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The development of facial emotion recognition: The role of configural information

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Abstract

The development of children's ability to recognize facial emotions and the role of configural information in this development were investigated. In the study, 100 5-, 7-, 9-, and 11-year-olds and 26 adults needed to recognize the emotion displayed by upright and upside-down faces. The same participants needed to recognize the emotion displayed by the top half of an upright or upside-down face that was or was not aligned with a bottom half that displayed another emotion. The results showed that the ability to recognize facial emotion develops with age, with a developmental course that depends on the emotion to be recognized. Moreover, children at all ages and adults exhibited both an inversion effect and a composite effect, suggesting that children rely on configural information to recognize facial emotions.

Keywords: Facial emotions; Development; Configural information; Inversion effect; Composite effect

Introduction

Processing of facial emotions emerges early (e.g., Barrera & Maurer, 1981; Walker-Andrews, 1997), but full proficiency seems not to be acquired before 10 years of age.

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Although preschoolers can label facial emotions at above chance levels (e.g., Markham & Adams, 1992; Russell & Widen, 2002; Widen & Russell, 2003), they are substantially less accurate than adults. The purpose of our study was to provide new evidence on development change in recognition of facial emotions during childhood.

Few studies have investigated the developmental course of facial emotion recognition, contrary to face recognition abilities, and the results are often inconsistent, mainly because of the great variety of methods used. A study by Bruce et al. (2000) suggested that development of facial emotion recognition depends on task demands. When children needed to point to which of two faces was happy, sad, angry, or surprised, they achieved nearly perfect accuracy by 6 years of age. However, when they needed to select which of two emotional faces expressed the same emotion as a third face, a good accuracy level was not reached until 10 years of age. In a similar study in which children needed to match an emotional photograph to one of four possibilities (neutral, surprise, happiness, or disgust), Mondloch, Geldart, Maurer, and Le Grand (2003) reported an increase in accuracy between 6 and 8 years of age, when performance reached the adult level. In a study by Kolb, Wilson, and Taylor (1992), children and adults were shown a single emotional photograph or a cartoon depicting an emotional situation and then needed to select from a panel of six different emotional photographs (happiness, sadness, fear, anger, disgust, and surprise) the face that expressed the same or correct emotion. Recognition of facial emotions improved between 6 and 8 years and between 8 and 10 years of age, depending on the task, and improved again between age 14–15 years of age and adulthood. There is also evidence that the developmental pattern is not uniform across emotions. Expressions of happiness and sadness seem to be correctly categorized earlier than those of fear and disgust (Boyatzis, Chazan, & Ting, 1993; Camras & Allison, 1985; Gosselin, 1995; see also Gosselin, 2005; Gosselin & Larocque, 2000). The developmental pattern for anger is less clear, with some results indicating a pattern similar to that for happiness and sadness (e.g., Gosselin, 1995) and others indicating that anger was less well categorized than happiness and sadness but also less well categorized than fear and disgust (e.g., Boyatzis et al., 1993).

Despite task- and emotion-related differences, performance generally improves with age. One hypothesis developed to explain improvement in face recognition is that adults are more likely than children to rely on the configural properties of faces (e.g., Leder & Bruce, 1998; Tanaka & Farah, 1993; Thompson, 1980; Yin, 1969). Three types of configural information are distinguished (for a review, see Maurer, Le Grand, & Mondloch, 2002): first-order relations (relative position of features, e.g., the eyes above the nose), second-order relations (fine spatial information, e.g., distance between features), and holistic information (features are perceived as a unique gestalt). Configural processing is distinguished from featural, componential, or local processing, where features are processed in a piecemeal or analytic way. Carey and Diamond (1977) suggested that children do not use configural information until they are 10 years of age. Children under age 10 would tend to base their judgments on local information such as features or paraphernalia. These authors noted that children under age 10 are highly sensitive to paraphernalia when recognizing unfamiliar faces. Moreover, they found no inversion effect (i.e., children were not impaired by presenting a face upside down), whereas such an effect is known to be strong in adults (Yin, 1969). The inversion effect is considered to demonstrate the weight of configural information; by modifying the relative position of features (e.g., the eyes are above the nose in an upright face, whereas they are below the nose in an upside-down face), inversion of a face interferes with configural processing (Maurer et al., 2002).

