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The development of emotion processing of body expressions from infancy to early childhood: A meta-analysis

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QV contributed to the conception and interpretation of the work; conducted the literature search and meta-analysis; worked on the draft of the manuscript. EG contributed to the conception and interpretation of the work; contributed to the literature search; worked on the draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

Keywords

emotion, body expression, development, Discrimination, recognition, Meta-analysis

Abstract

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Body expressions provide important perceptual cues to recognize emotions in others. By adulthood, people are very good at using body expressions for emotion recognition. Thus an important research question is: How does emotion processing of body expressions develop, particularly during the critical first 2-years and into early childhood? To answer this question, we conducted a meta-analysis of developmental studies that use body stimuli to quantity infants' and young children's ability to discriminate and process emotions from body expressions at different ages. The evidence from our review converges on the finding that infants and children can process emotion expressions across a wide variety of body stimuli and experimental paradigms, and that emotion-processing abilities do not vary with age. We discuss limitations and gaps in the literature in relation to a prominent view that infants learn to extract perceptual cues from different sources about people's emotions under different environmental and social contexts, and suggest naturalistic approaches to further advance our understanding of the development of emotion processing of body expressions.

Contribution to the field

An important question is how this ability develops. In this mini-review, we highlight gaps in the research on the development of emotion processing of body expressions in relation to a prominent view that infants learn to extract perceptual cues from different sources about people's emotions under different environmental and social contexts. To address this issue and to provide evidence to guide future research directions, we conducted a meta-analysis of developmental studies that use body stimuli to quantity infants' and young children's ability to discriminate and process emotions from body expressions at different ages. Our review provides a summary and quantification of the existent literature testing infants and children from 3-months to about 7-years-old. This summary will allow other researchers interested in the field to have a holistic view of the evidence to date, including the variety of outcome measurements (e.g., accuracy, EMG, ERPs), body stimuli and experimental manipulations used. We will also make available our data (descriptive statistics extracted from the studies for the meta-analysis) and R scripts to reproduce the findings in our review.

The development of emotion processing of body expressions from infancy to early childhood: A meta-analysis

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Key words:
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Abstract

Body expressions provide important perceptual cues to recognize emotions in others. By adulthood, people are very good at using body expressions for emotion recognition. Thus an important research question is: How does emotion processing of body expressions develop, particularly during the critical first 2-years and into early childhood? To answer this question, we conducted a meta-analysis of developmental studies that use body stimuli to quantity infants' and young children's ability to discriminate and process emotions from body expressions at different ages. The evidence from our review converges on the finding that infants and children can process emotion expressions across a wide variety of body stimuli and experimental paradigms, and that emotion-processing abilities do not vary with age. We discuss limitations and gaps in the literature in relation to a prominent view that infants learn to extract perceptual cues from different sources about people's emotions under different environmental and social contexts, and suggest naturalistic approaches to further advance our understanding of the development of emotion processing of body expressions.

Introduction

The ability to discriminate and recognize other people's emotion is important for social interactions. Adults process a rich combination of perceptual cues from people's facial, vocal and body expressions to recognize emotions quickly and accurately so they can take appropriate actions (Belin et al., 2011; de Gelder 2009; Keltner et al., 2016). These cues also include changes in body odour and temperature (de Groot and Smeets, 2017; Robinson et al., 2012; Rosen et al., 2015; Salazar-López et al., 2015). For emotion body expressions, adults seem to focus on perceptual cues in the upper body, including the arms and hands (Pollux et al., 2019; Ross & Flack, 2020). Bodies can provide more diagnostic information about emotions than other perceptual cues under certain circumstances, such as when a person is far away (Bhatt et al., 2016; de Gelder, 2009; Enea & Iancu, 2016). Thus, an important research question is how emotion processing develops, particularly during the critical first 2-years and into early childhood. For example, we recently showed that the focus on the upper body shown by adults may emerge as early as 7-months (Geangu & Vuong, 2020). Developmental research, however, has focused predominantly on facial expressions (Bayet & Nelson, 2019; Geangu et al., 2016a).

Our aim in this mini-review is to synthesize evidence from developmental studies of emotion processing of body expressions from infancy until early childhood to address the research question. We have two goals toward this aim. First, we highlight the importance of environmental and social contexts for learning perceptual cues to emotion expressions. As infants grow, different visual information related to faces and bodies become more prevalent in the visual field during their daily activities (Smith et al., 2018), and they experience more and more varied emotion expressions under different social contexts. Second, we present a meta-analysis of developmental studies that use body stimuli to quantity infants' and children's ability to discriminate and process emotion expressions at different ages. The evidence suggests that there is a shift from faces being prevalent in the visual field towards other parts of the body (e.g., hands; Ausderau et al., 2017; Fausey et al., 2016; Jayaraman et al., 2017; Smith et al., 2018), and so the meta-analysis may help us relate laboratory-based studies to infants' and children's natural learning environment. We conclude with suggestions for future research directions.

Emotion Body Expressions in Context

A prominent view of the development of emotion processing is that infants learn to extract perceptual cues from different sources about people's emotions and their communicative value (Campos et al., 1994; Leppänen & Nelson, 2009; Smith et al., 2018; Walle & Lopez, 2020; Widen, 2013). With respect to body expressions, infants frequently have people (e.g., parents, siblings) in their visual field view throughout the first year of life (Ausderau et al., 2017; Jayaraman et al., 2017). Importantly, the prevalence of different body parts that are present in the visual field changes during development. For example, faces are more prevalent than other body parts during the first 4 months after birth (Jayaraman et al., 2017). This prevalence shifts to other body parts after this age. Fausey et al. (2016) used head-mounted camera recordings in infants' home environment to demonstrate an increase in the proportion of hands in infants' visual field with a corresponding decrease in the proportion of faces, with a larger proportion of hands emerging between 6 and 9-months-old. The changes in prevalence of different body parts are observed across the first 2-years of life, and are likely due to cognitive and motor development that allow infants to more actively explore and interact with their environment and people (Ausderau et al., 2017; Fischer & Silvern, 1985; Flavell, 1982).

Thus as infants mature and explore their environment, they are likely to extract and process different body parts that become more prevalent in their visual field to recognize different emotion expressions, and possibly relate body parts to perceptual cues in other modalities such as vocal expressions or odor changes. The prevalence of bodies in the visual field may also be relevant for other social tasks. For example, infants as young as 6-months-old fixate on the hands of people who reach and grasp objects, and look less at other body parts that are in view (Falck-Ytter et al., 2006; Geangu et al., 2015; Kochukhova & Gredebäck, 2010). These changes in the availability of different body cues to emotions and social interactions also increase the opportunities infants have to learn the relation between body expressions and the social and non-social contexts in which they occur, further contributing to the development of emotion processing of body expressions (Campos et al., 1994; Leppänen & Nelson, 2009; Walle & Lopez, 2020; Widen, 2013). These experiences during maturation may lead to appropriate neuro-physiological responses associated with emotion processing (e.g., Krol et al., 2015; Rajhans et al., 2015; Ross et al., 2019).

