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Children's Recognition and Discrimination of Fear and Disgust Facial Expressions

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Abstract Facial expressions of fear and disgust have repeatedly been found to be less well recognized than those of other basic emotions by children. We undertook two studies in which we investigated the recognition and visual discrimination of these expressions in school-age children. In Study 1, children (5, 6, 9, and 10 years of age) were shown pairs of facial expressions, and asked to tell which one depicted a target emotion. The results indicated that accuracy in 9- and 10-year-olds was higher than in 5- and 6-year-olds for three contrasts: disgust–anger, fear–surprise, and fear–sadness. Younger children had more difficulty recognizing disgust when it was presented along with anger, and in recognizing fear when it was presented along with surprise. In Study 2, children (5, 6, 9, and 10 years of age) were shown a target expression along with two other expressions, and were asked to point to the expression that was the most similar to the target. Contrary to our expectations, even 5- and 6-year-olds were very accurate in discriminating fear and disgust from the other emotions, suggesting that visual perception was not the main limiting factor for the recognition of these emotions in school-age children.

Keywords Emotion · Facial expression · Recognition · Visual discrimination

Facial expressions play an important role in the communication of emotional states and in the regulation of social interactions in human beings. They provide information as to the category (such as fear or anger) and intensity of emotion, and allow protagonists involved in social interactions to adjust their behavior in the appropriate way (Ekman 1993; Izard 1991). Other nonverbal channels, like voice and gestures, also play a significant role in the communication of emotion, but the information they provide has not yet been found to be as specific (Johnstone and Scherer 2000).

Current evidence suggests that the ability to make a connection between facial expressions and specific basic emotions appears around the age of two. When shown only

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two pictures of facial expressions and asked to point to the face displaying a specific emotion, preschoolers generally do quite well. Using such a method, Bullock and Russell (1985) found that 2-year-olds achieve a level of performance above chance level for happiness, anger, fear, surprise, disgust, and sadness. Preschoolers' performance is also fairly good for most basic emotions with an array of three different facial expressions (Boyatzis et al. 1993; Camras and Allison 1985; Harrigan 1984; Markham and Adams 1992).

Although preschoolers are able to recognize most of the basic emotions, their performance is far from perfect. Significant improvement between the ages of 5 and 10 years has consistently been found in judgment tasks requiring participants to select the expression of a given emotion from an array of different expressions (Gao and Maurer 2009; Gosselin 1995; Gosselin and Larocque 2000; Markham and Adams 1992; Tremblay et al. 1987). It has also been reported in studies in which participants were shown one expression at the time and asked to select the right emotion name from an array of different names (Gosselin et al. 1995) or asked to generate an emotion label on their own (Vicari et al. 2000; Widen and Russell 2003).

The improvement with age in later childhood is not uniform across emotions. Expressions of happiness and sadness are already well-recognized by the age of five, with only modest gain or no gain at all in later childhood (Gao and Maurer 2008; Gosselin 1995; Vicari et al. 2000; Tremblay et al. 1987). Accuracy levels for expressions of fear and disgust, although above chance, are typically quite low in 5-year-olds, but improve substantially over the next five years (Gao and Maurer 2008; Gosselin 1995; Gosselin and Larocque 2000; Vicari et al. 2000). The developmental patterns of the recognition of anger and surprise are less clear. While some studies have reported high levels of accuracy in 5- and 6-year-olds for these emotions, other studies have found moderate levels of accuracy, with significant improvement in later years (Camras and Allison 1985; Gosselin 1995; Tremblay et al. 1987; Vicari et al. 2000).

Interestingly, the distribution of errors for a given emotion is not uniform. The confusion with surprise is the most frequent error made in recognizing expressions of fear in children between 5 and 10 years old (Bullock and Russell 1985; Gosselin 1995). The confusion with respect to expressions of disgust and anger has also been found to account for most of the errors in recognizing the facial expressions of these emotions (Bullock and Russell 1985; Camras 1980; Gosselin et al. 1995). Several researchers have also found that the confusion with happiness is the most common error in recognizing expressions of surprise (Bullock and Russell 1985; Gosselin 1995). The magnitude of these errors decreases over time, but the errors persist even into adulthood (Gosselin and Kirouac 1995; Wiggers 1982).

