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# Impact of major and minor mode on EEG frequency range activities of music processing as a function of expertise

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## Highlights

- High-density EEG responses to expressive string quartets
- Frequency domain analyses as a function of musical mode and expertise level
- Decrease of theta and gamma power in right posterior regions reflects efficiency
- Enhanced frontal beta and gamma activities in minor mode in experts

## Abstract

Processing western tonal music may yield distinct brain responses depending on the mode of the musical compositions. Although subjective feelings in response to major and minor mode are well described, the underlying brain mechanisms and their development with increasing expertise have not been thoroughly examined. Using high-density electroencephalography, the present study investigated neuronal activities in the frequency domain in response to polyphone musical compositions in major and minor mode in non-musicians, amateurs and experts. During active listening decrease of theta- and gamma-frequency range activities occurred with increasing expertise in right posterior regions, possibly reflecting enhanced processing efficiency. Moreover, minor and major compositions distinctively modulated synchronization of neuronal activities in high frequency ranges (beta and gamma) in frontal regions, with increased activity in response to minor compositions in musicians and in experts in particular. These results suggest that high-frequency electroencephalographic (EEG) activities carry information about musical mode, showing gradual increase of processing efficiency and sensitivity with musical expertise.

## Keywords

Expressive music; Musical mode; Expertise; EEG; Frequency domain

## Introduction

Musical experience progressively modulates musical processing, resulting in functional and structural brain plasticity [1-6]. But information is lacking on specific modulation of functional brain responses to major and minor mode as a function of expertise level in natural musical stimuli evolving over time.

The traditional explanation for the “sad” affective state induced by the minor mode as compared to the “happy” mood induced by major mode [7], is the higher degree of dissonance of the minor mode [8-

9]. However, controlling for confounding variables such as dissonance [10] and also tempo [11], also influencing mood, demonstrated that these parameters only explain part of the specific affective state induced by minor mode music. Musical training is influential in the recognition of the affective states of mode, but not essential [8]. Several limbic areas underpin the specific affective state evoked by the minor mode [12-14].

Pallesen and colleagues [14] did not observe processing differences between musicians and non-musicians while they listened to major, minor and dissonant isolated chords. Interestingly, all listeners showed typical brain responses to minor mode in emotion related areas [14].

Local and distant neuronal networks that communicate within distinct frequency-bands may both support music processing [15,16]. Communication within lower frequency bands (theta and alpha) between distantly connected areas may process top-down "cognitive" information. Bottom-up processing borne by short-range synchronization mediated by higher frequency-bands (beta and gamma) [16] may rather process more elementary features. However, there is also evidence for high-frequency-range synchronization over distributed cortical regions taking part in integration of complex sensory information [17]. In particular, oscillations in high-frequency-ranges (beta/gamma) are supposed to be crucial for binding different elements and fusing them into a coherent percept [18-20], pertinent for processing of music, a multi feature stimulus. The presence of enhanced gamma synchronizations among distinct cortical regions in musicians, compared to non-musicians, supports this view [15,21].

A more recent study by Pallesen et al. [22] showed stronger gamma-band phase locked activities in musicians when listening to non-prototypical chords, while gamma activities were stronger in non-musicians when listening to minor chords. Again, the reduced gamma activity in response to major chords in both musicians and non-musicians may be explained by weaker effort to process this most common mode in Western music [22]. Additionally, decreased theta synchronization in trained musicians may reflect reduced cognitive effort during listening as a consequence of enhanced memory function [23,24]. Moreover, overlapping of theta and gamma oscillations may serve working memory capacity [25-27], with a possible advantage for musicians who extensively train working memory during musical practice and performance [4,15].

The present study explored modulation of EEG brain oscillatory activities in several frequency ranges in people with 3 different levels of expertise in response to major and minor mode compositions. We expected first an effect of expertise revealed by differences in the degree of neuronal synchronization in low and high frequencies ranges [15,21,22], essentially in the right hemisphere [1,2,4,6,28,29]. Second, we anticipated an effect of musical mode manifesting more strongly with increasing expertise in higher frequency bands (beta/gamma) [22]. In order to verify these hypotheses, we studied music listening by analyzing associated brain oscillations in different frequency bands within three consecutive time-windows of 2 seconds from music onset. As mode effects establish quickly in a polyphone musical setting [22,30], we expected strongest effects in the first time-window (0-2 seconds).