Visual information for Emotion Processing of Body Expressions

By adulthood, research suggests that combinations of body postures and movements define signature cues for recognizing emotions from body expressions (Atkinson et al., 2004; Atkinson, 2013; Poyo Solanas et al., 2020a,b). For example, signature cues for *happy* expressions may include an upright posture with raised arms. The cues for *anger* expressions may include a forward-leaning posture and shaking fists, contrasted to a backward-leaning posture and hands in front of the body for *fear* expressions. *Sad* expressions have the most subtle cues that tend to include a dropped position of the head, with arms brought near the body. The existent evidence indicates that adults rely on visual information contained in the upper body (e.g., torso, arms and hands) to recognize emotions expressed in static body images (Pollux et al., 2019; Ross & Flack, 2020).

The naturalistic studies discussed in the previous section provide evidence that bodies are prevalent in infants' visual field from very early on (Fausey et al., 2016; Jayaraman et al., 2017; Smith et al., 2018). The results from these studies are complemented by behavioural and neural evidence that, from birth, infants are sensitive to body postures and movements (e.g., Bhatt et al., 2016; Geangu, 2008; Geangu et al., 2015; Hirai & Hiraki, 2005; Gillmeister et al., 2019; Simion et al., 2008). This initial sensitivity may help them orient and attend to bodies. Infants seem to also attend to visual information in the upper body like adults, in line with the increased prevalence of body parts in infants' visual field (Geangu & Vuong, 2020). Thus infants and young children's reliance on signature cues based on body parts for emotion processing of body expressions may reflect changes to the prevalence of different body parts in the visual field under different contexts during infancy and early childhood (Ausderau et al., 2017; Smith et al., 2018). There is currently no direct evidence for this possibility. Furthermore, developmental studies on the emotion processing of body expressions use different emotions, body stimuli and outcome measurements across different age groups, leading to gaps in the literature.

Review of Emotion Processing of Body Expressions

To address this issue and our overarching aim, we synthesize published studies on emotion processing of body expressions by infants and children. This synthesis can provide a holistic view to identify gaps and motivate future research. We conducted a literature search on PUBMED, Scopus, Medline, Embase and PsycInfo in October 2022 for articles which investigated emotion processing of body expressions in typically developing infants and children up to ~7.5-years-old. Although studies may include older age groups or developmental groups, we focused on typical development and body stimuli (or stimuli that included the body) within our age range. The electronic searches were complemented with hand citation searches. There were 1787 unique articles, with 3 additional articles from hand searches. QV undertook the searching and screening processes. See the Supplementary materials for details.

Study characteristics. Table 1 summarises the 38 articles included in the review. The studies are ordered by the youngest age group (mean age in months), and range from 3.4-months-old to 87.1-months-old (7.3-years-old). Most studies balanced the number of male and female participants. Several studies included comparisons to older age groups (e.g., adults) or developmental conditions (e.g., hearing impairments or mental disabilities). We include developmental milestones from Ausderau et al. (2017) to illustrate some known developmental changes occurring at different ages.

A few studies considered psychological (Rajhans et al., 2015), social (Krol et al., 2015) and cultural factors (Tuminello & Davidson, 2011; Yang et al., 2022) in emotion processing of body expressions. *Anger*, *fear*, *happy* and *sad* expressions were tested the most, and ~29% (11/38) included an emotionally *neutral* condition as recommended by Hepach and Westermann (2016). Other expressions included, for example, *disgust*, *surprise*, *pride* and *irritation*. The body stimuli ranged from abstract representations (e.g., point-light displays or schematic line drawings) to videos and real-time interactions with experimenters (Quam et al., 2012). Thus the stimuli could include static (e.g., body posture), dynamic (e.g., body movements) information (or both), and they could be combined with other perceptual cues such as faces and voices.

The studies used different outcome measurements, including accuracy, facial muscle activities from electromyography (EMG), eye-tracking measurements (e.g., fixations or pupil dilations), and event-related potentials (ERPs) in electroencephalography (EEG) related to different neural markers of emotion processing. One study measured facial thermal-imaging responses to body expressions (Nicolina et al., 2019). The studies also tested emotion processing of body expressions under different experimental conditions, such as body inversion. Several studies also compared emotion processing between different developmental conditions.

Meta-analysis. The studies in this review highlight the rich variety of body stimuli, outcome measurements and experimental manipulations used to test whether and how infants and children recognize emotion body expressions. Although this richness allows for a broad generalization, there is no quantification of infants and young children's overall ability to discriminate between different emotion pairs (given differences in these studies). Thus, the goals of the meta-analysis is to combine effect sizes across studies to determine: (1) whether there is an overall ability to discriminate between different expression pairs; (2) whether this ability differs between different pairs; and (3) whether this ability varies with age.

For 22 of the 38 articles, we could derive mean and standard deviation for each body expression from graphs and/or tables to be included in the meta-analysis. We focused on *anger*, *fear*, *happy*, *sad* and *neutral* expressions as most studies used one or more of these expressions, resulting in 10 possible pairs (~14% [3/22] included a *neutral* condition). We calculated Hedges' *g* as the effect size and took the absolute value to quantify participants' ability to discriminate expression pairs. We log-transformed any effect sizes calculated from sample proportion data (Nelson et al., 2013; Witkower et al., 2021). For each study included in the meta-analysis, the effect size was calculated separately for each outcome measurement, within-subject experimental condition and age group. The effect sizes were averaged across outcome measurements and within-subject conditions resulting in 2 (*sad* vs *neutral*) to 21 (*anger* vs *happy*) effect sizes for each pair. A random-effects model with restricted maximum likelihood estimation (REML) was used to test whether the overall effect size for each emotion pair was greater than zero. Lastly, we conducted a meta-regression between effect size and mean age (in months) for each pair. The meta-analysis was conducted using the meta (v6.1-0; Schwarzer et al., 2015) package for R-Studio (v1.4.1106). See Supplementary materials for details. The data and scripts are available at the Open Science Framework (https://osf.io/tyg6n/).

Figure 1 presents a forest plot for the 10 expression pairs, with studies ordered chronologically by the mean age in months. For the 6 pairs including two emotions (Row 1 in Figure 1), combining the effect sizes across all studies showed consistent evidence for small to medium effects (g=0.36 to 0.68; ps<0.001). The meta-regression showed inconsistent evidence that effect size varied with age for these pairs (ps>0.05).

A similar but weaker pattern was found when each emotion was compared to the *neutral* condition (Row 2 in Figure 1; 4 pairs). The mean effect size also ranged from small to medium effects. It was significantly greater than 0 for *anger* and *happy* expressions (g=0.69 and 0.28, respectively; ps<0.02) but not for *fear* and *sad* expressions (g=0.20 and 0.34, respectively; ps>0.07). There was a significant correlation between effect size and age for *anger* expressions (p<0.001) but not for the other expressions (ps>0.61 for *fear* and *happy* expressions; no solution for *sad* expressions). However, there was a small number of effect sizes that included a *neutral* condition (e.g., N=2 for *sad*, N=4 for the other emotions) and so we do not make any strong conclusions from these results.

