



Sound and Emotion

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Its all wrong ...

- Gamelan instruments are precisely tuned, but do not produce harmonic overtones or periodic waveforms, so every pitch theory must be wrong.
- Gamelan music employs dissonant ‘enemy tones’ in mode changes, but has no harmonicity.
- Gamelan musicians can pitch gamelan instruments, but Western musicians can’t.



A Psychological Perspective: Fast and slow thoughts

Daniel Kahneman described two different ways that the brain forms thoughts:

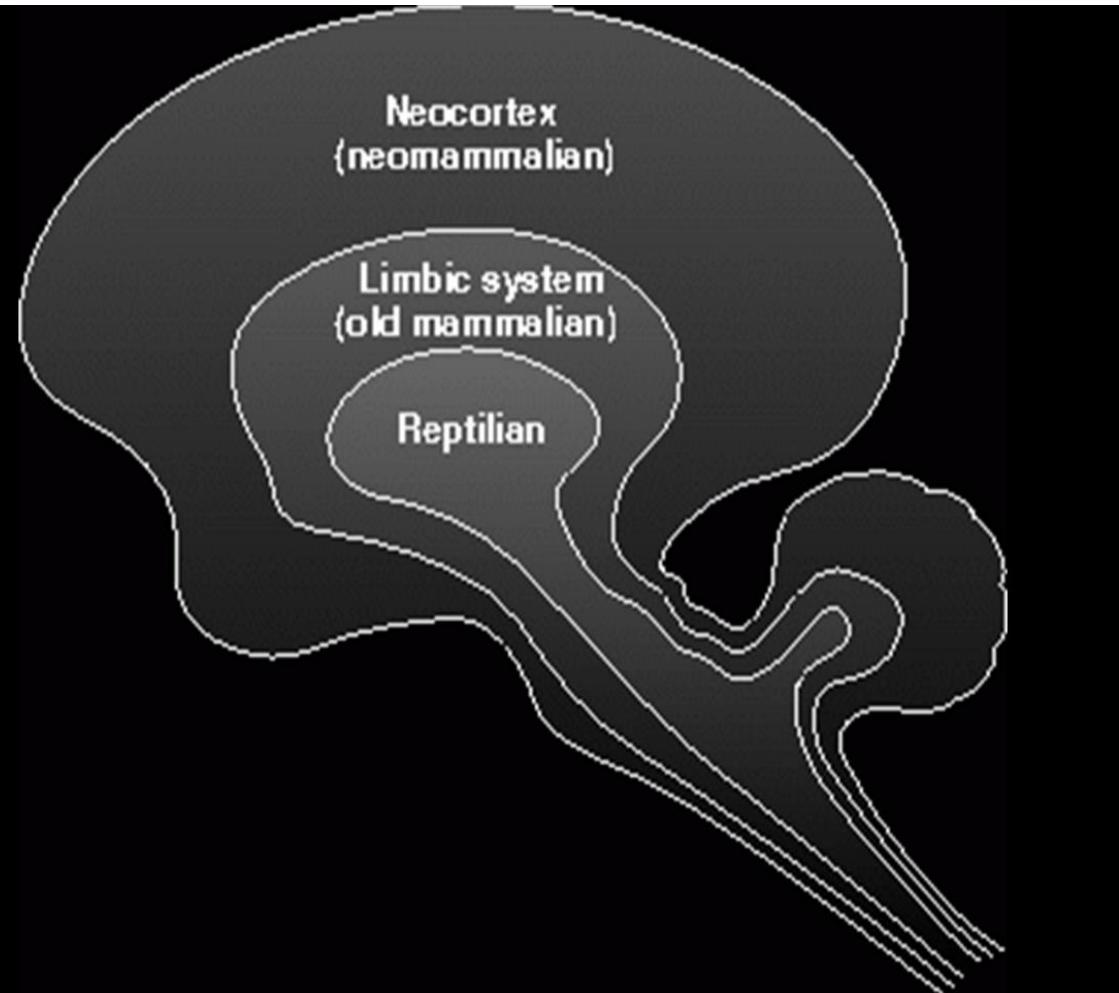
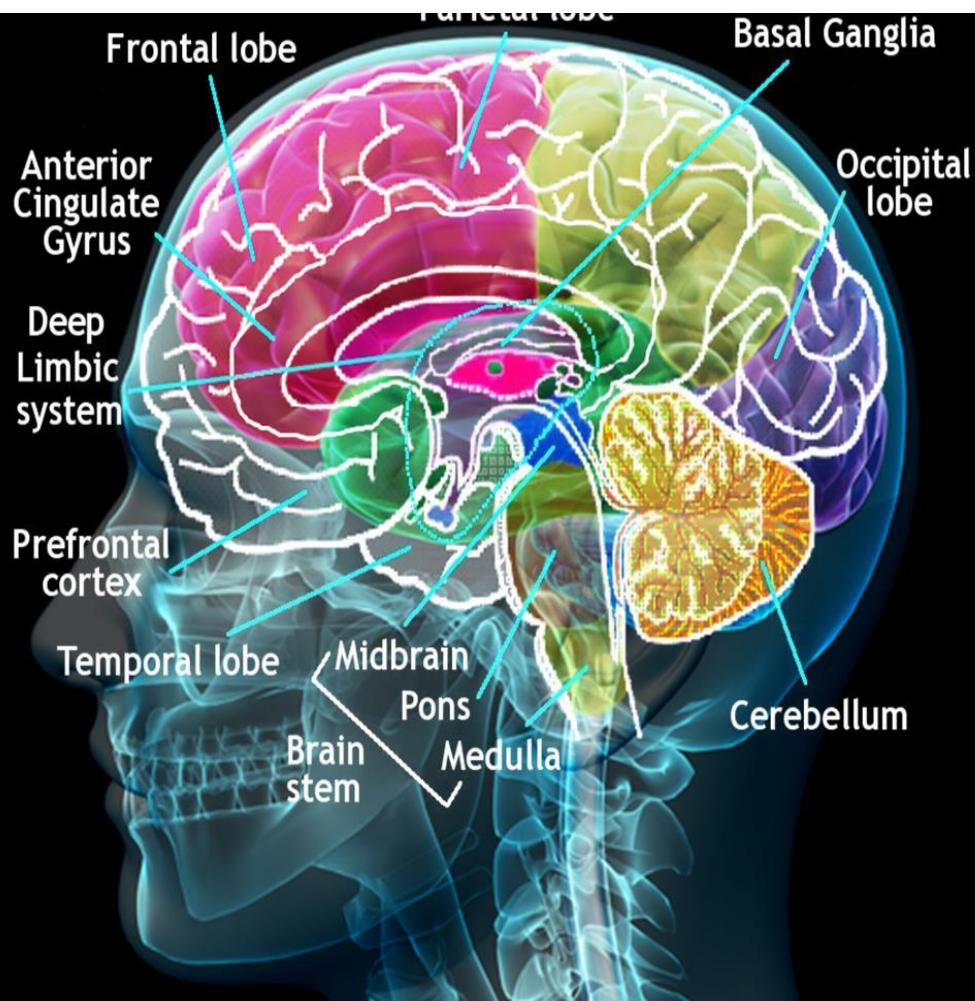
1. Fast, automatic and emotional
2. Slow, conscious and logical