## Materials and Methods

### *Participants*

Three groups of right-handed participants were recruited according to three levels of musical expertise: 20 professional pianists (Experts, "E": 24.5 ± 4.5 years; 10 women), 20 amateur pianists ("A": 22.2 ± 3.1 years; 10 women) and 19 non-musicians ("N": 24.0 ± 4.5 years; 9 women). The groups were matched for gender, age and fluid intelligence; experts were advanced students and established musicians or teachers; all non-musicians and amateurs were University students (for comprehensive information on the participants and the group compositions, please consult [4]).

### *Materials and experimental procedure*

The procedure used in this project was approved by the ethics committee of the local faculty, in agreement with the ethical standards of the declaration of Helsinki. A great number (n=120) of ecological and varied musical stimuli (style "common practice period") through all 24 major and minor tonalities were specifically created (for details see [4]) by a professional composer (see Acknowledgements), 30 were used during fMRI [4] and 90 during high-density EEG recordings. For the current study based on the EEG recordings, stimuli thus consisted of 90 original expressive compositions (mean duration ~10 sec.), 45 in minor and 45 in major mode covering all 24 tonalities, of string quartets for 2 violins, viola and cello. Each stimulus was replicated 3 times with 3 levels of transgression at musical closure, resulting in a total of 270 stimuli (see Fig. 1 for two examples; corresponding soundfiles are provided in the Supplementary material). The endings of the pieces were either regular (tonic chord, degree I, in root position), subtly transgressed (tonic chord in first inversion $I^6$) or apparently transgressed, ending on a subdominant chord, degree IV, in first inversion ($IV^6$). For a comprehensive description of the transgressions we refer to [4]. Rater sensitivity (d-prime) for detecting the transgressions perfectly separated the 3 expertise levels, validating the composition of the groups (see [4], Figure 3, p. 2217). However the influence of the endings at ~10 sec. after stimulus onset on mode perception at the beginnings of the pieces may be considered insignificant. These stimuli were administered by “E-prime” software (Psychology Software Tool, Inc.). Subjects were asked to keep their eyes open, focus on a central fixation cross and to listen actively. Musical stimuli were presented in a pseudo-randomized order within a counterbalanced design to avoid any sequential effects. EEG was continuously recorded during the experiment. During fMRI [4] and EEG recordings subjects responded to the question whether the stimuli ended correctly or not. In this study investigating major and minor mode processing, we focused on 3 time windows of the pieces from stimulus onset: from 0 to 2000 ms, displayed in Fig. 1, from 2000 to 4000 ms and from 4000 to 6000 ms.

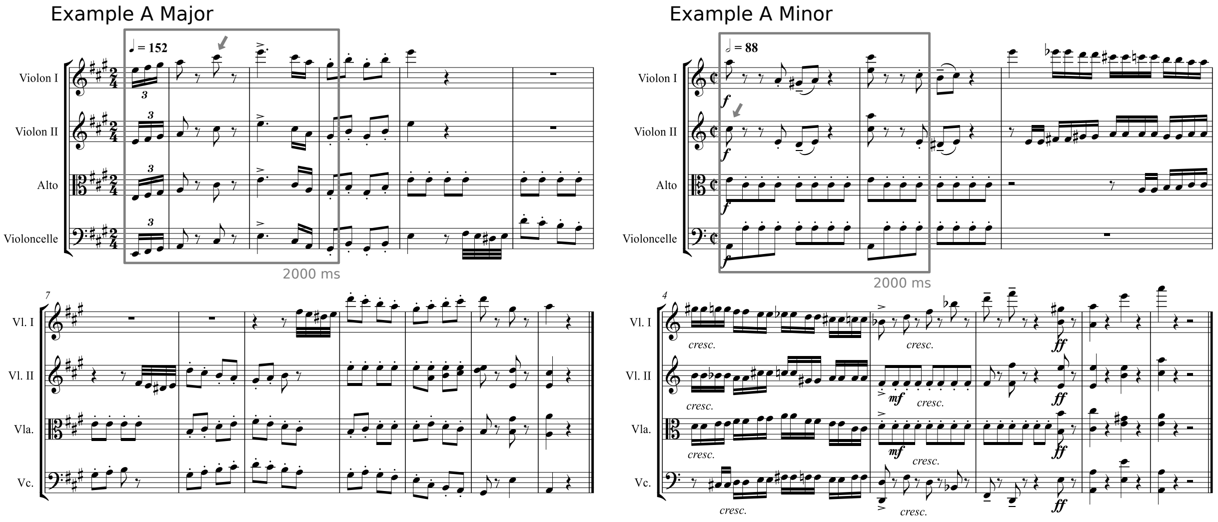

**Figure 1:** Two examples of musical stimuli (string quartets) in D major and D minor.

Gray frames indicate the first 2000 ms of the pieces and arrows point first appearance of the mediant indicating the mode.