Discussion and Future Directions

Our review identified a wide range of laboratory-based developmental studies of emotion processing of body expressions. We also note that researchers use different terms for similar or related emotions, such as *joy* vs *happy* (e.g., Lagerlof & Djerf, 2009), as well as more ambiguous cases such as *win* and *lose* (Nyugen & Nelson, 2021) which can be associated with *happy/excitement* and *disappointment*. Many individual effect sizes in these studies had confidence intervals that included 0. However across these studies, the evidence suggests that infants and children can discriminate between emotion expressions across a variety of body stimuli and experimental paradigms, and that infants and children can integrate perceptual cues across bodies, faces and voices. A similar pattern was seen for discriminating emotion from neutral body expressions, but this finding is limited by the small number of effect sizes.

The ability to recognize emotions is often *inferred* from infants' and children's ability to discriminate emotion pairs. Several studies in our review measured neuro-physiological outcomes while participants viewed different emotion body expressions, such as ERP components (e.g., Krol et al., 2015; Rajhans et al., 2016), EMG responses (Addabo et al., 2020; Geangu et al., 2016), pupil dilations (Geangu & Vuong, 2023) and facial temperature (Nicolina et al., 2019). Importantly, these measurements are related to emotion processing in adults (Kret et al., 2013; Robinson et al., 2012; Yeh et al., 2016). They suggest that infants and children can *process the emotional content of body expressions* using static (e.g., body posture) and dynamic (e.g., body movements) cues, rather than *discriminating emotion pairs* (Ross & Atkinson, 2020). A second finding is that emotion-processing abilities do not vary with age (as indicated by the meta-regression for the 6 emotion pairs), which is surprising given the developmental milestones and changes in visual information that are prevalent in infants' and children's visual field as they mature (Ausderau et al., 2017; Smith et al., 2018).

These 2 main findings should be considered in light of emotion processing in adults. Although body postures and gestures contribute to emotion processing in adulthood, body cues do not necessarily convey all emotions equally (Atkinson et al., 2004; Atkinson, 2013; Poyo Solanas et al., 2020a,b) and may need to interact with other perceptual cues for effective emotion processing in the natural environment. For example, body expressions may be important for disambiguating fear and surprise, which can be easily confused with facial expressions (Actis-Grosso et al., 2015; Smith & Schyns, 2009). Thus our review and meta-analysis underscores the importance of investigating the development of emotion processing from multiple perceptual cues.

The 2 main findings should also be considered in light of potential limitations highlighted by our review. First, the sample size for young infants tend to be less than for older infants and children resulting in more variability for the younger group. Second, young infants were not tested with as many emotion pairs compared to the older age groups leaving a gap in understanding the early development of emotion processing of body expressions. This younger age group also tended to be tested with fewer emotion expressions within a study (e.g., typically 2 expressions) than older age groups. There was also a smaller proportion of studies that included a *neutral* condition (~29%; Hepach & Westermann, 1996). Third, there is a relatively small number of body-stimulus databases used across all studies (see Table 1). Nearly all studies with infants younger than 9-months used the stimuli from Atkinson et al. (2004). For other age groups, several studies used static and dynamic body-stimulus databases that have only been validated by adults. A few studies recorded their own body expression videos with different expressivity (e.g. expressive dance movements; Boone & Cunningham, 1998). Finally, few studies presented naturalistic stimuli that combined body, facial and vocal cues. Those that did manipulated the congruency of the emotion expression between different cues, leading to stimuli that were not necessarily naturalistic.

Given these limitations, we suggest several future research directions. The first is to test young infants with a larger variety of emotion body expressions, including neutral expressions (Hepach & Westermann, 1996). It would also be important to test infants longitudinally to map out the developmental trajectory for emotion processing of body expressions. Future work can also combine different outcome measurements (e.g., pupil dilation, EMG and EEG), use naturalistic dynamic multi-sensory perceptual cues (e.g., Geangu et al., 2011; Quadrelli et al., 2019; Poulin-Dubois et al., 2018), test different cultures (e.g., Geangu et al., 2011, 2016a; Quadrelli et al., 2019; Poulin-Dubois et al., 2018; see Parkinson et al., 2017, for adults), and investigate factors contributing to observed individual differences (e.g., Crespo-Llado et al., 2018). One key limitation is that the body stimuli used in laboratory studies are visually impoverished and may not capture many of the perceptual cues that infants and children may experience in their daily activities (e.g., Smith et al., 2018). Given the importance of the maturing infants' environmental and social contexts, future studies can be conducted in the *real world* and focus on, for example, the frequency of different facial and body emotion expressions in the infants' visual field, parenting behaviors, and the context in which emotion expressions occur (e.g., Fausey et al., 2016; Jayaraman et al., 2017; Smith et al., 2018). These directions will be highly challenging but will be important to address the gaps in understanding the development of emotion processing of body expressions—and emotion processing more generally—highlighted by our mini-review.

References

** included in the mini-review*; *** included in the meta-analysis*

1. Actis-Grosso, R., Bossi, F., & Ricciardelli, P. (2015). Emotion recognition through static faces and moving bodies: A comparison between typically developed adults and individuals with high level of autistic traits. *Frontiers in Psychology, 6.* https://doi.org/10.3389/fpsyg.2015.01570.
2. **Addabbo, M., Vacaru, S.V., Meyer, M., & Hunnius, S. (2020). Something in the Way You Move: Infants Are Sensitive to Emotions Conveyed in Action Kinematics. *Developmental Science,* 23, e12873. https://doi.org/10.1111/desc.12873.
3. Atkinson, A. P. (2013). Bodily expressions of emotion: Visual cues and neural mechanisms. In J. Armony and P. Vuilleumier (Eds.). "The Cambridge handbook of human affective neuroscience". Cambridge University Press.
4. Atkinson, A.P., Dittrich, W.H., Gemmell A.J., & Young, A.W. (2004). Emotion perception from dynamic and static body expressions in point-light and full-light displays. *Perception*, *33*, 717-746.
5. Ausderau, K. K., Dammann, C., McManus, K., Schneider, M., Emborg, M. E., & Schultz-Darken, N. (2017). Cross-species comparison of behavioral neurodevelopmental milestones in the common marmoset monkey and human child. *Developmental psychobiology*, *59*(7), 807-821.
6. **Balas, B., Auen, A., Saville, A., & Schmidt, J. (2018). Body Emotion Recognition Disproportionately Depends on Vertical Orientations During Childhood. *International Journal of Behavioral Development* 42, 278-283. https://doi.org/10.1177/0165025417690267.
7. Bänziger, T., Mortillaro, M., & Scherer, K. R. (2012). Introducing the Geneva Multimodal Expression corpus for experimental research on emotion perception. *Emotion, 12*(5), 1161-1179.
8. Bayet, L., & Nelson, C. A. (2019). The perception of facial emotion in typical and atypical development. Handbook of Emotional Development. Cham: Springer, 105-138.

