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Echoing the emotions of others: empathy is related to how adults and children map emotion onto the body

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ABSTRACT
Empathy involves a mapping between the emotions observed in others and those experienced in one's self. However, effective social functioning also requires an ability to differentiate one's own emotional state from that of others. Here, we sought to examine the relationship between trait measures of empathy and the self-other distinction during emotional experience in both children and adults. We used a topographical self-report method (emBODY tool) in which participants drew on a silhouette of a human body where they felt an emotional response while watching film and music clips, as well as where they believed the character in the film or performer was feeling an emotion. We then assessed how the degree of overlap between the bodily representation of self versus other emotions related to trait empathy. In adults, the degree of overlap in the body maps was correlated with Perspective Taking. This relationship between cognitive empathy and degree of overlap between self and other was also found with children (8–11 years old), even though children performed worse on the task overall. The results suggest that mapping emotions observed or imagined in other's bodies onto our own is related to the development of empathy.

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Empathy; emotion; body maps; music; film; child development

> Empathy is about finding echoes of another person in yourself. (Mohsin Hamid)

Successful social functioning depends on our ability to identify, connect with, and appropriately react to the feelings of others. This capacity to recognise and experience the emotional states of others is referred to as empathy (Decety & Jackson, 2004). Previous research has shown that highly empathic individuals are more likely to attend to emotionally-relevant information and to understand as well as to spontaneously adopt the emotional states of others (Zaki, Bolger, & Ochsner, 2008). Empathy is often conceptualised as having two main subcomponents: a cognitive component and an affective component (Zaki & Ochsner, 2012). Cognitive empathy refers to the ability to explicitly consider and understand the internal states of others through effortful representation and is related to the concepts of mentalising, Perspective Taking, and theory of mind (Shamay-Tsoory, Aharon-Peretz, & Perry, 2009). Affective empathy refers to the ability to vicariously take on the internal states of others, and is related to the concepts of emotional contagion and experience sharing (Shamay-Tsoory et al., 2009).

For an experience to be considered empathic, it is well accepted that an affective state must be induced in the self as a result of recognising an emotional state of another (Singer, 2006). Emotional experiences are characterised by changes that occur in the body in response to an external stimulus (Damasio, 1999). Emotions, when defined this way, i.e. as programmatic bodily state changes, can be separated from the concept of *feelings,* which would refer specifically to the conscious experience of the bodily state changes associated with a particular emotion (Damasio & Carvalho, 2013). Emotions, according to this definition, are therefore external and observable, whereas feelings are internal and subjective (Damasio, 1999).

However, the exact nature of the affective responses, the characteristics of the emotions and the quality of the feelings, that occur during empathic

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experiences remains a matter of debate. Because of this, the types of experiences that can be considered empathic are ill-defined and highly variable (Vignemont & Singer, 2006). Some researchers argue that the internally-experienced affective state must match that of the observed other for the response to be considered empathic, further contending that it is precisely this congruency that separates empathy from related concepts such as sympathy (Singer & Lamm, 2009). Others have remarked that a clear separation between one's own internal state and the internal state of others is also a necessary component of empathy and that this self-other distinction is what enables a person to act and behave prosocially in response to the empathic experience (Decety & Jackson, 2004). To further complicate the issue, the ways in which we comprehend the mental state of another, whether by imagining how we would feel if in the other person's situation or by imaging how that person feels in that situation, can lead to different emotional experiences and ultimately different behaviours (Batson, Early, & Salvarani, 1997). Here, we define empathy as any situation in which a person experiences an emotion in response to an emotion recognised in another person. This includes both direct observation of another or imagination of how another would feel. What remains uncertain is how the content of the emotional experience during empathic situations overlaps with the content of the recognised emotions in others.

One perspective that may help to resolving some of these outstanding questions regarding empathy is to examine how the cognitive abilities that underlie empathy develop throughout childhood and into adulthood. The available evidence seems to suggest that the cognitive concept of the self, as being a distinct entity from others, appears to develop around 4 months of age (Rochat & Striano, 2002). By 12 months, infants are aware that another person's intentions and goals are separate from their own (Warneken & Tomasello, 2009). Infants at this age help others in need and comfort others in distress (Decety, 2010) and by 24 months, these prosocial behaviours become more specific to the other's needs and occur spontaneously, without any extrinsic motivation (Decety & Meyer, 2008). Interestingly, these helping behaviours persist without overt outward cues of distress, indicating that the child is engaging in some form of Perspective Taking to feel compassion for another's pain without direct observation of that pain (Vaish & Warneken, 2011).

Empathy presupposes that a child can recognise and accurately identify the emotional states of others. Infants as young as 4 months behave differently in response to vocal cues expressing positive or negative affect (Fernald, 1993). Toddlers at the age of 2 can correctly categorise facial expressions along broad categories of valence, though do not categorise them into specific emotional labels (Widen, 2013). The ability to move from broad, bivalent categories of emotions to more refined, specific categories, occurs naturally with age. By 4 years old, children can correctly label emotions conveyed through stories that were read to them (Widen & Russell, 2010) as well as the prosody of spoken language (Morton & Trehub, 2001; Quam & Swingley, 2012) without any additional external cues, such as facial expressions. Similar findings have been found with musical stimuli as well (Morton & Trehub, 2007).

Correctly comprehending another's emotion is linked to empathy in children as well. Children ages 3–7 who have enhanced Perspective Taking are better able to identify the true feelings of others (Belacchi & Farina, 2012). In another study, 5-year-old children, as compared to 10-year-old participants, rarely reported experiencing the same emotion of the character in a film, even though they could still correctly identify the emotional state of that character (Zajdel et al., 2013). Additionally, trait empathy was found to mediate the relationship between age and the experience of a congruent emotion in response to the film clip (Zajdel et al., 2013).

This research provides evidence that children utilise different affective cues from adults to label emotions of others, suggesting that emotional processing, and therefore empathy, continue to change throughout childhood and into adulthood (Knafo, Zahn-waxler, Hulle, & Robinson, 2008). However, the exact nature of how children experience and distinguish between self emotions and those observed or imagined in others remains unclear.

Because empathy requires an emotional response, it is reasonable to presume that empathic responses are grounded in conscious feelings that can be mapped onto the body. A recent paper provided evidence that unique patterns of self-reported activation and deactivation across the human body can describe a particular emotion (Nummenmaa, Glerean, Hari, & Hietanen, 2014). Using a self-report, topographical tool in which participants drew on a silhouette of a human body where they felt activity when experiencing an emotion, the researchers were able to show that different emotions were associated with statistically distinguishable body maps, independent of the modality in which they were induced (Nummenmaa et al., 2014). A follow-up study found that children from ages 6–17 years old were also able to associate discrete emotional categories with statistically discriminable body maps and that the specificity of these body maps increased linearly with age (Hietanen, Glerean, Hari, & Nummenmaa, 2016).