### *EEG acquisition, raw data processing and analyses*

EEG was recorded from 256 AgCL carbon-fiber coated electrodes using a Hydrocel Geodesic Sensor Net®. The vertex was used as the recording reference, and EEG was continuously digitized at 1 kHz and band-pass filtered between 0.1 and 100 Hz; impedances were kept below 30 kΩ. The channels located on the cheeks and below the Nz–Iz equator were omitted after recording and the remaining 204 channels were submitted to further analysis.

Using "BrainVision Analyzer" software, signals were segmented offline over three consecutive time-windows from stimulus onset (0-2; 2-4; 4-6 sec.). We chose to analyze the EEG data in the frequency domain, because a musical score does not always reveal its mode at sound onset: chords may build up quickly but progressively. In all stimuli, the mode was well established within the first 2 seconds: the appearance of the mediant, i.e. minor or major third composing the tonic chord and determining the mode, occurred at 472 +/- 581 ms with no difference between mode conditions (t=1.344; p=.182), in the 90 different pieces used.

Only epochs without artifacts were retained after visual inspection of each segment, and bad or noisy channels were interpolated with a spherical spline [31]. In order to correct for random and stationary noise, signals were averaged referenced [32]. However, no classical baseline correction was applied in order to avoid omitting specific cognitive states according to the experimental groups. Fast Fourier Transforms (hamming window of 10%) were applied to each segment for each electrode. Then, all segmented signals were grouped according to major or minor mode for each time-window of 2 seconds. The power spectra of each mode condition were averaged, electrode per electrode and subject by subject, before being exported per frequency band. Seven frequency bands were retained: theta (4-7 Hz), alpha low (8-10.5 Hz), alpha high (10.5-14 Hz), beta low (14-20 Hz), beta high (20-30 Hz), gamma low (30-45 Hz), and gamma high (60-90 Hz). For each of them, we performed a logarithmic transform of the power amplitude measured at each electrode site in order to normalize the data. Values were then averaged within nine predefined Regions Of Interest (ROIs following a 3x3 mapping of cortical regions, each including 15 electrode sites distributed in three caudality positions –frontal, central and posterior– crossed with three lateralized positions –left, center and right–; cf. legend of Fig. 2). Oscillatory activities specific to each ROI were investigated through factorial ANOVAs with repeated measures: Expertise (Non-musicians – Amateurs – Experts) x Mode (Major – Minor).

## Results

### First time-window of analysis (0-2 sec.)

Figure 2 depicts mean power activities obtained in each of the 9 ROIs, according to the 7 frequency bands and the 3 expertise groups, in response to minor and major expressive compositions (mean oscillatory brain activity during the first 2000 ms after stimulus onset). Results of all 2-way ANOVAs (Expertise (3) x Mode (2)) conducted on each ROI and each frequency band separately are displayed in supplementary Table 1 (in supplementary data). All significant main effects (absence of any significant interaction effect) are reported by means of asterisks in Figure 2.

First we report the absence of any significant effects from analyses in both alpha band subdivisions. Then, only theta (4-7 Hz) and gamma (30-45 Hz and 60-90 Hz) frequency ranges yielded significant main effects of the factor Expertise (Ex), that were systematically observed in the posterior-right (PR) region. In the theta band the effect manifested by a lower activity in experts compared to non-musicians and amateurs. In contrast, post-hoc comparisons in both gamma subdivisions dissociated significantly only experts from non-musicians, with amateurs showing intermediate power activities. The higher gamma frequency band also yielded effects of Expertise in the frontal left (FL) and central right (CR) regions.