Fast pathways involve associating new information with our long-term memory, rather than using this information to formulate new ideas and models.

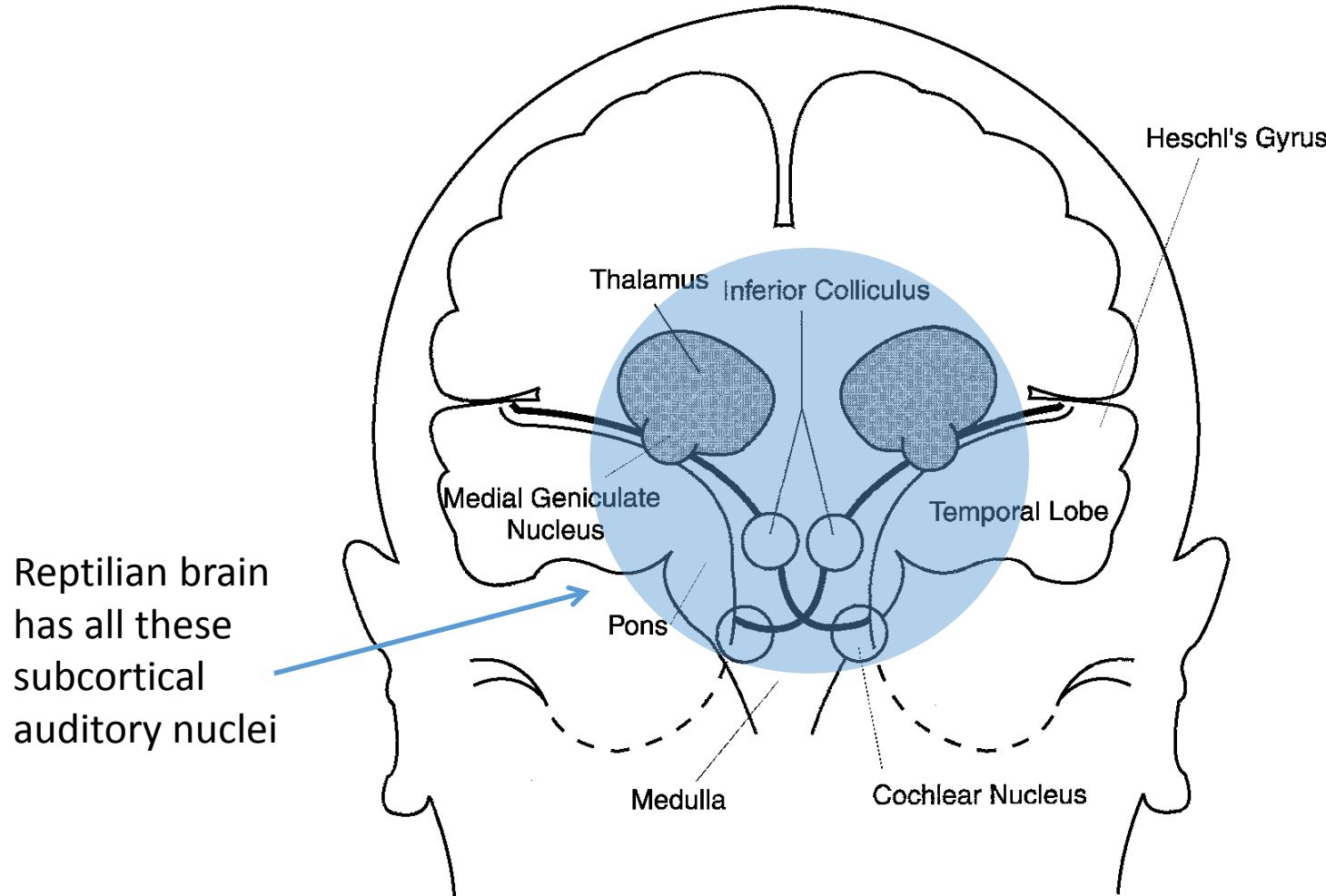
Fast pathways employ embodied cognition and primitive sensory processing strategies.

What if pitch and harmony were processed by embodied cognition?