In both examples, the emBODY tool allowed researchers to quantify how and where specific emotions are felt and experienced on the body. This tool may therefore provide a novel way of examining the nature of the emotional experience associated with empathy. By assessing how individuals report experiencing an emotion on their body as well as how they imagine that same emotion to be experienced on the body of others, we can quantify and qualify the self-other distinction. Furthermore, we can evaluate how the individual body maps of emotion are related to a trait measures of empathy. Empathy measures have previously been shown to correlate with the frequency with which a person spontaneously matches one's facial expressions to those of an observed other (Sun, Wang, Wang, & Luo, 2015). We used the emBODY tool to extend these findings beyond the face alone, by evaluating how self vs. other emotions map onto the entire body and how this mapping relates to empathy.

The present study

In two studies, we test whether the overlap between body maps representing felt emotional states and body maps representing emotions of others is associated with trait empathy and age using a topographical self-report measure and ecologically-valid, naturalistic stimuli. In study 1, adult participants watched film clips and listened to music clips designed to evoke one of four possible emotions and reported sensations on the body using a computerised version of the emBODY tool in two conditions: one for the self and one for a character in the film or performer of the piece of music. Trait measures of empathy (both cognitive and affective) were additionally assessed. In Study 2, a sample of children completed a similar task using an age-appropriate measure of empathy and film clips. Movies and music were chosen as stimuli for these studies because they can convey and induce a range of everyday emotions (Juslin, 2013), can depict naturalistic and ecologically-valid emotional situations, and can trigger empathic responses in the viewer or listener (Eisenberg, Spinrad, & Sadovsky, 2006) in adults and children (Zajdel et al., 2013).

To determine if the emotional experiences reported on the body were statistically separable and independent of modality, we conducted classification analyses on averaged body maps to predict the emotion of the stimulus based on the drawing. To determine if empathic abilities is related to the degree to which bodily experiences of felt emotions match bodily experiences of emotions attributed to others, we calculated the degree of overlap between the self and other body maps and correlated these overlap scores with a self-report measure of trait empathy.

Study 1: Body maps of emotion in adults

Methods

Participants

Adult participants were recruited from the University of Southern California ($N = 82$, 59 females, $M_{age} = 22.20$, age range: 18–27, $SD = 1.62$). A post-hoc power analysis indicated that a sample size of 82 would give a power of 0.78 to find a correlation with a moderate effect size (assuming a *p*-value threshold of $p < .05$). Participants completed three separate tasks: (1) emBODY drawings with film stimuli, (2) emBODY drawings with musical stimuli, and (3) a survey to assess personality, mood, and empathy. The order in which the participants completed each of three components was counterbalanced across participants. All participants spoke English and gave informed consent and all experimental procedures were approved by the USC Institutional Review Board.

Stimuli selection

Film and music pieces were selected based on online pilot surveys in which people rated 11 musical clips and 9 film clips in terms of the emotions that they believed the character or the performer was conveying. Sixty people completed the survey (36 females, $M_{age} = 19.73$, age range: 18–58, $SD = 7.82$). Each clip lasted 1.5 min on average. The clips used in the pilot survey were selected by the experimenters based on previous studies using film and music for emotion induction (Schaefer, Nils, Sanchez, & Philippot, 2010), publically available datasets of films and music used for mood induction (Rottenberg, Ray, & Gross, 2007; Yang & Chen, 2012), and online message boards and social media sites dedicated to discussing music and film. For the pilot survey, film clips were selected to convey one of the following emotions: happiness, sadness, fear, as well as several clips believed to convey a mixture of two or more emotions. We included a "mixed" emotional category for films in to address outstanding questions regarding how the ability to process more complex, naturalistic emotions relates to empathy (Zajdel et al., 2013).

Music clips for the pilot survey were selected to convey one of the following emotions: happiness, sadness, anger, and calmness. Given previous research showing the inherent difficulty with inducing anger in response to film clips (Tettamanti et al., 2012), we chose not to include anger as one of the possible emotions for the film clips. We also wanted to avoid the possibility that a participant felt angry because of the actions of the character, rather than because they were observing the character feeling angry. Additionally, we did not include fear as a possible emotion for the music clips because we were primarily interested in studying the self-other distinction during emotional responses to music and we felt that it was unlikely that the performer of a piece of fearful music would be understood as being afraid during the performance. Although using different emotional categories makes it more difficult to directly compare results between these two tasks, we believe that this decision is justified in light of how variable and idiosyncratic emotional response can be to these naturalistic stimuli. Ultimately, the purpose of using two different types of naturalistic stimuli is to evaluate whether more ecologically valid emotional responses can be reliably mapped onto the human body based on self-reported patterns of activation and deactivation, and not to compare results across the two stimuli types.

After listening to a musical clip or watching a film clip, participants in the pilot survey used a 5-point Likert-scale to report how happy/joyful, how angry/tense, how calm/peaceful, how sad/sorrowful, and how fearful/afraid the character or performer felt in the clip or while performing the piece of music, from 1 (not at all) to 5 (very). We then selected film clips and music clips that had the highest average ratings for the question corresponding to the intended emotion of the stimulus. Two clips were selected for each of the four emotional categories. For example, the two clips that had the highest reported rates of induced "happiness" were selected as the two "happy" clips. For the "mixed" emotional category, we selected film clips in which people reported consistently experiencing both happiness and sadness. Specifically, we selected the two clips in which the absolute value of the difference between the "happiness" and "sadness" ratings were the lowest. For the music clips, one exemplar for each emotion contained lyrics and the other did not contain lyrics. The 8 film clips and 8 music clips that were selected and used in this study are presented in Table 1. For full list of

Table 1 . List of (A) film stimuli and (B) musical stimuli and intended emotions of each.

