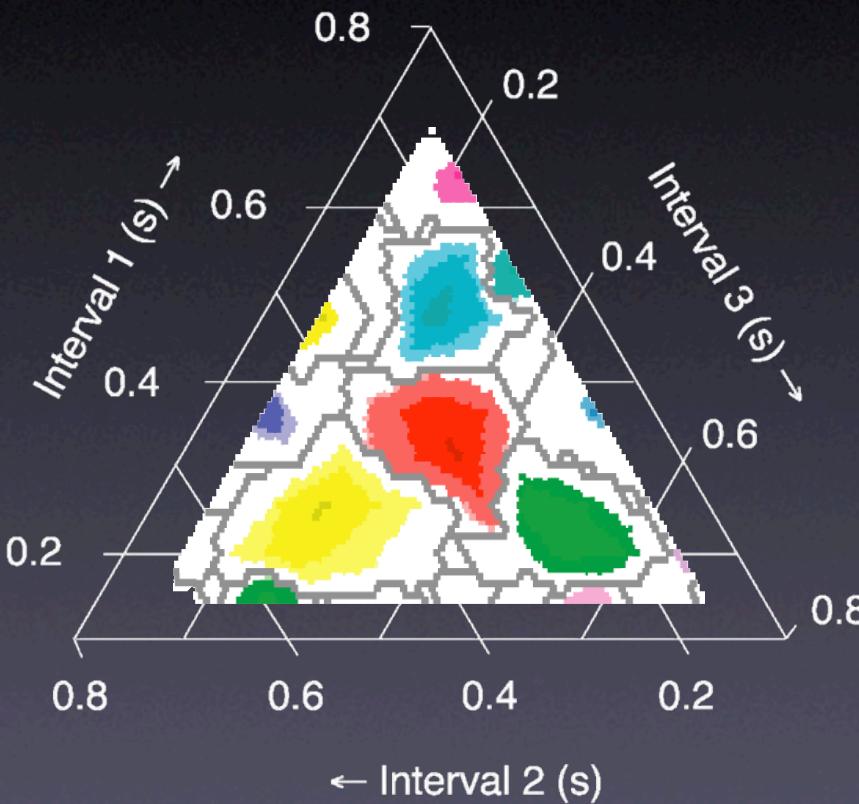
# Wat horen luisteraars?

