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

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Author contribution statement

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

Word count: 168

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 quantify 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 quantify 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.

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4 **The development of emotion processing of body expressions from infancy to early childhood:**

5 **A meta-analysis**

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18 Emotion, body expression, development, discrimination, recognition, meta-analysis
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27 *Abstract*

28 Body expressions provide important perceptual cues to recognize emotions in others. By adulthood,
29 people are very good at using body expressions for emotion recognition. Thus an important research
30 question is: How does emotion processing of body expressions develop, particularly during the
31 critical first 2-years and into early childhood? To answer this question, we conducted a meta-
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38 emotions under different environmental and social contexts, and suggest naturalistic approaches to
39 further advance our understanding of the development of emotion processing of body expressions.

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52 *Introduction*

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

67 Our aim in this mini-review is to synthesize evidence from developmental studies of
68 emotion processing of body expressions from infancy until early childhood to address the research
69 question. We have two goals toward this aim. First, we highlight the importance of environmental
70 and social contexts for learning perceptual cues to emotion expressions. As infants grow, different
71 visual information related to faces and bodies become more prevalent in the visual field during their
72 daily activities (Smith et al., 2018), and they experience more and more varied emotion expressions
73 under different social contexts. Second, we present a meta-analysis of developmental studies that
74 use body stimuli to quantify infants' and children's ability to discriminate and process emotion
75 expressions at different ages. The evidence suggests that there is a shift from faces being prevalent
76 in the visual field towards other parts of the body (e.g., hands; Ausderau et al., 2017; Fausey et al.,
77 2016; Jayaraman et al., 2017; Smith et al., 2018), and so the meta-analysis may help us relate

78 laboratory-based studies to infants' and children's natural learning environment. We conclude with
79 suggestions for future research directions.

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81 *Emotion Body Expressions in Context*

82 A prominent view of the development of emotion processing is that infants learn to extract
83 perceptual cues from different sources about people's emotions and their communicative value
84 (Campos et al., 1994; Leppänen & Nelson, 2009; Smith et al., 2018; Walle & Lopez, 2020; Widen,
85 2013). With respect to body expressions, infants frequently have people (e.g., parents, siblings) in
86 their visual field view throughout the first year of life (Ausderau et al., 2017; Jayaraman et al.,
87 2017). Importantly, the prevalence of different body parts that are present in the visual field changes
88 during development. For example, faces are more prevalent than other body parts during the first 4
89 months after birth (Jayaraman et al., 2017). This prevalence shifts to other body parts after this age.
90 Fausey et al. (2016) used head-mounted camera recordings in infants' home environment to
91 demonstrate an increase in the proportion of hands in infants' visual field with a corresponding
92 decrease in the proportion of faces, with a larger proportion of hands emerging between 6 and 9-
93 months-old. The changes in prevalence of different body parts are observed across the first 2-years
94 of life, and are likely due to cognitive and motor development that allow infants to more actively
95 explore and interact with their environment and people (Ausderau et al., 2017; Fischer & Silvern,
96 1985; Flavell, 1982).

97 Thus as infants mature and explore their environment, they are likely to extract and process
98 different body parts that become more prevalent in their visual field to recognize different emotion
99 expressions, and possibly relate body parts to perceptual cues in other modalities such as vocal
100 expressions or odor changes. The prevalence of bodies in the visual field may also be relevant for
101 other social tasks. For example, infants as young as 6-months-old fixate on the hands of people who
102 reach and grasp objects, and look less at other body parts that are in view (Falck-Ytter et al., 2006;
103 Geangu et al., 2015; Kochukhova & Gredebäck, 2010). These changes in the availability of

104 different body cues to emotions and social interactions also increase the opportunities infants have
105 to learn the relation between body expressions and the social and non-social contexts in which they
106 occur, further contributing to the development of emotion processing of body expressions (Campos
107 et al., 1994; Leppänen & Nelson, 2009; Walle & Lopez, 2020; Widen, 2013). These experiences
108 during maturation may lead to appropriate neuro-physiological responses associated with emotion
109 processing (e.g., Krol et al., 2015; Rajhans et al., 2015; Ross et al., 2019).

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111 *Visual information for Emotion Processing of Body Expressions*

112 By adulthood, research suggests that combinations of body postures and movements define
113 signature cues for recognizing emotions from body expressions (Atkinson et al., 2004; Atkinson,
114 2013; Poyo Solanas et al., 2020a,b). For example, signature cues for *happy* expressions may include
115 an upright posture with raised arms. The cues for *anger* expressions may include a forward-leaning
116 posture and shaking fists, contrasted to a backward-leaning posture and hands in front of the body
117 for *fear* expressions. *Sad* expressions have the most subtle cues that tend to include a dropped
118 position of the head, with arms brought near the body. The existent evidence indicates that adults
119 rely on visual information contained in the upper body (e.g., torso, arms and hands) to recognize
120 emotions expressed in static body images (Pollux et al., 2019; Ross & Flack, 2020).