A. Film

Title	Scene	Emotion
Cast Away	Tom Hanks makes fire	Happy 1
Little Miss Sunshine	Abigail Breslin finds out she made it into the beauty pageant	Happy 2
Blue Valentine	Ryan Gosling and Michelle Williams break up	Sad 1
Basketball Diaries	Leonardo DiCaprio begs his mom for money	Sad 2
Misery	Kathy Bates tortures James Caan	Fear 1
Copycat	Harry Connick Jr. tries to kill Sigourney Weaver	Fear 2
About Schmidt	Jack Nicholson receives a letter from a Tanzanian boy who he has been supporting	Mixed 1
Life is Beautiful	Roberto Benigni and his son send a message to his wife over the concentration camp guard tower	Mixed 2

B. Music

Title	Artist	Emotion	Lyrics
Fascination	Alphabeat	Happy 1	Yes
Symphony No. 6 – *3rd mvmt*	Beethoven	Happy 2	No
9 crimes	Damien Rice	Sad 1	Yes
Symphony No. 5 – *Adagietto*	Mahler	Sad 2	No
All Hail to the New Flesh	Strapping Young Lad	Angry 1	Yes
Requiem – *Dies Irae*	Verdi	Angry 2	No
The Beautiful Girls	La Mar	Calm 1	Yes
Piano Concerto, op. 11	Chopin	Calm 2	No

stimuli used in the pilot study as well as further details on the pilot survey and stimuli selection, see Supplementary Materials and Supplementary Table 1.

Procedure and measures

During testing sessions, the experiment was presented on a MacBook computer, with all measures programmed using Psychtoolbox.

EmBODY tool. To report their emotional responses during film viewing or music listening, participants used a computerised version of the emBODY tool (Nummenmaa et al., 2014) with several key modifications. Participants were presented with two silhouettes of a human body, one for reporting increasing or stronger activity in response to the stimulus and the other for reporting decreasing or weakening activity in response to the stimulus. Participants were presented with the silhouettes once for the *self* condition, in which they were instructed to use the mouse to colour on the bodies where they felt increasing or decreasing activity in response to the stimulus, and once for the *other* condition, in which they were instructed to colour on the bodies where they believed a specified character in the film, or performer of the piece of music, was feeling increasing or decreasing activity. In the film task, participants were presented with a picture of the character from the film clip for whom they should report their responses. The order of self and other for each trial was completely random (see Supplementary Figure 1 for an example trial and instructions).

After completing the drawings for both conditions, participants were asked to select the emotion they felt most strongly in response to the clip out of the following choices: happy, sad, fear, angry, calm, or more than one emotion. Using a 5-point Likert scale, they additionally selected how intensely they felt that emotion (1 – very little, 5 – very strongly). They then selected the emotion they believed the character/performer was feeling most strongly in the clip as well as how intensely the character/performer felt that emotion using the same Likert scale as in the *self* condition. Finally, using a 5-point Likert scale, participants reported how much they enjoyed the clip (1 – strongly dislike, 5 – strongly like) as well as how familiar they were with the clip (1 – not at all familiar, 5 – extremely familiar). These five questions were always presented in the same order.

All film trials were presented together and all music trials were presented together, but the order of the two tasks (film or music) was counterbalanced across participants. Within each task, the order of the individual stimuli, as well as the order of self or other drawing conditions, was randomised. No differences in ratings of emotional experience nor in overlap scores were found between participants who received the film task first and those who received the music task first (see Supplementary Materials for results testing the effects of order).

Survey. All participants completed a survey in the lab on a MacBook computer screen, either at the beginning of the study or at the end, the order of which was counterbalanced across all participants. The survey that included questionnaires designed to assess current mood, personality, trait empathy, and basic demographic information. Empathy was measured using the Interpersonal Reactivity Index (Davis, 1983). Because subtypes of empathy are known to correlate with various personality traits (De Corte et al., 2007), we included a measure of the Big 5, the Ten Item Personality Index (TIPI; Gosling, Rentfrow, & Swann, 2003). Mood has been shown to influence emotional responses to music and film (Vuoskoski & Eerola, 2011) and was assessed both before and after stimuli presentation using the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). The PANAS contains four subscales, each of which represent one quadrant of a bi-dimensional space of arousal and valence: positive activation (PA) mood, positive deactivation (PD) mood, negative activation (NA) mood, and negative deactivation (ND) mood. Each participant completed the PANAS twice, once at the beginning of the study and once at the end so that we could measure how, and along what dimensions, mood changed in response to the stimuli. All other measures were collected only once, either before or after the emBODY drawings, the order of which was counterbalanced. The survey also included an attention check question. One participant failed to correctly answer this attention question and was subsequently excluded from further analysis.

emBODY tool analysis. All data were preprocessed and analysed using Matlab R2013b. Data from completed drawings contained information regarding the intensity of the drawing at each location of the body. To account for slight variations in the level of precision regarding the location of reported bodily sensations, the data were smoothed using a Gaussian kernel with a sigma value of 5. For each trial and each condition (self vs. other), the decreasing-activity body map was subtracted from the increasing-activity body map. Locations on the body where the drawings were, on average, statistically different from zero were mapped onto a blank silhouette of the body, resulting in an image that reflects the locations where bodily changes occurred for each emotional state. The pre-processing steps are described further the Supplementary Materials.

Classification analysis. Classification was performed using the PyMVPA software package (Hanke et al., 2009) in combination with LibSVM's implementation of a multi-class (4-way) linear support vector machine (SVM; http://www.csie.ntu.edu.tw/~cjlin/libsvm/) to predict one of four emotion labels based on the bodily drawings. In the LibSVM environment, the multi-class implementation of linear SVM performs a series of binary, one vs. one classifications combined with a voting strategy using every combination binary classification results to designate the ultimate label. The cost parameter was determined automatically by the classifier according to the norm of the data. This classification analysis was conducted both within and across the two conditions (self vs. other) as well as within and across the two trial types (music vs. film). Prediction accuracy of our model was evaluated using a leave-one-participant-out cross-validation procedure. See Supplementary Materials for details on the classification analyses.

Degree of overlap between self and other conditions. The degree of spatial overlap between the self and other body maps was calculated for each trial by assessing the number of pixels in the two bodies that contained the same value (either activation or deactivation) at each location, divided by the number of pixels that contained different values (activation or deactivation on either self or other but not both). The resulting value is a ratio of overlap between the self and other body map, with numbers greater than 1 indicating that the self and other body maps were more spatially similar than different, whereas numbers less than 1 indicate that the self and other bodies were more spatially distinct. See Supplementary details for further information on how overlap scores were calculated. Multiple regression was then conducted to determine partial correlations between measures of empathy and self-other overlap, while controlling for gender, age, personality, and mood.