9. Belin, P., Bestelmeyer, P. E. G., Latinus, M., & Watson, R. (2011). Understanding voice perception. *British Journal of Psychology*, 102, 711-725.

10. Bhatt, R. S., Hock, A., White, H., Jubran, R., & Galati, A. (2016). The development of body structure knowledge in infancy. *Child Development Perspectives*, *10*(1), 45-52.

11. **Boone, R.T. & Cunningham, J.G. (1998). Children's Decoding of Emotion in Expressive Body Movement: The Development of Cue Attunement. *Dev Psychol* 34, 1007-1016. https://doi.org/10.1037//0012-1649.34.5.1007.

12. *Brosgole, L., Gioia, J.V., & Zingmond, R. (1986). Facial- and Postural-Affect Recognition in the Mentally Handicapped and Normal Young Children. *Int J Neurosci* 30, 127-144. https://doi.org/10.3109/00207458608985662.

13. Campos, J. J., Mumme, D. L., Kermoian, R., & Campos, R. G. (1994). A functionalist perspective on the nature of emotion. *Monographs of the Society for Research in Child Development, 59*, 284-303.

14. Crespo-Llado, M. M., Vanderwert, R. E., & Geangu, E. (2018). Individual differences in infants' neural responses to their peers' cry and laughter. *Biological psychology*, *135*, 117-127.

15. de Gelder, B. (2009). Why bodies? Twelve reasons for including bodily expressions in affective neuroscience. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*, 3475-3484.

16. de Gelder, B., & van den Stock, J. (2011). The bodily expressive action stimulus test (BEAST). Construction and validation of a stimulus basis for measuring perception of whole body expression of emotions. *Frontiers in Psychology*, *2*, 181.

17. de Groot, J. H., & Smeets, M. A. (2017). Human fear chemosignaling: evidence from a meta-analysis. *Chemical Senses*, *42*, 663-673.

18. Enea, V., & Iancu, S. (2016). Processing emotional body expressions: state-of-the-art. *Social Neuroscience*, *11*(5), 495-506.

19. Falck-Ytter, T., Gredebäck, G., & Von Hofsten, C. (2006). Infants predict other people's action goals. *Nature neuroscience*, *9*(7), 878-879.

20. Fausey, C. M., Jayaraman, S., & Smith, L. B. (2016). From faces to hands: Changing visual input in the first two years. Cognition, 152, 101-107.

21. Flavell, J. H. (1982). On cognitive development. *Child development*, 1-10.

22. Fischer, K. W., & Silvern, L. (1985). Stages and individual differences in cognitive development. *Annual Review of Psychology*, *36*(1), 613-648.

23. Geangu, E. (2008). Notes on self awareness development in early infancy. *Cognition, Brain, Behavior*, *12*(1), 103.

24. Geangu, E. (2015). Development of empathy during childhood across cultures. In: International Encyclopedia of the Social and Behavioral Sciences. Elsevier, pp. 549-553. ISBN 9780080970875

25. Geangu, E., Hauf, P., Bhardwaj, R., & Bentz, W. (2011). Infant pupil diameter changes in response to others' positive and negative emotions. *PloS one*, *6*(11), e27132.

26. Geangu, E., Ichikawa, H., Lao, J., Kanazawa, S., Yamaguchi, M. K., Caldara, R., & Turati, C. (2016a). Culture shapes 7-month-olds' perceptual strategies in discriminating facial expressions of emotion. *Current Biology*, *26*, R663-R664.

27. **Geangu, E., Quadrelli, E., Conte, S., Croci, E., & Turati, C. (2016). Three-Year-Olds' Rapid Facial Electromyographic Responses to Emotional Facial Expressions and Body Postures. *J Exp Child Psychol* 144, 1-14. https://doi.org/10.1016/j.jecp.2015.11.001.

28. Geangu, E., Quadrelli, E., Lewis, J. W., Macchi Cassia, V., & Turati, C. (2015). By the sound of it: an ERP investigation of human action sound processing in 7-month-old infants. *Developmental Cognitive Neuroscience*, *12*, 134-144.

29. **Geangu, E., & Vuong, Q.C. (2020). Look up to the Body: An Eye-Tracking Investigation of 7-Months-Old Infants' Visual Exploration of Emotional Body Expressions. *Infant Behav Dev* 60, 101473. https://doi.org/10.1016/j.infbeh.2020.101473.

30. **Geangu, E. & Vuong, Q.C. (2023). Seven-months-old infants show increased arousal to static emotion body expressions: Evidence from pupil dilation. *Infancy*. http://doi.org/10.1111/infa.12535

31. Gillmeister, H., Stets, M., Grigorova, M., & Rigato, S. (2019). How do bodies become special? Electrophysiological evidence for the emergence of body-related cortical processing in the first 14 months of life. *Developmental Psychology*, *55*(10), 2025.

32. *Gioia, J.V. & Brosgole, L. (1988). Visual and Auditory Affect Recognition in Singly Diagnosed Mentally Retarded Patients, Mentally Retarded Patients with Autism and Normal Young Children. *Int J Neurosci* 43, 149-163. https://doi.org/10.3109/00207458808986164.

33. *Hao, J. & Su, Y. (2014). Deaf Children's Use of Clear Visual Cues in Mindreading. *Res Dev Disabil* 35, 2849-2857. https://doi.org/10.1016/j.ridd.2014.07.034.

34. *Heck, A., Chroust, A., White, H., Jubran, R., & Bhatt, R.S. (2018). Development of Body Emotion Perception in Infancy: From Discrimination to Recognition. *Infant Behav Dev* 50, 42-51. https://doi.org/10.1016/j.infbeh.2017.10.007.

35. Hepach, R., & Westermann, G. (2016). Pupillometry in infancy research. *Journal of Cognition and Development*, *17*(3), 359-377.

36. Hirai, M., & Hiraki, K. (2005). An event-related potentials study of biological motion perception in human infants. *Cognitive Brain Research*, *22*(2), 301-304.

37. **Hock, A., Oberst, L., Jubran, R., White, H., Heck, A., & Bhatt, R.S. (2017). Integrated Emotion Processing in Infancy: Matching of Faces and Bodies. *Infancy* 22, 608-625. https://doi.org/10.1111/infa.12177.

38. Jayaraman, S., Fausey, C. M., & Smith, L. B. (2017). Why are faces denser in the visual experiences of younger than older infants? *Developmental Psychology, 53*(1), 38.

39. **Ke, H., Vuong, Q.C., & Geangu, E. (2022). Three- and Six-Year-Old Children Are Sensitive to Natural Body Expressions of Emotion: An Event-Related Potential Emotional Priming Study. *J Exp Child Psychol* 224, 105497. https://doi.org/10.1016/j.jecp.2022.105497.