121 The naturalistic studies discussed in the previous section provide evidence that bodies are
122 prevalent in infants' visual field from very early on (Fausey et al., 2016; Jayaraman et al., 2017;
123 Smith et al., 2018). The results from these studies are complemented by behavioural and neural
124 evidence that, from birth, infants are sensitive to body postures and movements (e.g., Bhatt et al.,
125 2016; Geangu, 2008; Geangu et al., 2015; Hirai & Hiraki, 2005; Gillmeister et al., 2019; Simion et
126 al., 2008). This initial sensitivity may help them orient and attend to bodies. Infants seem to also
127 attend to visual information in the upper body like adults, in line with the increased prevalence of
128 body parts in infants' visual field (Geangu & Vuong, 2020). Thus infants and young children's
129 reliance on signature cues based on body parts for emotion processing of body expressions may

130 reflect changes to the prevalence of different body parts in the visual field under different contexts
131 during infancy and early childhood (Ausderau et al., 2017; Smith et al., 2018). There is currently no
132 direct evidence for this possibility. Furthermore, developmental studies on the emotion processing
133 of body expressions use different emotions, body stimuli and outcome measurements across
134 different age groups, leading to gaps in the literature.

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140 *Review of Emotion Processing of Body Expressions*

141 To address this issue and our overarching aim, we synthesize published studies on emotion
142 processing of body expressions by infants and children. This synthesis can provide a holistic view
143 to identify gaps and motivate future research. We conducted a literature search on PUBMED,
144 Scopus, Medline, Embase and PsycInfo in October 2022 for articles which investigated emotion
145 processing of body expressions in typically developing infants and children up to ~7.5-years-old.

146 Although studies may include older age groups or developmental groups, we focused on typical

147 development and body stimuli (or stimuli that included the body) within our age range. The

148 electronic searches were complemented with hand citation searches. There were 1787 unique

149 articles, with 3 additional articles from hand searches. QV undertook the searching and screening

150 processes. See the Supplementary materials for details.

151 *Study characteristics.* Table 1 summarises the 38 articles included in the review. The studies
152 are ordered by the youngest age group (mean age in months), and range from 3.4-months-old to
153 87.1-months-old (7.3-years-old). Most studies balanced the number of male and female participants.
154 Several studies included comparisons to older age groups (e.g., adults) or developmental conditions

155 (e.g., hearing impairments or mental disabilities). We include developmental milestones from
156 Ausderau et al. (2017) to illustrate some known developmental changes occurring at different ages.

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

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

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

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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 ($ps>0.05$).

206 A similar but weaker pattern was found when each emotion was compared to the *neutral*
207 condition (Row 2 in Figure 1; 4 pairs). The mean effect size also ranged from small to medium
208 effects. It was significantly greater than 0 for *anger* and *happy* expressions ($g=0.69$ and 0.28 ,
209 respectively; $ps<0.02$) but not for *fear* and *sad* expressions ($g=0.20$ and 0.34 , respectively;
210 $ps>0.07$). There was a significant correlation between effect size and age for *anger* expressions
211 ($p<0.001$) but not for the other expressions ($ps>0.61$ for *fear* and *happy* expressions; no solution for
212 *sad* expressions). However, there was a small number of effect sizes that included a *neutral*
213 condition (e.g., $N=2$ for *sad*, $N=4$ for the other emotions) and so we do not make any strong
214 conclusions from these results.

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217 *Discussion and Future Directions*

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

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230 The ability to recognize emotions is often *inferred* from infants' and children's ability to

231 discriminate emotion pairs. Several studies in our review measured neuro-physiological outcomes

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

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

250 The 2 main findings should also be considered in light of potential limitations highlighted
251 by our review. First, the sample size for young infants tend to be less than for older infants and
252 children resulting in more variability for the younger group. Second, young infants were not tested
253 with as many emotion pairs compared to the older age groups leaving a gap in understanding the
254 early development of emotion processing of body expressions. This younger age group also tended
255 to be tested with fewer emotion expressions within a study (e.g., typically 2 expressions) than older
256 age groups. There was also a smaller proportion of studies that included a *neutral* condition (~29%;
257 Hepach & Westermann, 1996). Third, there is a relatively small number of body-stimulus databases

258 used across all studies (see Table 1). Nearly all studies with infants younger than 9-months used the
259 stimuli from Atkinson et al. (2004). For other age groups, several studies used static and dynamic
260 body-stimulus databases that have only been validated by adults. A few studies recorded their own
261 body expression videos with different expressivity (e.g. expressive dance movements; Boone &
262 Cunningham, 1998). Finally, few studies presented naturalistic stimuli that combined body, facial
263 and vocal cues. Those that did manipulated the congruency of the emotion expression between
264 different cues, leading to stimuli that were not necessarily naturalistic.

