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BRIEF REPORT

Children's Knowledge and Feelings Align in Response to Emotional Music

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Examining emotion recognition and response to music can isolate recognition of and resonance with emotion from the confounding effects of other social cues (e.g., faces). In a within-sample design, participants aged 5–6 years in the eastern region of the United States ($N = 135$, $M_{age} = 5.98$, $SD_{age} = .54$; 78 female, 56 male; eight Asian, 43 Black, 62 White, 13 biracial, and nine "other") listened to clips of calm, scary, and sad music. In separate sessions, participants identified the emotional content of the music or reported on the feelings elicited by the music clip, with above-chance accuracy. Emotion *recognition* was associated with age and higher levels of child emotional verbal expressivity. Children with higher parent-reported empathy reported greater *resonance* with the emotion conveyed by music, specifically for sad music. Recognition and resonance were correlated (i.e., alignment), although the relationship varied as a function of the emotion expressed, with the greatest alignment for sad music. Results provide insights into emotion recognition and resonance in the absence of direct social signals and provide evidence that children's ability to recognize and resonate with emotion differs depending on characteristics of the music and the child.

Public Significance Statement
Our research contributes to how music perception and response can uniquely further our understanding of emotional development. Children accurately recognize and resonate with the emotions conveyed in music. We discuss translational implications for leveraging music as a tool to understand and improve socioemotional competence in children.

Keywords: emotion perception, emotion categorization, music, emotion development, prosocial behavior

Supplemental materials: https://doi.org/10.1037/dev0001572.supp

Recognizing and responding appropriately to emotion is key to social functioning (Decety & Jackson, 2004). Prior research has explored how children respond to emotional cues conveyed directly by other people, typically facial expressions (Barrett et al., 2019), which introduce specific confounds that limit understanding of emotion processing across development. Studies are needed that separate emotional content from overt social signals that might otherwise provide contextual clues allowing children to more accurately recognize or respond to emotion (Sloboda & Juslin, 2001). Emotional music does not involve direct social signals and therefore represents a useful context for exploring emotion recognition and resonance (Eerola & Vuoskoski, 2013; Timmers, 2017), with evidence that emotional signals from music are recognizable across cultures and contexts (Balkwill et al., 2004; Juslin, 2013a, 2013b).

Emotional music may be a particularly valuable tool to examine emotion recognition during childhood, with sensitivity to musical

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A subset of the results was included in the 2022 *Cognitive Science Society Proceedings*. The authors reviewed and agreed to their contributions.

The datasets and script are available at https://osf.io/8u627/. The task will be shared upon request. We report how we determined our sample size, data exclusions, and all manipulation measures in the study. Table S6 in the online supplemental materials reports open science verifications. The study was not preregistered.

Rista C. Plate served as lead for formal analysis, visualization, and writing–original draft. Callie Jones served in a supporting role for writing–review and editing. Joshua Steinberg served in a supporting role for conceptualization and writing–review and editing. Grace Daley served in a supporting role for conceptualization and writing–review and editing. Natalie Corbett served in a supporting role for conceptualization and writing–review and editing. Rebecca Waller served as lead for conceptualization, data curation, funding acquisition, methodology, project administration, resources, and supervision and served in a supporting role for formal analysis. Rista C. Plate and Callie Jones contributed equally to conceptualization and methodology. Rista C. Plate and Rebecca Waller contributed equally to writing–review and editing. Callie Jones, Joshua Steinberg, Grace Daley, and Natalie Corbett contributed equally to data curation.

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features emerging early in life (Picci & Scherf, 2016). Infants distinguish metrical structure (Hannon & Johnson, 2005), pitch (He et al., 2009), and dissonance (Masataka, 2006), while discrimination of tempo (Dalla Bella et al., 2001) and major–minor divisions (Kastner & Crowder, 1990) develop across childhood. These processes happen in parallel with other developmental processes unfolding during the same period and may depend on domain-general mechanisms, expected input, and cultural- or education-specific experiences (Hannon & Trainor, 2007). Music emotion recognition also follows a similar developmental pattern as emotion recognition of other stimuli types (e.g., faces). Children identify happiness early in life and develop recognition of negative emotions later, with reliable recognition of fear emerging after the preschool years (Durand et al., 2007; Eerola & Vuoskoski, 2013; Widen, 2013).