Effects of factor Mode (Mo) showed in all beta (14-20 Hz and 20-30 Hz) and gamma frequency ranges (30-45 Hz and 60-90 Hz). They quasi-systematically concerned all frontal regions in all four frequency-ranges and post-hoc comparisons revealed that most of these effects were restricted to the Expert group and associated to lower power amplitude in response to major compositions; only the upper beta subdivision also showed similar simple effects in the amateur group. The upper gamma subdivision showed additional main effects of Mode in the central center (CC), posterior center (PC) and central right (CR) regions.

Subsequent time-windows of analysis (2-4; 4-6 sec.)

Oscillatory brain activities collected in the subsequent time-windows (2-4 and 4-6 sec.) showed similar effects of the factor Expertise (progressive decrease) in the gamma frequency range and attenuated effects in the theta range. Secondly, effects of factor Mode disappeared in both beta subdivisions and were attenuated or absent in the gamma bands. Finally, only alpha frequency bands manifested new significant effects in the 2-4 seconds time-window compared to the initial period (0-2 sec.). An effect of Mode (increased activity in response to minor mode) was detected in the central (CC) region in the lower alpha sub-band (8-10.5 Hz). In the alpha upper subdivision (10.5-14 Hz), this mode effect showed an interaction defined by increased activities in minor mode exclusively in the amateur group in posterior-left (PL), frontal- (FR) and central-right (CR) regions (full quantitative data are not reported for the sake of brevity).

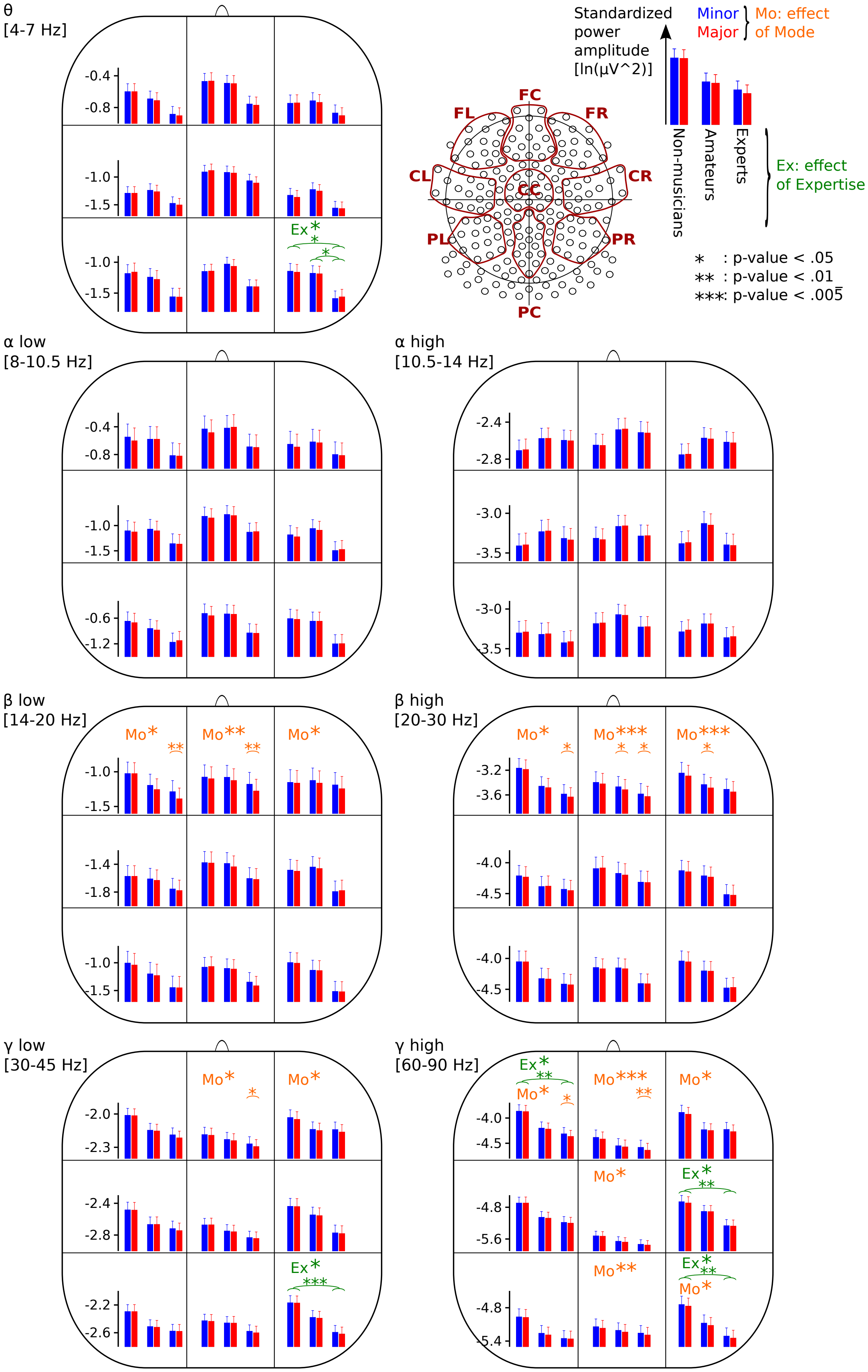
θ
[4-7 Hz]
-0.4
-0.8
-1.0
-1.5
-1.0
-1.5
Ex*
*
*
Standardized
power
amplitude
[ln(µV^2)]
Minor
Major
Mo: effect
of Mode
Non-musicians
Amateurs
Experts
Ex: effect
of Expertise
FC
FL
FR
CL
CC
CR
PL
PR
PC
* : p-value < .05
** : p-value < .01
***: p-value < .005
α low
[8-10.5 Hz]
-0.4
-0.8
-1.0
-1.5
-0.6
-1.2
α high
[10.5-14 Hz]
-2.4
-2.8
-3.0
-3.5
-3.0
-3.5
β low
[14-20 Hz]
Mo*
**
Mo**
**
Mo*
-1.0
-1.5
-1.4
-1.8
-1.0
-1.5
β high
[20-30 Hz]
Mo*
*
Mo***
*
*
Mo***
*
-3.2
-3.6
-4.0
-4.5
-4.0
-4.5
γ low
[30-45 Hz]
Mo*
*
Mo*
-2.0
-2.3
-2.4
-2.8
Ex*
***
-2.2
-2.6
γ high
[60-90 Hz]
Ex*
**
Mo*
*
Mo***
**
Mo*
-4.0
-4.5
Mo*
Ex*
**
-4.8
-5.6
Mo**
Ex*
**
Mo*
-4.8
-5.4