However, Carey and Diamond's (1977) hypothesis has been challenged by studies demonstrating that children under 10 years of age can process faces configurally (Baenninger, 1994; Carey & Diamond, 1994; Flin, 1985; Freire & Lee, 2001; Tanaka, Kay, Grinnell, Stansfield, & Szechter, 1998). Notably, an inversion effect was reported at younger than 10 years of age. Flin (1985) found that inversion altered children's performance as young as 7 years in the same way as older children and adults. In Brace and colleagues' (2001) study, children as young as 5 years showed an inversion effect, but 2- to 4-year-olds did not. Recently, Sangrigoli and de Schonen (2004) showed an inversion effect in 3-year-olds. Even newborns and infants are sensitive to face orientation (Gallay, Baudouin, Durand, Lemoine, & Lécuyer, 2006; Slater et al., 2000; Turati, Sangrigoli, & de Schonen, 2004). Carey and Diamond (1994) themselves reported an increasing inversion effect from 6 to 10 years of age, suggesting a development of the ability to process configural information.

Configural processing of facial information by children was also observed with paradigms used specifically to provide evidence for holistic processing of faces, namely, the composite face paradigm and the whole-part paradigm. In the composite face paradigm, a composite stimulus is made up by joining the top half of a face with the bottom half of another face. Adults are slower and less accurate to recognize either half part when the top and bottom parts are vertically aligned (creating a new face stimulus) than when the same top and bottom parts are misaligned. A similar composite effect (i.e., the recognition of a person from a half-part of the face is interfered by the alignment of a counter-part from another face) was observed in 4-year-olds and adults (De Heering, Houthuys, & Rossion, 2007; for a similar observation from 6- to 10-year-olds, see Carey & Diamond, 1994). In the whole-part paradigm, participants need to recognize face features either embedded in the whole face stimulus or presented in isolation. A whole-part advantage effect (i.e., features are better recognized in the context of a normal face than when isolated) was reported in 4- and 6-year-olds, again of similar amplitude to older children (Pellicano & Rhodes, 2003; Tanaka et al., 1998). Such effects have also been demonstrated in infants. Notably, Cashon and Cohen (2003; see also Cohen & Cashon, 2001) reported that 4-month-olds look longer at a "switched" (or composite) face, made up of the internal features of a familiar face and the external features of another familiar face, than at each whole familiar face. Thus, the composite face was perceived as a new face by infants despite its being built up with only familiar parts. This observation was extended to 8-month-olds by switching single features rather than all internal features; infants reacted when only the eyes, nose, or mouth of a familiar face was put into another familiar face (Schwarzer & Zauner, 2003). Thus, there is now sufficient evidence demonstrating the early ability of children to process configural information.

Little is known about the role of configural information in the development of the ability to recognize facial emotions. This topic of investigation is quite important because configural information also plays a significant role in facial emotion recognition by adults. Calder, Young, Keane, and Dean (2000; see also Calder & Jansen, 2005) observed a composite effect in emotion recognition similar to the one reported by Young, Hellawell, and Hay (1987) in face recognition; that is, when the top and bottom halves of a composite face depict different emotions, recognition of the emotion in either half is slower and less accurate than when the composite face is inverted or the two halves are offset laterally. Thus, it can be hypothesized, as for face recognition, that the development of the ability to process configural properties of faces also underlies the development of the ability to process facial emotions.

The main aim of the current research concerned the possible role of configural information in the development of recognition of facial emotions. Configural information plays an important role in adults' recognition of facial emotions (e.g., Calder & Jansen, 2005; Calder, Young, Keane, & Dean, 2000), but the role of configural information in children's recognition of facial emotions is unknown. In particular, testing children's sensitivity to facial emotion orientation and composite emotion would help to reveal the processes that underlie developmental change in recognition of facial emotions. Testing both the inversion and the composite effects is important because many authors have suggested that the various paradigms do not tap into the same type of configural information or are differentially sensitive to this information (Baudouin & Humphreys, 2006; Calder & Jansen, 2005; Maurer et al., 2002; Mondloch, Le Grand, & Maurer, 2002). Consequently, testing configural effects provides a more complete view of the role of configural information in children; the inversion effect informs us about the consequences of disturbing the processing of configural information by altering first-order relations, whereas the composite effect tests more specifically the role of holistic information in the recognition of facial emotion.