# Results categorization ( $N=29$ )

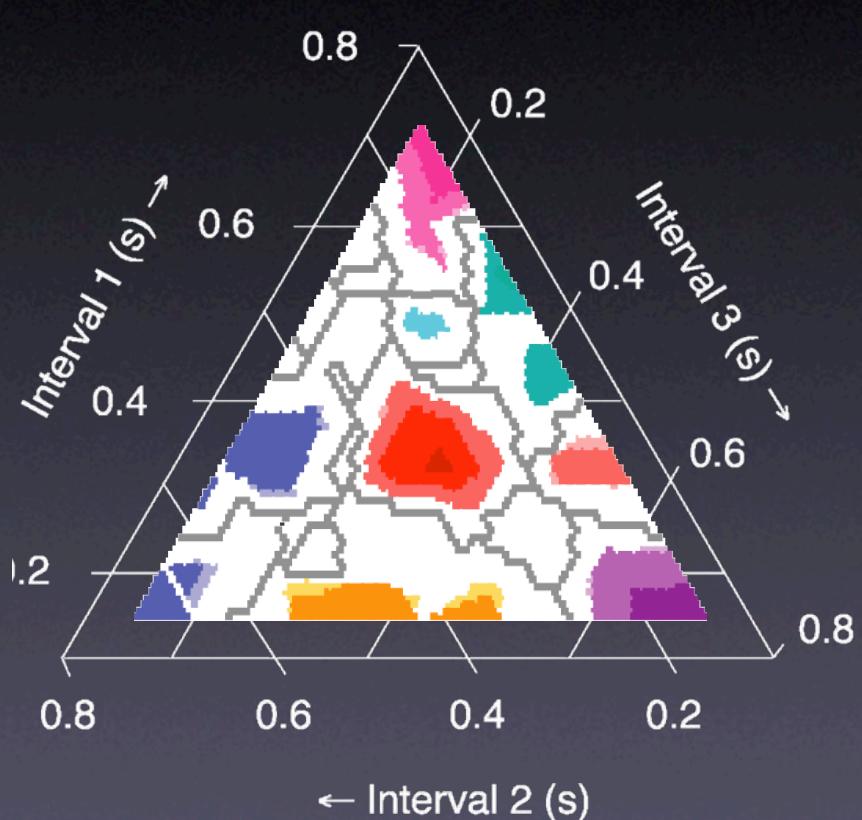


# Meter influences categorization

Duple meter

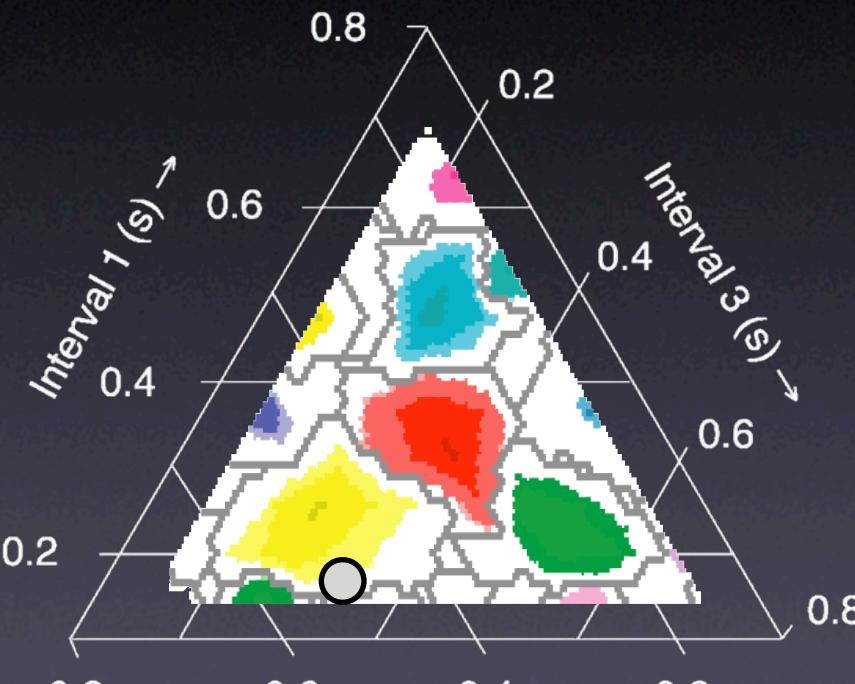


Triple meter



