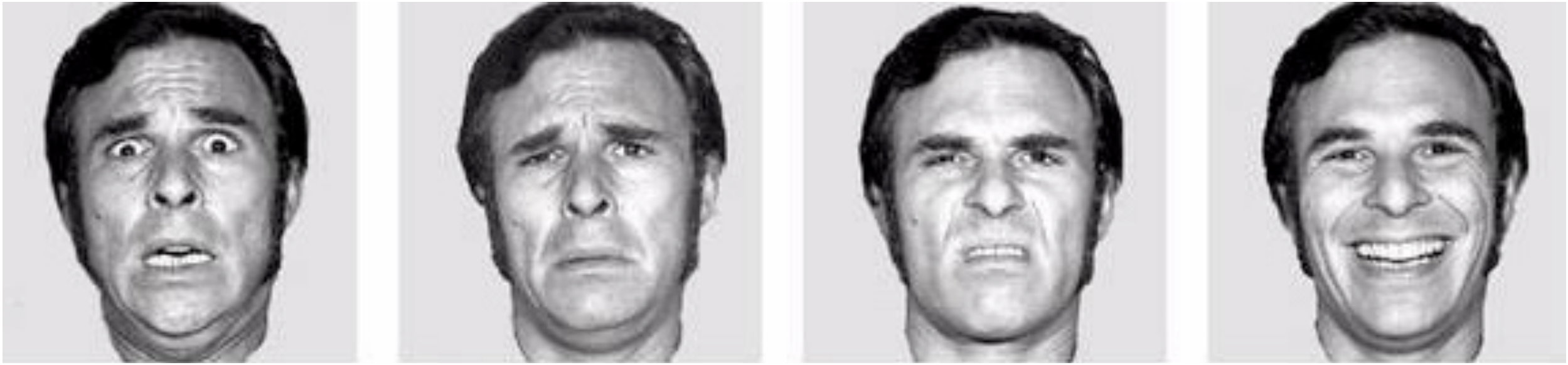
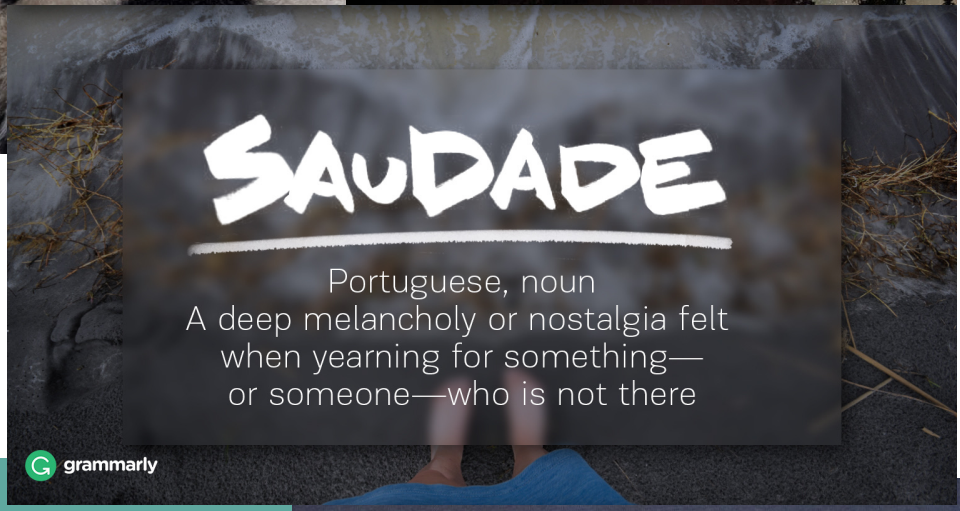
Music and Emotions

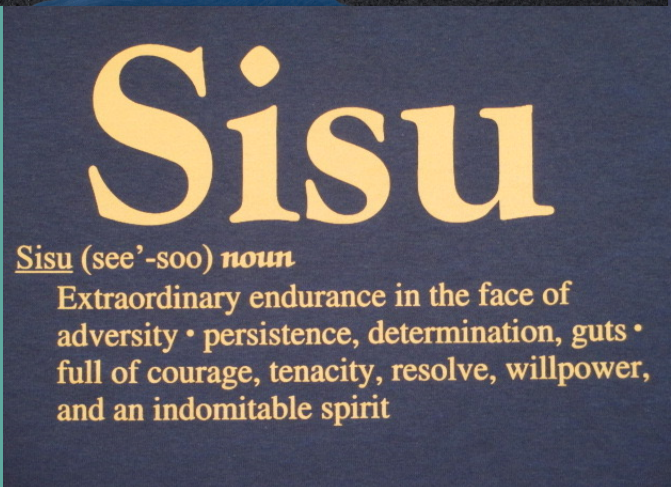
ENJOYING SONIC PATTERNS

Music and Emotions



Untranslatable culturally-rooted emotions





What is an emotion (I)?

"everyone knows what an emotion is, until asked to give a definition"

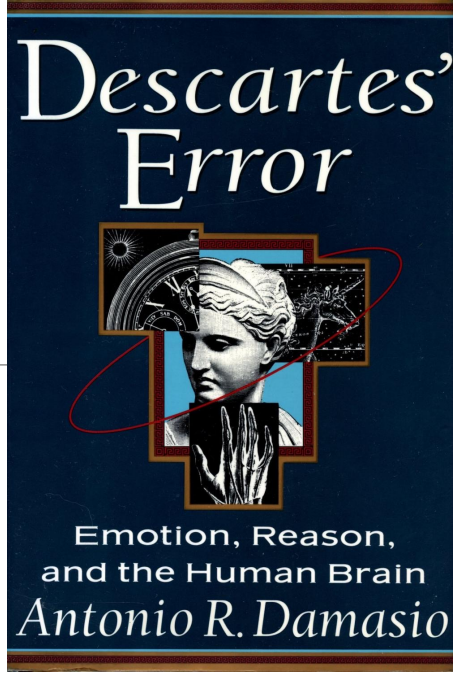
(Fehr & Russell, 1984, p.464)

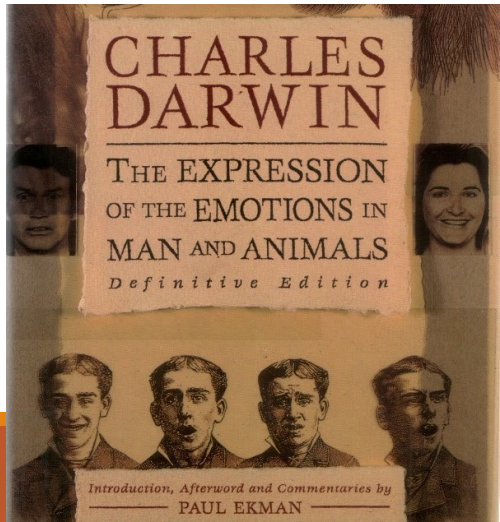
Emotion is both an everyday concept and a scientific construct

Emotion as opposed to reason: *Descartes' error* (Damasio 1994)

Emotions have survival value, they are not "bells and whistles" of behavior

They are linked to survival issues: danger, competition, loss & cooperation





Communicating vs. generating emotions

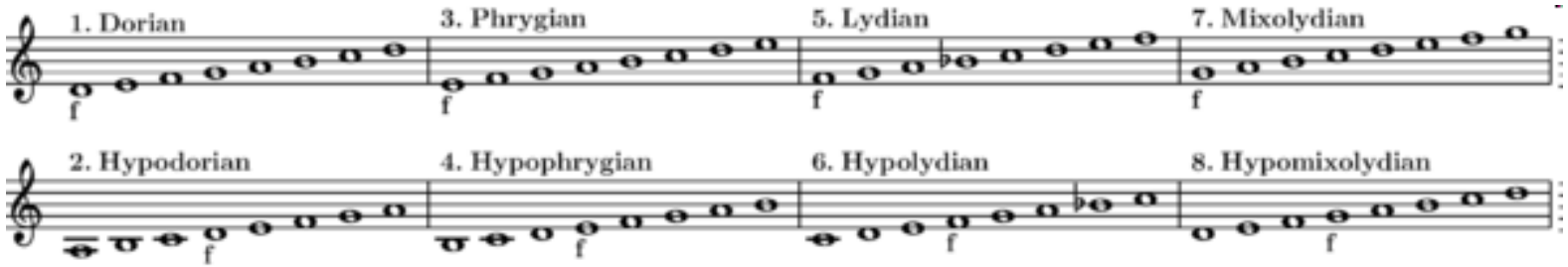
Music is a communicative device (as speech): Is this music happy/sad/aggressive/solemn?

Could you parse the emotional content of Gagaku, Gamelan, 京剧 jīngjù, or Industani music?

Music is a brain changer (as drugs): Do you feel happy/sad/aggressive/tender when listening to this music?

Do you always feel sad when you listen to sad music? Feel aggressive when listening to such kind of music?