Children of four ages and adults participated in two tasks. In the first task, they were asked to recognize six different emotional categories: happiness, anger, disgust, fear, sadness, and neutrality. The faces were upright in one session and upside down in another session. This task allowed us to study the development of the ability to process each emotion and informed us about the presence of an inversion effect in emotion recognition at each age. In the second task, participants were asked to recognize the emotion depicted in the top half of faces when, in each case, the bottom half was the same person's face displaying another emotion. The two halves were either aligned or shifted, and they were presented either upright or upside down. In adults, alignment in upright faces creates a new emotional configuration (the composite effect) that interferes with the recognition of the emotion displayed by each half; recognition is slower than it is in the shifted and upside-down conditions (Calder et al., 2000). This task allowed us to find out whether children would exhibit the same composite effect as do adults. More precisely, it was informative about whether holistic information would interfere in the processing of facial emotion to a similar extent in children and adults.

Method

Participants

Five different age groups participated in the experiment: 26 5- and 6-year-olds (12 girls and 14 boys, mean = 5 years 9 months, range = 5 years 4 months to 6 years 2 months), 24 7- and 8-year-olds (10 girls and 14 boys, mean = 7 years 10 months, range = 7 years 1 month to 8 years 4 months), 24 9- and 10-year-olds (13 girls and 11 boys, mean = 9 years 9 months, range = 9 years 2 months to 10 years 10 months), 26 11- and 12-year-olds (17 girls and 9 boys, mean = 11 years 10 months, range = 11 years 2 months to 12 years 6 months), and 26 adults (14 women and 12 men, mean = 22 years 5 months, range = 18 years 9 months to 29 years 5 months). Children were tested individually in a quiet room of their school either one by one or in pairs, depending on the number of experimenters. Adults were tested in a university office or at home.

Materials

Photographs of 36 persons (23 females and 13 males) were used during the facial emotion recognition task with whole upright and upside-down faces. There were 6 photographs for each of 6 facial emotions, with each person expressing a single emotion (anger, disgust, fear, happiness, sadness, or neutrality). The emotional valence of the faces was verified via a pretest on emotion category and intensity, where 11 adults were asked whether the photographs were happy, fearful, angry, sad, disgusted, neutral, or other; after having selected a category, they rated the intensity of the emotion from 0 to 10. We used photographs that had been categorized in the same emotional category by at least 91% of the participants and with an intensity of at least 5 (of the possible 10). The photos depicting different emotions did not differ on either percentage of choice or intensity (all Fs < 1).

In the composite task, we used the photographs from Baudouin and Humphreys (2006) of 8 persons (3 females and 5 males) expressing anger and 8 persons (6 females and 2 males) expressing happiness. Each photo was cut through the bridge of the nose (as was done by Calder et al., 2000). The top half was presented to 8 adults who were asked to state whether the face expressed happiness, anger, or fear. In the faces used, emotion was recognized accurately by at least 6 of 8 adults. We created 16 stimuli by pairing each top-half photo with a bottom-half photo of the same person expressing another emotion—fear for half of the persons in each emotional set, happiness for the 4 remaining persons expressing anger, and anger for the 4 remaining persons expressing happiness. We used fear on the bottom part for some stimuli so that participants could not deduce the emotion in the top half (happiness or anger) from the emotion displayed in the bottom half (anger or happiness). Two versions were created for each pair of top- and bottom-half emotions: an aligned face made by aligning the two parts so that participants were under the impression they were seeing a single face and an unaligned face made by shifting the bottom part to the left or right by roughly half of the face's width. The shift side was alternated across pairs so that there was the same number of right/left shifts for each possible association of emotions. The photograph of another person was used to created 8 stimuli for the training session, with 4 aligned faces and 4 unaligned faces, and four different kinds of associations of emotion (happiness/anger, happiness/fear, anger/happiness, and anger/fear).