Critically, however, music emotion recognition diverges from emotion recognition of faces in children, contingent on certain characteristics. For example, children with autism spectrum disorder show intact recognition of emotional music, despite differences in recognizing emotion from faces (Stephenson et al., 2016). Thus, evidence suggests that children are sensitive to the emotion conveyed by music, that individual differences in recognizing emotional music relate meaningfully (and with specificity) to different socioemotional difficulties, and that a better understanding of how children process and respond to emotion in music could generate novel insights into emotional development more broadly.

In addition to signaling emotion, music can evoke powerful feelings in the listener. Emotional resonance with music converges with established dimensions of emotional signals, including valence and arousal (Vuoskoski & Eerola, 2011). Different features of music that evoke different emotions reflect multiple, intersecting mechanisms (e.g., brain stem reflex, rhythmic entrainment, evaluative conditioning, contagion, visual imagery, episodic memory, musical expectancy, asthetic judgment model; Juslin & Västfjäll, 2008), including brain stem reflexes, associative learning, episodic memory, and cognitive appraisal (Sakka & Juslin, 2018). Many of these domain-general mechanisms exist early in development (Trehub & Hannon, 2006). From infancy, children can separately convey their resonance (e.g., crying indicating distress; Fox, 1991) and recognition (e.g., via looking times) of emotions (Ruba & Pollak, 2020). However, it remains challenging to disentangle reports of emotion recognition and resonance. Emotion recognition and resonance could be differentially related to core developmental skills, including the possibility that *recognition* relates more strongly to epistemic knowledge (Nook et al., 2020) and *resonance* to socioemotional skills or empathy (Belacchi & Farina, 2012).

Studies also need to investigate the *alignment* of recognizing and resonating with emotional music (e.g., accurately recognizing music as sad and then feeling sad in response to that music). Results from adult studies are mixed, suggesting that emotional music recognition and resonance are often, but not always, in alignment (Gabrielsson, 2001), with negative emotions typically evidencing lower alignment than positive emotions (Kallinen & Ravaja, 2006; Zentner et al., 2008). No prior studies have investigated the alignment of emotion recognition and resonance in children. Addressing this knowledge gap is important because alignment may also work in concert with child characteristics, such as prosocial behavior or emotion knowledge, to promote interpersonal functioning (Cirelli et al., 2014; Clark & Giacomantonio, 2013). Better understanding of how children connect subjective feelings to emotional cues may provide new insights into socioemotional development.

In this study, we aimed to replicate prior research showing that children identify emotion in brief music clips above chance ("recognition"), focusing on scary, sad, or calm music. We also tested the hypothesis that children report *feeling* the emotion conveyed by music ("resonance"). Prior studies suggest that fearful music engages threat-processing systems (Aubé et al., 2015) and have linked sad music to an evoked empathic response (Belacchi & Farina, 2012). Thus, we hypothesized that resonance would be stronger for scary and sad music relative to calm music. Finally, we examined the alignment of recognition and resonance. We hypothesized that recognition and resonance would be moderately correlated, but left as exploratory the question of whether alignment would vary as a function of emotion type. For each aim, we hypothesized that more accurate recognition, higher resonance, and greater alignment would be evident among older children (Gregory et al., 1996), and those with higher emotion verbal expressivity (Barrett et al., 2007) and empathy (Decety & Jackson, 2004).

Method

Participants

Participants were 135 English-speaking children ($M_{age} = 5.98$ years, $SD_{age} = 0.54$; 78 female, 56 male; eight Asian, 43 Black, 62 White, 13 biracial, nine "other") recruited from a city in the northeastern United States (see the online supplemental materials for more details). We assessed 5- to 6-year-olds because this age period is when emotion recognition is still developing, particularly for negatively-valenced emotions (Widen, 2013).