Modes and Emotions



Name	Mode	D'Arezzo	Fulda	Espinoza
Dorian	I	serious	any feeling	happy, taming the passions
Hypodorian	II	sad	sad	serious and tearful
Phrygian	III	mystic	vehement	inciting anger
Hypophrygian	IV	harmonious	tender	inciting delights, tempering fierceness
Lydian	V	happy	happy	happy
Hypolydian	VI	devout	pious	tearful and pious
Mixolydian	VII	angelical	of youth	uniting pleasure and sadness
Hypomixolydian	VIII	perfect	of knowledge	very happy

http://en.wikipedia.org/wiki/Musical_mode

Affective phenomena
(from Scherer, 2000)

Preferences: evaluative judgments of stimuli in the sense of liking or disliking, or preferring or not over another stimulus (*like, dislike, positive, negative*)	**Interpersonal stances:** affective stance taken toward another person in a specific interaction, colouring the interpersonal exchange in that situation (*distant, cold, warm, supportive, contemptuous*)
Emotions: relatively brief episodes of synchronized response of all or most organismic subsystems in response to the evaluation of an external or internal event as being of major significance (*angry, sad, joyful, fearful, ashamed, proud, elated, desperate*)	**Attitudes:** relatively enduring, affectively coloured beliefs and predispositions towards objects or persons (*liking, loving, hating, valuing, desiring*)
Mood: diffuse affect state, most pronounced as change in subjective feeling, of low intensity but relatively long duration, often without apparent cause (*cheerful, gloomy, irritable, listless, depressed, buoyant*)	**Personality traits:** emotionally laden, stable personality dispositions and behavior tendencies, typical for a person (*nervous, anxious, reckless, morose, hostile, envious, jealous*)

What is an emotion (II)?

Emotion is a complex set of interactions among subjective and objective factors, mediated by neural/hormonal systems, which can

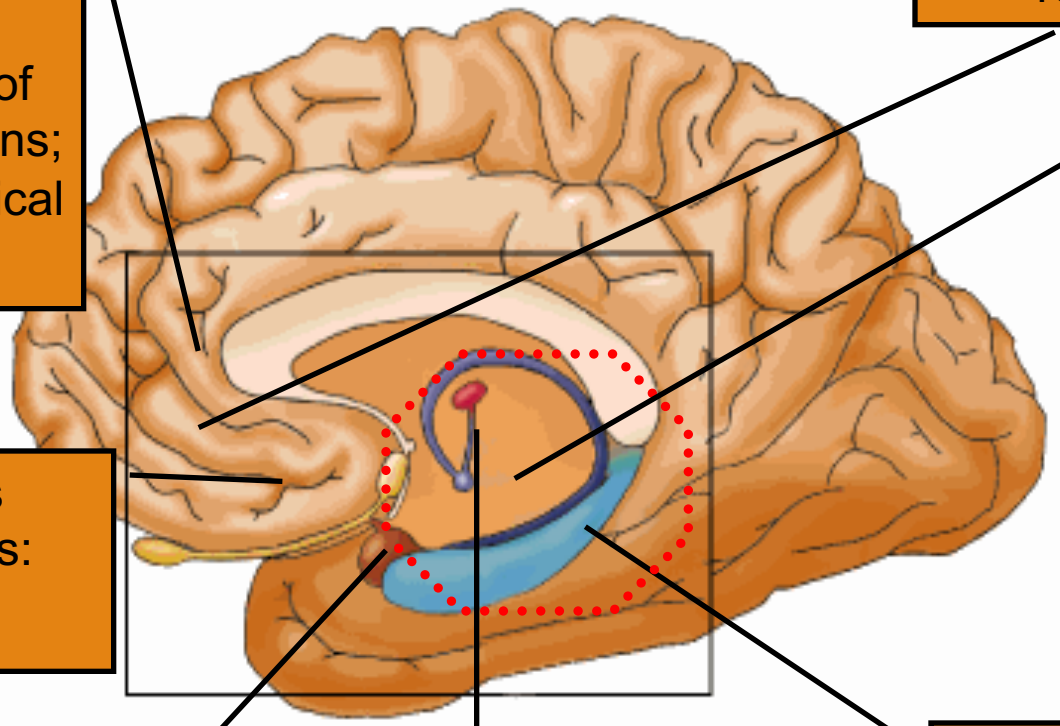
(a) give rise to **affective experiences** such as feelings of arousal (activation at different behavior levels), pleasure/displeasure, etc.

(b) generate **cognitive processes** (e.g. increasing attention, appraisals, labeling processes, social bonding)

(c) activate widespread **physiological adjustments** (e.g., increasing heart-rate, sweating, crying…)

(d) lead to **behavior** that is often, but not always, expressive, goal-directed, and adaptive (e.g., running away, reiterating exposure…)

The limbic system++



Prefrontal cortex: modulation of the action plans; autobiographical memories

Caudate nucleus: anticipation of reward

Auditory cortex: acoustic-musical analysis

Nuclueus accumbens: reward

Amygdala: survival value/behavior: good, bad, fly, chase, mate

Hypothalamus-hypophysis: hormonal release

Hippocampus: episodic memory –links to past experiences

Why does music *convey* (express) emotion?

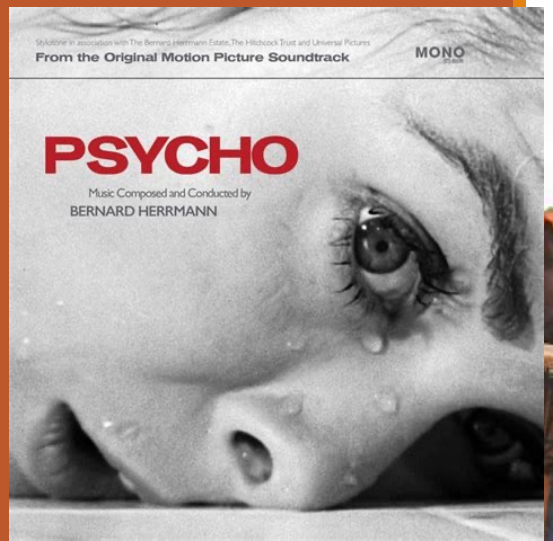
Hearing **resemblance** between the music and the natural expression of the emotion (similarity to speech)

- Loudness and spectral dissonance found in an angry voice and in angry music
- Minor scale resembling spectra of subdued (depressed) speech
- Melodic contours may resemble questions, severe statements, etc.
- Big and fast melodic leaps analog of happy jumps
- Descending contours analog of body movements (arms, head)
  - https://youtu.be/8361qIY8wpk?t=2085

Why does music *convey* (express) emotion?

Accumulated **connotations** a certain musical phenomena acquire in a culture: we learn in our culture which musical cues correspond to which feeling.

- Brass instrumentation and slow tempo meaning "solemnity"
- Drums meaning "dance"
- Atonal music meaning "mystery"



Musical Features used to express emotions

Table 1. Summary of musical features correlated with discrete emotions in musical expression.