Recognizing basic emotions from the face is the result of a complex process involving conceptual, as well as perceptual abilities. According to Widen and Russell (2003), children begin with a very simple meaning system for emotions. The word happy, for instance, seems to be used by 2-year-olds to label all emotions. At the age of three, most children use two words to label emotions: one for happiness and the other for sadness or for anger. It is only at the beginning of their fourth year that these three words are used by most children. The words related to fear and surprise are added to children's meaning system at the beginning of the fifth year while those related to disgust are added at the end of the fifth year. This developmental pattern for the acquisition of emotion categories fits quite well with the pattern we have described earlier for the recognition of facial expressions. However, it is not clear to what extent this pattern may really account for the recognition of facial expressions in late childhood. Is the differentiation between basic emotion categories

complete in 6-year-olds? If so, it could not account for the improvement in the recognition of facial expressions in late childhood. On the contrary, if the differentiation among emotion categories is still under way in school-age children, does it account for a significant part of the improvement in the recognition of facial expressions?

Although a large corpus of studies has documented infants' ability to discriminate between facial expressions (Bornstein and Arterberry 2003; Labarbera et al. 1976; Nelson 1987; Nelson and Dolgin 1985; Striano et al. 2002), less is known about the development of this ability in late childhood. Past research in visual development has shown that improvement in pattern recognition, in particular, of complex visual patterns, still takes place in the second half of childhood (Gibson and Spelke 1983). Such an improvement has been related to more complete visual scanning of objects as well as more efficient use of processing resources. For instance, compared to 4-year-olds, 9-year-olds tend to allocate far more resources to difficult items than to easy items while performing various discrimination tasks (Small 1990; Vurpillot et al. 1975).

Facial expressions are clearly complex visual objects composed of several features located in different regions of the face. While some features are perceptually easy to detect, like the mouth opening or the eye opening, other features are more subtle and only involve fine wrinkling of the skin. Furthermore, it is important to note that the degree of distinctiveness between emotions is not uniform (Ekman 2003). Fear shares more facial features with surprise than with sadness and anger, and more facial features with sadness and anger than with happiness and disgust. Disgust has more common features with anger than with happiness, surprise, fear, and sadness. Among the basic emotions, happiness has the most distinctive facial configuration. Its main feature, the smile, created by the action of the *zygomatic major,* is very salient and is not found in any other emotions. Given the complexity of facial expressions, we think it is likely that the visual discrimination between the facial expressions of emotions still improves during late childhood and is responsible, at least in part, for the better recognition of facial expressions.

Evidence concerning the relation between the degree of distinctiveness between facial expressions and their recognition was reported by Gosselin and Simard (1999). In their study, these authors presented 5- and 9-year-olds with pairs of facial expressions of fear and surprise and asked them which one was fear for half of the trials and which one was surprise for the other half. In order to assess the effect of the distinctiveness of the two types of expressions, some pairs differed by only one facial feature (the lowering of the brows or the mouth stretch) while other pairs differed by two facial features (the lowering of the brows and the mouth stretch). The results indicated that 9-year-olds were more accurate than 5-year-olds, and, more importantly, that accuracy increased as a function of the distinctiveness of the two emotions. The effect of the degree of distinctiveness of the two emotions was strong, accounting for 17% of the variance.

To our knowledge, very little evidence has been gathered concerning the visual discrimination between facial expressions in school-age children. Vicari et al. (2000) used a matching task to assess perceptual abilities in children between the ages of 5 and 10. Participants were presented with a target expression and asked to choose, from an array of four expressions, the one that best corresponded to what the stimulus person was feeling. The results indicated high accuracy in 5-year-olds for happiness, disgust, and surprise, with no improvement in later childhood. Significant improvement between the ages of 5 and 10 years was found for anger and fear. Sadness was fairly well discriminated from other emotions in 5-year-olds, with only a modest improvement in accuracy over the next

5 years. Although informative, this study did not necessarily assess visual accuracy per se because the instructions given to children included a reference to emotion concepts.

In the present paper, we investigated the recognition and discrimination of facial expressions of fear and disgust during late childhood. We chose these emotions because they have consistently been found to have a slower developmental pattern, with significant improvement even in late childhood. Close inspection of the errors made by children indicates that fear and disgust are more often confused with other negative or neutral emotions (like surprise) than with positive emotions. For this reason, we focused our analysis on children's ability to distinguish fear and disgust from anger, sadness, and surprise.