Results

Emotion labels of film and music clips

Several participants had to be removed from the subsequent analysis due to errors in recording or inappropriate responses to the attention check question in the survey. We removed any participant who was unable to complete all trials of a given task, which occurred on several occasions when either the custom Matlab script or the online emBODY tool failed to execute properly. A total of 76 people completed all the film clip ratings and 68 people completed the entirety of the music task as well as the survey.

We first evaluated the frequency with which people reported experiencing the intended emotion of the clip as well as the frequency with which people reported that the character was experiencing the intended emotion of the film clip ("accuracy" of emotion label). On average, participants reported experiencing the intended emotion themselves 62% of the time and that the character in the film was experiencing the intended emotion 58% of the time. Both accuracies were determined to be significantly greater than what would be expected by random guessing (1/4 = 25% chance of correctly identifying the intended emotion) according to a one-way t-test (self: t (78) = 19.05, $p < 0.001$, Cohen's $d = 2.14$; other: $t(78) = 16.33$, $p < 0.001$, Cohen's $d = 1.84$). The reported emotional state of the performer of the piece of music matched the intended emotion of the piece of music 54% of the time and the reported emotional state of the participant matched the intended emotion 57% of the time. Both accuracies were determined to be significantly greater than chance of 25% according to a one-way t-test (self: $t(78) = 16.41$, $p < 0.001$, Cohen's $d = 1.85$; other: $t(78) = 14.59$, $p < 0.001$, Cohen's $d = 1.64$). Interaction effects of emotion by condition as well as self-report ratings of intensity are presented in the Supplementary Materials.

emBODY results

The average body maps for each film clip are shown in Figure 1(A and B) for the music clips. Visual inspection of the averaged body maps appear to match colloquial and cross-cultural understanding of emotions and where they are felt on the body, such as in the head and on the chest (Nummenmaa et al., 2014). Participants also reported more activity on the body during higher arousal emotions, i.e. anger and happy, and less activity on the body in response to low-arousal emotions, i.e. sadness and calm.

Classification results

Any trial in which the participant did not draw on either the left activation image or the right

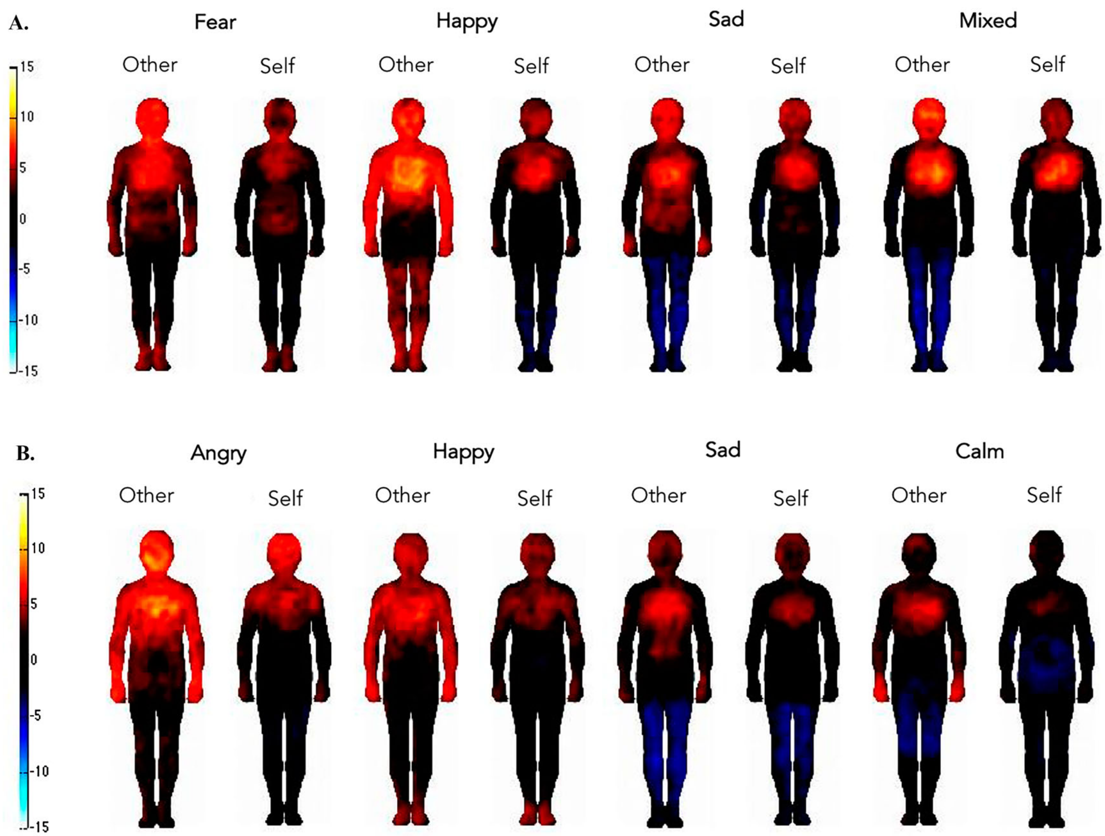

Figure 1. Visualisation of averaged emBODY results in response to (A) film clips and (B) music clips by condition and emotion. Images were created by subtracting the decreasing-activity body map from the increasing-activity body map for each trial and the two trials per each emotion were averaged. Univariate t-tests were conducted to compare pixelwise activation and deactivation of the resulting body maps against zero. False discovery rate (FDR) correction with an alpha level of 0.05 was applied to the statistical maps to control for Type I and pixels where drawings were statistically different than zero were then projected back onto a blank silhouette. The colour bar indicates t-statistic range. Red-yellow represents regions of the body map that were significantly more activated than deactivated in response to the film. Blue represents regions of the body map that were significantly more deactivated than activated.

deactivation image was removed. Thirty-one trials were removed for this reason, resulting in 1,198 unique film maps and 1,079 unique music maps. After subtracting deactivation maps from activation maps, a principal components analysis was conducted for each condition to reduce the data to 220 components that explained greater than 95% of the variance.

For the film clips, the SVM classifier successfully predicted the intended emotion of the clip 40% of the time (average across all cross-validation folds). This was found to be significantly above chance (25%) according to permutation testing ($p < 0.001$). The accuracies for predicting the emotion label only within the other condition were higher, at 50% overall, whereas the accuracy with the drawing from the self condition was 36%. Both self and other condition accuracies were found to be statistically above chance according to permutation testing at $p < 0.001$. Training on the self condition data and testing on the other condition body maps resulted in an overall accuracy of 37%. The reverse cross-classification results in an accuracy of 35%, both of which were considered significantly above chance according to permutation testing with 1000 random permutations of emotion labels ($p < 0.001$).