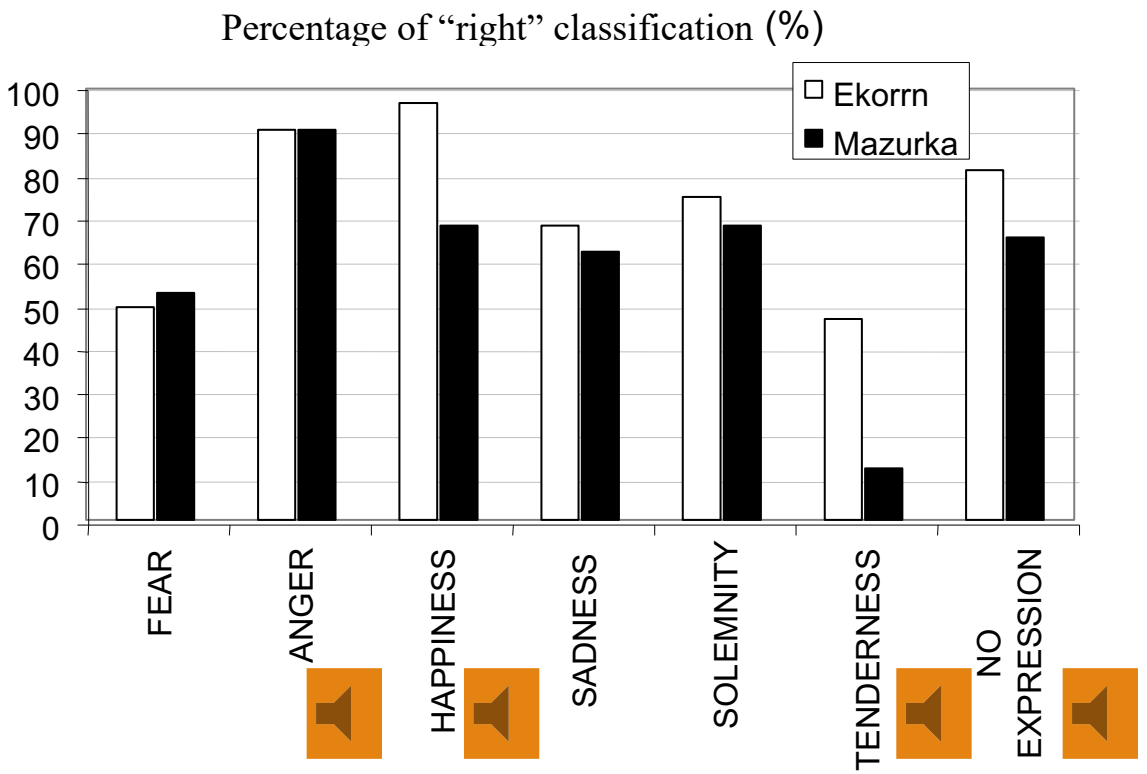
Emotion	Musical features
Happiness	Fast tempo, small tempo variability, major mode, simple and consonant harmony, medium-high sound level, small sound level variability, high pitch, much pitch variability, wide pitch range, ascending pitch, perfect 4th and 5th intervals, rising micro intonation, raised singer's formant, staccato articulation, large articulation variability, smooth and fluent rhythm, bright timbre, fast tone attacks, small timing varibility, sharp contrasts between "long" and "short" notes, medium-fast vibrato rate, medium vibrato extent, micro-structural regularity
Sadness	Slow tempo, minor mode, dissonance, low sound level, moderate sound level variability, low pitch, narrow pitch range, descending pitch, "flat" (or falling) intonation, small intervals (e.g., minor 2nd), lowered singer's formant, legato articulation, small articulation variability, dull timbre, slow tone attacks, large timing variability (e.g., rubato), soft contrasts between "long" and "short" notes, pauses, slow vibrato, small vibrato extent, ritardando, micro-structural irregularity
Anger	Fast tempo, small tempo variability, minor mode, atonality, dissonance, high sound level, small loudness variability, high pitch, small pitch variability, ascending pitch, major 7th and augmented 4th intervals, raised singer's formant, staccato articulation, moderate articulation variability, complex rhythm, sudden rhythmic changes (e.g., syncopations), sharp timbre, spectral noise, fast tone attacks/decays, small timing variability, accents on tonally unstable notes, sharp contrasts between "long" and "short" notes, accelerando, medium-fast vibrato rate, large vibrato extent, micro-structural irregularity
Fear	Fast tempo, large tempo variability, minor mode, dissonance, low sound level, large sound level variability, rapid changes in sound level, high pitch, ascending pitch, wide pitch range, large pitch contrasts, staccato articulation, large articulation variability, jerky rhythms, soft timbre, very large timing variability, pauses, soft tone attacks, fast vibrato rate, small vibrato extent, micro-structural irregularity
Tenderness	Slow tempo, major mode, consonance, medium-low sound level, small sound level variability, low pitch, fairly narrow pitch range, lowered singer's formant, legato articulation, small articulation variability, slow tone attacks, soft timbre, moderate timing variability, soft contrasts between long and short notes, accents on tonally stable notes, medium fast vibrato, small vibrato extent, micro-structural regularity

Note. Shown are the most common findings in the literature. For a more detailed treatment of studies, see Gabrielsson and Juslin (2003), Juslin (2001a), Juslin and Laukka (2003), and Juslin and Lindström (2003).

Synthesis of Emotion

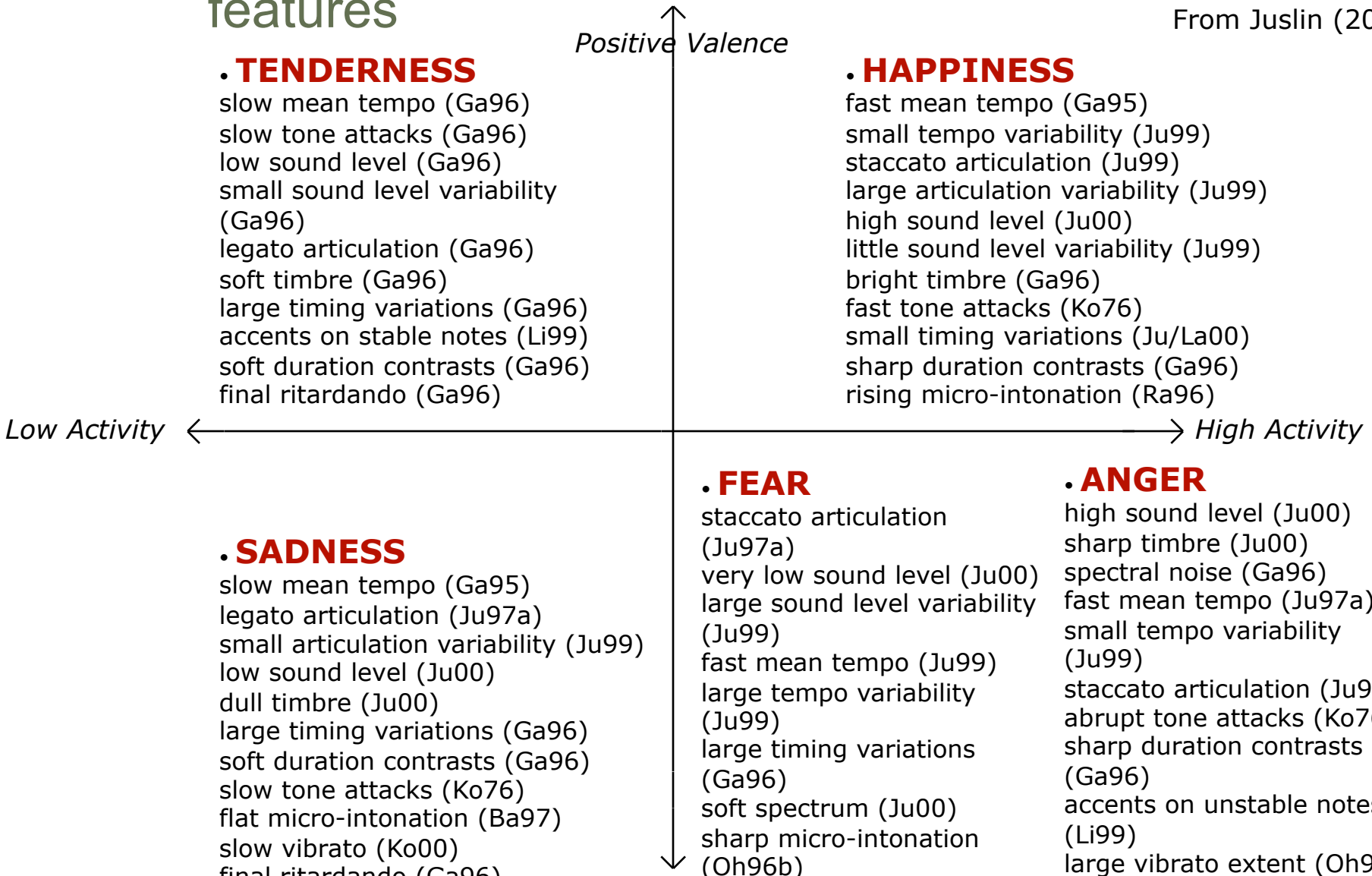
An example of the “analysis by synthesis” strategy:

different renditions of the same piece are synthesized by changing musical parameters, then we study the effect of the parameter-tuning on the perceived emotions (anger, happiness, tenderness, neutral…)

