Deep Phenotyping of Affective Experiences Evoked by Music: "ManyMusic🎶"

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Background

Despite considerable advances in understanding music-evoked emotions[1], our understanding of the underlying mechanisms has remained fragmental. Major limitations come from the enormous dynamics and complexity of emotional experiences during natural music listening[2], the variability of the music people hear, know, and like[3], and the uniqueness of individual neural functioning which we only begin to sense[4]. Therefore, it is most certainly impossible to attain a more comprehensive understanding of music-evoked emotions with traditional experiments that are based on a small number of short and often artificially manipulated pieces of selected musical genres (mainly classical), and rely on group statistics of brain activity.

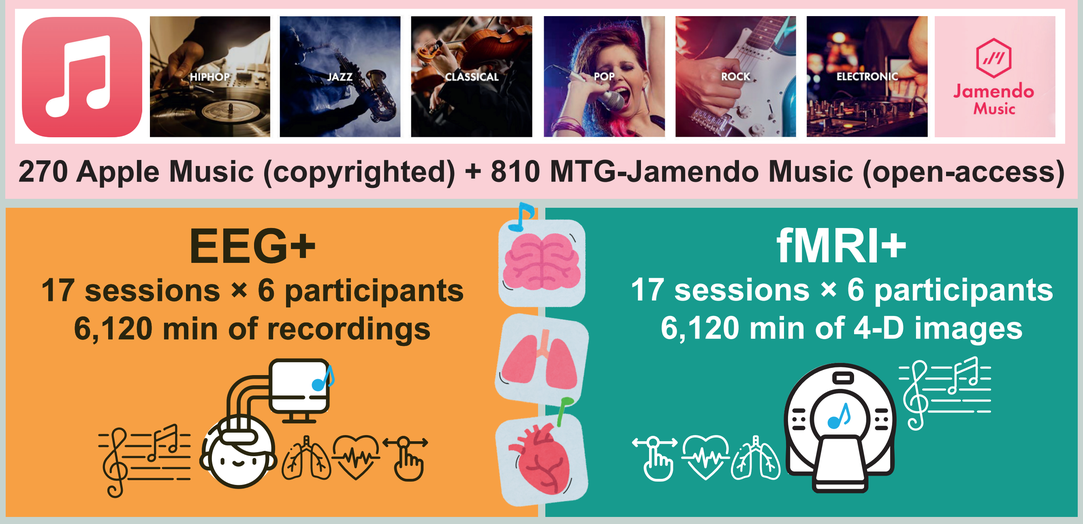
Aims

We aim to create a massive multi-modal dataset for precise modelling of music-evoked emotions, called "ManyMusic🎶". Specifically:

Stimulus: ***Full-length*** presentation of 1,080 musical pieces from ***diverse genres*** eliciting ***various emotions***

Measurement: ***Extensive sampling*** of subjective experience of music-evoked affect in selected individuals to precisely capture subject-specific mechanisms

Accessibility: ***Fully open-access*** dataset of music audio (MTG-Jamendo), computational music features (including Apple Music), behavioural and neurophysiological responses



Project overview. *Many (>1,000) musical pieces will be used for deep-phenotyping of music-evoked emotions using behavioural ratings, EEG+ (electroencephalography and other physiological recordings including respiration rate, heart rate, electrodermal activity), and fMRI+ (functional magnetic resonance imaging, respiration rate and heart rate).*

Stimulus selection

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One thousand eighty full-length musical pieces
(25% self-selected; 75% experimenter-selected using DNN-based recommendations).

Self-selected music (N = 270)

Six participants selected 45 favorite exemplars that evoke one of the target emotions based on Geneva Emotional Music Scale (GEMS)[7] from Apple Music (5 tracks for 9 emotions). 270 tracks in various genres (jazz, rock, classical, Latin, pop, techno, hip-hop, non-Western pop) were purchased and downloaded.

Experimenter-selected music (N = 810)

- **Initial source**: MTG-Jamendo[5] (55,609 tracks created by semi-professional musicians across various genres; freely available for research)
- **Refined source**: ManyMusic tracks[6] (1,920 tracks selected based on DNN predictions of genre and affect; rated in terms of liking comparably to random Spotify tracks by 233 human raters)
- **Individual playlists**: Each participant selected 135 tracks from recommendations drawn from the ManyMusic tracks. Recommendations were based on cosine similarity of audio transformer MAEST[8] embeddings between participants' self-selected tracks and the ManyMusic tracks.