Procedure

Whole facial emotion recognition task

Participants were told that they would see upright faces of different persons expressing various emotions. They were informed about the emotional categories and were given a sheet of paper with the name of each category followed by a sentence (derived from Ekman & Friesen, 1971) describing the emotional state (e.g., his/her child is sick, and he/she feels very sad). The experimenter read the names and sentences with the participants to ensure that they understood the emotional states described. The sentences were used to avoid any misunderstanding of the labels and allowed children either to respond from the labels of the sentences or to use some new labels different from those used by the experimenter (e.g., "unhappy"). When a child used a new label, the experimenter verified that it corresponded to the label of the sentence with the child.

The 36 photographs were then presented individually in random order and remained visible on the computer screen until participants responded. For the youngest group, the experimenter repeated the 6 possible categories on each photograph and entered the responses on the keyboard. No feedback was given to participants about their responses. Half of the participants started with upright faces, and the other half started with inverted ones. After participants had judged all 36 photos, the photos were presented again, but this time upright for those who began with inverted faces and inverted for those who began with upright faces.

Composite facial emotion recognition task

After the first task, participants were told that they would see stimuli in which two facial parts expressing different emotions were presented together either aligned or not aligned. They were asked to say whether the top part (eye area) was happy or angry without paying attention to the bottom part (mouth area), which was there to distract them. They answered by pressing one of two keys on the keyboard as quickly as possible without neglecting accuracy. Each participant performed two sessions: one where the stimuli were upright and one where they were inverted. The session order was alternated across participants. Each session started with a training session consisting of 8 trials. This was followed by 32 test trials (two presentations of each person: one aligned and the other unaligned) in random order. For unaligned emotions, the top half was presented in the center of the screen, in the same position as for aligned emotions. Each trial started with the display of a fixation point for 1000 ms, followed by a blank screen for 1000 ms. Then the stimulus was presented and remained on the screen until the participant responded. The second session was strictly the same except that the stimuli were either upright or upside down.

Data analysis

The A' indicator from the signal detection theory was used instead of the percentage of correct categorization (Grier, 1971). The rationale was that when participants are not sure of their responses, some may choose a particular emotion more frequently than the other emotions (e.g., neutral), increasing the percentage of correct categorizations for this category relative to the others. In terms of signal detection theory, the decision criterion would be less strict for this emotion, and consequently the number of false alarms (e.g., neutral responses for another expression) and the number of hits (neutral responses for neutral expressions) both would increase. Response accuracy computed from the number of hits would be biased compared with other emotions. A' is an index of discriminability; it measures the participant's ability to discriminate the target emotion from other emotions. A' ranges from 0 to 1, with 1 corresponding to situations where the participant recognized the emotion every time it was presented without "recognizing" it in other expressions and 0.5 corresponding to performance at chance levels (i.e., the participant "recognized" the emotion as often on a face that really expressed that emotion as on a face that expressed another emotion).

We also used the B'' index from signal detection theory that indicates whether participants were biased toward certain emotions rather than others (Grier, 1971). Bias can be liberal (the participant tends to "recognize" the emotion even in other emotions) or conservative (the participant tends not to recognize the emotion). B'' ranges from -1 (liberal criterion) to 1 (conservative criterion), with 0 indicating a neutral criterion.

Correlation between inversion and composite effects

To test whether participants were consistent across the inversion and composite effects, we computed the Bravais–Pearson coefficient of correlation between the inversion effect (discriminability for upright faces minus discriminability for upside-down faces) in the whole facial emotion recognition task and the composite effect (discriminability for unaligned upright faces minus discriminability for upright aligned faces) in the composite facial emotion recognition task.

Results

Whole facial emotion recognition task

Two $5 \times 6 \times 2$ analyses of variance (ANOVAs) (Age $\times$ Emotion $\times$ Orientation) were performed, with age as a between-subject factor and emotion and orientation as within-subject factors, respectively, for discriminability A' and decision criterion B''.

Discriminability A′

The means in each experimental condition are presented in Table 1. The main effect of age group was significant, $F(4,121) = 25.99$, $p < .0001$, as was the main effect of emotion, $F(5,605) = 61.88$, $p < .0001$. However, these effects were qualified by an interaction between emotion and age group, $F(20,605) = 6.28$, $p < .0001$.

