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Emotional responses to musical mode: Do auditory and musical abilities play a role? Comment on "The major-minor mode dichotomy in music perception" by Carraturo et al.

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The distinction between major and minor modes has been central to Western tonal music since the 17th century, often serving as a mechanism for conveying emotional valence. The major mode is typically associated with positive emotions such as happiness and optimism, while the minor mode is linked to negative emotions such as melancholy and sadness. Whether these associations are learned or innate remains debated. They may arise primarily from cultural exposure or reflect natural responses to basic acoustic features—such as harmonicity and pitch height—that are relevant in vocal communication [1,2]. Nevertheless, the culture-specific nature of major and minor modes suggests a role for learning [3]. In contrast, tempo appears to be a more universal emotional cue [4]. Even among listeners exposed extensively to Western music, tempo is a stronger predictor of happy-sad judgments than mode [5,6], and variations in tempo have a greater impact on arousal than mode does on valence [7].

A recent review and meta-analysis [8] synthesized research on the behavioral and neural correlates of major-minor perception. Analyzing 70 studies, Carraturo et al. found that most evidence comes from Western participants and focuses primarily on emotional and preference judgments related to mode. Their meta-analyses confirmed that major and minor modes evoke distinct emotional evaluations and neural responses, with the most prominent neural differences observed in auditory regions such as the superior temporal gyrus.

Carraturo et al. [8] also found that mode perception varies across individuals depending on age, cultural background, mood, personality, clinical conditions such as depression, and music training. For example, musically trained individuals show greater sensitivity to major-minor distinctions, both behaviorally [9] and at the neural level [10], which are likely to shape emotional responses and preferences [6,11]. Nevertheless, one important but overlooked factor in the review—and in the broader literature—is natural musical and auditory abilities, which likely contribute to mode perception.

Many factors typically linked to music training also correlate with natural musical ability, or musical aptitude, even among individuals with no formal training. For example, nonverbal reasoning correlates with both music training and musical ability, although the association with training disappears for professional musicians [12] or after accounting for musical ability [13,14]. A similar pattern emerges for grammar skills, which correlate with music training and musical ability [15,16], yet the association with training disappears after controlling for ability [16]. Second-language learning also correlates with both music training and musical ability [17], but findings regarding training effects are inconsistent [16,18,19]. For emotion recognition, musical ability is linked to recognizing vocal emotions in children [20] and adults [21], even after accounting for music training—whereas the association between

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emotion recognition and music training disappears after accounting for musical ability.

Why does controlling for musical ability eliminate many of the associations with music training? One possibility is that training improves performance on musical-ability tests, which then mediate associations with other perceptual and cognitive abilities. Indeed, music training and musical aptitude are consistently and positively correlated [22], with moderate effect sizes ($r \approx 0.4$). Nevertheless, evidence that music training improves auditory processing is weak [23,24], and the causal effect could go in the opposite direction. For example, a five-year longitudinal study found that music training correlated with musical ability both at the beginning and end of the study [25]. After accounting for baseline musical ability, training no longer predicted musical ability at the study's conclusion. In contrast, initial musical ability predicted the extent of music training children received over the next five years. Moreover, individual differences in musical aptitude were stable over time, with test-retest reliability comparable to that of intelligence ($r \approx 0.7$).

Musical ability is closely linked to general auditory processing, which can be measured through adaptive psychoacoustic tasks [26] or with neural responses to small differences in basic acoustic features such as pitch [27]. Musical-aptitude tests typically include subtests evaluating melody perception—discrimination of tone sequences varying in pitch—and rhythm perception—discrimination of tone sequences varying in temporal structure. Baldé et al. [26] reported that rhythm perception was associated with better (lower) thresholds on eight of nine psychoacoustic tasks, spanning both temporal (e.g., duration discrimination) and nontemporal (e.g., pitch discrimination) domains. In contrast, melody perception was best predicted by pitch-perception abilities. Although music training also correlated with improved pitch processing, associations between auditory processing and musical ability remained significant independently of training. In short, basic auditory skills help to explain individual differences in musical ability, which in turn predicts engagement in music training.

If auditory and musical abilities are linked to music training as well as its correlates, they could also play a role in mode perception and its associated emotional responses. Suggestive evidence for this view comes from a study on recognizing emotions in speech prosody and nonverbal vocalizations [21]. Additional tests included beat-alignment perception, pitch discrimination, and duration discrimination, which were combined to form an aggregate measure of auditory and musical ability. This measure predicted emotion recognition independently of music training and cognitive ability, and fully explained observed associations between music training and emotion recognition. Conversely, congenital amusia—a disorder of music processing linked to impaired pitch perception—can be accompanied by deficits in recognizing vocal emotions [28] and reduced emotional sensitivity to changes in musical mode [29] at behavioral and neural levels [30].

Further systematic research on how auditory and musical abilities relate to the emotional processing of major and minor modes could deepen our understanding of individual differences in mode perception, expanding Carraturo et al.'s [8] proposed model. It could also refine interpretations of associations between music training and mode perception, and contribute to broader debates on near and far transfer [24] and the bases of musicality.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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