For the music clips, the SVM classifier successfully predicted the intended emotion of the clip 35% of the time. Within the other condition, average accuracy was 36%. Within the self condition, average accuracy was 31%. Both were determined to be statistically greater than chance according to permutation testing at $p < 0.001$. Training on the self condition data and testing on the other condition body maps resulted in an accuracy of 33%. The reverse cross-classification results in an accuracy of 36%, both of which were considered significantly above chance according to permutation testing with 1000 random permutations of emotion labels ($p < 0.001$). The accuracies corresponding to each emotion individually for both film and music are presented in Table 2 and additional metrics of classification performance are presented in Supplementary Table 2. Confusion matrices are presented in Supplementary Figure 4A–C for film and Supplementary Figure 4D–F for music.

Finally, we conducted the classification analysis across tasks, training on the body maps from the music task and testing on the body maps from the film task and vice versa. Only data from the happy and sad trials were included in this analysis, as they were the only emotions present in both the film and music conditions. Training on the music body maps and testing on the film maps resulted in an overall accuracy of 57%, which was significantly greater than theoretical chance (50%) according to permutation testing ($p < 0.001$). The reverse cross-classification, training on film and testing on music, resulted in an accuracy of 54% and was not significant ($p = 0.50$).

Spatial overlap between the self and other condition

The spatial overlap between self and other drawings was calculated as described in the Supplementary Materials and the regions that exhibited significant overlap across participants are presented in Figure 2 (A) (film) and (B) (music).

For the film task, the average overlap measure between self and other condition was 0.57 (SD = 0.41). A one-way ANOVA showed that there was a significant main effect of emotion, $F(3,225) = 4.58$, $p = 0.004$, $\eta^2_G = 0.03$. Post-hoc t-test revealed that the degree of overlap in the mixed emotion trials (M = 0.71, SD = 0.57) was significantly greater than in the happy emotion condition (M = 0.43, SD = 0.76; $t(75) = 2.84$, $p = 0.02$ corrected; see Supplementary Figure 5).

Table 2 . Classification accuracies for predicting the intended emotion of the stimulus based on the body maps per condition and trial type.

	Self		Other	
Emotion	Film	Music	Film	Music
Happy	0.39	0.25	0.46	0.25
Sad	0.19	0.34	0.44	0.41
Calm	–	0.25	–	0.40
Fear	0.46	–	0.45	–
Angry	–	0.35	–	0.38
Mixed	0.37	–	0.63	–
All	0.35	0.31	0.50	0.36

Note. *p < 0.05.

For the spatial overlap between the self and other drawing during the music task, the overall overlap between self and other was 0.57 overall (SD = 0.41). A one-way ANOVA showed no significant main effect of emotion, $F(3,207) = 0.30$, $p = 0.82$, $\eta^2_G = 0.002$ (see Supplementary Figure 5).

Correlations and regression with overlap scores

Degree of spatial overlap between conditions across all film clips was positively correlated with the Perspective Taking subscale of the IRI, when controlling for age and gender (ß = 0.19, $t(72) = 2.76$, $p < 0.01$). Perspective Taking remained significantly positively correlated with overall overlap when adding the three other subtypes of empathy (Fantasy, Empathic Concern, and Personal Distress) into the model. None of the other subtypes of empathy were significantly correlated with overall spatial overlap. Positive activation mood (before stimulus presentation) was also found to be positively correlated with overall overlap, when controlling for age, gender, and the other measures of empathy (ß = 0.10, $t(65) = 2.20$, $p = 0.03$, see Table 3). Post-hoc correlation analyses showed that positive activation mood was also positively correlated with degree of felt emotional response to the film clips, as indicated by self-report ratings of intensity of felt emotional response ($r(75) = 0.32$, $p < 0.01$) as well as the amount of overall drawing on the body maps in the self condition ($r(74) = 0.23$, $p = 0.04$).

Degree of spatial overlap between conditions averaged across all music clips was found to be positively correlated with Perspective Taking, when controlling for age, gender, and years of music training (ß = 0.24, $t(62) = 2.10$, $p = 0.04$). Perspective Taking remained significantly positively correlated with overall overlap when adding the three other subtypes of empathy (Fantasy, Empathic Concern, and Personal Distress) into the model. Positive activation mood (before stimuli presentation) was found to be positively correlated with overall overlap, when controlling for age, gender, years of musical training, and all measures of empathy (ß = 0.18, $t(58) = 2.78$, $p = 0.007$, see Table 4). For the music stimuli, positive deactivation mood was also positively correlated self-report ratings of intensity of felt emotional

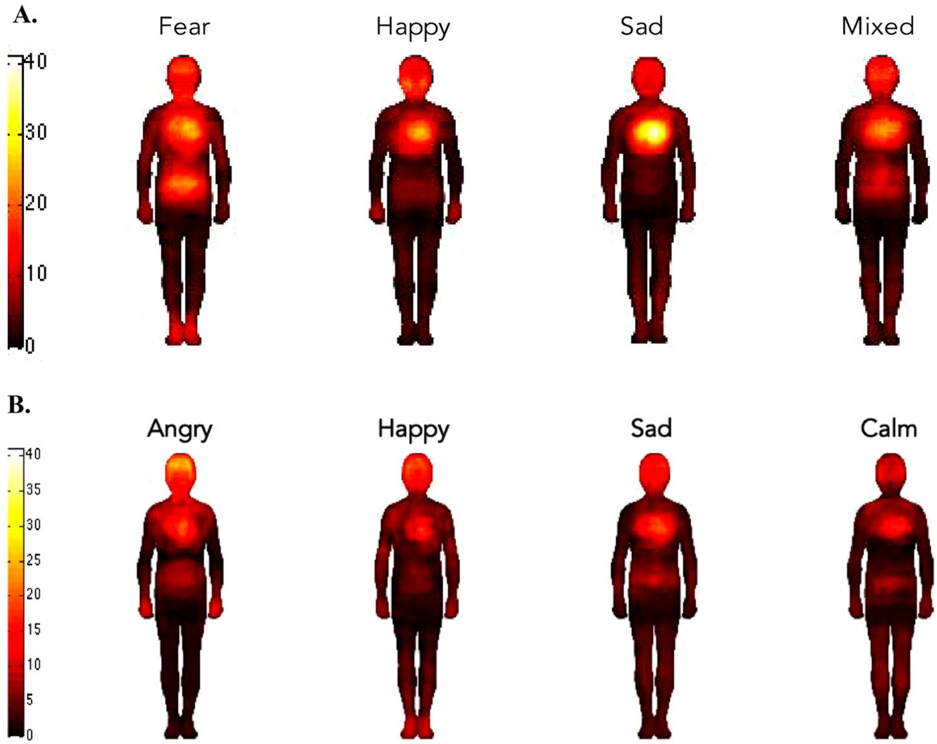

Figure 2. Spatial overlap between self and other for (A) film and (B) music. Each body map was binarised so that + 1 indicated that the participant drew on the activation body more so than the deactivation body, and −1 indicated the participant drew on the deactivation body more so than the activation body. For each trial, the self body maps were compared to the other body maps by calculating the number of pixels that contained the same value for both drawing at the same location. The spatial overlap between the self and other condition per trial and emotion was visualised by plotting the number of participants that had the same value at each pixel on the body. Yellow colours signify that more participants had the same number at that particular location at the body, i.e. more participants reported feeling the same way in this location as the character or performer(s).