Linear comparisons were performed to determine whether the discriminability that increased significantly with age was significant for each emotion. The age group effect was significant for each emotion, $Fs(4,121) = 2.73$, $p < .05$. For happiness, post hoc Fisher LSD tests ($p < .05$) indicated that, despite a significant increase in discriminability with age, none

Table 1
Discriminability (A') by orientation, emotion, and age group

	5 Years	7 Years	9 Years	11 Years	Adults
Upright faces					
Happiness	.94 (.06)	.96 (.04)	.98 (.03)	.98 (.02)	.99 (.02)
Anger	.88 (.09)	.88 (.09)	.91 (.11)	.92 (.05)	.93 (.06)
Disgust	.65 (.25)	.71 (.23)	.81 (.21)	.90 (.07)	.94 (.05)
Fear	.82 (.19)	.90 (.13)	.94 (.11)	.97 (.03)	.97 (.03)
Sadness	.92 (.06)	.88 (.05)	.89 (.11)	.91 (.06)	.92 (.10)
Neutral	.70 (.22)	.87 (.15)	.93 (.10)	.96 (.03)	.97 (.05)
Overall	.82 (.08)	.87 (.07)	.91 (.07)	.94 (.02)	.95 (.03)
Upside-down faces					
Happiness	.86 (.10)	.90 (.08)	.94 (.06)	.95 (.04)	.97 (.03)
Anger	.64 (.20)	.65 (.24)	.72 (.23)	.78 (.18)	.84 (.09)
Disgust	.51 (.24)	.58 (.24)	.66 (.24)	.82 (.10)	.85 (.14)
Fear	.80 (.18)	.86 (.10)	.87 (.15)	.91 (.08)	.91 (.06)
Sadness	.64 (.18)	.68 (.18)	.59 (.23)	.68 (.17)	.75 (.16)
Neutral	.60 (.27)	.74 (.16)	.86 (.14)	.86 (.10)	.91 (.05)
Overall	.68 (.10)	.74 (.10)	.78 (.11)	.83 (.07)	.87 (.06)

Note. Standard deviations are in parentheses.

of the differences between the age groups considered two by two was significant. For anger, the two youngest age groups had a significantly lower discriminability than did adults. For disgust, the three youngest age groups had a significant lower discriminability than did the 11-year-olds and adults. The 5-year-olds differed significantly from the 9-year-olds. For fear, discriminability was significantly lower for the 5-year-olds than for the other four age groups. For sadness, as for happiness, none of the differences between the age groups considered two by two was significant. For neutrality, discriminability was significantly lower for the 5-year-olds than for the other four age groups and for the 7-year-olds than for the older age groups. No other differences were significant.

The main effect of orientation was significant; discriminability was greater for upright facial emotions (.90) than for inverted ones (.78), $F(1,121) = 320.52$, $p < .0001$. This effect was qualified by a significant interaction between age group and orientation, $F(4,121) = 2.91$, $p < .05$. Linear comparisons indicated that the effect of orientation was significant for all groups, $F\text{s}(1,121) = 30.48$, $p < .0001$. Thus, the significant interaction indicated that the inversion effect was significant at every age, but the difference between upright and inverted faces decreased with age (.14 for 5-year-olds, .13 for 7- and 9-year-olds, .11 for 11-year-olds, and .08 for adults). The interaction between orientation and emotion was also significant, $F(5,605) = 34.52$, $p < .0001$. Linear comparisons indicated that the orientation effect was significant for all emotions, $F\text{s}(1,121) = 19.95$, $p < .0001$, but the inversion effect was strongest for sadness (.24) and weakest for fear and happiness (.05), with the rest intermediate (anger, .18; disgust, .12; and neutrality, 09).

The interaction among age group, emotion, and orientation was not significant, $F(20,605) = 1.21$. Thus, the previous effects were not qualified by the other factors.

Decision criterion B″

The main effect of age group was significant, $F(5,605) = 28.57$, $p < .0001$, as were the main effects of orientation, $F(1,121) = 42.65$, $p < .0001$, and emotion. However, these effects were qualified by significant interactions between emotion and orientation, $F(5,605) = 10.32$, $p < .0001$, and among emotion, age group, and orientation, $F(20,605) = 1.97$, $p < .01$. The means associated with the three-way interaction are illustrated in Fig. 1. Overall, and whatever the orientation, participants adopted a liberal criterion for happiness and a more conservative criterion for anger, disgust, fear, and sadness. The impact of orientation was to make participants' criterion more conservative for most emotions for inverted faces; however, the criterion for neutrality became more liberal.