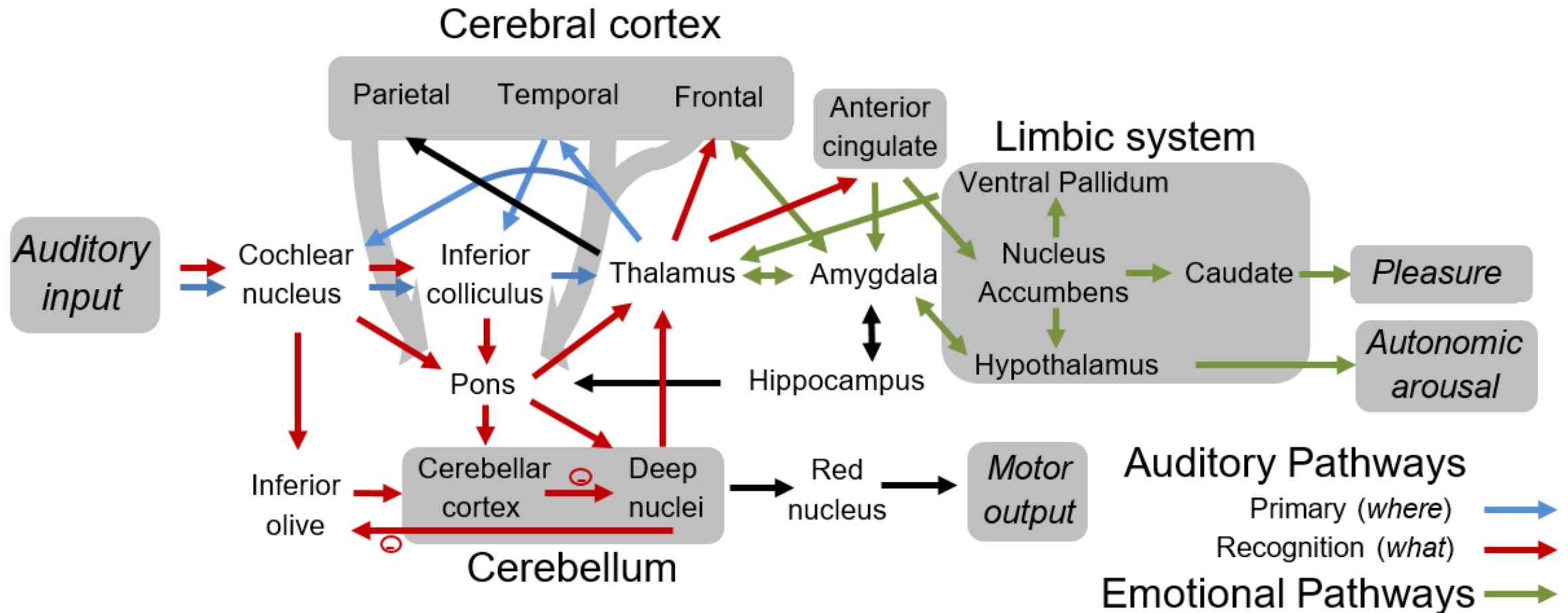
What are the primitive brain pathways?



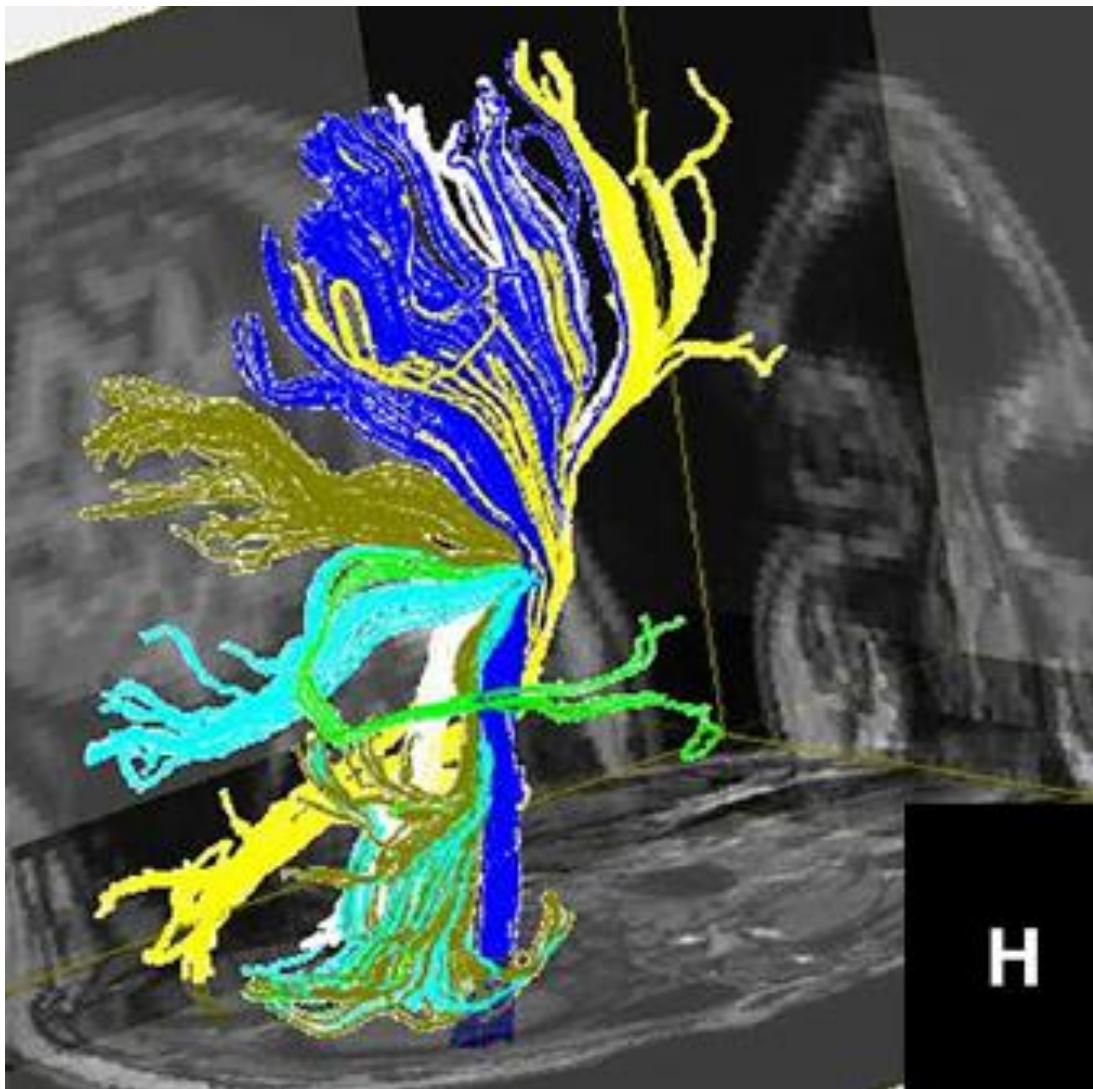
The Primary Auditory Pathway



Auditory processing by sub-cortical pathways



Cortico-ponto-cerebellar connectivity revealed in Diffusion Tensor Imagery



Frontal (yellow), temporal (olive), and occipital (aqua) connectivity with ponto-cerebellar pathways.

But the primary auditory pathway is so small it is yet to be observed by DTI!