**Figure 2:** Power amplitudes observed in each of the 9 ROIs, according to the 7 frequency bands and the 3 expertise groups, in response to minor and major expressive compositions.

The 9 ROIs are depicted in the right upper panel: FL = frontal left, CL = central left, PL = posterior left, FC = frontal center, CC = central center, PC = posterior center, FR = frontal right, CR = central right, PR = posterior right (scales of power amplitude ($\ln(\mu V^2)$) are defined for each line, namely frontal, central, and posterior). The 7 frequency bands are defined as: theta (4-7Hz), alpha low (8-10.5Hz), alpha high (10.5-14Hz), beta low (14-20Hz), beta high (20-30Hz), gamma low (30-45Hz) and gamma high (60-90 Hz). All plots summarize 3x2 repeated measures ANOVAs: Expertise (Non-musicians – Amateurs – Experts) x Mode (minor in blue – major in red); whiskers indicate the standard error, asterisks indicate the level of significance: *p < .05, **p < .01, ***p < .005 (corresponding to a Bonferroni-correction for multiple tests: 9 ROI).

## Discussion

The key finding of this study is that during the two first seconds of processing, high level musical expertise decreases gamma and theta band neuronal synchronization in right posterior regions in an expressive musical context, probably reflecting higher efficiency of music processing. This efficiency may be underpinned by enhanced working memory capacity following increasing expertise, conveyed by overlapping theta and gamma activities [26].

A secondary finding in this first time-window is that minor compositions induced enhanced synchronization in the beta and gamma bands, mainly in frontal sites, as compared to major ones. This can be also explained by efficiency, as the greater facility of participants (musicians and experts in particular) to process the more familiar major mode expressed through decreased synchronization [22]. This impact of musical expertise on perception of musical mode is consistent with our prior findings on musical skill using Gordon's test [4,33] and our own in-house test on musical syntax processing [4] within the same population.