Table 3 . Multiple regression models predicting film spatial overlap scores using various self-report measures as predictors.

Variable	Model 1	Model 2 (add IRI)	Model 3 (add TIPI)	Model 4 (add PANAS)	Model 5 (all)
Age	−0.03	−0.04	−0.04	−0.06	−0.06
Gender	0.00	0.02	0.03	0.05	0.05
Perspective Taking	**0.19****	**0.17***	**0.17***	**0.15***	**0.17***
Fantasy	–	0.05	0.04	0.03	0.03
Personal Distress	–	−0.13	−0.14	−0.10	−0.11
Empathic Concern	–	0.02	−0.02	0.04	0.00
PA mood	–	–	–	**0.10***	**0.10***
PD mood	–	–	–	−0.09	−0.09
NA mood	–	–	–	0.06	0.06
ND mood	–	–	–	−0.12	−0.12
Openness	–	–	0.04	–	0.02
Conscientiousness	–	–	0.00	–	0.01
Extraversion	–	–	0.02	–	0.01
Agreeability			0.02	–	0.02
Emotional Stability	–	–	−0.01	–	−0.03
R^2	–	0.15	0.17	0.27	0.28
Adjusted R^2	0.05	0.08	0.02	0.16	0.10

Note. *p < 0.05. **p < 0.01.

Table 4 . Standardised beta values for multiple regression models predicting music spatial overlap scores using various self-report measures as predictors.

Variable	Model 1	Model 2 (add IRI)	Model 3 (add TIPI)	Model 4 (add PANAS)	Model 5 (all)
Age	0.02	0.01	0.00	0.00	−0.02
Gender	0.07	0.07	0.04	0.17	0.13
Perspective Taking	**0.22***	**0.24***	**0.29***	**0.22***	**0.30***
Fantasy	–	0.06	0.04	0.05	0.03
Personal Distress	–	−0.06	−0.08	0.01	−0.03
Empathic Concern	–	−0.05	−0.04	−0.12	−0.07
PA mood	–	–	–	**0.18***	**0.20****
PD mood	–	–	–	−0.10	−0.11
NA mood	–	–	–	−0.02	−0.02
ND mood	–	–	–	−0.11	−0.18
Openness	–	–	−0.09	–	−0.11
Conscientiousness	–	–	0.00	–	0.01
Extraversion	–	–	−0.02	–	−0.06
Agreeability	–	–	0.01	–	−0.02
Emotional Stability	–	–	−0.04	–	−0.09
Years Music Training	−0.02	−0.01	−0.01	−0.01	−0.01
R^2	0.10	0.11	0.14	0.25	0.32
Adjusted R^2	0.05	0.02	−0.04	0.11	0.12

Note. $^*p < 0.05$. $^{**}p < 0.01$.

response (r(66) = 0.50, $p < 0.01$) as well as the amount of overall drawing on the body maps in the self condition (r(66) = 0.27, $p = 0.03$).

Discussion

Results from study 1 indicate that in adult participants, self-reported emotion-specific body maps in response to film and music were statistically separable. In addition, maps about one's own body contained relevant and specific information corresponding to how others were imagined to be feeling. Furthermore, the label given to self-reported emotional responses did not always match the emotional label given to the characters in the film or the performer of the piece of music. The emotions were also rated as being more intense in others than in the self. Finally, we found the degree to which a person matched his/her body maps of emotions to the body maps of others was correlated with Perspective Taking.

Study 2: Body maps of emotion for self and other in children

Methods

Participants

Child participants were part of a 5-year, ongoing longitudinal study being conducted in our lab (see Supplementary Materials for more information). In the present study, 60 children between the ages of 8–11 (26 females, $M_{age} = 9.93$, SD = 0.57) from that cohort were included. Because some of these children had extensive music training and others did not, to avoid the potential influence of instrumental instruction on emotional responses to music, child participants completed a version of the emBODY ratings with film clips only.

Procedure and materials

The procedure was largely similar to the film task of Study 1, with several key differences. In study 2, we used child-friendly movie clips that conveyed the emotions happy, sad, and fear (see Supplementary Table 3 for list of stimuli used). After watching the clip, children reported on a 4-point rating scale (1) what emotion the character was feeling, (2) how strongly he/she was feeling it, (3) what emotion they were feeling in response to the movie, and (3) how strongly they felt it. The children then completed a paper version of the emBODY task (using pencils) for both the self and other condition. Resulting drawing were scanned and analysed as described in study 1. The degree of overlap between the self and other bodies for each child was correlated with responses to the Bryant Empathy Index (Bryant, 1982), a self-report questionnaire that assesses empathic abilities in children, and the Reading the Mind in the Eyes Test (RMET) for children, which is a measure of Theory of Mind (Baron-cohen, Wheelwright, Hill, Raste, & Plumb, 2001). Classification analysis using a linear SVM classifier was then conducted on these body maps to predict the intended emotion. As with adults, classification was conducted within each condition (self and other) separately, as well as across conditions.

Results

Self-report ratings of emotion of film clips

On average, children reported that the character in the film was experiencing the intended emotion 96% of the time and reported experiencing the intended emotion themselves 61% of the time, both of which were determined to be significantly greater than theoretical chance (25%) using a one-way t-test (other: $t(60) = 50.51$, $p < 0.001$, Cohen's $d = 3.97$; self: $t(60) = 9.25$, $p < 0.001$, Cohen's $d = 1.18$). Interaction effects of emotion by condition as well as self-report ratings of intensity are presented in the Supplementary Materials.

emBODY results

Averaged body maps corresponding to each of the film clips are presented in Figure 3. In the other condition, similarities between the body maps of adults in study 1 can be seen: the happy and fearful film clips in the other condition were associated with widespread activity throughout the body, but particularly in the head and chest. Sadness in the other condition was associated with deactivation in the extremities.