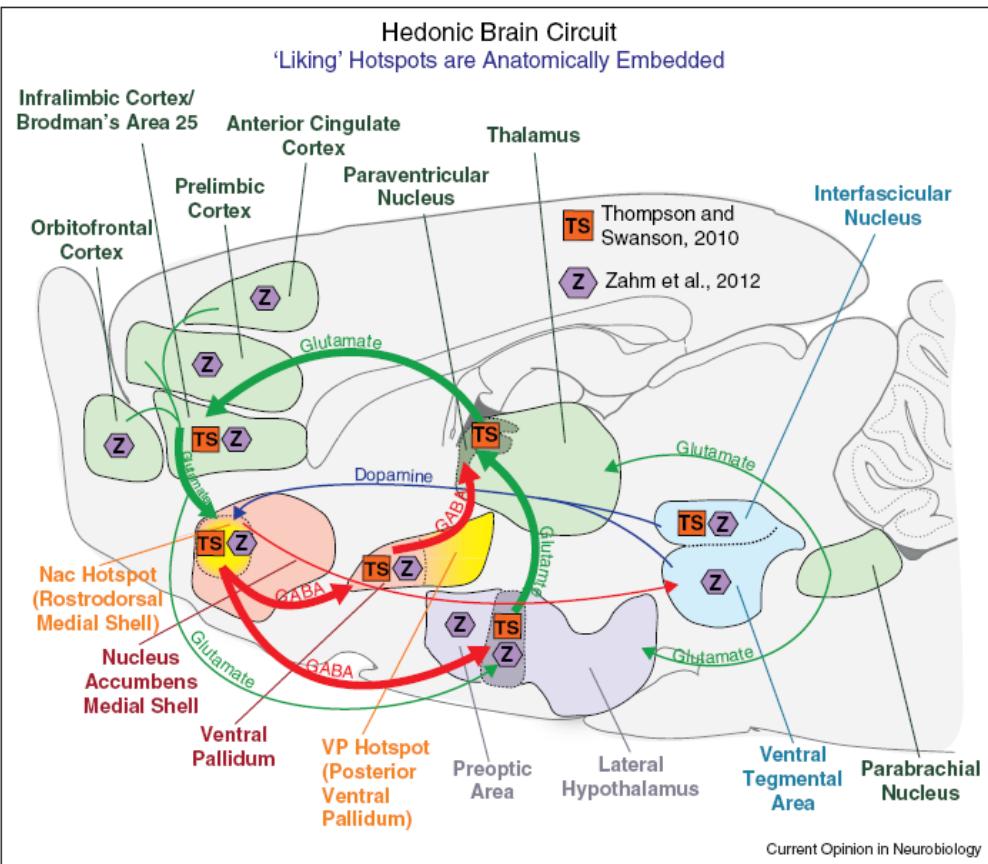
Keser Z, Hasan KM, Mwangi BI, Kamali A, Ucisik-Keser FE, Riascos RF, Yozbatiran N, Francisco GE and Narayana PA (2015)

Diffusion tensor imaging of the human cerebellar pathways and their interplay with cerebral macrostructure.

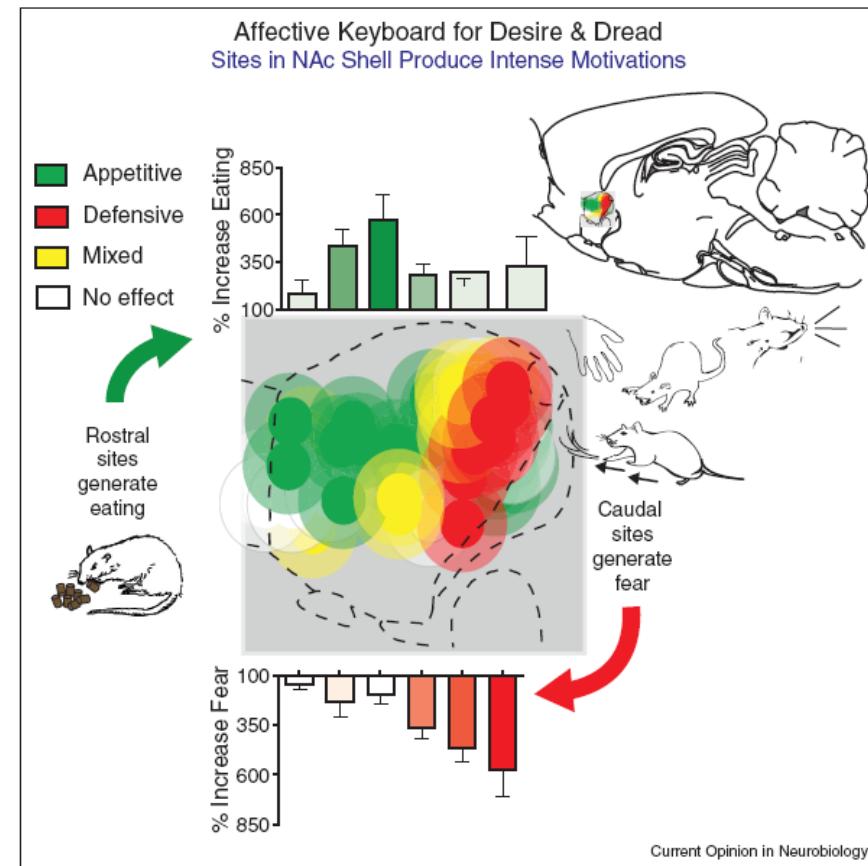
Frontiers in Neuroanatomy

Pleasure and pain in the limbic system

Working memory, attention and emotional regulation in frontal cortex provides context to modulate emotional responses generated by nucleus accumbens (NAc).



The 'affective keyboard' in the NAc enervates intense dread or desire by activation across an array of sites.