Design and Procedure

As part of the Social Affiliative Mechanisms of Empathy study, participants completed two waves of data collection separated by approximately 6–8 weeks (see the Methods in the online supplemental materials for more details). For both waves, the parent and child participated in a 45-min Zoom call hosted by a trained research assistant who navigated the child through the emotional music tasks. Parents responded to questionnaires via a Qualtrics survey after the visit. The University of Pennsylvania Institutional Review Board approved the research.

Measures

Music Emotion Listening Task

Music Emotion Listening Task (MELT) includes 21 instrumental (i.e., no lyrics) music clips, each 5 s long, validated by previous research (Bigliassi et al., 2015; Eerola & Vuoskoski, 2011; Nawrot, 2003; Omar et al., 2010; Quintin et al., 2011; Robazza et al., 1994; Spackman et al., 2005; Vieillard et al., 2008). There are seven clips each for calmness, sadness, and fear (see the online supplemental materials for more details). Participants completed the recognition or resonance versions of MELT separately, with the order randomly assigned across visits. For both, participants completed two practice trials where they heard a music clip and selected a response. Participants could not respond until the entire clip had played and could not repeat the clip. To test recognition,

participants categorized a clip as "sad," "calm," or "scary" by selecting the emotion conveyed in the music using a validated and colored pictorial scale that reduced reliance on verbal/reading ability (Figure S1 in the online supplemental materials; Chester et al., 2023). The response options were on the screen while the participants listened to the clips to remove memory requirements in the task. To test resonance, participants listened to each music clip and were asked, "How does the music make you feel?" with the following response options: "calm," "scared," "sad," "happy," or "angry." We included additional options in the resonance task to minimize the constraints on children's subjective responses while maintaining an age-appropriate number of options for children. For both tasks, children could also respond "I don't know" for any trial (0% of responses on the recognition task were, "I don't know"; 8% of responses on the resonance task were, "I don't know").

Child Emotion Verbal Expressivity

Children named all the emotion/feeling words they knew in 30 s (total score; the online supplemental materials includes instructions, and Table S1 in the online supplemental materials has descriptives). We also evaluated overall verbal fluency in a productive word task where children were asked to name all the "A" words they knew in 30 s then all the "S" words they knew in 30 s (mean of total "A" and "S" words).

Child Empathy

We assessed empathy using parent reports on the 23-item Griffith Empathy Measure (Dadds et al., 2008). Items are on a 9-point scale (-4 = *strongly disagree* to 4 = *strongly agree*; we used total scores; recognition: $\alpha = .83$; resonance: $\alpha = .84$; correlation across visits: $r = .68$, $p < .001$).

Transparency and Openness

Analytic strategy and tools are available in the online supplemental materials. Deidentified datasets and analysis scripts are available on the Open Science Framework (https://osf.io/8u627/). The experimental task will be shared upon request. We report how we determined our sample size, all data exclusions, and all manipulations and measures in the study. Design and analyses were not preregistered.