The results from the subsequent time-windows of analysis (2-4 and 4-6 sec.) showed mainly an attenuation of expertise and mode effects as observed in the first time-window (0-2 sec.), confirming that mode perception establishes rapidly in polyphone music in both non-musicians and musicians. Previous studies mainly based on chord listening also reported rapidly modulated brain responses to major and minor mode within the first seconds of processing [22,30]. Our computations of the appearance of the first third with respect to the tonic within this 0-2 sec. time window underpin these observations. However, even if most effects were either weakened or absent in the subsequent time-windows, two additional results should be considered.  First the observed progressive decrease with expertise in the gamma frequency ranges was maintained, and secondly, mode and interaction effects emerged in the alpha ranges between 2-4 seconds; the latter showing increased activity with minor mode compositions only in the amateur group.

Altogether these data support the hypothesis that the first 2 sec. represent a sufficiently long time-window to allow the brain to establish a representation of mode in all participants' minds.

Although non-musicians and amateurs are perfectly capable of processing tonal music and capture the affective states of minor and major mode [8,11,34], processing potentially becomes more efficient and concise with increasing expertise and proficiency. The here-analyzed data do not allow to draw any conclusions on the quantitative or qualitative nature of the observed differences as a function of expertise in the different frequency bands. However, the observed gradual differences with increasing expertise of brain and behavioral responses to musical transgressions in the same pool of participants as here in [4], provide a clear indication of more concise expectations allowing more efficient processing. Even more so as underlying brain sources were located amongst others in error detection areas that were less activated with increasing expertise. Last but not least, experts manifested superior working memory [4].

As a main effect of expertise, we observed significantly decreased theta and gamma power activities. In the theta band, this effect appeared in the posterior right region, showing distinct responses of experts versus non-experts (non-musicians and amateurs confounded). Regarding the effects of expertise in the gamma frequency range, we observed a significant decrease in experts as compared to non-musicians; the power amplitude activities of the amateurs being situated at an intermediate level. The current data thus also manifest some gradual changes with expertise, as we could show before [4,6].

A decrease of power amplitude in the theta and gamma band characterized musical expertise in the current experiment, as opposed to some results observed in the literature [15,35]. This contrast may be explained by the very high training level of our experts (30.7 hours per week on average at age 18-25), by our rich musical stimuli, as well as by the chosen time windows of analysis of 2 seconds. In the current context, we interpret the decrease of power amplitude by high efficiency and low effort during music processing in this population. According to Bhattacharya and collaborators [21], the increased local power activities in the theta and gamma band in non-musicians may reflect the effort to bind relevant information specific for music processing, whereas this integration of multi feature information is less effortful for trained musicians. Thus, the observed progressive decrease of theta and gamma power amplitude according to expertise in the present results likely reflects the transition from strong and inefficient local synchronizations towards more distributed gamma band activities in the brain, consistent with higher efficiency in binding perceived musical attributes into coherent percepts. Interestingly, these effects persist over the two subsequent time-window analyses. Therefore we suggest that brain plasticity induced by increased musical training leads to more efficient musical processing, particularly in rich and expressive musical settings.

Mode effects during the 0-2 sec.time-window manifested principally in experts and occasionally in amateurs. The musical sensitivity acquired by the musicians through their practice progressively sharpens their expectations and representations when listening to music, and minor and major mode represent distinct emotional categories [14,36]. Therefore, expertise and mode effects follow the same trend, versus decreased power for expertise and for the more frequently occurring major mode, explaining the absence of interaction.

Interestingly, these mode effects expressed as enhanced synchronization for minor mode and manifested in higher frequency ranges, likely reflecting increased processing effort. In the same vein, Pallesen and colleagues [22] postulated that the more frequently used major mode requires less processing resources due to familiarity. This effect restricted to phase locked responses independently of expertise. We could now extend this finding by showing expert dependent modulation of power amplitude over a time window of 2 seconds from stimulus onset during processing of rich musical stimuli.

In the subsequent two time-windows these mode effects attenuated. However, punctual mode and interaction effects emerged during the 2-4 sec. time-window in the alpha ranges. The fact that only amateurs show mode effects (minor > major) in this time-window in the alpha range, may represent delayed working memory activity as compared to the experts [25].

Finally, the presence of mode effects in anterior and interhemispheric regions on the scalp may reflect involvement of frontal brain areas as well as limbic structures, consistent with the literature [12-14]. Emotional responses to musical major and minor mode may rely on these structures that become more sensitive to mode with increased musical proficiency.