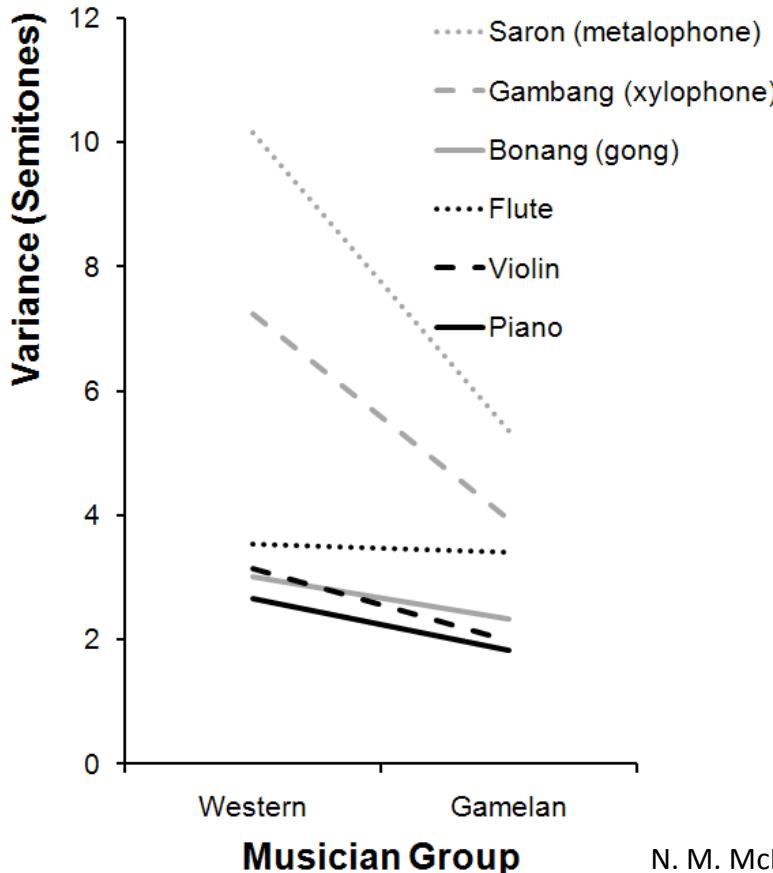


Music, Memory and Embodied Cognition

- Long term memory is created in cortico-ponto-cerebellar networks in response to common musical experiences.
- Long term memory drives auditory streaming (eg pitch), musical expectations and aesthetic responses.
- Activated long term memories prime spatial (pitch/time) working memory in dorsal cortical regions and are labelled in lateral frontal regions associated with language.
- Successful recognition activates the Nucleus Accumbens and usually leads to a reward (dopamine) response associated with pleasure and harmony, whereas failure to recognize stimuli leads to anxiety (adrenal) response associated with dissonance.

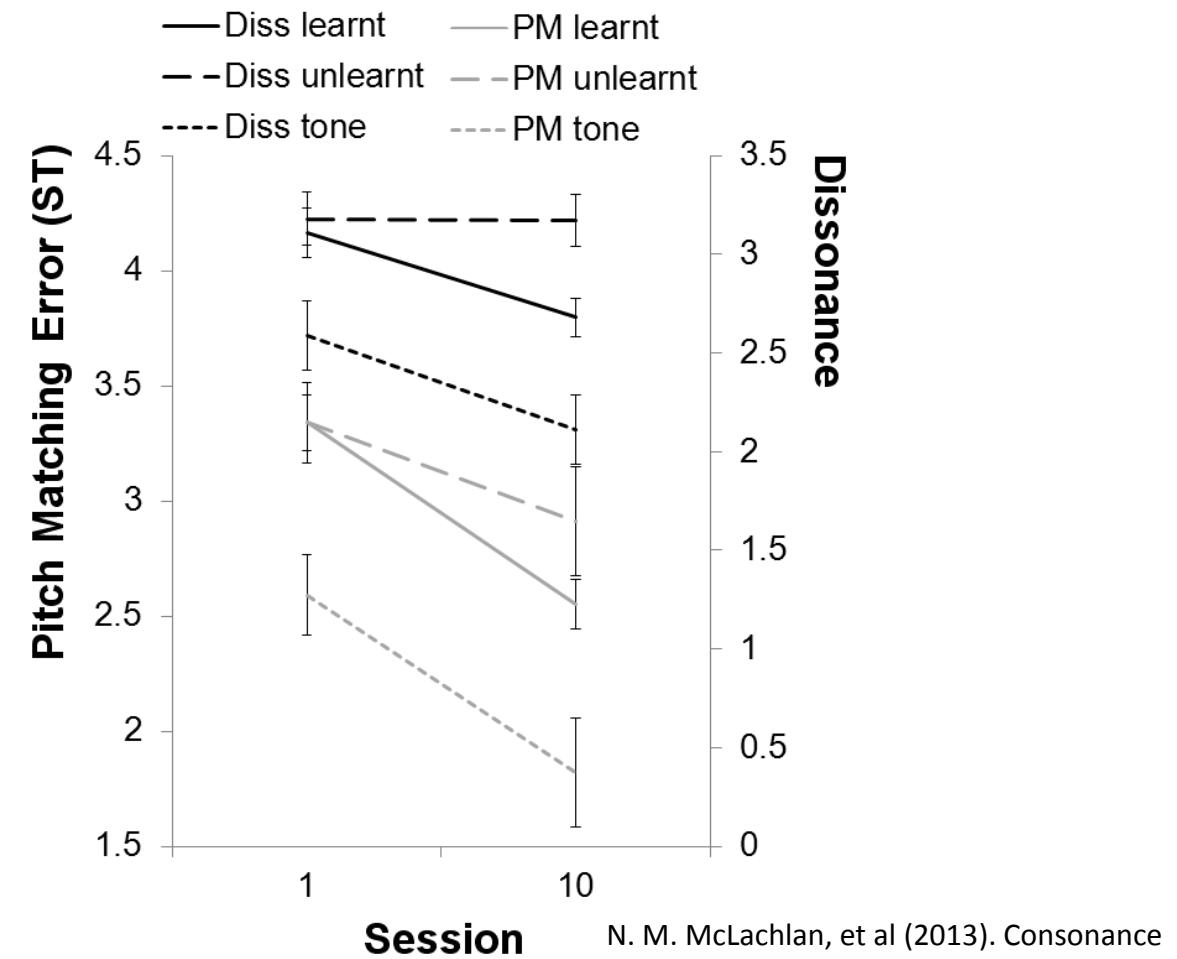
What does this mean for music?

Brainstem recognition mechanisms allow pitch height can be associated with a wide range of spectra.