40. Keltner, D., Tracy, J., Sauter, D. A., Cordaro, D. C., & McNeil, G. (2016). Expression of emotion. *Handbook of Emotions*, 467-482.

41. Kochukhova, O., & Gredebäck, G. (2010). Preverbal infants anticipate that food will be brought to the mouth: An eye tracking study of manual feeding and flying spoons. *Child Development*, *81*(6), 1729-1738.

42. Kret, M. E., Roelofs, K., Stekelenburg, J., & de Gelder, B. (2013). Emotional signals from faces, bodies and scenes influence observers' face expressions, fixations and pupil-size. *Frontiers in Human Neuroscience*, *7*, 810.

43. **Krol, K.M., Rajhans, P., Missana, M., & Grossmann, T. (2015). Duration of Exclusive Breastfeeding Is Associated with Differences in Infants' Brain Responses to Emotional Body Expressions. *Frontiers in Behavioral Neuroscience* 8. https://doi.org/10.3389/fnbeh.2014.00459.

44. **Lagerlöf, I. & Djerf, M. (2009). Children's understanding of emotion in dance. European Journal of Developmental Psychology 6, 409-431. https://doi.org/10.1080/17405620701438475.

45. Leppänen, J. M., & Nelson, C. A. (2009). Tuning the developing brain to social signals of emotion. Nature Reviews Neuroscience, 10(1), 37-47.

46. *Missana, M., Atkinson, A.P., & Grossmann, T. (2015a) Tuning the Developing Brain to Emotional Body Expressions. *Dev Sci* 18, 243-253. https://doi.org/10.1111/desc.12209.

47. **Missana, M. & Grossmann, T. (2015b). Infants' Emerging Sensitivity to Emotional Body Expressions: Insights from Asymmetrical Frontal Brain Activity. *Dev Psychol* 51, 151-160. https://doi.org/10.1037/a0038469.

48. **Missana, M., Rajhans, P. Atkinson, A.P., & Grossmann, T. (2014). Discrimination of Fearful and Happy Body Postures in 8-Month-Old Infants: An Event-Related Potential Study. *Front Hum Neurosci* 8, 531. https://doi.org/10.3389/fnhum.2014.00531.

49. *Mondloch, C. J., Horner, M., & Mian, J. (2013). Wide Eyes and Drooping Arms: Adult-Like Congruency Effects Emerge Early in the Development of Sensitivity to Emotional Faces and Body Postures. *J Exp Child Psychol* 114, 203-216. https://doi.org/10.1016/j.jecp.2012.06.003.

50. *Nelson, N. L. & Russell, J.A. (2011). Preschoolers' Use of Dynamic Facial, Bodily, and Vocal Cues to Emotion. *J Exp Child Psychol* 110, 52-61. https://doi.org/10.1016/j.jecp.2011.03.014.

51. *Nelson, N. L. & Russell, J.A. (2012). Children's Understanding of Nonverbal Expressions of Pride. *J Exp Child Psychol* 111, 379-385. https://doi.org/10.1016/j.jecp.2011.09.004.

52. **Nelson, N. L., Hudspeth, K., & Russell, J.A. (2013). A Story Superiority Effect for Disgust, Fear, Embarrassment, and Pride. *Br J Dev Psychol* 31, 334-348. https://doi.org/10.1111/bjdp.12011.

53. *Nelson, N. L. & Mondloch, C.J. (2018). Children's Visual Attention to Emotional Expressions Varies with Stimulus Movement. *J Exp Child Psychol* 172, 13-24. https://doi.org/10.1016/j.jecp.2018.03.001.

54. *Nguyen, T.T. & Nelson, N.L. (2021). Winners and Losers: Recognition of Spontaneous Emotional Expressions Increases across Childhood. *J Exp Child Psychol* 209, 105184. https://doi.org/10.1016/j.jecp.2021.105184.

55. **Nicolini, Y., Manini, B., De Stefani, E., Coude, G., Cardone, D. et al. (2019). Autonomic Responses to Emotional Stimuli in Children Affected by Facial Palsy: The Case of Moebius Syndrome. *Neural Plast* 7253768. https://doi.org/10.1155/2019/7253768.

56. **Ogren, M., Kaplan, B., Peng, Y., Johnson, K.L., & Johnson, S.P. (2019). Motion or Emotion: Infants Discriminate Emotional Biological Motion Based on Low-Level Visual Information. *Infant Behav Dev* 57, 101324. https://doi.org/10.1016/j.infbeh.2019.04.006.

57. *Parker, A. E., Mathis, E.T., & Kupersmidt, J.B. (2013). How Is This Child Feeling? Preschool-Aged Children's Ability to Recognize Emotion in Faces and Body Poses. *Early Educ Dev* 24, 188-211. https://doi.org/10.1080/10409289.2012.657536.

58. Parkinson, C., Walker, T. T., Memmi, S. & Wheatley, T. (2017). Emotions are understood from biological motion across remote cultures. *Emotion, 17*(3), 459-477.

59. Pollux, P. M., Craddock, M., & Guo, K. (2019). Gaze patterns in viewing static and dynamic body expressions. *Acta psychologica*, *198*, 102862.

60. Poulin-Dubois, D., Hastings, P. D., Chiarella, S. S., Geangu, E., Hauf, P., Ruel, A., & Johnson, A. (2018). The eyes know it: Toddlers' visual scanning of sad faces is predicted by their theory of mind skills. *PloS one*, *13*(12), e0208524.

61. Poyo Solanas, M., Vaessen, M., & de Gelder, B. (2020a). Limb contraction drives fear perception. *bioRxiv*.

62. Poyo Solanas, M., Vaessen, M., & de Gelder, B. (2020b). The role of computational and subjective features in emotional body expressions. *Scientific Reports, 10*(1)*,* 1-13.

63. Quadrelli, E., Geangu, E., & Turati, C. (2019). Human action sounds elicit sensorimotor activation early in life. *Cortex*, *117*, 323-335.

64. *Quam, C. & Swingley, D. (2012). Development in Children's Interpretation of Pitch Cues to Emotions. *Child Dev* 83, 236-250. https://doi.org/10.1111/j.1467-8624.2011.01700.x.

65. **Rajhans, P., Jessen, S., Missana, M., & Grossmann, T. (2016). Putting the Face in Context: Body Expressions Impact Facial Emotion Processing in Human Infants. *Dev Cogn Neurosci* 19, 115-121. https://doi.org/10.1016/j.dcn.2016.01.004.

66. *Rajhans, P., Missana, M., Krol, K.M., & Grossmann, T. (2015). The Association of Temperament and Maternal Empathy with Individual Differences in Infants' Neural Responses to Emotional Body Expressions. *Dev Psychopathol* 27, 1205-1216. https://doi.org/10.1017/S0954579415000772.