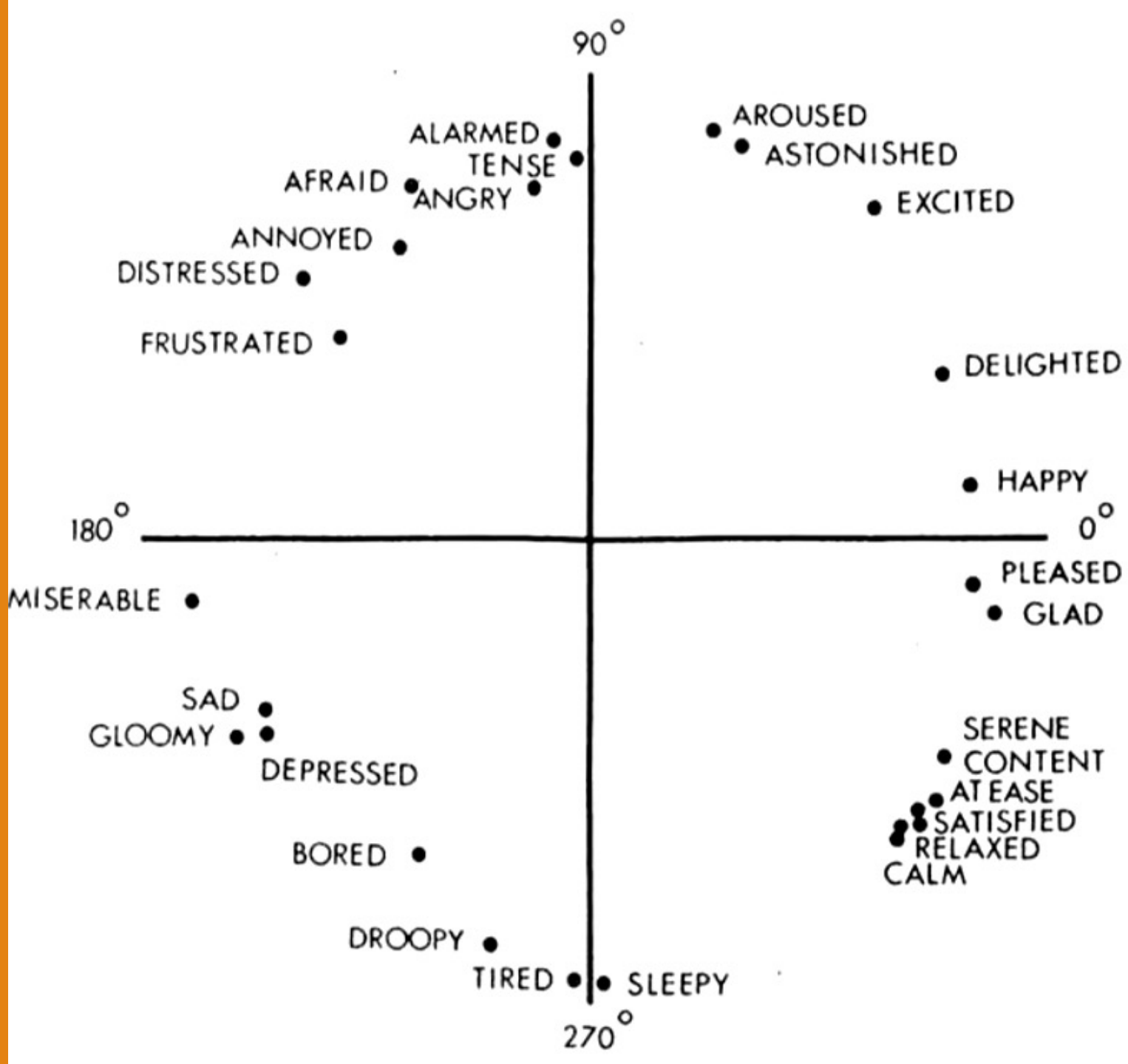


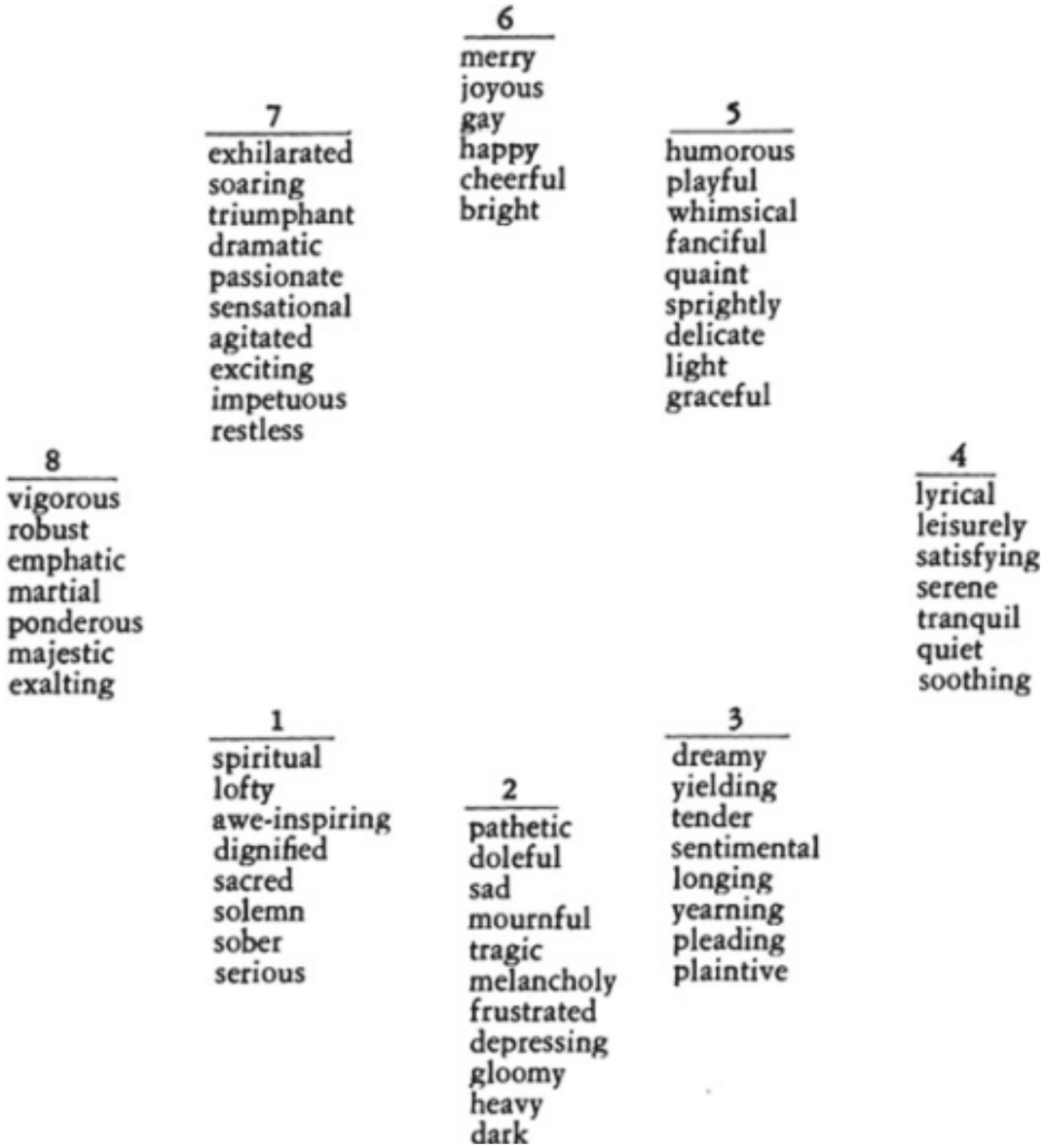
Dimensional representation with determining features

From Juslin (2001)