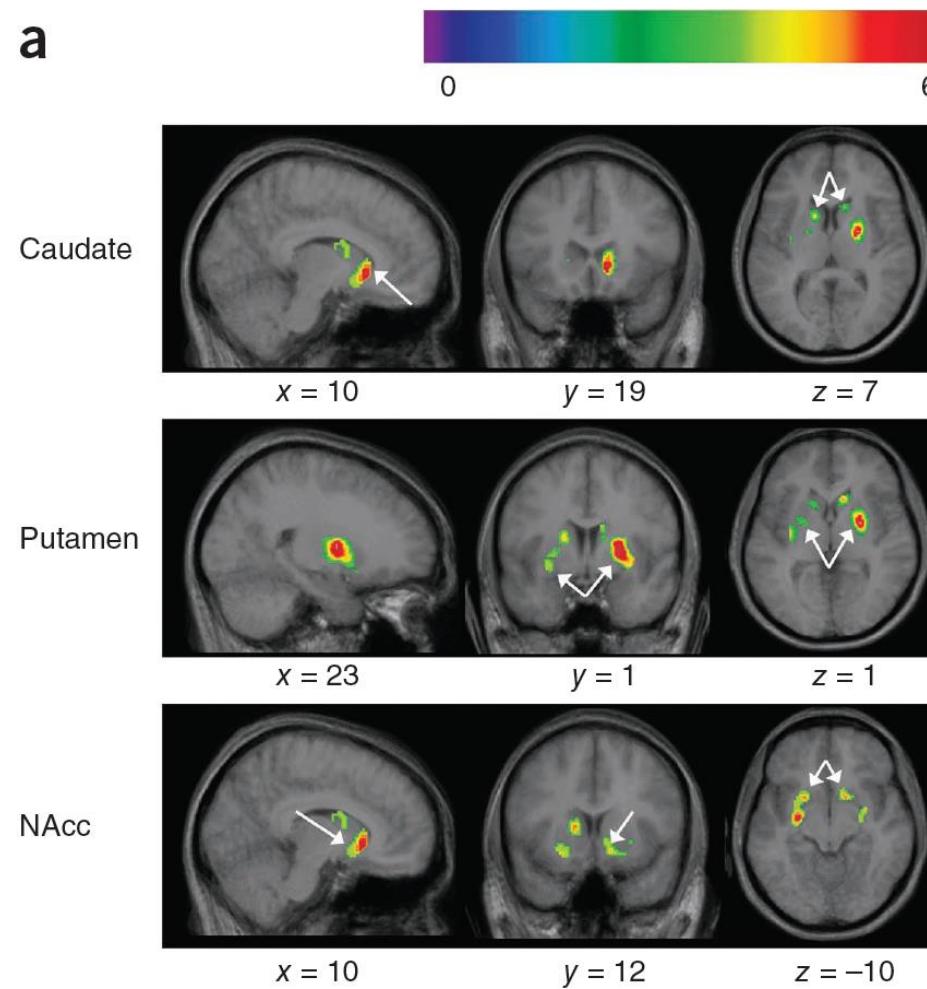
N. M. McLachlan, et al (2013). The musical environment and auditory plasticity: Hearing the pitch of percussion. *Frontiers in Psychology*.

Failure of recognition mechanisms for unfamiliar stimuli causes poor pitch accuracy and dissonance.

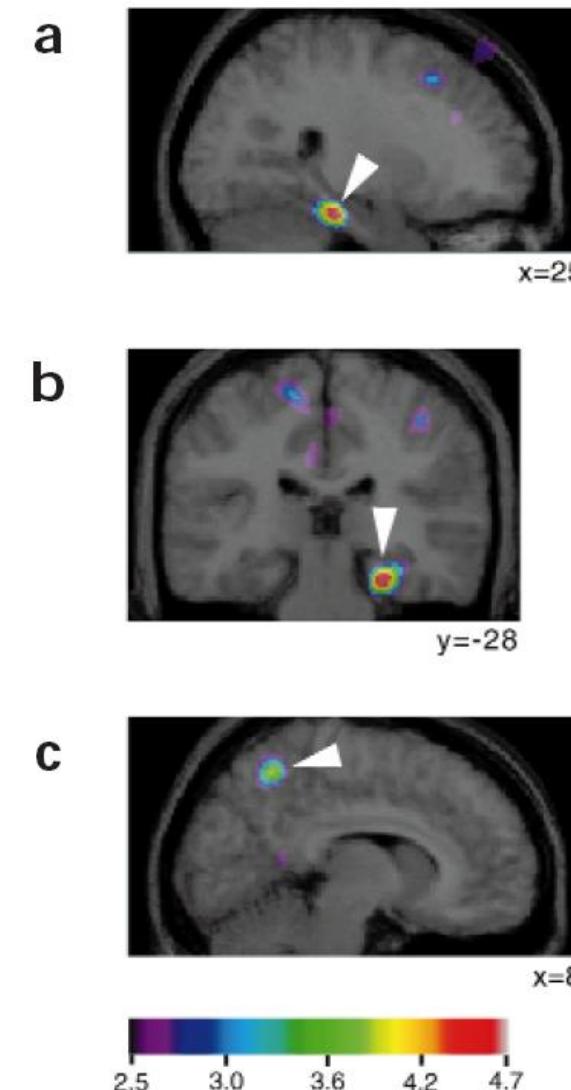


N. M. McLachlan, et al (2013). Consonance and pitch, *J. Exp. Psych: Gen.*,

Robert Zattore's lab showed successful prediction of music patterns produces cognitive reward (consonance) associated with activation of the Nucleus Accumbens and caudate