To study age-related change in the decision criterion, linear comparisons were performed to test for the effect of age group for each emotion in each orientation. The age group effect was significant for neutrality and sadness for both upright and upside-down faces, $F\text{s}(4,121) = 4.62$, $p < .01$, becoming increasingly liberal with age for neutrality and increasingly conservative for sadness. The age effect was not significant for the other emotions regardless of orientation, $F\text{s}(4,121) \leqslant 2.35$.

Composite facial emotion recognition task

Two $5 \times 2 \times 2$ ANOVAs (Age $\times$ Orientation $\times$ Facial Alignment) were performed for discriminability A' and decision criterion B'' with age group as a between-subject factor and orientation and alignment of face as within-subject factors.

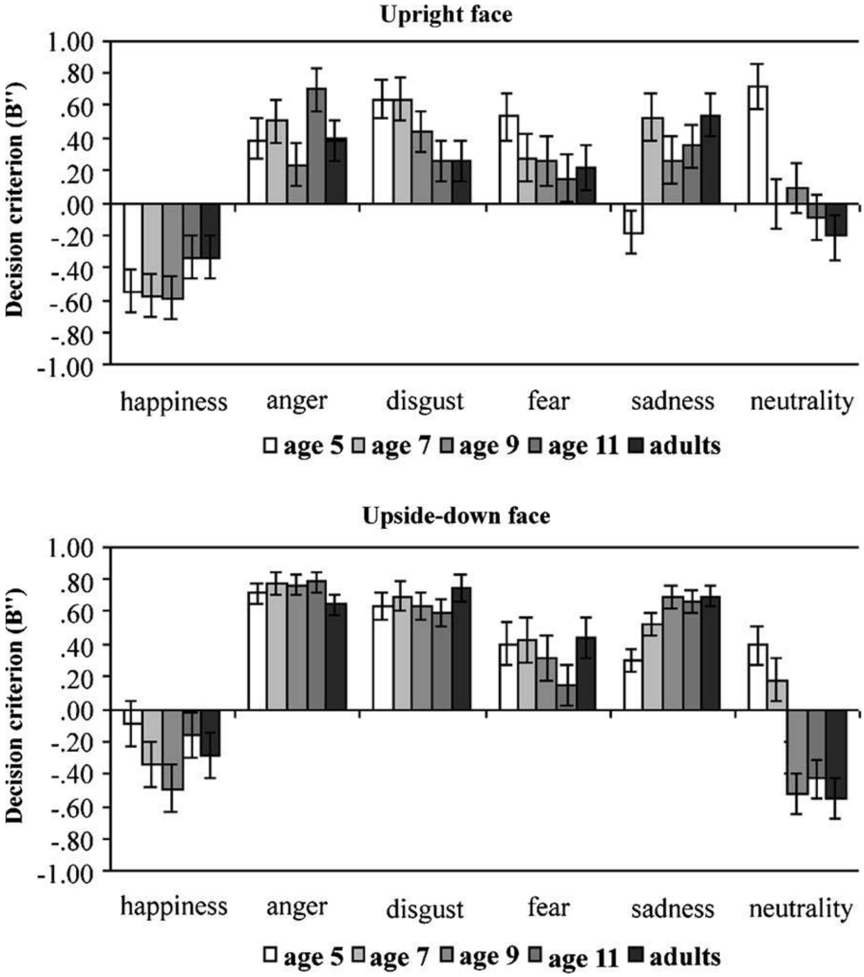

Fig. 1. Decision criterion (bias) B″ by age group, emotion, and orientation. Error bars correspond to standard errors.

Discriminability A′

The means in each experimental condition are presented in Fig. 2. The main effect of age was significant, $F(4,121)=13.89$, $p<.0001$. Post hoc Fisher's LSD tests ($p<.05$) indicated that 5-year-olds (.72) were significantly less accurate than 9-year-olds through adults, whereas 7-year-olds (.78) and 9-year-olds (.80) were comparably accurate but were significantly less accurate than 11-year-olds (.89) and adults (.92). Age did not interact with orientation or facial alignment, $Fs(4,121) \leqslant 1.77$.