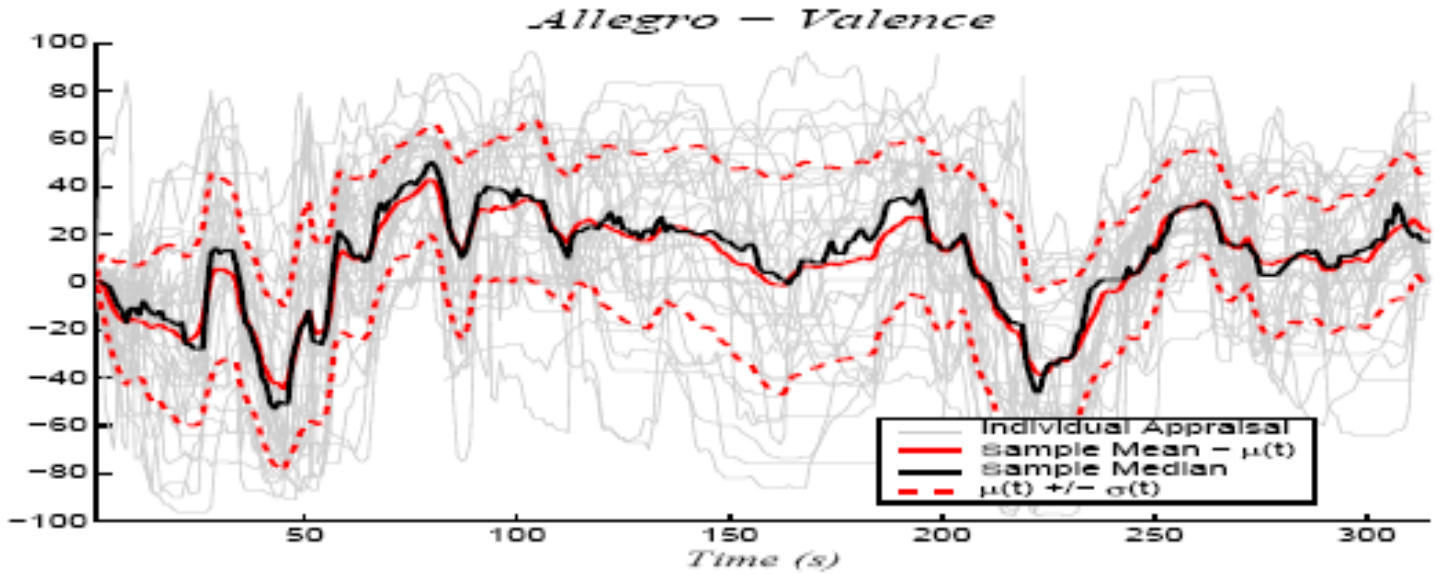
Russell's (1980) circumplex model



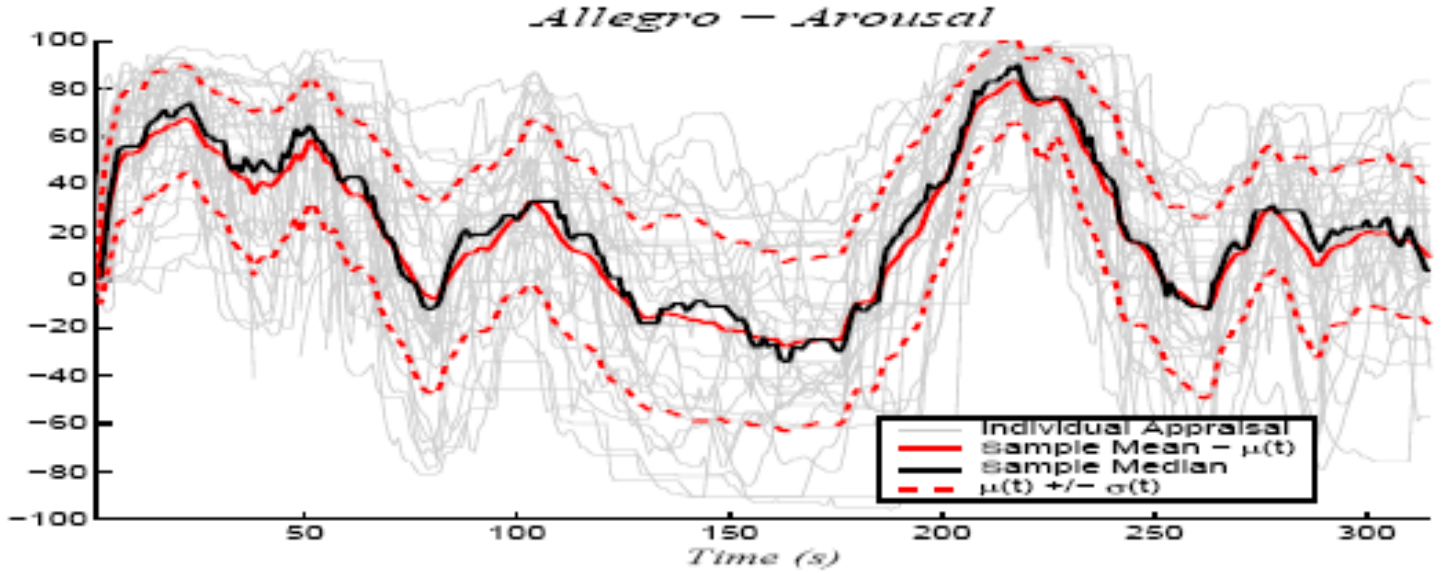


Hevner's (1936) categorical model

Emotion in time



(a) Valence



Why does music *induce* emotions? Juslin & Västfjäll (2008)

Musical expectation – the anticipation infinite game

Arousal – the activation of our systems

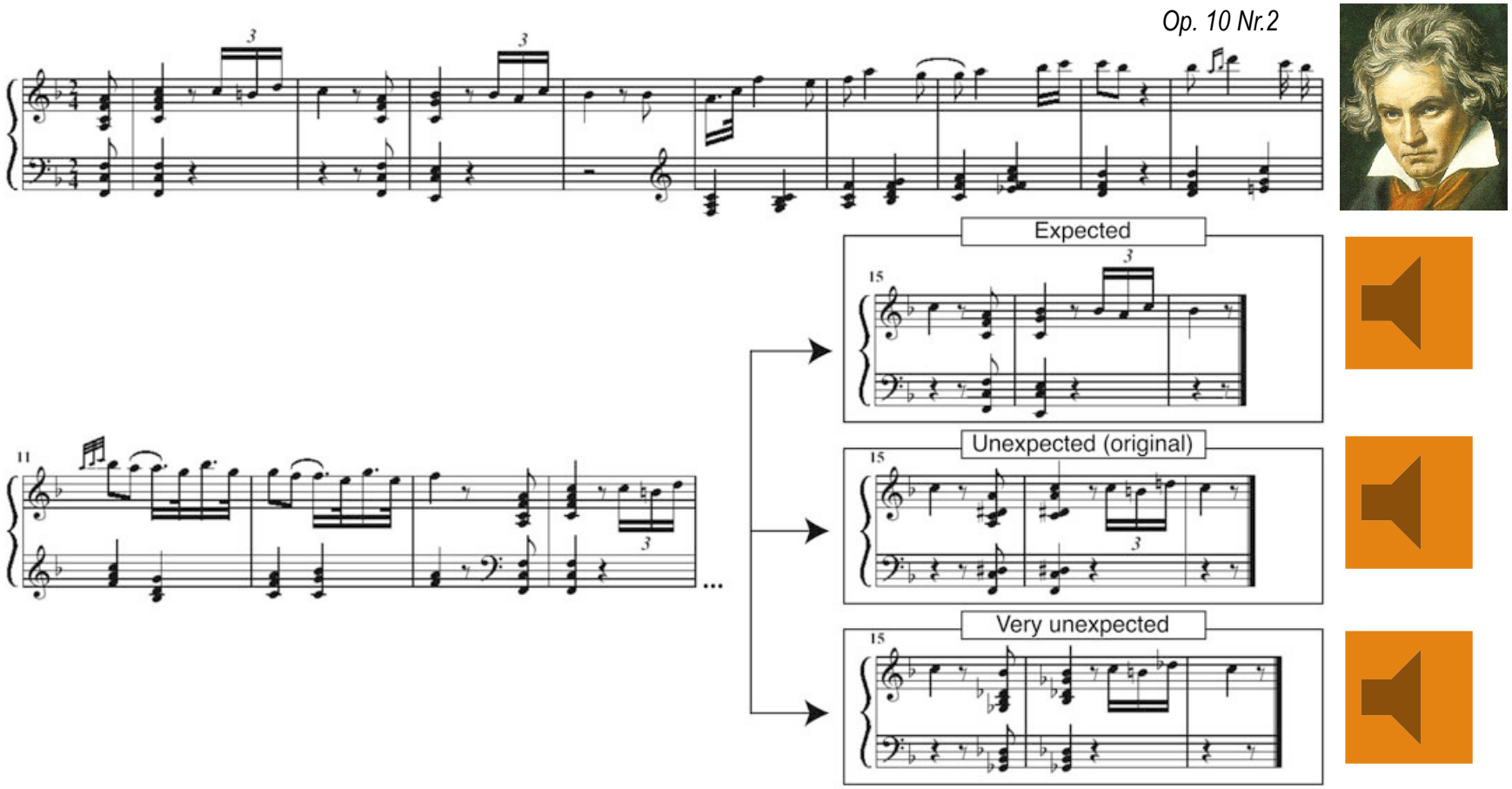
Mood contagion – “monkey see, monkey do”

Associations – ”they are playing our song, darling”, can be unconscious

Imagery – multimodality

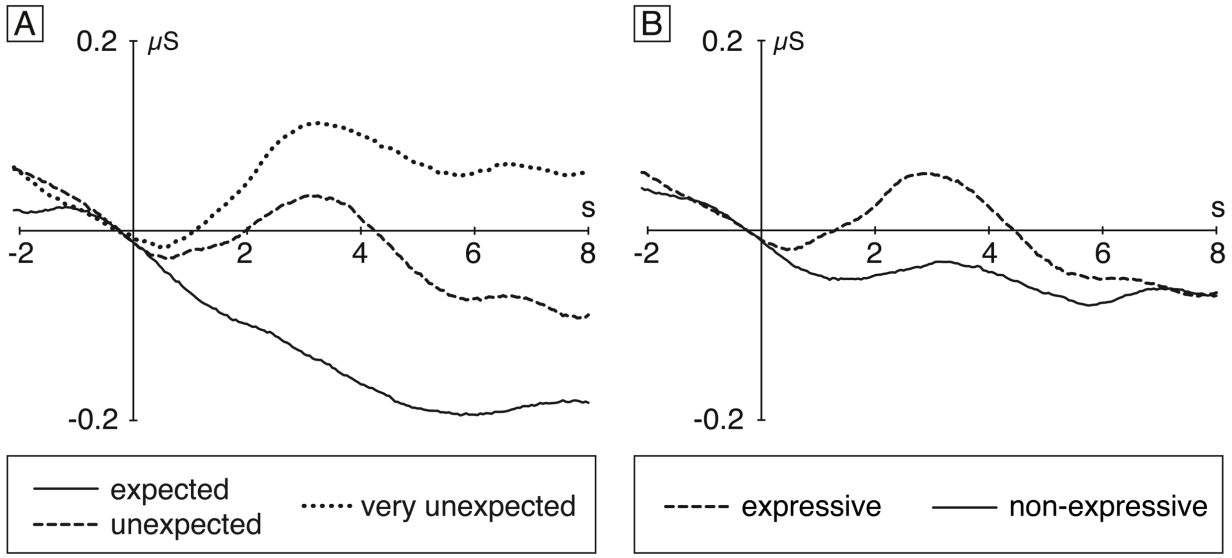
Violations of musical regularities elicit emotional responses

First, the original version of a piano sonata was played by a pianist. This original version contained an unexpected chord as arranged by the composer (see middle panel in the lower right). After the recording, the MIDI file with the unexpected (original) chord was modified offline using MIDI software so that the unexpected chord became expected, or very unexpected chord (see top and bottom panels). From each of these three versions, another version without musical expression was created by eliminating variations in tempo and key-stroke velocities (excerpts were modified offline using MIDI software). Thus, there were six versions of each piano sonata: Versions with expected, unexpected, and very unexpected chords, and each of these versions played with and without musical expression.