## Conclusion

EEG frequency activities in response to expressive string quartets showed gradual brain activity modulation according to musical expertise, expressed by theta and gamma power decrease, mainly in right posterior regions. Also, musicians and experts in particular presented more sustained beta and gamma activities in response to compositions in minor mode, mostly in frontal regions. Altogether, these results support enhanced processing efficiency and increased sensitivity for mode with musical training, accompanied by cerebral plasticity.

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## Conflict of interest

None declared.

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## Supplementary material

Supplementary Table 1: Repeated measures ANOVAs (Expertise x Mode) for each ROI of each frequency band.

F and p-values stemming from RM ANOVAs for each ROI of each frequency band: Expertise (Non-musicians – Amateurs – Experts) x Mode (Minor – Major). Last column displays significant post hoc comparisons (Fisher's LSD) related to each significant main effect of Expertise and Mode. Underlined values depict significant effects, and dashed lines trend effects.

ROIs defined as follows: FL = frontal left, CL = central left, PL = posterior left, FC = frontal center, CC = central center, PC = posterior center, FR = frontal right, CR = central right, PR = posterior right. Asterisks indicate the level of significance: ▵ P < 0.065, *P < 0.05, **P < 0.01, ***P < $0.00\overline{5}$ (corresponding to a Bonferroni-correction for multiple tests: 9 ROI).