The main effects of orientation and alignment were significant, $Fs(1,121) \geqslant 19.96$, $p<.0001$, but they were qualified by a significant interaction between alignment and orientation, $F(1,121)=20.06$, $p<.0001$. Linear contrasts indicated that although participants were less accurate for aligned upright faces (.81) than for unaligned ones (.89), $F(1,121)=54.53$, $p<.0001$, the difference was nonsignificant for inverted faces (.79 vs. 80),

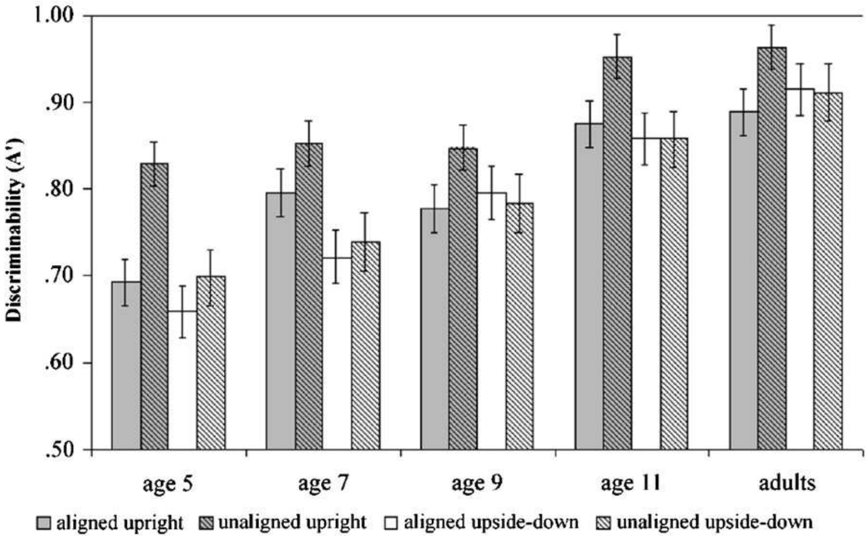

Fig. 2. Composite effect on discriminability A'. Error bars correspond to standard errors.

$F(1,121) = 0.43$. As shown in Fig. 2, at every age, participants were most accurate for aligned upright faces and approximately equally accurate on all other types of faces.

Decision criterion B″

The main effect of age was not significant, $F(4,121) = 1.06$, and did not interact with the other factors, $Fs(4,121) \leqslant 1.90$. The only significant effect was the main effect of orientation, $F(1,121) = 19.96$, $p < .001$. Participants were significantly more biased toward angry responses for upright faces (−.20) than for upside-down faces (−.04).

Correlation between the inversion and composite effects

The correlation between the inversion effect in the whole facial emotion recognition task and the composite effect in the composite facial emotion recognition task was not significant, $r = -11$. This correlation remained not significant when the inversion effect was computed only from the discriminability for happiness and anger in the whole facial emotion recognition task, $r = -.17$.

Discussion

The first conclusion of the current study is that the development of the ability to recognize emotions from facial expressions is not the same for all emotions. Happiness and sadness appear to be accurately recognized by children as young as 5 or 6 years of age, with an accuracy level very close to that of adults. Fear did not reach the adult level until 7 years of age, anger needed 2 more years, and disgust needed 4 more years. Even neutrality needed to develop before it could be distinguished from emotions because children under 9 years of age had a tendency (more pronounced than that of adults) to perceive an emotion (generally happiness or sadness) on neutral faces. Thus, children accurately discriminate a more limited set of emotions than do adults. At 5 or 6 years of age, their emotion-processing ability is mature (i.e., close to the adult level) for two emotions: happiness and sadness. By the time they reach roughly 10 years of age, children have added fear, anger, and neutrality to their set and their ability to process disgust is improving, reaching the adult level at 11 or 12 years of age.