Not surprisingly, children's performance in recognition tasks depends upon the requirements of the tasks. The more demanding the task is in terms of visual attention or information retrieval, the poorer the performance is. The right method to use depends upon the type of questions asked by researchers. To the extent that researchers are interested in children's knowledge of facial emotional expressions, we think it is better to use a recognition task which is as undemanding as possible in terms of visual attention and information retrieval. For this reason, we designed a very simple recognition task in which participants were presented with one emotion label and only two different facial expressions, and asked to point to the one displaying the target emotion (Study 1). Similarly, for the visual discrimination task (Study 2), participants were presented with one target expression (fear or disgust) and asked to choose, from an array of two expressions, the one that was the most similar to the target expression. Contrary to Vicari et al. (2000), we made no reference to emotion concepts when we asked participants to match the facial expressions. This was done to ensure that the task was concerned only with visual discrimination. Furthermore, the methods used for the recognition and discrimination tasks were identical (except for the type of judgment), allowing a direct comparison between performance in the two tasks.

We also carefully selected the facial expressions among the JACFEE set developed by Matsumoto and Ekman (1989). Using the Facial Action Coding System (Ekman and Friesen 1978a), two independent judges coded the pictures of the JACFEE set, and then we selected several expressions per emotion that corresponded to a facial emotional prototype proposed by Ekman and Friesen (1978b). Such a strategy also allowed us to ensure that the various exemplars of the same emotion were consistent across stimulus persons.

Study 1

The aim of this study was to examine children's recognition of facial expressions in school-age children. In order to keep the requirements of the recognition task as undemanding as possible in terms of visual attention and information retrieval, only two facial expressions per trial were presented along with an emotion label. Facial expressions of fear and disgust were contrasted with those of three other emotions: anger, sadness, surprise. On the basis of the findings of previous studies, we expected 9- and 10-year-olds to recognize fear and disgust better than 5- and 6-year-olds. Second, we hypothesized that fear would be recognized less accurately when it is contrasted with surprise than with anger, sadness, or disgust. Third, we expected that disgust would be recognized less accurately when contrasted with anger than with sadness, fear, or surprise.

Method

Participants

Twenty-nine 5- and 6-year-olds as well as 29 9- and 10-year-olds participated in this study. They were enrolled in two middle-class, urban elementary schools located in Gatineau, a city in western Quebec, Canada. The younger group contained 15 girls ($M = 6.04$, $SD = .29$) and 14 boys ($M = 6.16$, $SD = .25$) and the older group contained 14 girls ($M = 10.14$, $SD = .29$) and 15 boys ($M = 10.00$, $SD = .50$). All participants spoke French as their mother tongue. Only children with informed parental consent took part in this study. Finally, the recruitment of participants and the conduct of the study were carried out in conformity with the ethical standards in research at the University of Ottawa.

Materials

The materials included facial stimuli selected from the Japanese and Caucasian Facial Emotional Expressions collection (Matsumoto and Ekman 1989). This collection includes 56 photographs of people displaying facial expressions of the seven basic emotions: anger, disgust, happiness, fear, sadness, surprise, and contempt. Half of the people are Japanese and half are Caucasian. The collection also contains equal numbers of men and women. Previous judgment studies with adults reported that the stimuli from this collection were successfully categorized by Americans as well as Japanese decoders, whose accuracy levels were high and analogous (Matsumoto and Ekman).

For the purpose of this study, we selected 23 photographs from the JACFEE collection, among which six for the practice trials and 17 for the test trials. Two independent judges coded the JACFEE set with the FACS (the inter-rater reliability was .83.), and then we selected several expressions per emotion that corresponded to a facial emotional prototype proposed by Ekman and Friesen's (1978b). Table 1 describes the various facial action units involved in each type of facial expression. All people exhibited the same facial pattern for a given emotion.

The six pictures selected for the practice trials were arranged in pairs so as to form three different contrasts: happiness–sadness, anger–happiness, sadness–anger. The 17 pictures used for the test trials included pictures of fear (3), surprise (6), sadness (2), anger (3), and disgust (3). They were arranged in pairs so as to form seven types of contrasts: fear–anger, fear–sadness, fear–disgust, fear–surprise, disgust–anger, disgust–sadness, and disgust–surprise. We created four exemplars of each contrast yielding a total of 28 pairs of facial stimuli, each one distinct in terms of gender and ethnicity combination. In order to do so, some pictures were used more often than others. The pair of stimuli always appeared on the

Table 1 Description of the facial expressions shown to participants in study 1

Emotion	Facial action units
Happiness	Cheek raiser, lip corner puller, lips part
Fear	Inner brow raiser, outer brow raiser, brow lowerer, upper lid raiser, lip stretcher, lips part
Anger	Brow lowerer, upper lid raiser, chin raiser, lip tightener
Surprise	Inner brow raiser, outer brow raiser, upper lid raiser, jaw drop
Sadness	Inner brow raiser, brow lowerer, lip corner depressor
Disgust	Nose wrinkler

right side of the computer screen next to a verbal label which was displayed on the left side. Half of the contrasts involving the expression of fear were presented with the label "fear" whereas the other half were presented with the label corresponding to the emotion that contrasted fear (anger, sadness, surprise, and disgust). In a similar manner, half of the contrasts that involved the expression of disgust used the label "disgust" while the other half used the label associated with the emotion that contrasted disgust (sadness, anger, surprise, and fear). The factors gender and ethnic group (Caucasian vs. Asian) were counterbalanced over the different contrasts.