Soundfile 1: Music example 1: A Major

Soundfile 2: Music example 2: A Minor

## Supplementary material: Table 1

| | | RM ANOVA | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ROI** | | **FL** | | **CL** | | **PL** | | **FC** | | **CC** | | **PC** | | **FR** | | **CR** | | **PR** | | |
| Effect | *df* | *F* | *p* | *F* | *p* | *F* | *p* | *F* | *p* | *F* | *p* | *F* | *p* | *F* | *p* | *F* | *p* | *F* | *p* | LSD *p-value* |
| **4-7 Hz** | | | | | | | | | | | | | | | | | | | | |
| Ex | 2,56 | 2.343 | .105 | 1.200 | .309 | 2.138 | .127 | 2.682 | .077 | 0.843 | .436 | 2.736 | .073 | 0.787 | .460 | 1.958 | .151 | **3.760** | **.029*** | PR $_{N-E}$: 0.018*<br>PR $_{A-E}$: 0.025* |
| Mo | 1,56 | 0.988 | .324 | 2.013 | .162 | 0.204 | .653 | 0.010 | .753 | 0.531 | .469 | 0.750 | .390 | 2.133 | .150 | 3.353 | .074 | 0.008 | .931 | |
| Ex x Mo | 2,56 | 0.269 | .765 | 0.555 | .577 | 1.731 | .186 | 0.118 | .889 | 2.483 | .093 | 1.070 | .350 | 0.951 | .393 | 0.342 | .712 | 0.863 | .427 | |
| **8-10.5 Hz** | | | | | | | | | | | | | | | | | | | | |
| Ex | 2,56 | 0.593 | .556 | 0.630 | .536 | 1.154 | .323 | 0.696 | .503 | 1.067 | .351 | 1.429 | .248 | 0.278 | .758 | 1.444 | .245 | 2.282 | .112 | |
| Mo | 1,56 | 1.286 | .262 | 0.994 | .323 | 0.271 | .605 | 0.873 | .354 | 0.554 | .460 | 1.476 | .229 | 1.650 | .204 | 1.016 | .318 | 0.068 | .795 | |
| Ex x Mo | 2,56 | 0.786 | .461 | 0.096 | .909 | 1.474 | .238 | 1.138 | .328 | 0.468 | .631 | 0.627 | .538 | 0.252 | .778 | 1.297 | .281 | 0.094 | .911 | |
| **10.5-14 Hz** | | | | | | | | | | | | | | | | | | | | |
| Ex | 2,56 | 0.361 | .698 | 0.369 | .693 | 0.221 | .802 | 0.576 | .565 | 0.391 | .678 | 0.360 | .699 | 0.635 | .534 | 1.012 | .370 | 0.458 | .635 | |
| Mo | 1,56 | 0.028 | .869 | 0.007 | .933 | 0.592 | .445 | 0.012 | .918 | 0.013 | .908 | 0.009 | .925 | 0.119 | .732 | 0.092 | .762 | 0.669 | .417 | |
| Ex x Mo | 2,56 | 0.094 | .911 | 0.341 | .712 | 0.009 | .991 | 0.091 | .913 | 0.200 | .819 | 0.098 | .907 | 0.145 | .865 | 0.458 | .635 | 0.191 | .827 | |
| **14-20 Hz** | | | | | | | | | | | | | | | | | | | | |
| Ex | 2,56 | 1.004 | .373 | 0.438 | .647 | 1.073 | .350 | 0.207 | .813 | 0.652 | .525 | 0.990 | .378 | 0.047 | .954 | 1.487 | .235 | 2.195 | .121 | |
| Mo | 1,56 | **6.958** | **.011*** | 1.445 | .234 | 2.703 | .106 | **7.708** | **.007**** | 2.457 | .123 | 2.514 | .118 | **4.190** | **.045*** | 0.398 | .531 | 0.201 | .655 | FL $_{E}$: 0.006**<br>FC $_{E}$: 0.007** |
| Ex x Mo | 2,56 | 1.920 | .156 | 0.363 | .697 | 0.452 | .639 | 1.094 | .342 | 0.825 | .443 | 2.860 | .066 | 0.594 | .556 | 0.716 | .493 | 0.010 | .990 | |
| **20-30 Hz** | | | | | | | | | | | | | | | | | | | | |
| Ex | 2,56 | 2.111 | .131 | 0.465 | .630 | 1.263 | .291 | 0.345 | .709 | 0.391 | .678 | 0.843 | .436 | 0.636 | .533 | 1.538 | .224 | 1.870 | .164 | |
| Mo | 1,56 | **4.957** | **.030*** | 1.334 | .253 | 0.436 | .512 | **11.479** | **.001***** | 0.555 | .459 | 1.422 | .238 | **11.771** | **.001***** | 3.001 | .089 | 0.095 | .760 | FL $_{E}$: 0.044*<br>FC $_{A}$: 0.017*<br>FC $_{E}$: 0.031*<br>FR $_{A}$: 0.028* |
| Ex x Mo | 2,56 | 0.435 | .649 | 0.833 | .440 | 0.069 | .933 | 0.400 | .672 | 1.042 | .359 | 0.239 | .788 | 0.062 | .940 | 0.121 | .886 | 0.289 | .750 | |
| **30-45 Hz** | | | | | | | | | | | | | | | | | | | | |
| Ex | 2,56 | 2.507 | .091 | 1.816 | .172 | 2.290 | .111 | 0.534 | .589 | 1.044 | .359 | 0.825 | .443 | 0.854 | .431 | **3.100** | **.053**$^{\Delta}$ | **4.868** | **.011*** | PR $_{N-E}$: 0.003*** |
| Mo | 1,56 | **3.635** | **.062**$^{\Delta}$ | 1.245 | .269 | 0.295 | .590 | **5.747** | **.020*** | 1.688 | .199 | 1.896 | .174 | **6.431** | **.014*** | 1.017 | .317 | 2.229 | .141 | FC $_{E}$: 0.015* |
| Ex x Mo | 2,56 | 1.376 | .261 | 0.885 | .419 | 0.099 | .906 | 0.945 | .395 | 0.538 | .587 | 0.576 | .565 | 0.267 | .767 | 0.100 | .905 | 0.433 | .651 | |
| **60-90 Hz** | | | | | | | | | | | | | | | | | | | | |
| Ex | 2,56 | **3.946** | **.025*** | **2.983** | **.059**$^{\Delta}$ | 2.088 | .133 | 0.620 | .542 | 0.974 | .384 | 0.192 | .826 | 2.021 | .142 | **3.812** | **.028*** | **3.935** | **.025*** | FL $_{N-E}$: 0.009**<br>CR $_{N-E}$: 0.008**<br>PR $_{N-E}$: 0.007** |
| Mo | 1,56 | **4.288** | **.043*** | 0.851 | .360 | 2.741 | .103 | **9.551** | **.003***** | **4.997** | **.029*** | **7.981** | **.007**** | **5.838** | **.019*** | 1.832 | .181 | **7.150** | **.010*** | FL $_{E}$: 0.020*<br>FC $_{E}$: 0.008** |
| Ex x Mo | 2,56 | 1.105 | .338 | 0.181 | 0.849 | 0.504 | .607 | 0.756 | .474 | 0.247 | .782 | 0.034 | .966 | 0.387 | .681 | .668 | .517 | 0.060 | .942 | |