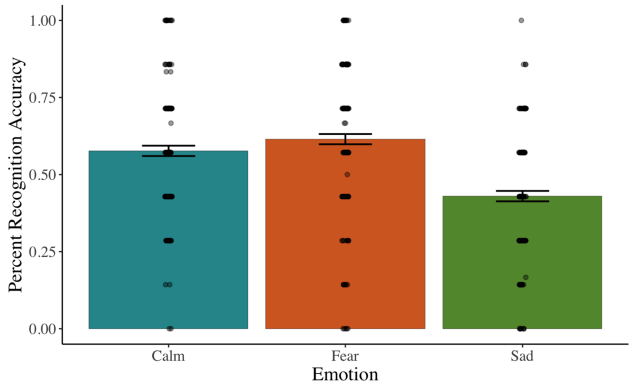
Results

Emotion Recognition

Children accurately recognized emotional music above chance, chance was 25% for four response options: calm, sad, scared, and "I don't know"; $M_{\text{PercentCorrect}} = 54\%$, $t(123) = 19.38$, $p_{\text{adj}} < .001$. Accuracy was also above chance for each separate emotion (Table S2 in the online supplemental materials). Children categorized sad music with less accuracy than calm or scary music, $F(2, 246) = 27.09$, $p < .001$, $\eta^2_g = .10$; calm-vs.-fear $t(123) = -1.26$, $p_{\text{adj}} = .63$; calm-vs.-sad $t(123) = 5.48$, $p_{\text{adj}} < .001$; fear-vs.-sad $t(123) = 7.56$, $p_{\text{adj}} < .001$ (Figure 1; Figure S2 shows accuracy for each music clip individually). Visit order, condition, gender, or whether the clips had been validated in a child sample were unrelated to accuracy ($ps > .07$).

Figure 1

Recognition Accuracy by Emotion Conveyed in Music



Note. See the online article for the color version of this figure.

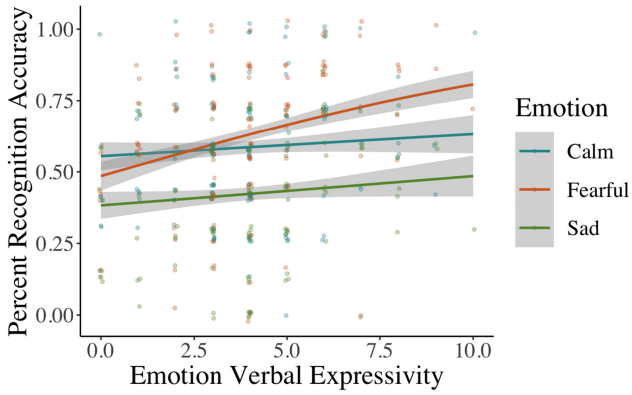
Emotion recognition accuracy was higher in older children ($\beta = .30$, $t = 3.38$, $p < .001$), which was similar across emotion types. Emotion verbal expressivity was also associated with accuracy, such that children who had verbalized more emotion words were better at recognizing emotional music ($\beta = .20$, $b = .02$, $t = 2.04$, $p = .04$), with a significantly stronger association for scary versus sad and calm music, $\chi^2(2) = 6.18$, $p = .045$; calm-vs.-fear $z = -2.27$, $p = .02$; sad-vs.-fear $z = -2.08$, $p = .04$; sad-vs.-calm $z = .19$, $p = .85$ (Figure 2). In contrast to emotion verbal expressivity, verbal fluency (A/S words) was not associated with recognition accuracy. Finally, empathy was not related to emotion recognition accuracy nor was the interaction between empathy and emotion type significant ($ps > .10$).

Emotion Resonance

Children reported feeling the emotion conveyed in the music above chance on average, chance = 17% for six response options; $M_{\text{PercentCorrect}} = 41\%$, $t(128) = 16.00$, $p_{\text{adj}} < .001$, and for each emotion (Table S2 in the online supplemental materials). Children

Figure 2

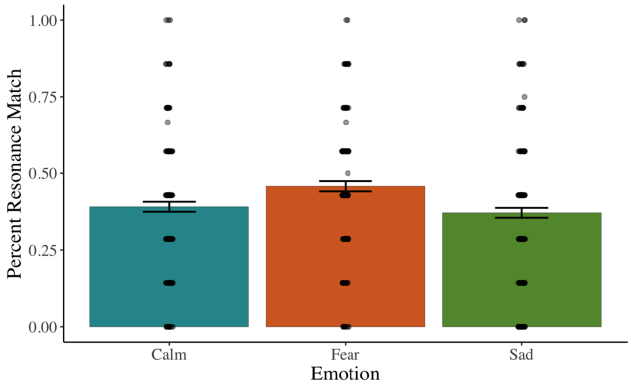
Relationship Between Emotion Verbal Expressivity and Recognition Accuracy by Emotion



Note. See the online article for the color version of this figure.