Procedure

The judgement task was conducted individually by the experimenter, in a room situated close to the participants' classroom. Once the child's assent was obtained, the experiment began with a 'warm-up' session in which the participant and the experimenter discussed the various ways the human face changes according to an individual's emotional state. Then, the child was invited to produce the following facial expressions: happiness, sadness, anger, fear, surprise, and disgust. All participants' attention was drawn to the perceivable and important changes that occurred in their facial anatomy while they portrayed different expressions. Next, they were informed that they would see 28 consecutive pairs of faces on a laptop computer screen, each of which would be presented with an emotion word displayed on the left side of the screen. The experimenter instructed the children that they would have to point their finger at the expression, among the pairs of facial stimuli, which corresponded to the verbal label.

Before starting the trials, three familiarization trials were run in order to ensure the children's understanding of the task. These trials (happiness–sadness, anger–happiness, and sadness–anger) allowed the participants to become accustomed to the task without actually visualizing the stimuli specific to the test phase. The first practice trial was a static trial because the stimuli remained displayed on the screen until the participant gave a response. The participants' answers, whether right or wrong, were mildly praised by the experimenter with comments such as: "Ok, let's keep going". Then children were told that the real task would be carried out a bit faster and that they would have to respond within a time limit. The second and third practice trials gave the participant the opportunity to prepare for the task. These two trials consisted of dynamic trials, meaning that the stimuli were displayed on the computer screen for a determined period (7 s) after which they disappeared and the screen went blank.

After the warm-up session the experimenter ran the 28 test trials. In each test trial, the stimuli were shown on the computer after which a blank screen appeared for an inter-trial period. This allowed the experimenter to indicate the participants' answers on the computer's keyboard. The inter-trial period lasted for 3-s before the next trial began. In each trial, the experimenter asked: "Can you point with your finger to the face that is the angry/sad/afraid/surprised/disgusted face?" The children's answers were mildly praised, with the experimenter saying things such as "OK, let's try the next one" or he/she restating the participant's response by replying, for instance: "OK, you say this one is the sad face".

Results

Our dependent measure was the index of accuracy (Wagner 1993), and it was defined as the proportion of hits actually observed minus the proportion of hits expected by chance, divided by the proportion of hits expected by chance. Overall accuracy was high for older

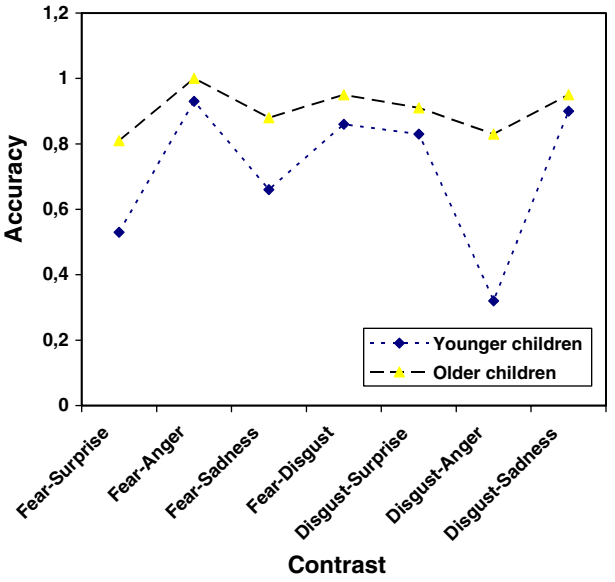

Fig. 1 Mean accuracy in recognizing facial expressions of fear and disgust as a function of age, and contrast

children ($M = .89$ for boys and $M = .92$ for girls) as well as for younger children ($M = .78$ for boys and $M = .66$ for girls). A series of t-tests confirmed that accuracy was above chance (all $p < .0001$) in all cases: $t(13) = 16.39$ for the younger boys, $t(14) = 10.24$ for the younger girls, $t(14) = 27.33$ for the older boys, and $t(13) = 26.22$ for the older girls.