Skin conductance responses (SCRs)

A: Grand-average of SCRs elicited by expected, unexpected (original), and very unexpected chords (averaged across expressive and non-expressive conditions). Compared to expected chords, unexpected and very unexpected chords elicited clear SCRs. Notably, the SCR elicited by very unexpected chords was larger than the SCR to unexpected (original) chords, showing that the magnitude of SCRs is related to the degree of harmonic expectancy violation. **B**: Grand-average of SCRs elicited by expressive and non-expressive chords (averaged across expected, unexpected, and very unexpected conditions). Compared to non-expressive chords, chords played with musical expression elicited a clear SCR.



Koelsch et al., *PLoS-ONE* 2008

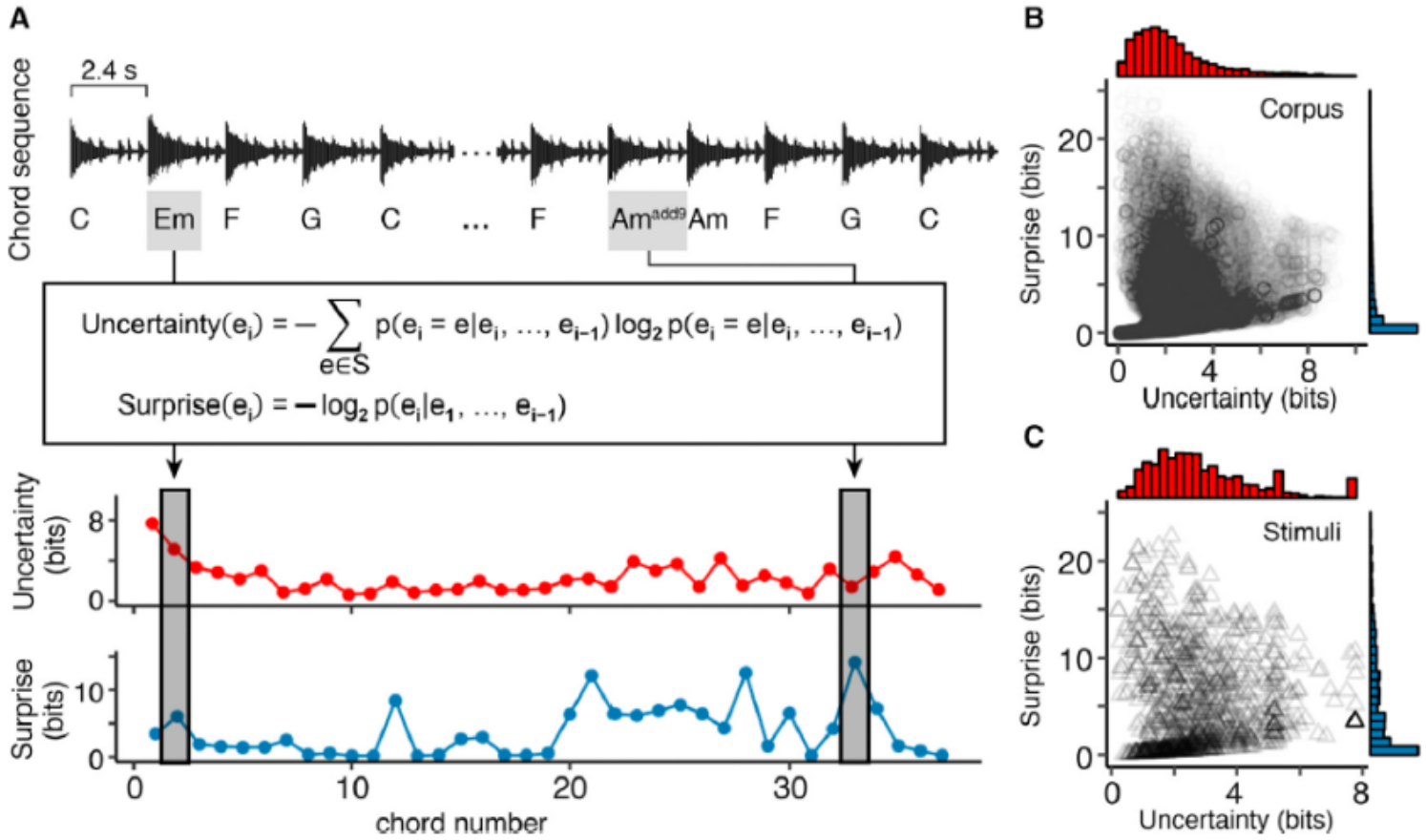
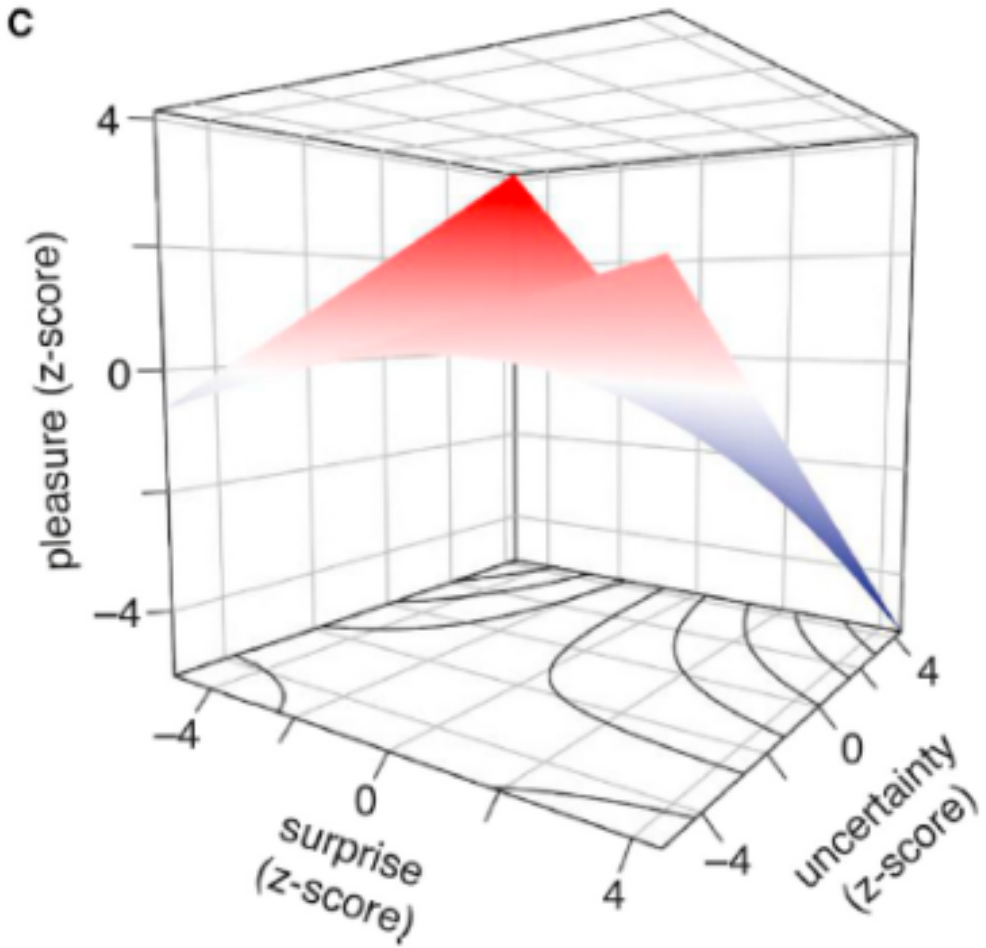


Figure 1. Quantifying Uncertainty and Surprise of a Chord

(A) An unsupervised statistical-learning model was trained on a corpus of 745 US Billboard "Hot 100" pop songs to derive the uncertainty (red) and surprise (blue) of chords (here, "Knowing Me, Knowing You" by ABBA; refer to Audio S1). Uncertainty is the lack of a clear expectation when anticipating an event *before* it is heard, while surprise occurs when what is *actually* heard deviates from expectations. Uncertainty of chord e_i is quantified by its entropy, or expected negative log-probability, taken across the set of all chords S in the corpus and conditional on the previous context of chords $\{e_1, \ldots, e_{i-1}\}$ in the progression. Surprise of chord e_i is quantified by its information content, and is the negative log-probability of the actual chord conditional on the context. Gray bars indicate points of high uncertainty but low surprise, and low uncertainty but high surprise. Subjects (n = 79) were asked to either rate the pleasantness of each chord (2.4 s) from 30 pop song chord progressions behaviorally or listen attentively and focus on how they fitted together in the context while undergoing fMRI scanning.

(B and C) Scatterplot and marginal densities of the uncertainty and surprise for all chords in the McGill Billboard corpus [21] (circles, n = 80,943) and in our chord stimuli (triangles, n = 1,039; Table S1).