The fact that the discriminability of some emotions was lower for children than for adults does not mean that children do not recognize these emotions. Their performance was above chance levels in all cases, even for disgust, and a close inspection of data reveals that children did not assign labels in a random or arbitrary manner. In other words, they did not "lack" some emotional categories. Rather, it appears that these emotional categories exist but are poorly defined with unclear boundaries. Thus, these children did not randomly assign the labels of less well-defined categories (which is what they would do in the absence of the category) but rather used them in an inaccurate way. The strongest evidence for the existence of less well-recognized emotion categories is the finding that young children know these categories when tested in other ways. Obviously, children can feel disgust or fear before they are 5 or 6 years of age. They are also able to describe events associated with these emotions (including disgust) when they are informed about the emotions by their labels or behavioral consequences (e.g., Widen & Russell, 2004) Thus, they can associate emotional states with the correct labels, and they know the behavioral consequences of these emotional states. Given that they know the different emotions, their low ability to recognize them on faces results from a lack of knowledge about their effects on facial expressions. It is the ability to accurately discriminate facial expressions and to associate them with the corresponding emotional categories that develops during the first decade of life, with some categories clearly being defined faster than others.

The lack of clear definitions for some emotional categories also leads children to adopt a pattern of decision criteria—and consequently to exhibit certain kinds of bias—that is quite different from the adult pattern. Adults have the tendency to respond happy or neutral, adopting a stricter criterion for negative emotions. Consequently, expressions that are less obvious are put into the happy or neutral category more frequently. Young children have not clearly defined a category for neutral expressions, so they adopt a liberal criterion for sadness at the same time as for happiness. This leads them to put ambiguous expressions into one of these two categories. This was particularly visible here for the youngest children when confronted with emotions they had difficulty in categorizing (e.g., disgust, [but also] neutrality). Thus, adults tend to put ambiguous emotions into one of two categories: happiness or neutrality. The youngest children, not being able to use neutrality because of its unclear boundaries, replace it with a more well-defined emotion—sadness—rather than using only happiness. They act as if they "need" a second category with a liberal criterion to cut the emotional environment into at least two parts, pleasant/unpleasant for the youngest children rather than pleasant/not pleasant for adults. The development of a more clearly defined category for neutrality is accompanied by a shift from sadness to neutrality as the second liberal category.

Regarding the role of configural information in facial emotion recognition, our study showed, first, that children process facial emotion in a configural/holistic way. This information automatically interferes with the recognition of the emotion displayed on facial parts in the same way, and with the same magnitude, as for adults. Children's performance, like that of adults, was impaired by the inversion of emotions, as was that of adults. This observation mirrors that reported in the literature for face recognition, namely that when children's ability to process configural information is tested with the inversion or composite paradigm (or a similar paradigm), they exhibit a sensitivity to configural information that is similar to that of adults despite differences in overall performance (Baenninger, 1994; Carey & Diamond, 1994; Flin, 1985; Freire & Lee, 2001; Tanaka et al., 1998). The conclusion from these data is that configural information does not play a crucial role in the development of face recognition ability. The current study extended this conclusion to the processing of facial emotion.

Beyond the role of configural information in the development of emotion recognition, the current study also indicated that configural processing of faces sustains facial emotion recognition in a similar way as it sustains face recognition. Both an inversion effect and a composite effect were reported in both adults and children. These observations parallel those made in face recognition tasks. Thus, configural processing is involved in the extraction of both identity and emotion. It is also similarly involved in the development of both abilities. Nevertheless, we failed to find a link between the inversion and composite effects, suggesting that they were not driven by the same underlying process and type of information. The composite effect is known to be sensitive to holistic information (Farah, Wilson, Drain, & Tanaka, 1998; Maurer et al., 2002; Tanaka & Farah, 1993). Thus, the composite effect we found here shows that, among the different types of facial information and, more particularly, configural information, children as young as 6 years process facial emotion in a holistic way as they process facial identity (Carey & Diamond, 1994) and as adults process facial emotion (Calder et al., 2000). The mechanisms and information that are disturbed by inversion are less clear. Reversing the face probably disturbs the extraction of different types of information, in particular holistic information and second-order relations. Thus, the effect is sensitive to configural information, but it does not tell us which one. The lack of correlation with the composite effect in our study would suggest that holistic processing was not involved and would make the second-order relations a good candidate But inverting the face can also disturb the processing of componential information (e.g., Baudouin & Humphreys, 2006; Mondloch et al., 2002), adding complexity to any conclusion. Further studies are needed to explore the various possibilities. Nevertheless, and whatever the mechanism and type of information behind the inversion effect, they seem to be involved to a similar extent in children and adults recognizing facial emotions.

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