We expected an increase in overall recognition with increasing age. Given the perfect performance of older children for some contrasts (the variance was null), it was not possible to examine the effects of age, gender, and contrast with a factorial design including all these factors at once. Therefore, we performed one analysis to test the effect of age and gender and two separate analyses to test the effect of contrast, one per age group. In order to decrease the heterogeneity of variances, the data were first submitted to an arcsine transformation.[1] A 2 × 2 (Age × Gender) ANOVA indicated a main effect of age, $F(1, 54) = 16.06$, $p < .0002$, accounting for 21% of the variance (partial ω^2). As predicted, 9- and 10-year-olds ($M = .90$) were more accurate than 5- and 6-year-olds ($M = .72$).

The effect of contrasts was examined with a separate ANOVA for each age group because the variance was null in the older age group for the contrast fear–anger. The first analysis indicated a significant effect of the contrast factor in younger children, $F(6, 168) = 11.17$, $p < .0001$, accounting for 23% of the variance. The Tukey test ($p < .05$) revealed that accuracy was lower for the contrast disgust–anger than for the contrasts disgust–sadness, disgust–fear, and disgust–surprise (see Fig. 1). It also showed that accuracy for the contrast fear–surprise was lower than for the contrast fear–anger, and fear–disgust, but did not differ from accuracy for the contrast fear–sadness. For older children, only six contrasts were included in the analysis given that the variance was null

[1] The data were also submitted to arcsine transformations prior to ANOVAs in the rest of this article.

for the contrast fear–anger. No significant effect was found, although the F ratio was near significance, $F(5, 140) = 2.28$, $p < .06$, and the ordering of the means in the expected direction.

Six ANOVAs were then performed to examine the effect of age for the different contrasts.[2] The contrast fear–anger was not considered given the absence of variance in older children for this contrast. The analyses indicated a significant effect of age for three contrasts: disgust–anger, $F(1, 57) = 15.89$, $p < .0002$, $\omega^2 = .20$, fear–surprise, $F(1, 57) = 5.93$, $p < .02$, $\omega^2 = .08$, and fear–sadness, $F(1, 57) = 5.22$, $p < .03$, $\omega^2 = .07$. For each of these contrasts, older children were more accurate than younger children.

The effect of ethnicity and gender of stimulus persons on recognition accuracy was assessed with a 2 × 4 (Age × Stimulus person) ANOVA, with repeated measures for the latter factor. There were four levels for the factor stimulus person because the pairs of expressions for a given contrast differed according to ethnicity only, gender only, both ethnicity and gender, or did not differ according to these dimensions. As was shown in the previous analyses, accuracy was found to improve as a function of age, $F(1, 56) = 5.56$, $p < 02$, but did not differ according to variations in ethnicity and gender of the stimulus persons.

Discussion

Our objective was to examine the recognition of facial expressions of fear and disgust in school-age children. On the basis of past research, we hypothesized that the recognition of these two emotions would improve during the second half of childhood. This hypothesis was supported by the data: 9- and 10-year-olds performed generally more accurately than 5- and 6-year-olds. More importantly, our results allowed us to specify where the improvement took place among the different contrasts. Older children were found to be better than younger children in distinguishing fear from surprise, disgust from anger, and fear from sadness.

We made special efforts to design a recognition task which was as simple as possible in terms of visual attention and information retrieval. The target expression was presented along with only one other expression, and we provided children with emotion labels. It is interesting to note that some improvement in the recognition of fear and disgust took place during the second half of childhood with such a simple task. Because of the simplicity of the task, we think the improvement in accuracy reflects a better knowledge of fear and disgust expressions, not simply a better ability to distribute visual attention between the stimuli or to retrieve information from memory.

As expected, even 5- and 6-year-olds' performances were above chance level. This suggests that the recognition of fear and disgust is well underway in young school-age children. In fact, such results concur with a number of studies showing adequate recognition by 5 years of age when using a relatively simple recognition task with pairs or triads of expressions (Boyatzis et al. 1993; Bullock and Russell 1985; Camras and Allison 1985).

Our study showed that the ability to recognize disgust and fear expressions varies based on the adjacent displayed stimuli. As predicted, we found that fear was harder to recognize when it was presented along with surprise, and disgust harder to recognize when it was presented along with anger. Such data are clearly in line with a number of studies showing that disgust–anger and fear–surprise confusions are the most common forms of error, even

[2] It was not possible to perform an Age x Contrast ANOVA because the variance was null for the contrast fear-anger in the older age group.

in adults. (Bullock and Russell 1985; Camras and Allison 1985; Gosselin 1995; Gosselin and Larocque 2000; Gosselin et al. 1995).