# Meter influences categorization

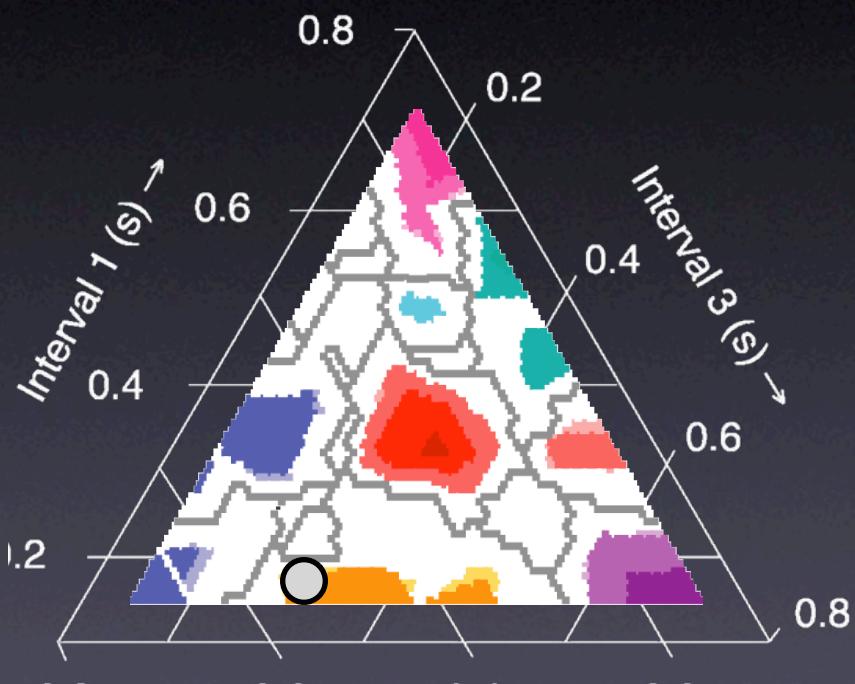
Duple meter



$\text{♪} \text{♪} \text{♪}$   
64% 1-2-1 ←  
10% 1-3-2

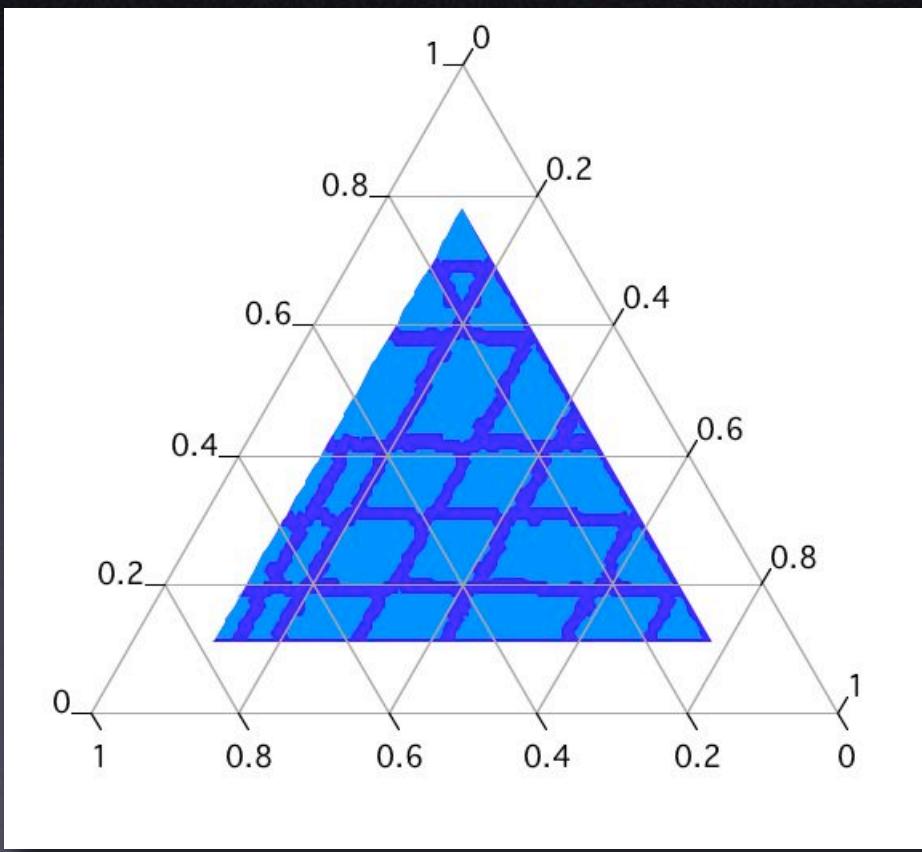
0.263 0.421 0.316 → 1-3-2 36%  
1-2-1 0%