67. Robinson, D. T., Clay-Warner, J., Moore, C. D., Everett, T., Watts, A., Tucker, T. N., & Thai, C. (2012). Toward an unobtrusive measure of emotion during interaction: Thermal imaging techniques. *Biosociology and Neurosociology*. Emerald Group Publishing Limited, 225-266.

68. Rosen, J. B., Asok, A., & Chakraborty, T. (2015). The smell of fear: Innate threat of 2, 5-dihydro-2, 4, 5-trimethylthiazoline, a single molecule component of a predator odor. *Frontiers in Neuroscience*, *9*, 292.

69. **Ross, P., Atkins, B., Allison, L., Simpson, H., Duffell, C. et al. (2021). Children Cannot Ignore What They Hear: Incongruent Emotional Information Leads to an Auditory Dominance in Children. *J Exp Child Psychol* 204, 105068. https://doi.org/10.1016/j.jecp.2020.105068

70. Ross, P. & Atkinson, A. P. (2020). Expanding simulation models of emotional understanding: The case for different modalities, body-state simulation prominence, and developmental trajectories. *Frontiers in Psychology, 11*, 309. https://dio.org/10.3389/fpsyg.2020.00309.

71. Ross, P., de Gelder, B., Crabbe, F., & Grosbras, M. H. (2019). Emotion modulation of the body-selective areas in the developing brain. *Developmental Cognitive Neuroscience*, *38*, 100660.

72. Ross, P., & Flack, T. R. (2020). Removing hand information specifically impairs emotion recognition for fearful and angry body stimuli. *Perception, 49*, 98-112.

73. Salazar-López, E., Domínguez, E., Ramos, V. J., De la Fuente, J., Meins, A., Iborra, O., Gálvez, G., Rodríguez-Artacho, M. A., & Gómez-Milán, E. (2015). The mental and subjective skin: Emotion, empathy, feelings and thermography. *Consciousness and Cognition*, *34*, 149-162.

74. *Sanders, G. (2006). The Perception and Decoding of Expressive Emotional Information by Hearing and Hearing-Impaired Children. *Early Child Development and Care* 21, 11-26. https://doi.org/10.1080/0300443850210102.

75. Sauter, D. A., Eisner, F., Ekman, P., & Scott, S. K. (2010). Cross-cultural recognition of basic emotions through nonverbal emotional vocalizations. *Proceedings of the National Academy of Sciences*, *107*(6), 2408-2412.

76. Simion, F., Regolin, L., & Bulf, H. (2008). A predisposition for biological motion in the newborn baby. Proceedings of the National Academy of Sciences, 105(2), 809-813.

77. Smith, F. W., & Schyns, P. G. (2009). Smile through your fear and sadness: Transmitting and identifying facial expression signals over a range of viewing distances. *Psychological Science*, *20*(10), 1202-1208.
78. Smith, L. B., Jayaraman, S., Clerkin, E., & Chen, Y. (2018). The developing infant creates a curriculum for statistical learning. Trends in Cognitive Sciences, 22(4), 325-336.
79. Schwarzer, G., Carpenter, J.R., & Rücker, G. (2015). Meta-analysis with R. London: Springer. ISBN 978-3-319-21415-3.
80. Thoma, P., Bauser, D. S., & Suchan, B. (2013). BESST (Bochum Emotional Stimulus Set)—A pilot validation study of a stimulus set containing emotional bodies and faces from frontal and averted views. *Psychiatry Research*, *209*(1), 98-109.
81. Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., ... & Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry research*, *168*(3), 242-249.
82. *Tsou, Y.T., Li, B., Kret, M.E., Frijns, J.H., & Rieffe, C. (2021). Hearing status affects children's emotion understanding in dynamic social situations: An eye-tracking study. *Ear and Hearing* 42, 1024-1033.
83. **Tuminello, E. R. & Davidson, D. (2011). What the Face and Body Reveal: In-Group Emotion Effects and Stereotyping of Emotion in African American and European American Children. *J Exp Child Psychol* 110, 258-274. https://doi.org/10.1016/j.jecp.2011.02.016.
84. **Vieillard, S. & Guidetti, M. (2009). Children's perception and understanding of (dis)similarities among dynamic bodily/facial expressions of happiness, pleasure, anger, and irritation. *J Exp Child Psychol.* 102, 78-95. https://doi.org/10.1016/j.jecp.2008.04.005.
85. Volkova, E., De La Rosa, S., Bülthoff, H. H., & Mohler, B. (2014). The MPI emotional body expressions database for narrative scenarios. *PloS one*, *9*(12), e113647.

86. Walle, E. A., & Lopez, L. D. (2020). Emotion recognition and understanding in infancy and early childhood. In J. B. Benson (Ed.), Encyclopedia of Infant and Early Childhood Development, 2nd edition, vol. 1 (pp. 537-545). Elsevier.

87. Widen, S. C. (2013). Children's interpretation of facial expressions: the long path from valence-based to specific discrete categories. *Emotion Review, 5*(1), 72-77.

88. **Witkower, Z., Tracy, J.L., Pun, A., & Baron, A.S. (2021). Can children recognize bodily expressions of emotion? *Journal of Nonverbal Behavior* 45, 505-518. https://doi.org/10.1007/s10919-021-00368-0.

89. **Yang, Y., Hou, W., & Li, J. (2022). Validation of the Bodily Expressive Action Stimulus Test among Chinese Adults and Children. *Psych J* 11, 392-400. https://doi.org/10.1002/pchj.542.

90. Yeh, P. W., Geangu, E., & Reid, V. (2016). Coherent emotional perception from body expressions and the voice. *Neuropsychologia, 91,* 99-108. https://doi.org/10.1016/j.neuropsychologia.2016.07.038.

91. ** Zieber, N., Kangas, A., Hock, A., Bhatt, R.S. (2014a). Infants' Perception of Emotion from Body Movements. *Child Dev* 85, 675-684. https://doi.org/10.1111/cdev.12134.

92. **Zieber, N., Kangas, A., Hock, A., Bhatt, R.S. (2014b). The Development of Intermodal Emotion Perception from Bodies and Voices. *J Exp Child Psychol* 126, 68-79. https://doi.org/10.1016/j.jecp.2014.03.005.