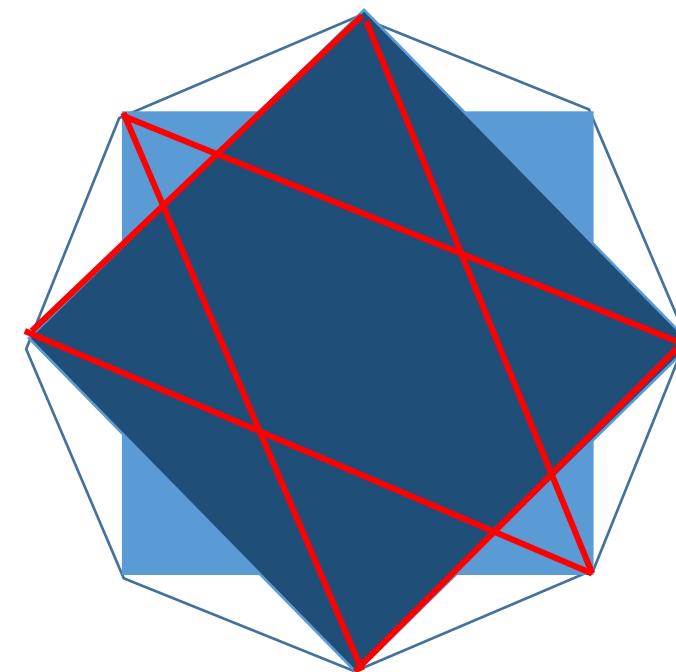
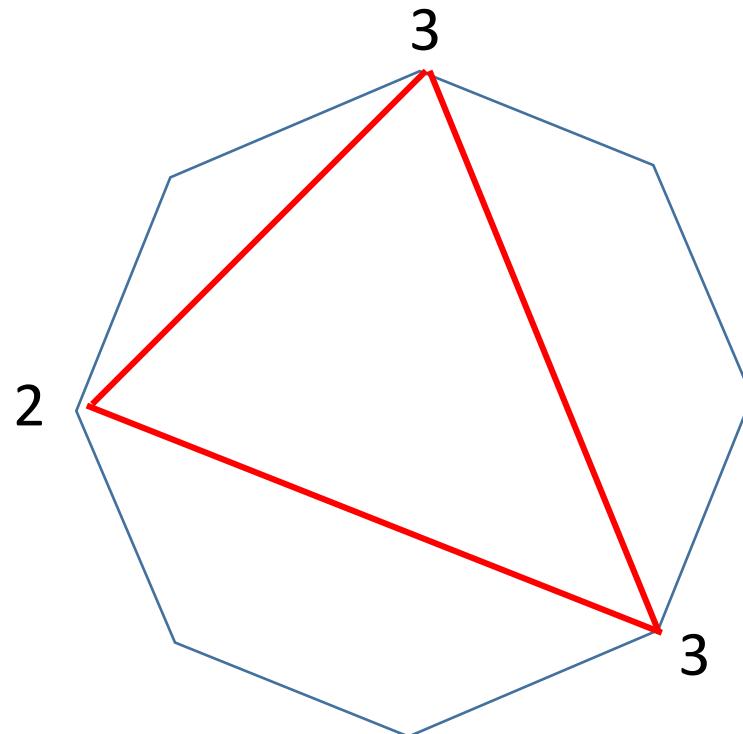


Distinctly different brain regions activate for dissonant stimuli (right parahippocampus as predicted).



Integration of auditory streams

Balinese *Kecak* music suggests that spatialized auditory streams may be integrated by a more familiar rhythmic structure.

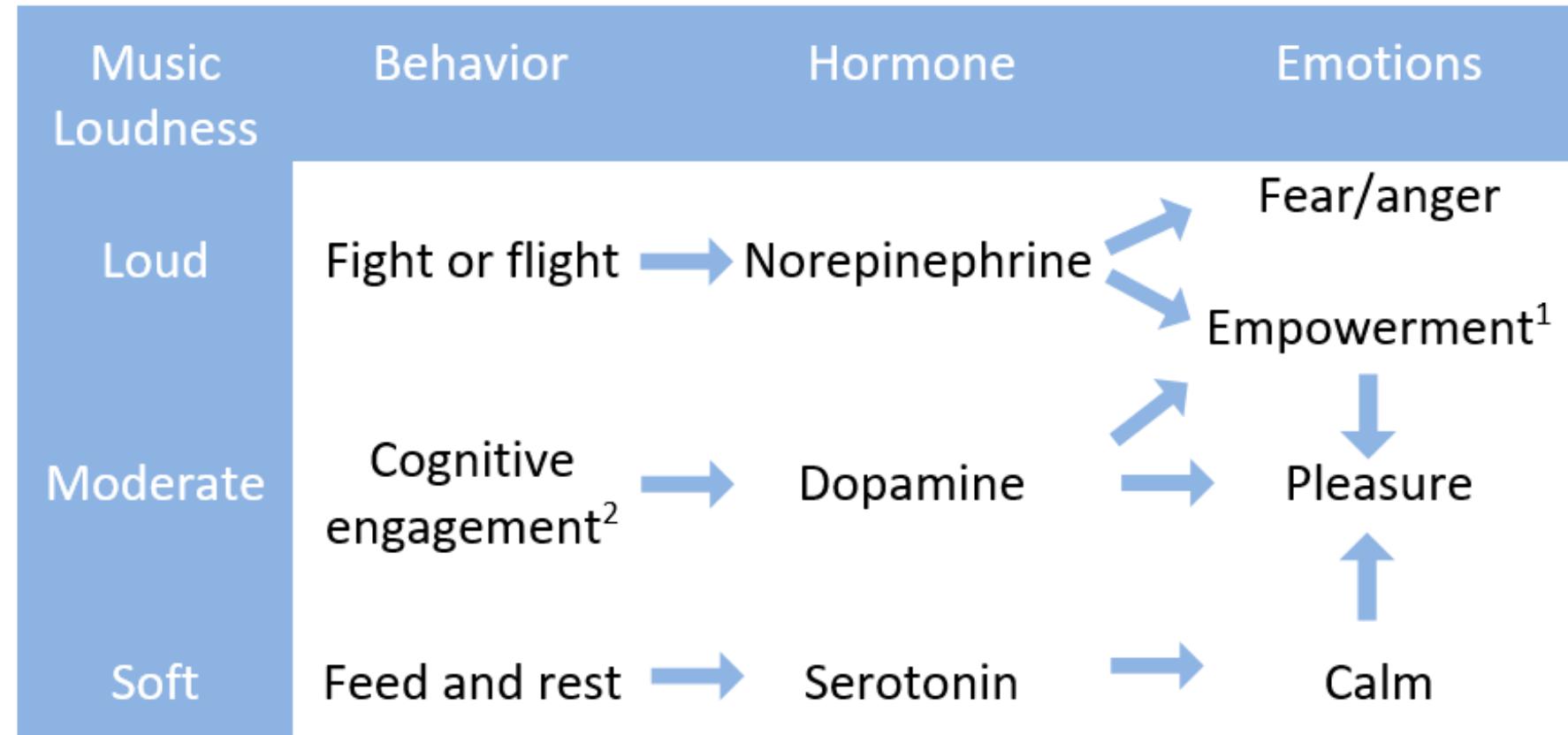


N. M. McLachlan (2000). A Spatial Theory of Rhythmic Resolution.
Leonardo Music Journal

Interdependent self-construal and social wellbeing

- Long-term memory templates for more common musical structures prime working memory more strongly than templates for less common musical structures.
- Spatial/ timbral/ pitch streaming of the less common individual parts is overwhelmed by the priming of the more common structure.
- When acoustic identities are people, this amounts to a merging of social identities in the minds of each performer.
- More elaborate and powerful music can be created by a well-rehearsed group, leading to greater social empowerment and affiliations.
- Increased social empowerment and affiliation is synonymous with decreased depression and social anxiety.