Figure 3

Resonance Match by Emotion Conveyed in Music



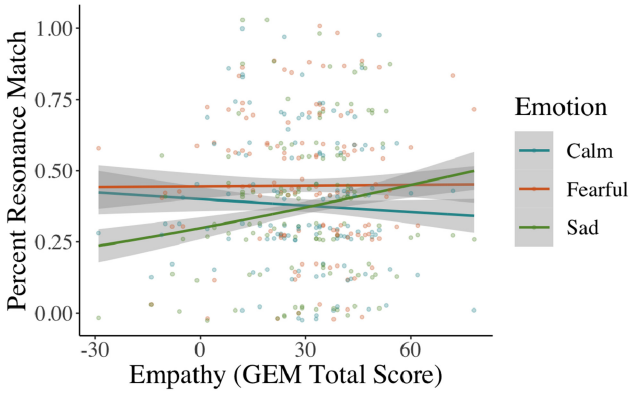
Note. See the online article for the color version of this figure.

were more likely to report feeling scared when hearing fearful music than they were to report feeling sad or calm in response to sad or calm music, $F(1.82, 232.80) = 5.44$, $p = .006$, $\eta^2_{lg} = 0.02$; calm-vs.-fear $t(128) = -2.54$, $p_{adj} = .04$; calm-vs.-sad $t(128) = 0.61$, $p_{adj} = 1.00$; fear-vs.-sad $t(128) = 3.57$, $p_{adj} < .001$ (Figure 3; Figure S3 shows resonance for each music clip individually). Resonance was unrelated to visit order, condition, gender, or whether the clips had previously been validated in a child sample ($ps > .06$).

Unlike emotion recognition, we found no association between age and resonance nor did age interact with emotion type ($ps > .10$). That is, children resonated with emotional music similarly at different ages. Emotional resonance was also not significantly related to emotion verbal expressivity, overall verbal fluency, or empathy ($ps > .10$). However, the interaction between empathy and emotion type was significant, $\chi^2(2) = 6.11$, $p = .047$, such that children with lower empathy exhibited lower resonance with sad music relative to calm or scary music (calm-vs.-fear $z = -0.62$, $p = .53$; calm-vs.-sad $z = -2.39$, $p = .02$; fear-vs.-sad $z = -1.80$, $p = .07$; Figure 4).

Figure 4

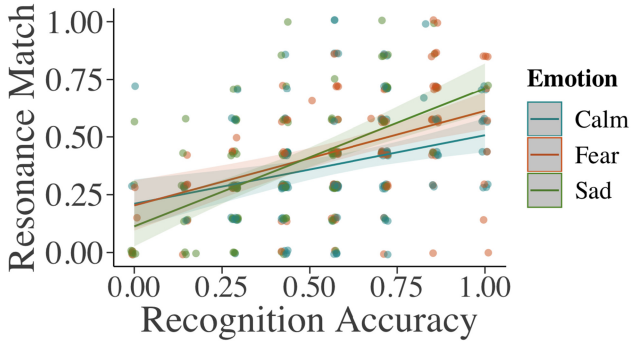
Relationship Between Empathy and Resonance Match by Emotion



Note. GEM = Griffith Empathy Measure. See the online article for the color version of this figure.

Figure 5

Relationship Between Recognition Accuracy Resonance Match (i.e., "Alignment") by Emotion



Note. See the online article for the color version of this figure.

Alignment of Recognition and Resonance

There was alignment between children's recognition of and resonance with emotional music, $\beta = .30$, $\chi^2(1) = 67.33$, $p < .001$ (Figure 5). The strength of this relationship was moderated by emotion type, $\chi^2(2) = 6.02$, $p = .049$; alignment was stronger for sad music compared to calm music (calm-vs.-fear $t = -0.97$, $p = .33$; calm-vs.-sad $t = -2.43$, $p = .02$; fear-vs.-sad $t = -1.62$, $p = .11$). Task order, condition, and gender ($ps > .10$) did not influence the relationship between recognition and resonance. In terms of individual differences, age, emotion verbal expressivity, and empathy were also not related to the degree of alignment and the interaction of child factors and emotion type did not moderate alignment ($ps > .09$).