Table 1. Summary characteristics of the 38 studies included in the mini-review

The studies are listed by first author and year and ordered by the mean age (in months) of the youngest age group tested by the author(s). The mean age is listed for each group tested, along with the sample size and number of females (F). Across these 3 columns, the age groups are presented in the same corresponding order and separated by commas. Other age groups tested in the same study are listed but not considered in this review. Other study characteristics include: body stimulus used; whether the stimuli included body motion, faces or voices; the emotion expressions tested; the outcome measurements; and additional summary information about any conditions tested (e.g., upright vs inverted bodies) and notes. The *Meta* column indicates whether the study was included in the meta-analysis or not. *Notes. Milestones from Ausderau et al. (2017).* * = *feature was included on some conditions. Atkinson = from Atkinson et al. (2004). BEAST = from de Gelder & van den Stock (2011). BESST = from Thoma et al. (2012). GEMEP = from Bänziger et al. (2012). Max Planck = from Volkova et al. (2014). NIMSTIM = from Tottenham et al. (2009). Saunter = from Saunter et al. (2010). The Excel file version of Table 1 is available at:* https://osf.io/tyg6n/

Age Category	Milestones	First Author	Year	Mean Months	N	Sex	Other Age Groups Tested	Body Stimulus	Motion	Face	Voice	Emotion	Outcome Measurements	Conditions/Notes	Meta
birth to 6 months	Visually tracks person moving across room; Regards toys (3 months)	Zieber	2014b	3.4, 3.5, 6.6	16, 16, 32	9F, 7F, 14F		full light videos (Atkinson)	Yes*	No	Yes*	Angry, Happy, Neutral	preference	Upright and inverted bodies (voices from Saunter)	Y
		Heck	2018	3.4, 5.0	60, 32	23F, 18F		full light videos (Atkinson)	Yes	No	Yes	Angry, Happy	preference	Body/voice congruency	N
	Calms in response to parent or soothing voice	Missani	2015a	4.3, 8.4	20, 20	10F, 9F		point light videos (Atkinson)	Yes	No	No	Fear, Happy	ERP (Pb, Nc and Pc components)	Upright and inverted bodies	N
	Lifts head to look around; Reaches/grasps hanging toys (4-5 months)	Missani	2015b	4.3, 8.4	20, 20	10F, 9F		point light videos (Atkinson)	Yes	No	No	Fear, Happy	ERP (frontal assymetry)	Upright and inverted bodies	Y
	Transfers objects from hand to hand; Begins to display separation anxiety and preference for specific caregiver	Hock	2017	6.4	30	19F		full light images (Atkinson)	No	Yes*	No	Angry, Happy, Sad	preference		Y
		Zieber	2014a	6.5	30*	18F		full light videos (Atkinson)	Yes	No	Yes*	Angry, Happy, Neutral	preference	Upright and inverted bodies (voices from Saunter)	Y
6 months to 1 year	Sits well without support	Geangu	2020	7.6	48	30F		body images (BEAST)	No	No	No	Angry, Fear, Happy, Neutral	eye tracking (proportion looking times, proportion fixations, fixation durations)		Y
		Geangu	2023	7.6	48	30F		body images (BEAST)	No	No	No	Angry, Fear, Happy, Neutral	eye tracking (pupil dilation)		Y
	Crawls on belly; Reach is smooth and efficient in all directions	Rajhans	2016	8.2	32	16F		full light images (Atkinson)	No	No	No	Fear, Happy	ERP (P1, N290, P400 and Nc components)	Priming by body on faces; Body/face congruency	Y
		Krol	2015	8.3	28	15F		full light images (Atkinson)	No	No	No	Fear, Happy	ERP (Nc component)	Compared groups with low and high exclusive breastfeeding (EBF) durations	Y
		Missani	2014	8.4	15	10F		full light images (Atkinson)	No	No	No	Fear, Happy	ERP (N290 and Nc components)	Upright and inverted bodies	Y
	Visually follows pointing, engages in joint attention (9 months)	Rajhans	2015	8.4	27	13F		full light images (Atkinson)	No	No	No	Fear, Happy	ERP (Nc component)	Also assessed temperament and maternal empathy	N
	Creeps on hands and knees; Begins standing unsupported; Gives object to adult to communicate need for help	Addabo	2020	11.6	17	6F		action videos (upper body)	Yes	No	No	Angry, Happy	EMG (corrugator supercilii; medial frontalis; zygomaticus major)		Y
	Walks indepdently	Ogren	2019	14.7, 15.0	26, 26	15F, 14F		point light videos	Yes	No	No	Angry, Happy, Sad, Neutral	preference		Y
2 to 4 years	Begins running; Well-coordinated, balanced gait; Social, parallel play begins (24 months)	Quam	2012	24.0, 36.0, 48.0, 60.0	12, 59, 27, 20	Not provided		live experimenter with puppet	Yes	Yes	Yes	Happy, Sad (puppet)	various		N
		Witkower	2021	24.0, 54.0, 84.0	164, 196, 168	Not provided	9-12yrs	body images (BEAST)	No	No	No	Angry, Fear, Sad	accuracy		Y
	Understands caregivers will return, increasing flexibility in relationship with caregivers; Associative play in groups	Mondloch	2013	37.0, 46.5, 71.9	12, 24, 12	Not provided	adults	body images	No	Yes	No	Fear, Sad	accuracy	Body/face congruency (faces from NIMSTIM)	N
		Geangu	2016	40.4	22	12F		body images (BEAST)	No	No	No	Angry, Fear, Happy, Neutral	EMG (corrugator supercilii; medial frontalis; zygomaticus major)		Y
		Nelson	2011	42.7, 53.6, 64.8	48, 48, 48	24F, 24F, 24F		body videos	Yes	Yes*	Yes*	Angry, Fear, Happy, Sad	accuracy	faces blurred or not	N
		Ke	2022	45.8, 78.2	17, 17	8F, 10F		point light videos (Max Planck)	Yes	No	No	Angry, Happy	ERP (N300 and N400 components)	priming by body on words; word/body congruency	Y
4 to 6 years	Cooperative play with peers to reach common goals	Lagerlof	2009	48.0, 60.0	20, 21	10F, 11F	8yrs, adults	dance videos	Yes	Yes	No	Angry, Fear, Happy, Sad	accuracy	Happy labelled as joy	Y
		Boone	1998	49.8, 60.6	25, 25	13F, 12F	8yrs, adults	dance videos	Yes	No	No	Angry, Fear, Happy, Sad	accuracy		Y
		Parker	2013	54.0	55	24F		body images	No	No	No	Angry, Disgust, Fear, Happy, Sad, Surprise, Neutral	accuracy	Angry labelled as mad, fear labelled as scared	N
		Nelson	2012	55.0, 80.0	36, 36	18F, 18F	8-11yrs	body videos	Yes	Yes*	Yes*	Pride	accuracy	faces blurred or not	N
		Nelson	2013	55.3, 63.8	68, 72	34F, 36F		body videos	Yes	Yes	Yes	Angry, Disgust, Fear, Happy, Sad, Surprise	accuracy		Y
		Nelson	2018	60.0	32	17F	9yrs, adults	body videos, body images from videos	Yes*	Yes*	No	Angry, Fear, Happy, Sad	accuracy, eye tracking (relative fixation number, relative fixation duration)	faces blurred or not	N
		Sanders	1985	60.0, 84.0	Not provided	Not provided	11yrs, 15yrs	schematic body drawings	No	No	No	not stated	accuracy	Compared hearing and non-hearing	N
		Tuminello	2011	63.3	111	Not provided		body images	No	Yes*	No	Anger, Fear, Happy, Sad, Surprise, Neutral		Compared African American and European American children	Y
		Hao	2014	65.8	25	13F		body videos (faces occluded)	Yes	No	No	Anger, Fear, Happy, Sad	accuracy		N
		Brosgole	1986	66.5	20	9F		animal line drawings	No	No	No	Angry, Happy, Sad, Neutral	errors	Compared mild, moderate and severe mental disabilities	N
		Yang	2022	67.8	41	21F	adults	body images BEAST)	No	No	No	Anger, Fear, Happy, Sad	accuracy	Tested asian participants	Y
		Gioia	1988	71.0	10	5F		animal line drawings	No	No	No	Angry, Happy, Sad	errors	Compared mild, moderate and severe mental disorders	N
6 to 8 years		Balas	2018	72.0	20	13F	8-11yrs, adults	body images (BESST)	No	No	No	Angry, Sad	acucracy, dprime, response criterion	Add spatial noise in vertical, horizontal or both directions	Y
		Tsou	2021	72.8	71	41F		social interaction videos	Yes	Yes	No	not stated	eye tracking (fixation ratios in defined areas of interests [AOIs])	Compared hearing and non-hearing	N
		Vieillard	2009	74.0	28	14F	8yrs, adults	body videos (GEMEP)	Yes	Yes	No	Angry, Happy, Irritation, Pleasure, Neutral	errors		Y
		Nguyen	2021	76.9	30	14F	8-10yrs, adults	body images	Yes	Yes*	No	win/lose	accuracy		N
		Nicolini	2019	79.2	15	6F		body videos	Yes	Yes	Yes	Fear, Happy, Sad, Neutral	thermal imaging	Compared with and without facial palsy	Y
		Ross	2021	87.1	32	Not provided	8-11yrs, adults	body images (BEAST)	No	No	Yes*	Happy, Fear	accuracy	Body/voice congruency, happy/fear voices	Y