Classification

Classification accuracy across both conditions was 39.7%, which was significantly greater than chance (0.33) according to permutation testing with 1,000 permutations ($p = 0.02$). Within the other condition only, classification accuracy of emotion was 49.0% ($p < 0.001$). Within the self condition, classification accuracy was 29.2%, which was not significantly above chance ($p > 0.05$). Training on data from the self condition data and testing on the other condition resulted in an accuracy of 38.9% ($p = 0.06$) and training on the other condition and testing on self resulted in an accuracy in 39.3% ($p = 0.03$). The confusion matrices are presented in Supplementary Figure 7.

Spatial overlap between the self and other condition

For the body maps corresponding to the overlap between the self and other condition, no region on the body was found to be significantly above the threshold set by the binomial distribution, meaning that child participants did not consistently draw on the same part of the body across the self and other condition. No significant differences in degree of overlap were found between the film clips (see Supplementary Figure 8).

Furthermore, the degree of overlap between the self and the other condition in the body maps collected from a sample of 60 children completing the emBODY task was in general less than the degree of overlap seen in the adult population. The average overlap score between self and other body maps in the children was 0.32, compared to 0.57 in adults during the film task. A between-within ANOVA was used to compare the degree of overlap across the self and other condition between the adult and children samples. Although children and adults watched different stimuli, both groups watched films intended to convey happiness, sadness, and fear. When comparing the degree of spatial overlap for the two

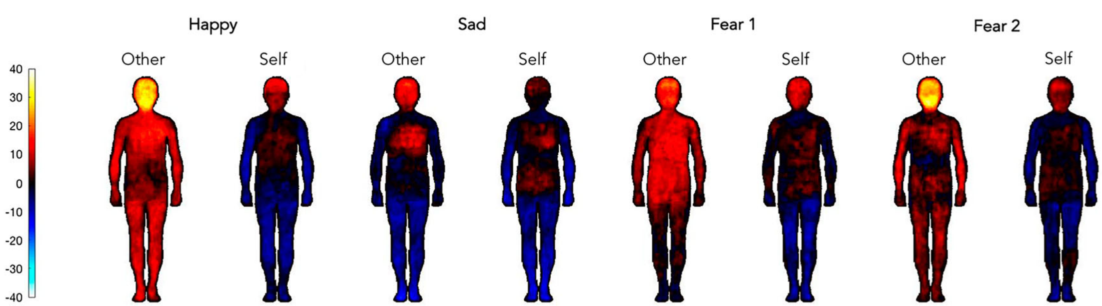

Figure 3. Visualisation of averaged emBODY results with children in response to film clips by condition and emotion. Images were first binarised and the decreasing-activity body map was subtracted from the increasing-activity body map for each trial for each participant. Values at each location were then summed and plotted on a blank silhouette. Red-yellow represents regions of the body map where more children reported increasing activity (more positive values), whereas blue represents regions of the body where more children reported decreasing activity (more negative values).

samples (adult and children) and three emotions (happy, sad, fear), the between-within ANOVA showed a main effect of sample, $F(1,114) = 4.42$, $p < 0.05$. Posthoc analysis showed that overall, the degree of spatial overlap was higher for the adult participants than the children participants, $t(441) = 3.48$, $p < 0.01$. The ANOVA also revealed a main effect of emotion, $F(2,228) = 3.78$, $p < 0.05$: spatial overlap scores were significantly higher in adults than children for the fear clips, but not the sad or happy clips ($t(134) = 3.15$, $p = 0.002$). The results are shown in Supplementary Figure 9.

Correlations and regression

Multiple regression analysis was used to predict overlap scores averaged across all emotions, including age and gender as covariates. Average overlap scores were positively correlated with scores on the Bryant Empathy Index (ß = 0.33, $t(40) = 2.19$, $p = 0.03$). Scores on the RMET were not significantly correlated with degree of overlap in any of the models (Supplementary Table 4). Correlations between the predictor variables are presented in the Supplementary Materials.

Discussion

With a group of child participants, we confirmed one of the findings from Study 1: there was a significant relationship between self-report measures of trait empathy and overlap between the bodily representation of self and other emotional states. At the same, the body maps associated with emotions in children were not statistically separable and the degree of overlap between the self and other was significantly lower than adults, suggesting that self-other distinction may be influenced by development.

General discussion

We sought to better understand how mapping emotions onto one's own body, and the body of another, is related to trait empathy. Using a topographical, self-report measure of emotional experience, we have shown that body maps corresponding to four distinct emotions induced by music and film clips are statistically separable in adults and similar across the two types of stimuli. Furthermore, emotional states mapped onto one's body could be used to predict the body maps of the same emotional states attributed to another and the degree of similarity between the self and other maps was correlated with Perspective Taking, a type of cognitive empathy. Perspective takers have been shown to spontaneously match their emotional state with that of others. Individuals higher on Perspective Taking are more likely to adopt pain-related facial expressions when observing another in pain, for example (Lamm, Porges, Cacioppo, & Decety, 2008). The results from our study corroborate these findings regarding a link between Perspective Taking and emotional resonance by demonstrating that individuals with higher trait-measures of Perspective Taking are more likely to report matching their physical states to those of others.

In addition to Perspective Taking, a participant's mood before the study influenced the degree of overlap between the self and other condition. Participants who were in a more positive, high arousing mood demonstrated greater overlap between the self and other condition. This could indicate that participants who were in a better mood coming into the study were more open to engaging with the stimuli in general. This explanation is supported by the finding that for both the music and the film task, the amount that a participant drew on the body maps was positively correlated with positive activation mood coming into the study. It may also be that being in a positive mood encouraged the more empathic participants to resonate emotionally with others. Indeed, we observed that intensity ratings of the felt emotion in response to the film clips was positively correlated with the pre-PANAS positive activation scores, suggesting that those who were in a better mood felt an emotion in response to the film clips more strongly. Given that intensity ratings were not independently correlated with degree of overlap, it may be that a person's mood enhances the positive relationship between empathy and degree of overlap by motivating the participant to be more engaged with the task and to be open to experiencing emotions observed in others.