Discussion

Our findings add to the literature by demonstrating emotion recognition of music among 5- to 6-year-old children. In addition to establishing the feasibility of a brief online assessment, we show that music emotion recognition is associated with emotion verbal expressivity, which coheres with literature establishing synergy between emotional language and emotion recognition (Hoemann et al., 2019). In a second assessment (separated by 6–8 weeks), children subjectively reported resonance with music. Resonance was relatively low when tested against a conservative chance value, suggesting more variability in the evoked feelings. Unlike recognition, there were no effects of age and emotion verbal expressivity on resonance. However, resonance with sad music was lower among children with lower empathy. These results should be interpreted with caution given potential collinearity between our empathy measure and resonance with sad music. However, observing relationships between emotion expressivity and age with recognition, but not resonance, lends weight to the notion that recognition relates to epistemic knowledge (Nook et al., 2020) while resonance plays a more prominent role in socioemotional skills (e.g., empathy; Belacchi & Farina, 2012). To inform intervention targets, we need research that investigates the relationship between empathy and music by integrating subjective report measures with objective measures of resonance (e.g., skin conductance, facial movements). Such an approach

could also help to distinguish between emotion recognition of music during the task and emotion activation in the listener.

Finally, we found alignment between recognition and resonance, with a stronger effect for sad music. A stronger connection between recognition and resonance for sad music is somewhat surprising given our finding that children overall had relatively lower recognition of sadness. It may be that among children who did accurately recognize sadness in our sample, there was a greater degree of resonance, though our results cannot speak to directionality. As none of our hypothesized child-level factors moderated the degree of alignment, future studies are needed to identify other sources of individual differences that could impact the relationship between recognition and resonance. Nevertheless, our findings increase the appeal of music to explore emotional development, particularly because emotional music resonance has been linked to increases in prosocial behavior and compassion (McDonald et al., 2022). Music could be usefully added to a toolbox of measures and contexts used to understand emotional development, with alignment reflecting a broader construct of emotional coherence that could be further understood by investigating myriad types of emotion signals, including music, vocal, and facial signals.

Our findings should be considered in the context of several key limitations, including more response options for the resonance versus recognition task (which may have resulted in a higher likelihood of within-valence confusion), use of a pictorial scale, brief and instrumental-only music clips, and a sample limited to one region in the United States with highly educated parents. Additionally, future research could measure music exposure and experience (e.g., music education; Mualem & Lavidor, 2015) and features of the child's emotional environment, which were not measured in the present study, but could elucidate relevant mechanisms that are well studied in the realm of emotion judgments, including context and conceptual knowledge (Brooks & Freeman, 2018). The ability to integrate these cues and make fine-grained distinctions along dimensions of valence and arousal changes over the course of development (Ruba et al., 2020), which needs further study within prospective designs of music recognition and resonance in children. Future studies need to include stimuli encompassing a wider range of emotional signals to build a comprehensive understanding of recognition and resonance across the full emotional space. Future research may also consider the component and dynamic features of the emotional signals. As a foundational step in this direction, we conducted a post hoc analysis of the relationships between features of the emotional music (i.e., tempo and key) and recognition and resonance. Children showed better recognition of sad clips with slower tempos (but accuracy did not vary based on tempo for calm or scary clips). Children also reported stronger resonance with sad and scary clips with slower tempos (full results in the online supplemental materials, "Analysis of Music Features: Key and Tempo").

Together, our study highlights the utility of using music clips to contribute to knowledge about the development of emotion recognition and resonance, reducing confounding influences of commonly studied social or contextual cues, such as language or body posture. Our results provide insights into emotional development in the absence of direct social signals. Finally, we show that children's ability to recognize and resonate with emotional music is associated with relevant individual differences and socioemotional characteristics.

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