265 Given these limitations, we suggest several future research directions. The first is to test
266 young infants with a larger variety of emotion body expressions, including neutral expressions
267 (Hepach & Westermann, 1996). It would also be important to test infants longitudinally to map out
268 the developmental trajectory for emotion processing of body expressions. Future work can also
269 combine different outcome measurements (e.g., pupil dilation, EMG and EEG), use naturalistic
270 dynamic multi-sensory perceptual cues (e.g., Geangu et al., 2011; Quadrelli et al., 2019; Poulin-
271 Dubois et al., 2018), test different cultures (e.g., Geangu et al., 2011, 2016a; Quadrelli et al., 2019;
272 Poulin-Dubois et al., 2018; see Parkinson et al., 2017, for adults), and investigate factors
273 contributing to observed individual differences (e.g., Crespo-Llado et al., 2018). One key limitation
274 is that the body stimuli used in laboratory studies are visually impoverished and may not capture
275 many of the perceptual cues that infants and children may experience in their daily activities (e.g.,
276 Smith et al., 2018). Given the importance of the maturing infants' environmental and social
277 contexts, future studies can be conducted in the *real world* and focus on, for example, the frequency
278 of different facial and body emotion expressions in the infants' visual field, parenting behaviors,
279 and the context in which emotion expressions occur (e.g., Fausey et al., 2016; Jayaraman et al.,
280 2017; Smith et al., 2018). These directions will be highly challenging but will be important to
281 address the gaps in understanding the development of emotion processing of body expressions—
282 and emotion processing more generally—highlighted by our mini-review.

283

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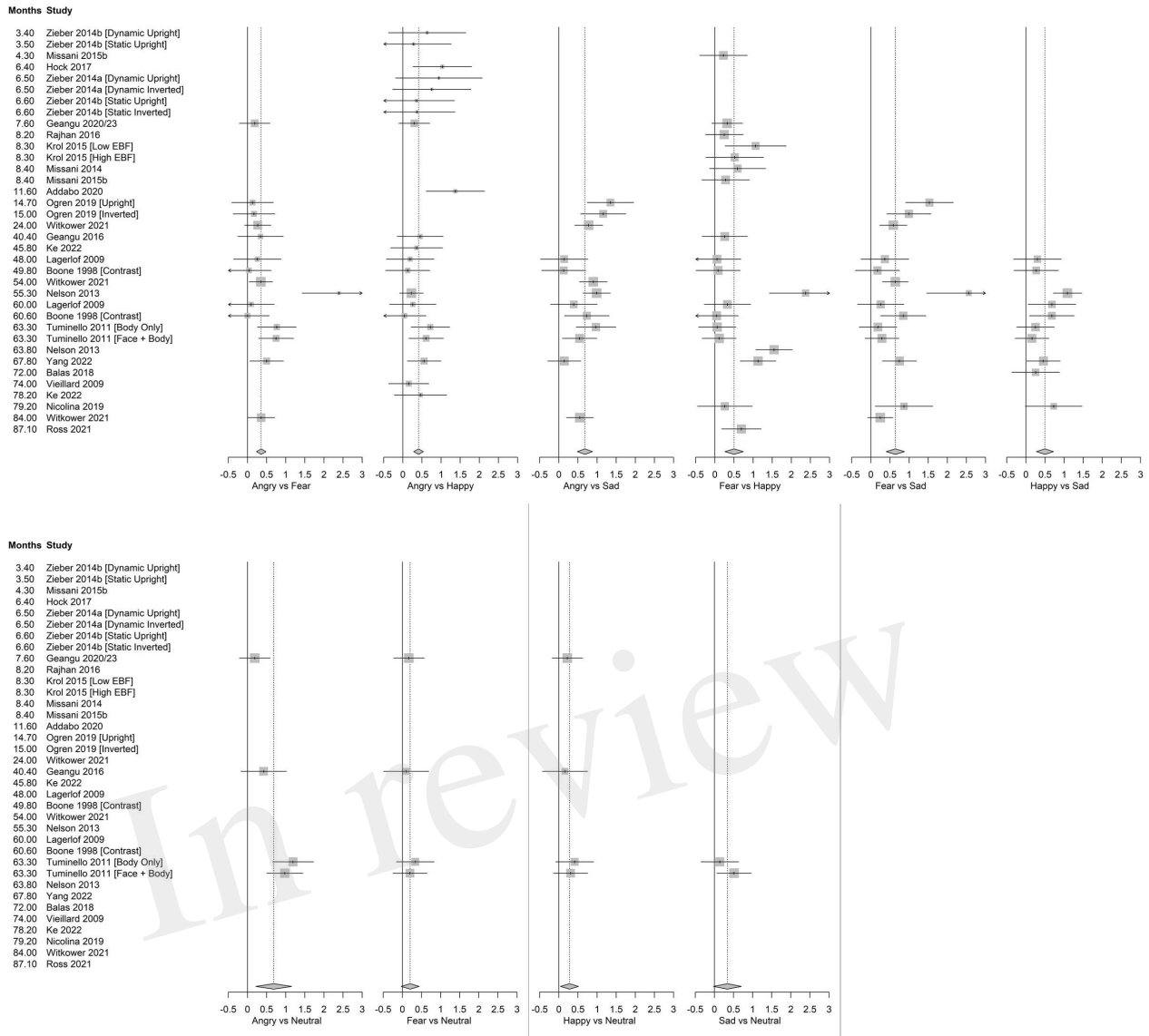
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533 **Table 1.** Summary characteristics of the 38 studies included in the mini-review