Triple meter

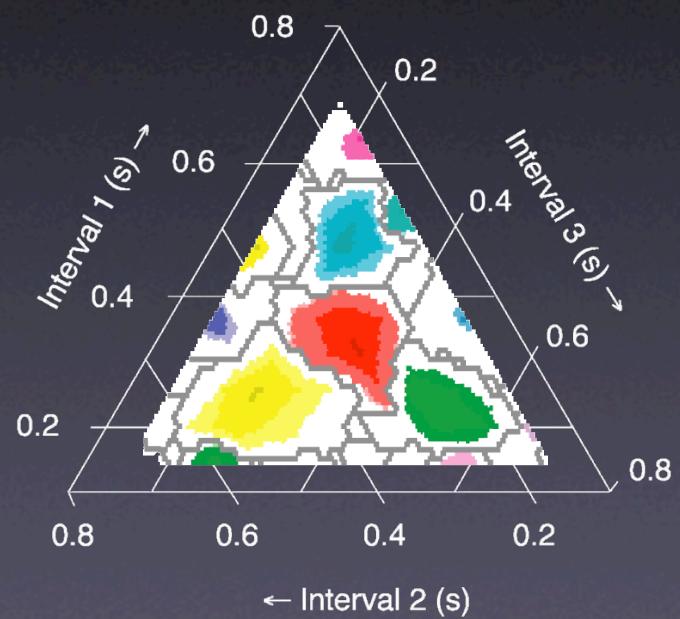


# Commercial quantizers

*Finale*

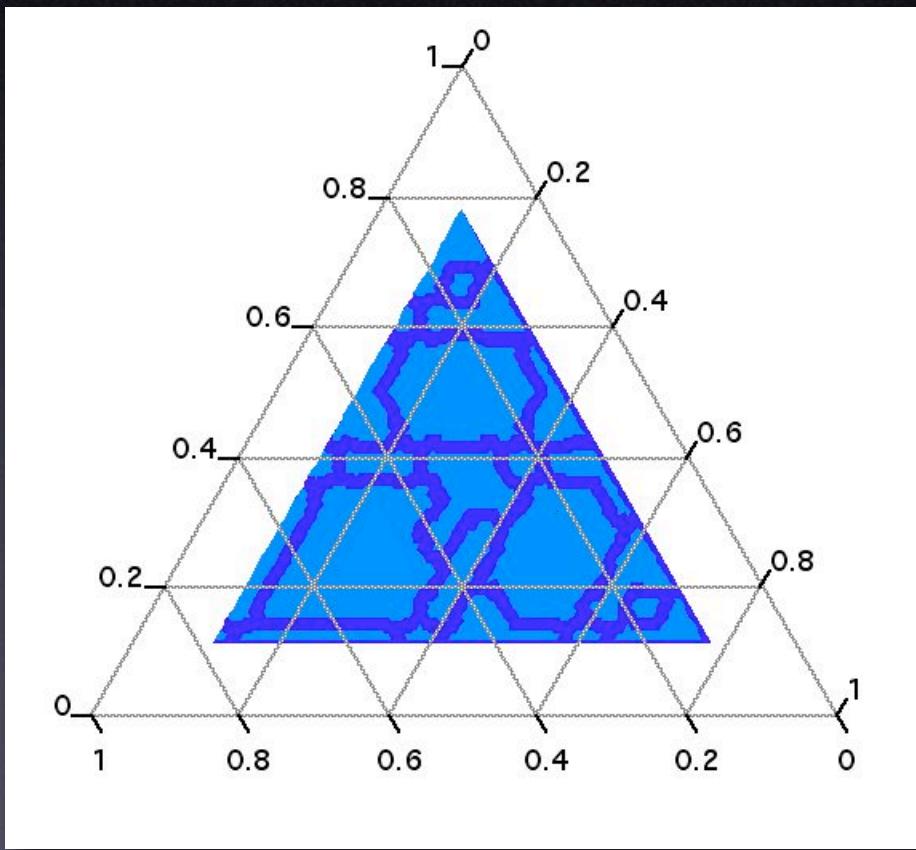


*Empirical data*

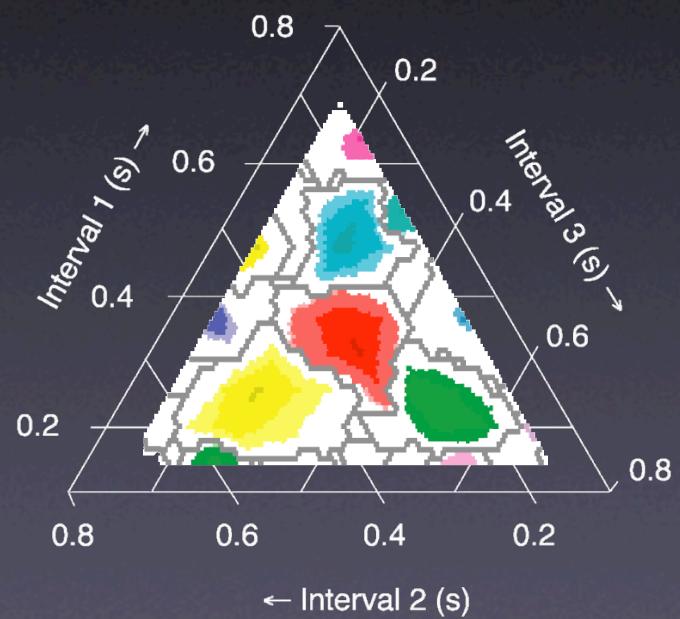


# Commercial quantizers

*Performer 6*



*Empirical data*



# Samenvatting

- Muziek is een uniek menselijk verschijnsel
- Muziek is verweven met onze cognitie
- Computationeel modelleren als methode
- Maar, methode is een middel —het geeft de tekortkomingen aan—, dat wat we nog niet begrijpen is interessant

# Meer informatie

[www.musiccognition.nl](http://www.musiccognition.nl)

# Referenties

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