Because our methodology uses labels meant to tap children's conceptual categories of emotions, a possible explanation of such results is an incremental conceptual differentiation hypothesis under which concepts of disgust and fear gradually emerge from previously acquired concepts of happiness, anger and sadness (Widen and Russell 2003). According to this type of explanation, children's conceptualization of disgust would be undifferentiated from anger, both being conceived of as a negative state with high arousal. Such an explanation is supported by the fact that disgust and angry faces are often rated in a similar way in terms of valence and activation (Bullock and Russell 1984, 1985). Fear and surprise could also be thought to form an overarching category as both are predicted to emerge around the same period (Widen and Russell 2003).

A second explanation for the confusions between fear and surprise and between disgust and anger pertains to similarity of their facial patterns. Facial expressions of fear and surprise share three different action units: the raising of the inner brows, the raising of the outer brows, and the raising of the upper eyelids. This is far more than what fear shares with any other emotions. Facial expressions of disgust and anger have in common the lowering of the inner part of the brows. For anger, this change in appearance is produced by the action unit Brow Lowerer while for disgust it is produced by the Nose Wrinkler. Camras (1980) and Wiggers (1982) proposed that confusion in recognizing facial expressions might result from poorer performance in visually discriminating between them. We examined this possibility in the next study.

Study 2

In this study, we investigated children's visual ability to discriminate fear and disgust from the other emotions. In order to allow a comparison with the results of the first study, we used the same visual materials and a very similar procedure. However, the judgment task differed as it was concerned only with the visual appearance of facial expressions, and not the portrayed emotion. First, we hypothesized that fear would be more difficult to distinguish from surprise than from anger, sadness, or disgust, and disgust would be more difficult to distinguish from anger than from sadness, fear, or surprise. Second, we expected 9- and 10-year-olds to be generally more accurate than 5- and 6-year-olds in the discrimination task.

Method

Participants

Fifty-eight children, enrolled in two middle-class, urban primary schools located in the Gatineau region of Quebec, Canada, participated in this study. Participants were equally distributed according to gender and age group (5–6 and 9–10 years). In the 5–6 year-old group, there were 17 girls ($M = 6.16$, $SD = .46$) and 10 boys ($M = 6.53$, $SD = .63$). In the 9 to 10-year-old group, there were 21 girls ($M = 10.29$, $SD = .67$) and 10 boys ($M = 10.22$, $SD = .60$). All participants spoke French as their mother tongue. Only children with informed parental consent took part in this study. Finally, the recruitment of participants and the conduct of the study were carried out in conformity with the rules of ethics at the University of Ottawa.

Materials

The visual stimuli were identical to the ones described in Study 1, with six different pictures for the practice trials and 17 different pictures for the test trials. However, the verbal label associated with each contrast was replaced by a criterion facial expression, meaning that the pictures used for this purpose were presented more often than in Study 1. For the three practice trials, the criterion facial expressions were those of happiness, anger, and sadness, while, for the 28 test trials, they were those of disgust and fear. The facial action units involved in each expression were therefore the same as those listed in Table 1 and were constant across stimulus persons. For a given trial, the criterion facial expression was presented on the left side of the computer screen and two facial expressions, corresponding to the response choices, were presented on the right side. Practice trials included the following response choices: happiness–sadness when happiness was the criterion, happiness–anger when the criterion was anger, and sadness–anger when the criterion was sadness. The response choices for the test trials were fear–surprise, fear–anger, fear–sadness and fear–disgust when the criterion was fear, and disgust–fear, disgust–surprise, disgust–anger, and disgust–sadness when the criterion was disgust. The relative position (left or right) of the two response choices was counterbalanced across the task. As for the factors gender and ethnicity, they were counterbalanced over the different contrasts.

Procedure

The procedure was virtually identical to that of study 1, except for the requested task which consisted of the main difference. This time, participants were asked to "point their finger at the expression on the right, among the pair of facial stimuli, that most resembled the expression on the left (the criterion expression)". Again, three practice trials were run in order to evaluate children's understanding of the task itself. These trials (happiness–sadness, anger–happiness, and sadness–anger) allowed children to familiarize themselves with the task without being exposed to the stimuli specific to the test phase. The first practice trial consisted of a static trial, meaning that the stimuli remained displayed on the screen until the participant responded. For this first practice trial only, the experimenter corrected the participant's answer if necessary by showing the common features of the criterion and target expressions. This part of the procedure was aimed at ensuring that children's visual analysis was focused on the invariant features of the facial expressions as opposed to irrelevant features such as hair color, gender, ethnic group, and physiognomic features unrelated to emotional expression. Participants were then instructed that the actual task would be performed a bit faster and that it would require them to respond within a time limit. In this respect, the second and third practice trials were dynamic trials, each stimulus being presented on the screen for 7 s., after which they were replaced by a blank screen.