Vincent K.M. Cheung, Peter M.C. Harrison, Lars Meyer, Marcus T. Pearce, John-Dylan Haynes, Stefan Koelsch (2019) Uncertainty and Surprise Jointly Predict Musical Pleasure and Amygdala, Hippocampus, and Auditory Cortex Activity, Current Biology, Volume 29, Issue 23



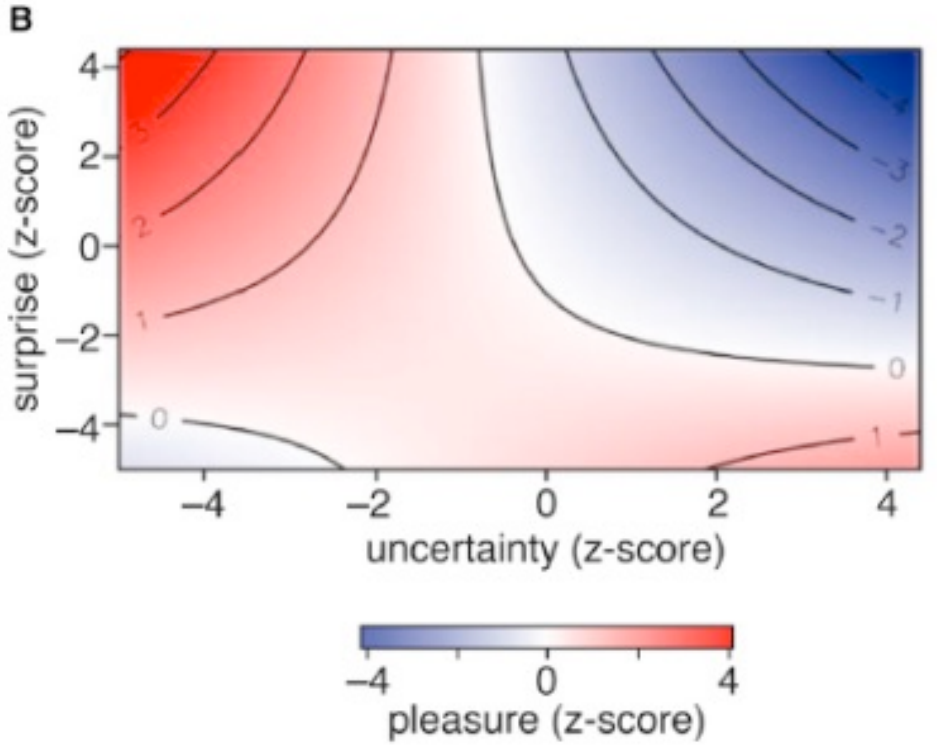


Figure 2. Uncertainty and Surprise Jointly Shape the Pleasure Rating of a Chord

(A) Standardized pleasure ratings to a chord progression taken from "Knowing Me, Knowing You" by ABBA (Audio S1). Diamonds indicate mean pleasantness ratings for each chord. Filled circles indicate fitted values from a linear mixed model with chord uncertainty, surprise, and their interaction as predictors. Error bars indicate 95% confidence intervals (95% CI). Low-level acoustic parameters were also included as covariates to control for sensory confounds.

(B) Contour plot demonstrating how pleasantness ratings jointly depend on uncertainty and surprise. When the tonal harmonic context does not allow for a prediction with high precision (i.e., when uncertainty is high), the pleasantness of a surprising chord is low. However, when the uncertainty is low, surprising chords are highly pleasurable.

(C) Data from (B) replotted in 3D. Although reminiscent of the characteristic inverted-U response from empirical aesthetics, the regression surface is in fact a saddle for which pleasantness varies nonlinearly across different levels of uncertainty and surprise.

Vincent K.M. Cheung, Peter M.C. Harrison, Lars Meyer, Marcus T. Pearce, John-Dylan Haynes, Stefan Koelsch (2019) Uncertainty and Surprise Jointly Predict Musical Pleasure and Amygdala, Hippocampus, and Auditory Cortex Activity, Current Biology, Volume 29, Issue 23

Chills

Salimpoor, V., Benovoy, M., Larcher, K., Dagher, A., and Zatorre, R.J. (2011). Anatomically Distinct Dopamine Release during Anticipation and Experience of Peak Emotion to Music. *Nature Neuroscience,* 14 (2): 257-262.

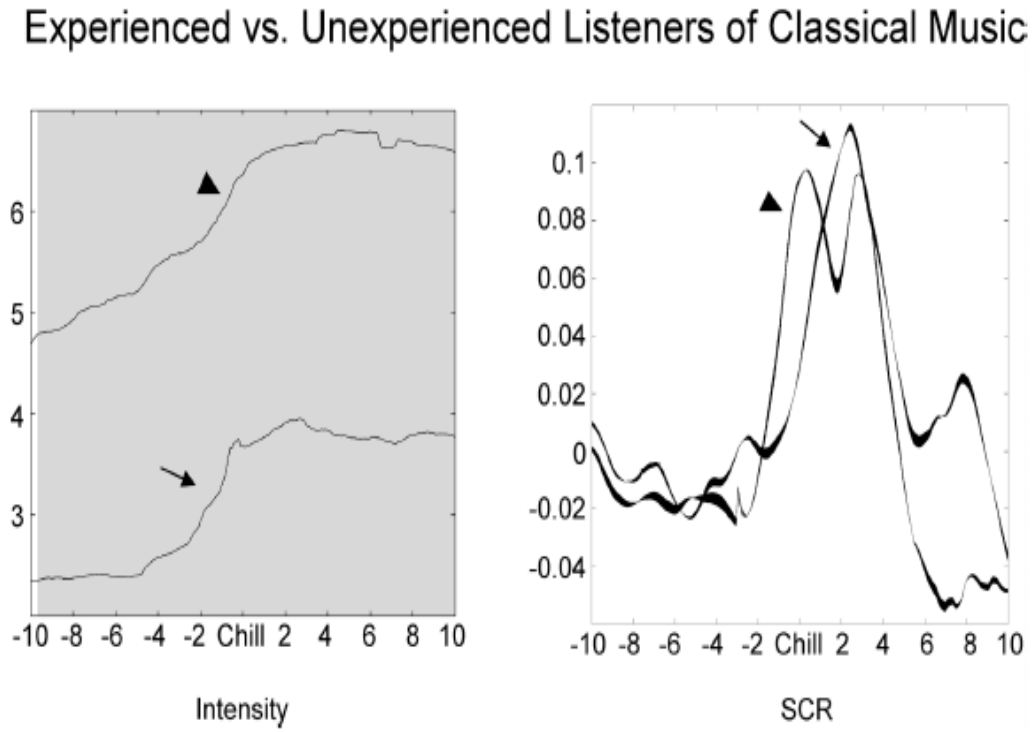
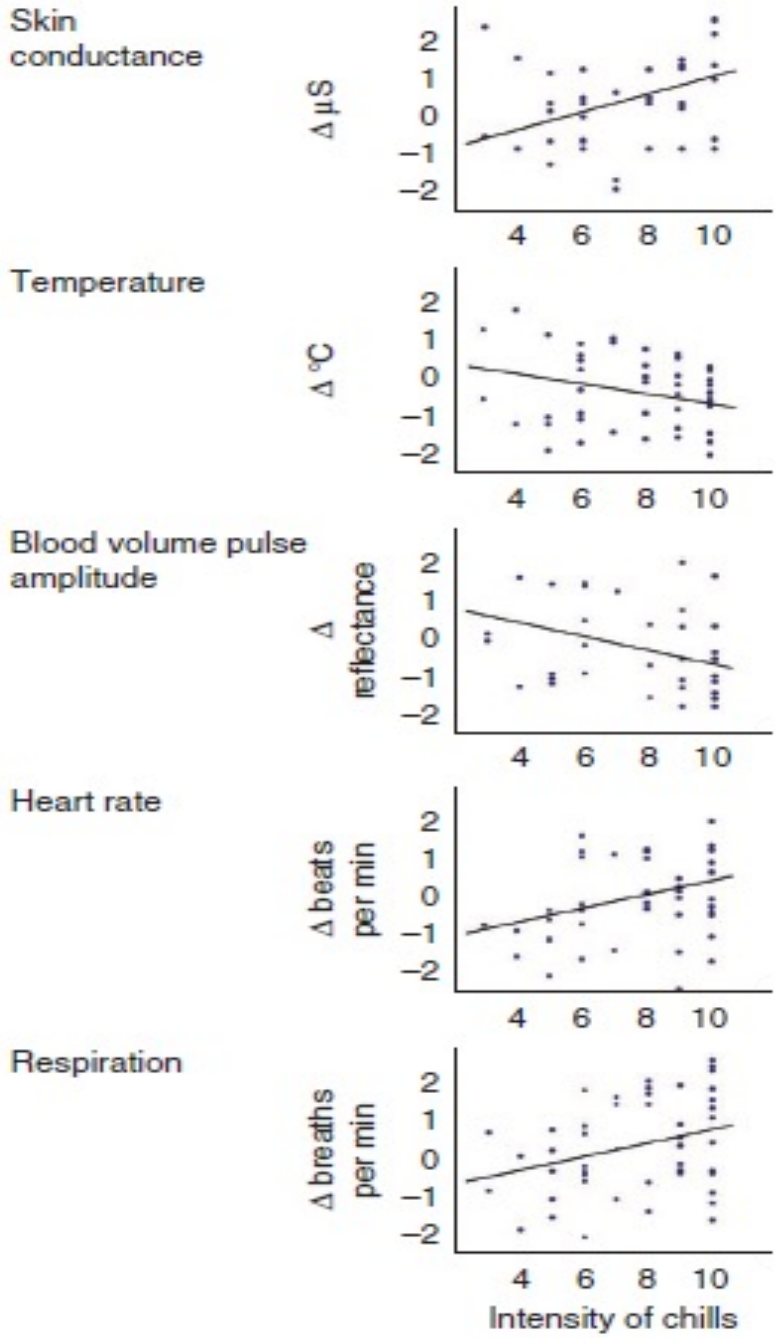
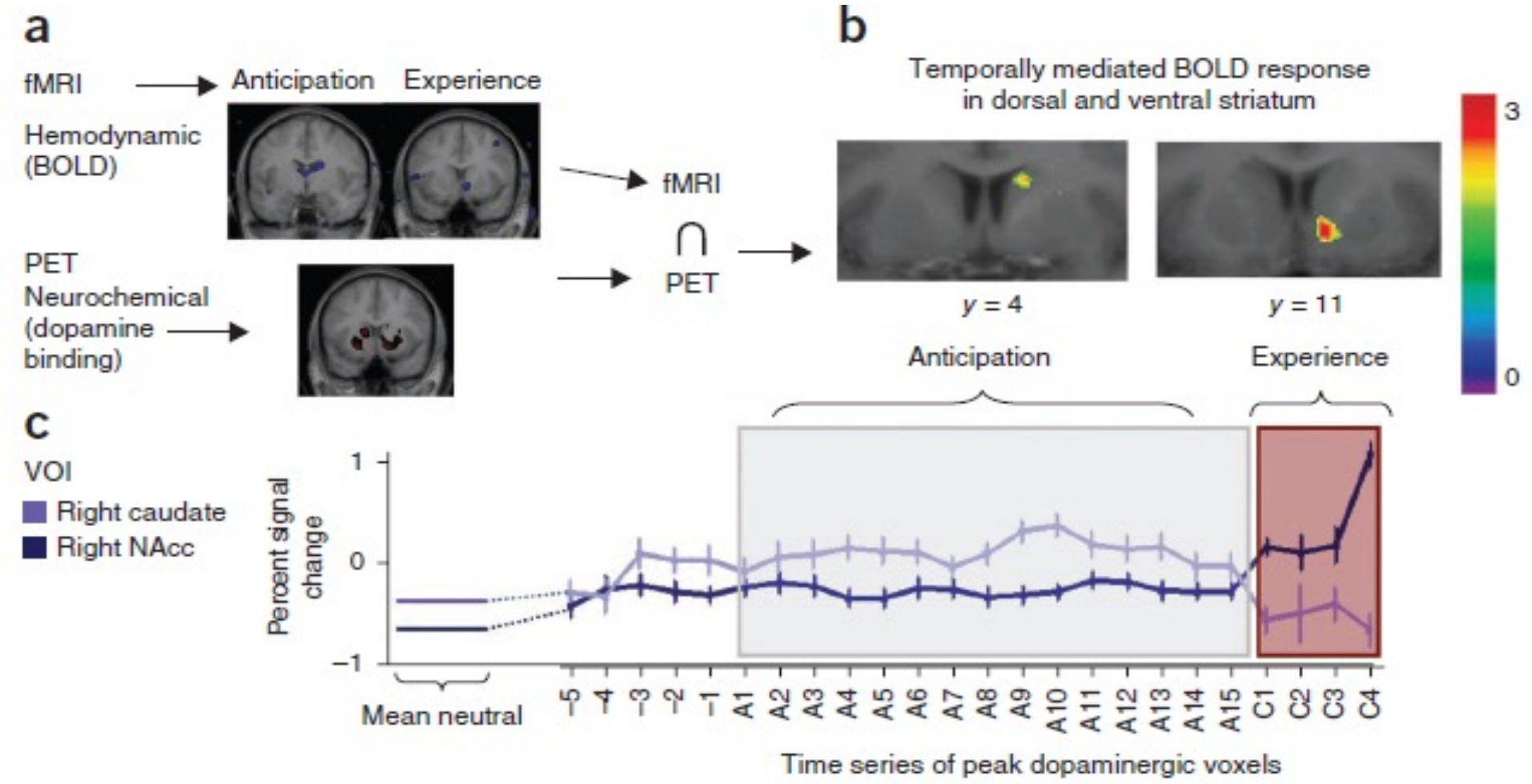