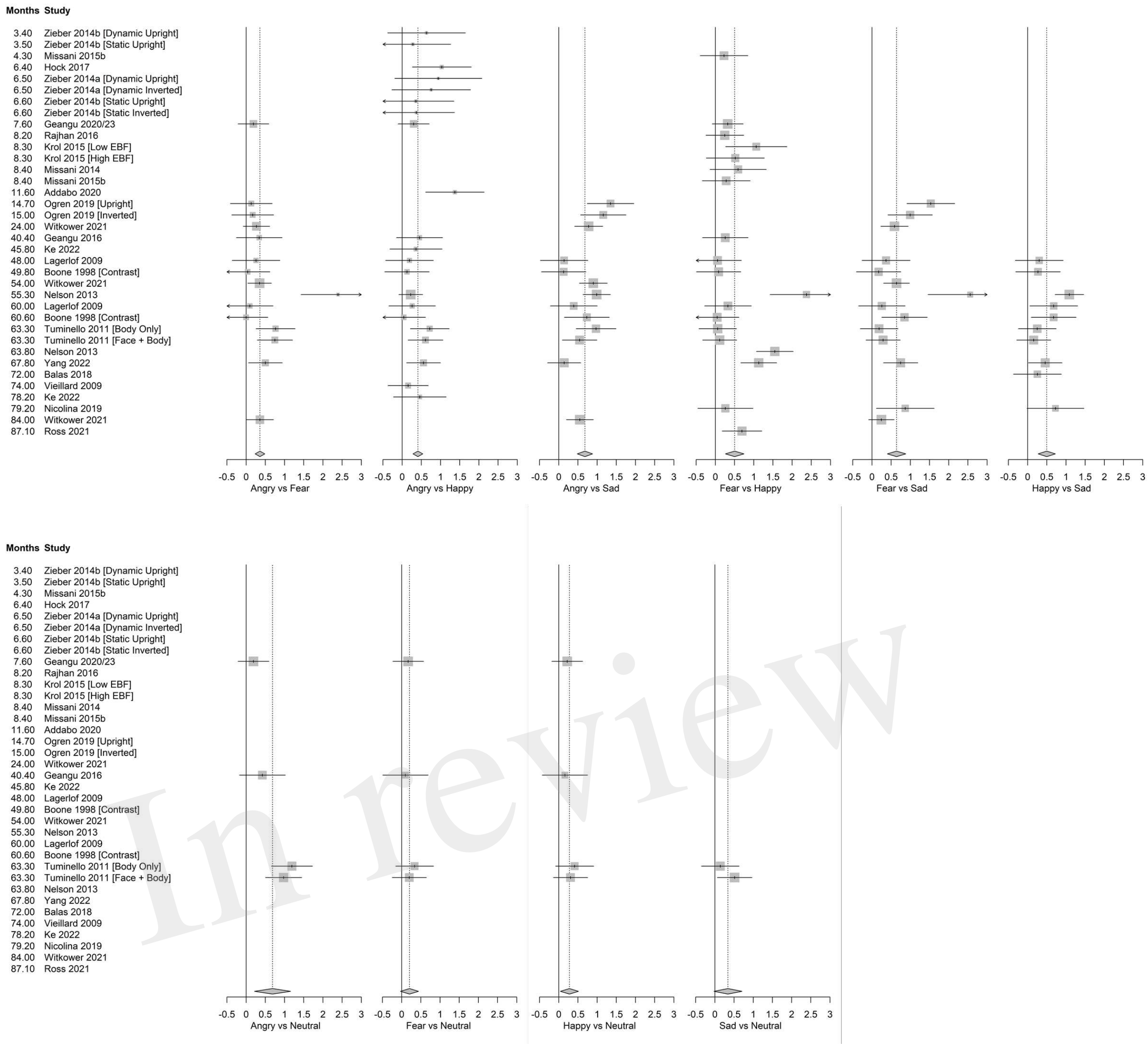

Figure 1. Forest plot of effect size estimate (Hedges' *g*) for each emotion pair

The effect sizes from the 22 studies are ordered chronologically based on mean age in months. Some studies tested groups in different conditions (as indicated in brackets). Horizontal lines depict 95% confidence interval (95%-CI), size of squares represents the weight of individual data sets, and diamonds represent mean effect sizes based on a random-effects model (vertical dashed line). The effect size mean and 95%-CI for each emotion pair (column), respectively, are: <u>Row 1</u> 0.36 [0.23; 0.48]; 0.41 [0.28; 0.54]; 0.68 [0.48; 0.88]; 0.50 [0.26; 0.74]; 0.64 [0.40; 0.88]; 0.50 [0.27; 0.72] (*p*s<0.001); <u>Row 2</u> 0.69 [0.22; 1.16] (*p*<0.001); 0.20 [-0.03; 0.44] (*p*=0.09); 0.28 [0.04; 0.51] (*p*=0.02); 0.34 [-0.03; 0.71] (*p*=0.07). *Notes.* The scale was truncated to Hedges' *g* = -0.5 to 3.0 for visualisation purposes. Arrows on the confidence interval indicate that the horizontal line extended beyond the limits of the truncated scale.

Figure 1.TIFF