After the preparatory phase, the test began and continued until the child completed all 28 test trials. In each test trial, the stimuli disappeared after 7 s and there was a blank screen for an inter-trial period. This allowed the experimenter to insert the children's answers by means of the computer's keyboard. The blank screen lasted for 3 s before the next trial began. In each trial, the experimenter asked: "Can you point to the expression (referring to the pair of facial expressions) that looks most like this one (referring the criterion expression)?" Again, the participant's answers were mildly praised.

Results

The dependent measure was also the index of accuracy (Wagner 1993) used in Study 1. As shown in Fig. 2, accuracy in discriminating facial expressions was generally high, with mean scores ranging from .74 to 1.00. Accuracy was perfect for the discrimination between fear and surprise in younger children as well as in older children. Accuracy was also perfect for two other types of discriminations in older children, namely fear–anger, and disgust–surprise. However, participants seemed to have more difficulty in discriminating disgust from anger than from sadness, fear, and surprise. While mean accuracy was .74 in younger children for discriminating between disgust and anger, it was .89 or higher for the other types of discrimination. A similar pattern of results was found in older children. A series of t tests confirmed that performance for the overall task was above chance for younger boys and girls, $t(9) = 21.69$, $p < .0001$ and $t(16) = 51.93$, $p < .0001$, as well as for older boys and girls, $t(9) = 50.28$, $p < .0001$ and $t(20) = 112.23$, $p < .0001$, respectively.

Given the absence of variance in many instances, it was not possible to assess the effects of age, gender, and contrast with a factorial design including all these factors at once. Therefore, separate and more focused analyses were performed in order to test our hypotheses. A 2 × 2 (Age × Gender) ANOVA revealed a main effect of age on overall performance in the discrimination task, $F(1, 54) = 5.41$, $p < .02$, $\omega^2 = .07$. Nine- and 10-year-olds ($M = .97$) did slightly better than 5- and 6-year-olds ($M = .92$). Differences in accuracy between the different contrasts were examined separately for each age group. In the younger group, six contrasts were considered (all contrasts except fear–surprise). A repeated design ANOVA indicated a significant effect of contrast, $F(5, 130) = 6.33$, $p < .0001$, $\omega^2 = .08$. The Tukey test ($p < .05$) showed that the younger children were less accurate in discriminating disgust from anger than from sadness, fear, or surprise. For older

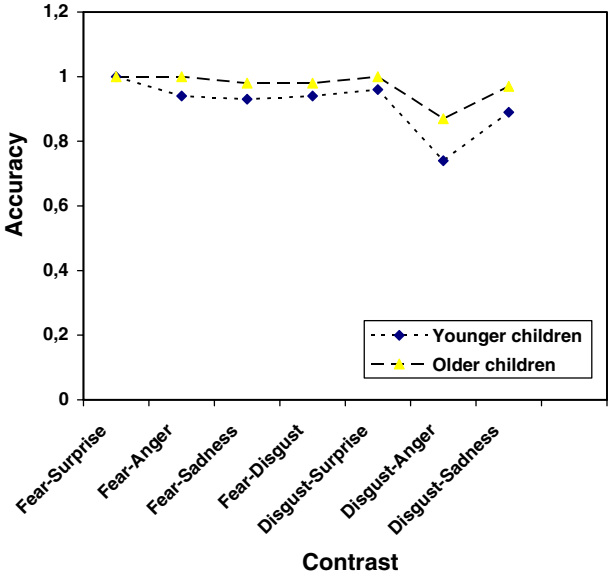

Fig. 2 Mean accuracy in discriminating facial expressions of fear and disgust as a function of age, and contrast

children, only four contrasts were included in the analysis of variance (fear–sadness, fear–disgust, disgust–anger, and disgust–sadness) as the variance was null for the other three contrasts. In this case, the effect of contrast failed to reach significance, although it was close to significance, $F(3, 90) = 2.97$, $p < .07$, and the means in the expected direction.

Given the above results, we decided to examine the effect of age more specifically by performing an analysis on the data pertaining to the contrast disgust–anger. This analysis revealed that the slight improvement in accuracy over childhood, from .74 in the younger group to .87 in the older group, was not significant, $F(1, 56) = 3.37$, $p < .07$.