534 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
535 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
536 corresponding order and separated by commas. Other age groups tested in the same study are listed but not considered in this review. Other study
537 characteristics include: body stimulus used; whether the stimuli included body motion, faces or voices; the emotion expressions tested; the outcome
538 measurements; and additional summary information about any conditions tested (e.g., upright vs inverted bodies) and notes. The *Meta* column
539 indicates whether the study was included in the meta-analysis or not. *Notes.* *Milestones from Ausderau et al. (2017).* * = feature was included on some
540 conditions. *Atkinson* = from *Atkinson et al. (2004)*. *BEAST* = from *de Gelder & van den Stock (2011)*. *BESST* = from *Thoma et al. (2012)*. *GEMEP* =
541 from *Bänziger et al. (2012)*. *Max Planck* = from *Volkova et al. (2014)*. *NIMSTIM* = from *Tottenham et al. (2009)*. *Saunter* = from *Saunter et al.*
542 (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 asymmetry)	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 independently	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 adults	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		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 Ke	2011 2022	42.7, 53.6, 64.8 45.8, 78.2	48, 48, 48 17, 17	24F, 24F, 24F 8F, 10F		body videos point light videos (Max Planck)	Yes Yes	Yes* No	Yes* No	Angry, Fear, Happy, Sad Angry, Happy	accuracy ERP (N300 and N400 components)	faces blurred or not priming by body on words; word/body congruency	N 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	accuracy	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
		Broscole	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 Gioia	2022 1988	67.8 71.0	41 10	21F 5F	adults	body images (BEAST) animal line drawings	No No	No No	No No	Anger, Fear, Happy, Sad Angry, Happy, Sad	accuracy errors	Tested asian participants Compared mild, moderate and severe mental disorders	Y N
6 to 8 years		Balas	2018	72.0	20	13F	8-11yrs, adults	body images (BESST)	No	No	No	Angry, Sad	accuracy, 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
		Viellard	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 Ross	2019 2021	79.2 87.1	15 32	6F Not provided	8-11yrs, adults	body videos body images (BEAST)	Yes No	Yes No	Yes* Yes*	Fear, Happy, Sad, Neutral Happy, Fear	accuracy accuracy	Compared with and without facial palsy Body/voice congruency, happy/fear voices	Y Y



544

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

546 The effect sizes from the 22 studies are ordered chronologically based on mean age in months.

547 Some studies tested groups in different conditions (as indicated in brackets). Horizontal lines depict

548 95% confidence interval (95%-CI), size of squares represents the weight of individual data sets, and

549 diamonds represent mean effect sizes based on a random-effects model (vertical dashed line). The

550 effect size mean and 95%-CI for each emotion pair (column), respectively, are: Row 1 0.36 [0.23;

551 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]

552 ($p < 0.001$); Row 2 0.69 [0.22; 1.16] ($p < 0.001$); 0.20 [-0.03; 0.44] ($p = 0.09$); 0.28 [0.04; 0.51]

553 ($p = 0.02$); 0.34 [-0.03; 0.71] ($p = 0.07$). *Notes.* The scale was truncated to Hedges' $g = -0.5$ to 3.0 for

554 visualisation purposes. Arrows on the confidence interval indicate that the horizontal line extended

555 beyond the limits of the truncated scale.

556

557

Figure 1.TIFF