Participant screening

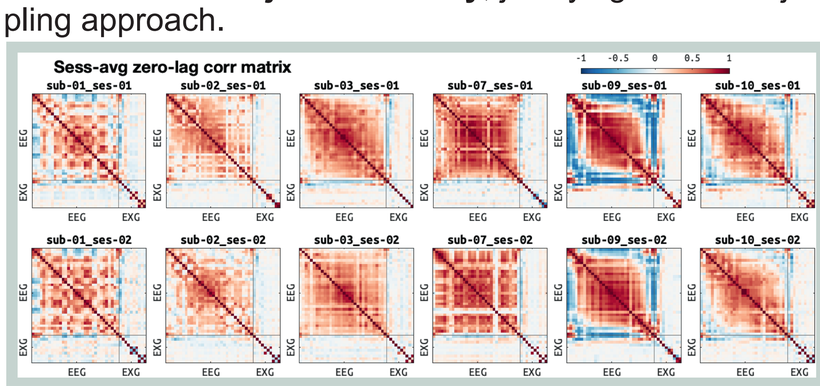
Six volunteers, who are musically experienced, highly susceptible to music-evoked emotions, MRI compatibility, and availability for 34 or more sessions over one year, were invited via a screening process.

EEG+ data collection

One hundred two sessions with 32-channel EEG, EOG, facial EMG, respiration rates, heart rates, electrodermal activity, and head motion recordings during music listening with concurrent dynamic rating of instantaneous evoked emotions (i.e., liking and disliking), followed by aggregated ratings (overall emotions and GEMS) after each track.

Cross-channel covariance patterns

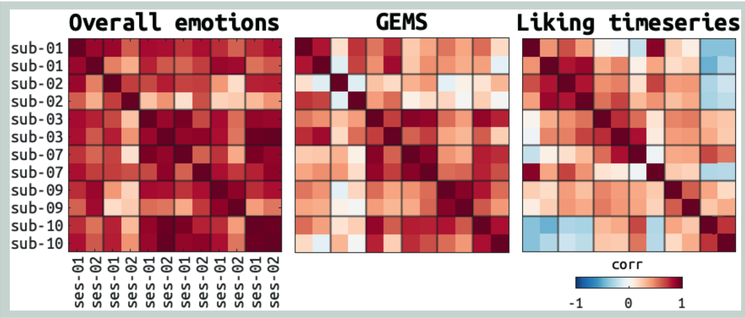
Zero-lag correlation patterns showed **high intra-subject consistency with marked inter-subject variability**, justifying within-subject extensive sampling approach.



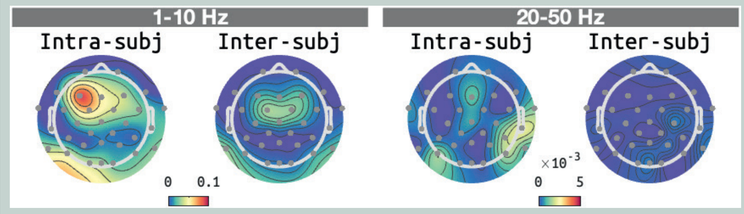
EEG+ correlation across channels. *EEG: 32 channels; EXG: vertical/horizontal EOGs, frowning/smiling EMGs, breathing, heart rates, EDA, X-/Y-/Z-acceleration and velocity.*

Reliability monitoring

Queen's *"Bohemian Rhapsody"* (~5 min) was presented at the end of all sessions. The data show **higher intra-subject (super-diagonal) correlations than inter-subject (higher-order off-diagonal) correlations** consistently across modalities, suggesting strong within-subject reliability.

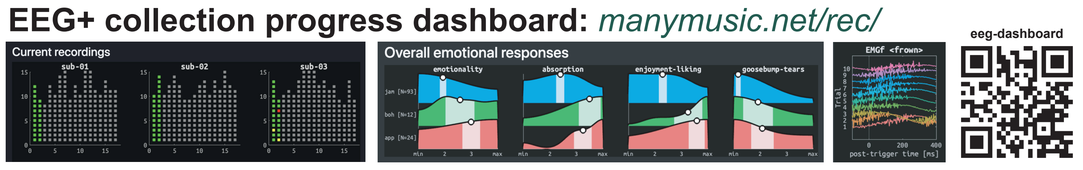


Behavioural correlation across sessions. *Overall emotions: emotionality, enjoyment, absorption to music, tears or goosebumps, style-familiarity. sub:subject; ses:session.*



EEG correlation across sessions. *EEG data were band-pass filtered ([1, 10] and [20, 50] Hz). Colour-mapped values are grand-averaged R^2 in %.*

EEG+ collection progress dashboard: *manymusic.net/rec/*



eeg-dashboard

fMRI+ data collection

One hundred two sessions with a CMRR multi-band GE-EPI at 3 Tesla, OptoActive noise-cancelling (~30 dB attenuation), an MR-safe breathing belt, a pulse oximeter, and an eye-camera during music listening without any task, followed by aggregated ratings (overall emotions and GEMS) after each track. After scanning, dynamic ratings will be collected during an out-of-scanner session on the same day.

Outlook

- **Timeline**: (1) EEG+: to be completed by April 2026, (2) fMRI+: by Sep 2026
- **Planned analyses:** (1) Computational modelling of music information such as audio-domain musical surprisal modelling[9] (2) Predictive modelling of stimulus-response associations such as linearized encoding analysis[10]

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