We like (our) music loud!



1. Empowerment requires social identification with the music
2. Cognitive engagement requires music training or enculturation

For vocal behaviour and serotonin see:
Joseph Jordania (2017), A New Model of Human
Evolution: How Predators Shaped Human Morphology
and Behaviour

Dominance in auditory display

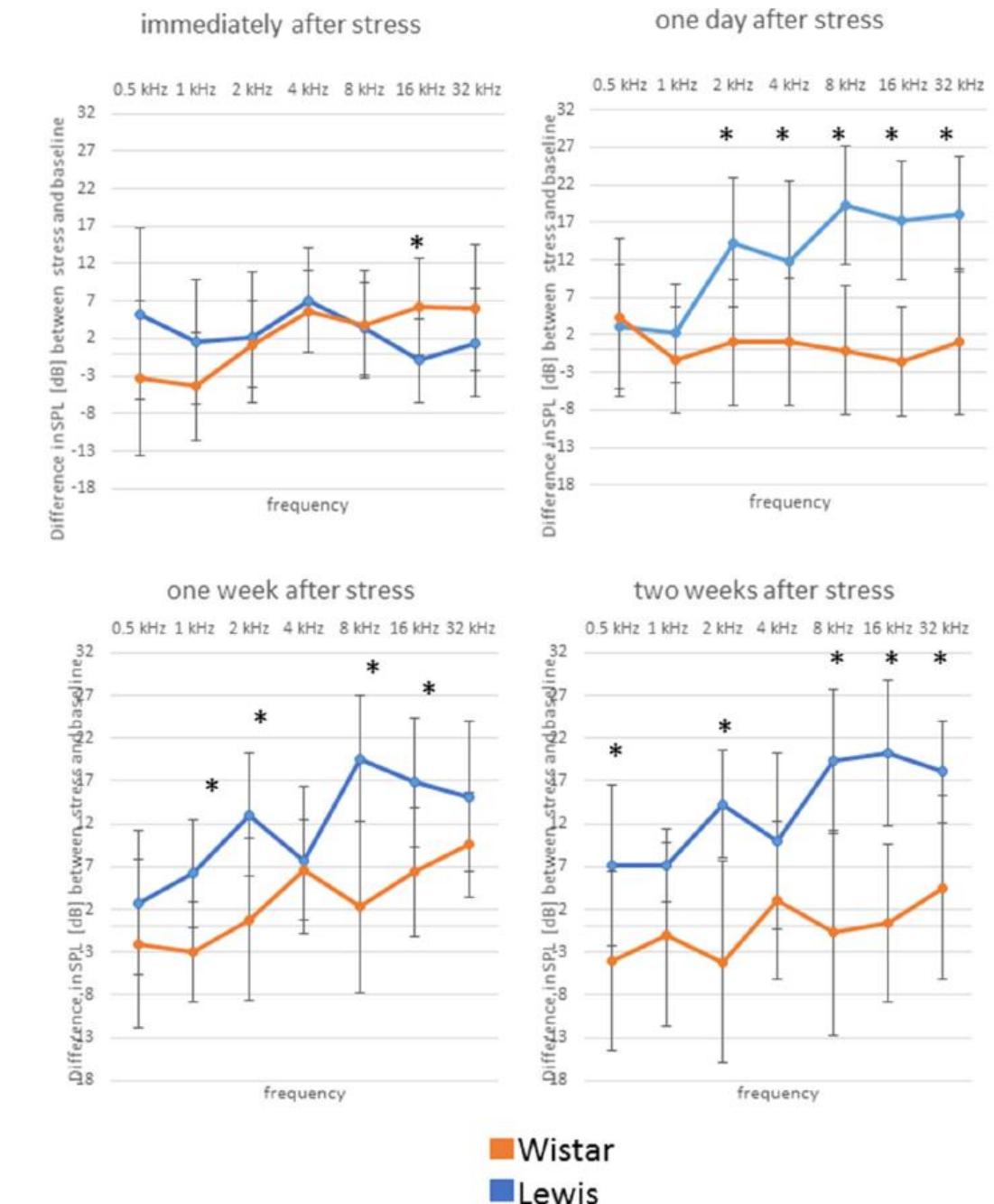
- Loud, low-pitched vocalizations are associated with physical dominance and aggressiveness in many animals
- Volitional dominance displays involve top down control of the amygdala by the dorsal anterior cingulate (otherwise we would scare ourselves)
- Loud, low-pitched speech in humans is associated with confidence and assertiveness, and suggests a role for autonomic arousal in empowerment and creativity.



Maori performing the Haka (Wikipedia)

Emotional control of auditory sensitivity

- Stress activates superior olivatory neurons that can increase cochlea sensitivity via outer hair cells by up to 20dB (hyperacusis)
- But some rats are sensitive to stress but others are not (just like people)!
- Vocalization inhibits inner hair cell sensitivity, and motor planning of vocalization inhibits superior olivatory neurons.
- So rumination in depression decreases auditory sensitivity (like reading a book)
- Decreased thresholds may drive auditory sensitivity to zero at frequencies where hearing is compromised leading to tinnitus



Conclusions 1: In relation to music and society

- Music perception involves multimodal, embodied cognition of familiar musical experiences in the ponto-cerebellar pathways – *this theory provides us with a cross-cultural account of music affect.*
- The outputs of sub-cortical processing prime cortical working memory and activate emotional responses in the limbic system.
- Volitional control of limbic responses suggests a neurobiological network that links human dominance displays, music and social identification/empowerment.
- Composite musical structures that are more familiar than their parts (such as chords and rhythms) can overwhelm segregation of these parts in working memory, leading to interdependent social construal and enhanced in-group affiliation.
- These music-brain processes can be reliably manipulated in educational and clinical settings using new music technologies to improve people's social connectedness and mental wellbeing.

Conclusions and speculations in relation to acoustic quality

- Identifiers of social empowerment (e.g. classical/rock music) have powerful effects on aesthetic judgements – just like gold plating
- Recognition of these identifiers in sound relies on embodied cognition – that takes years of practice or acculturation to acquire, and can not be easily undone
- Unfamiliar or ambiguous sounds that are difficult to identify create fear and anger, except for people high on the ‘open to experience’ personality trait
- Anxiety and depression can have substantial effects on auditory perception that are often mistaken as auditory disorders (e.g. tinnitus) AND empowerment through music participation may alleviate these conditions.