FIGURE 5. Comparison of chill samples (20 s) of participants highly experienced (arrowhead) and inexperienced (arrow) in classical music. Left intensity of feeling ratings, right skin conductance response (SCR). Significant differences (permutation test, $p < .05$) are shaded grey.

Chills


Skin conductance
Δ µS
2
1
0
−1
−2
4
6
8
10
Temperature
Δ °C
Blood volume pulse amplitude
Δ reflectance
Heart rate
Δ beats per min
Respiration
Δ breaths per min
Intensity of chills

Chills


a
fMRI
Anticipation
Experience
Hemodynamic (BOLD)
PET
Neurochemical (dopamine binding)
fMRI
PET
b
Temporally mediated BOLD response in dorsal and ventral striatum
3
0
y = 4
y = 11
Anticipation
Experience
c
VOI
Right caudate
Right NAcc
Percent signal change
1
0
−1
Mean neutral
−5 −4 −3 −2 −1 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 C1 C2 C3 C4
Time series of peak dopaminergic voxels

Chills

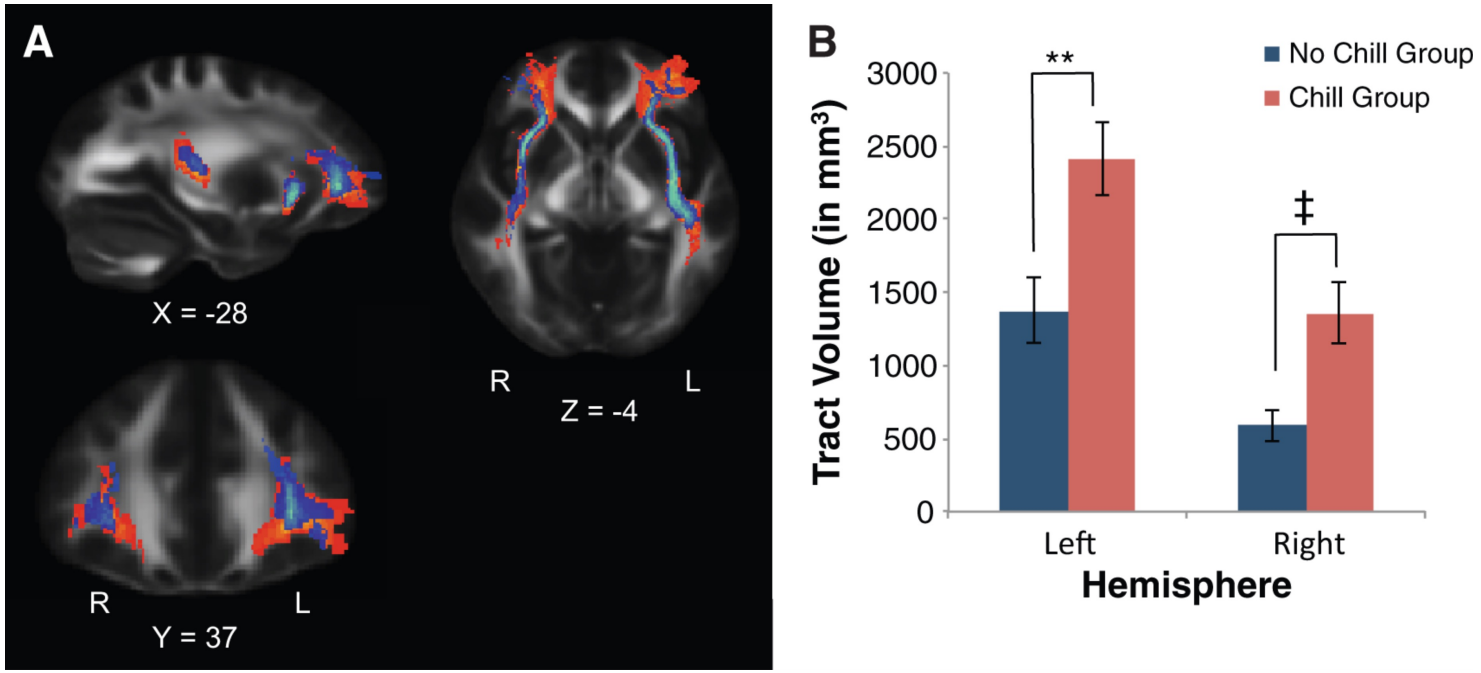


Fig. 3. Larger tract volume from pSTG to aIns and mPFC in Chill responders: (A) Diffusion tractography showed increased tract volume between auditory perception regions in the STG and emotional and social processing regions in the aIns and mPFC. (B) Tract volume between the STG, aIns and mPFC was significantly larger in individuals who frequently experience chills in response to music compared to matched controls. **P < 0.01 uncorrected. ‡ P < 0.05 after Bonferroni correction. Error bars denote standard error.