When compared to adult participants, the degree of overlap between the self and other body maps was significantly lower in children who watched child-friendly movie clips, potentially indicating that children at this age do not report feeling an emotion on their body in the same way as they imagine another might feel that emotion. Because the children in this study could correctly identify the intended emotion of the film clips, the results cannot be completely explained by an inability to recognise and label the emotions of others. Instead, it may be that the lack of overlap between self and other body maps reflects underdeveloped or alternative Perspective Taking strategies. While certain Perspective Taking abilities have been demonstrated in children below the age of 7 (Decety & Meyer, 2008), a recent neuroimaging study showed that naturally adopting another's perspective develops with age and that this increased efficiency is supported by changes in particular brain networks (Dosch, Loenneker, Bucher, Maring, & Klaver, 2010). Furthermore, children who demonstrated an ability to take both the cognitive and affective perspectives of another person were more likely to report matching the emotions they felt to the emotions being displayed in a video clip (Hinnant & O'Brien, 2007). Our results provide further support for this link between the development of cognitive empathy and emotional resonance in that, in our study, a self-report measure of cognitive empathy was correlated with the degree of overlap between self and other body maps with child participants. In other words, while children did not match their bodily representations of emotions to others as much as adults, the children who did demonstrated higher Perspective Taking abilities.

In adults, the classification results suggested that body maps corresponding to specific emotion were statistically separable from one another. Previous studies have shown that emotions elicited by music and films clips could be successfully classified based on psychophysiological signals (Kreibig & Wilhelm, 2007; Stephens, Christie, & Friedman, 2010) and neural signals (Kim, Shinkareva, & Wedell, 2017; Saarimaki et al., 2016), suggesting that discrete emotional states are characterised by unique patterns of activity in the autonomic nervous system as well as the brain. Additionally, in the original study using the emBODY tool, Nummenmaa et al. (2014) successfully classified the body maps corresponding to particular emotions induced by words, pictures, and short videos. Our results extend these findings by showing that emotions in response to naturalistic film and musical stimuli are additionally represented by self-reported bodily state changes that are unique to that discrete emotional category. Even in the absence of a lexical, affective label, participants could assess changes in the location and intensity of activity in and on their bodies in response to music and film, resulting in unique mappings for emotions of different valence. Furthermore, the patterns of activity reported on the body in response to film and music correspond to known physiological changes associated with the experience of everyday emotions, including significant activation in the chest and head area, which may reflect changes in heart rate, breathing, cognition, as well as the muscles that control facial expressions of emotion, all of which are typical bodily responses associated with an array of possible emotions (Levenson, 2003; Nummenmaa et al., 2014).

It is worth noting that the classification accuracies were not balanced across the emotion labels. That is, sad was more difficult to classify in the film condition and happy and calm were more difficult to classify in the music condition. When examining the confusion matrices, it appears that the classifier most often confused sadness with the mixed emotional state. Given that the mixed emotional film clips were designed to convey both sadness and happiness, it could be that the classifier is biased towards identifying aspects of the drawings that reflect the sad component of this dual-emotional state. For the music task, the happy body state was most often confused with the angry body state. While participants were unlikely to report that the happy piece sounded angry or vice versa, when examining the body maps for angry and happy, they do appear similar in that they both contain strong activations in the shoulders, head, and chest area, compared to other two trial types. Happiness and anger both tend to be characterised by high arousal (Russell, 1980), which may account for pattern of high activation in the body maps as well as for the classifier's confusion.

Classification performance using data from 8–11-year-old children was considerably worse than with adults, particularly in the self condition. This supports the findings from previous work in which body maps of felt emotions in response to emotional labels were less distinguishable in children as compared to adults (Hietanen et al., 2016). Intriguingly, children did not show an attenuated ability to correctly identify the emotional categories being conveyed in the clip, nor to report feeling that same emotion in response. Therefore, it could be that the less-specific body maps seen in children reflect an underdeveloped awareness of bodily changes or an inability to accurately report them. Previous research has shown that children (8–11) performed worse than adults on a task of interoceptive awareness that involved counting the number of heart beats felt during a period of time (Eley, Stirling, Ehlers, Gregory, & Clark, 2004). Using the emBODY tool with children at difference stages of development, Hietanen et al. (2016) reported that classification performance improved linearly with age, concluding that mapping the physiological and visceral responses associated with emotions onto the body is an ability that develops in tandem with other developmental changes in terms of interoceptive awareness and accurate sensation reporting. In our study, children were asked to report the bodily sensations associated with specific emotions on their own body's as well as another's body. The fact that the corresponding emotion of the body state maps attributed to others could be successfully classified suggests that at this age, children may be able to infer and accurately report the emotion-specific, body state changes in others, even without an attenuated ability to accurately report those same changes in their own body. This result may be indicative of differences in the cognitive strategies children use to take the perspective of others. Further research designed to probe how exactly children performed the two tasks, self-reported versus other-reported emotional experience, will be needed to better understand the developmental trajectory of bodily experiences of emotion and empathy.

Limitations

There are several limitations to the present studies and analyses that need to be addressed in future studies. Because cognitive abilities differ between adults and children, we decided to use a separate self-report measures of empathy as well as different stimuli in study 2, preferring scales and film clips that were more suitable for children in that age range. The methodological differences between study 1 and 2 are not trivial and we therefore want to be cautious when interpreting our findings as evidence for development differences between adults and children. Furthermore, none of the other subscales of empathy (cognitive nor emotional) were found to be significantly correlated with percent overlap between the self and other bodily maps of emotions, which may be surprising given the nature of the stimuli that were used. The fact that Perspective-Taking, but not Fantasy, was correlated with overlap may suggest that the matching of self and other bodily experiences of emotions is not influenced by how engrossed, absorbed, or transported the participants felt in response to the clips. Our study does not allow us to determine which cognitive strategy participants were using to complete to task and future research will be needed to determine how these two perspectives might change the resulting body maps.

Conclusion

Empathy is a complex human capacity that guides our emotional experience and lies at the heart of prosocial behaviours and moral development. In this study, we found that trait measures of cognitive empathy, one's tendency to take the perspective of another, is associated with greater overlap between self and other body maps of emotions. While children were less likely than adults to adopt the same bodily experience of emotion as another, a trait measure of cognitive empathy was additionally correlated with the degree of overlap between self and other body maps. By evaluating how both children and adults report experiencing an emotion on their body, and how they attribute these bodily experiences to others, our findings help clarify how we make a distinction between the self and others in empathic situations and if this relationship changes with development, ultimately furthering our understanding of how we can effectively communicate and connect with others.

Disclosure statement

No potential conflict of interest was reported by the authors.

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