In order to investigate further the discrimination between anger and the other emotions, we treated the data with a 2 × 2 (Age × Ethnicity) ANOVA, with repeated measures on the latter factor. Specifically, we compared discrimination scores when disgust was displayed by stimulus persons of the same ethnicity as those of the criterion photograph with discrimination scores when disgust was displayed by stimulus persons of different ethnicities. The analysis indicated no main effects or interaction effects.

Because Studies 1 and 2 used very similar methods, it was possible to make a direct comparison between the discrimination and recognition scores. In order to do so, we conducted separate analyses for each contrast and age group. Significant differences between recognition and discrimination scores were found in 5- and 6-year-olds for the contrasts disgust–anger, $F(1, 54) = 7.94$, $p < .007$, with discrimination scores ($M = .74$) higher than recognition scores ($M = .33$). However, both scores were equivalent in older children ($M = .87$ and .83, respectively). Discrimination scores ($M = .92$) were also higher than recognition scores ($M = .66$) for the contrast fear–sadness in the younger group. $F(1, 54) = 7.70$, $p < .008$. In the case of the fear–surprise contrast, discrimination scores were perfect. The Kruskal–Wallis test showed that they were significantly higher than recognition scores for younger children, χ^2 (1) = 19.90, $p < .0001$, as well as for older children, χ^2 (1) = 9.67, $p < .002$.

Discussion

Our objective was to examine the development of children's visual ability to discriminate facial expression of fear and disgust from those of other emotions. The fact that accuracy was high is interesting if we take into consideration that the visual material we used varied not only according to facial expression but also according to gender and ethnicity of the stimulus persons. From a perceptual perspective, our results are interesting as they indicate that children are able to extract the invariant features specifying emotions despite variations in gender and ethnicity. Although we confirmed the effect of age on overall accuracy, the improvement was very slight, meaning that the development of visual abilities does not account very much for the pattern of results obtained in Study 1. Contrary to our expectations, 5- and 6-year-olds reached perfect accuracy in discriminating fear from surprise. A slight support for the perceptual hypothesis was found for the discrimination between disgust and the other emotions. Younger children's performance was somewhat lower for the contrast disgust–anger than for the contrasts disgust–sadness, disgust–fear, and disgust–surprise. However, this difference was not found in older children, probably because accuracy was very high for each of the contrasts.

The modest improvement in overall performance associated with age suggests that some fine tuning of the visual system might still take place in later childhood. The exact nature of this improvement remains to be determined. According to past research, the ability to discriminate between visual patterns improves far beyond infancy and is related to various developmental changes, including physical maturation, better attention, more complete

visual exploration, and more efficiency in the allocation of processing resources. Our results suggest that such improvement is not limited to physical objects but also applies to social objects, such as facial expressions.

General discussion

Both studies have allowed us to better examine the evolution of the decoding of disgust and fear facial expressions in children between the ages of 5 and 10 years. Whereas the first study confirmed the previously observed higher incidence of fear–surprise and disgust–anger confusions, the second study informed us as to the development of the visual abilities involved in the discrimination of such contrasts. Because both studies employed identical contrasts and varied only in terms of the type of judgment performed by participants, it was possible to compare discrimination and recognition scores in order to estimate the role that limited perceptual abilities might play in such common errors. More precisely, if participants showed great difficulty in discriminating disgust from anger and fear from surprise, one could conclude that perceptual limitations play an important role in the errors observed in previously mentioned recognition tasks. Conversely, if discrimination scores were considerably stronger than recognition ones, this would suggest the fairly limited role of this perceptual aspect. If so, one would have to at least tentatively conclude that, instead, these errors stem from shortcomings in the conceptual development of such affective categories.

Comparing both types of scores tended to support the latter interpretation. Discrimination scores were higher than recognition scores for the contrasts disgust–anger and fear–sadness in younger children, and for the contrast fear–surprise in both age groups. Such data suggest that even though younger participants have relatively little difficulty extracting the invariant facial features of disgust and fear, their conceptualization of these emotions as a distinct state from anger, surprise, and sadness might still be imperfect. Consequently, our results suggest that limitations in the quality of visual analysis play a fairly limited role in the difficulties that school-age children experience when recognizing disgust and fear facial expressions.

Although discrimination scores for disgust were high, it is interesting to note that disgust was indeed harder to discriminate from anger than from any other expressions. It is therefore at least conceivable that the similarities between anger and disgust expressions, notably in the eyebrow and eye region, play some role in children choosing the angry faces more often than others when asked to point to the disgust expression. The fact that our results preclude such an argument in the case of fear and surprise hints at another interesting possibility. It is conceivable that subtle differences exist between conceptual and perceptual factors for different types of recognition errors. An increased difficulty in discriminating between facial features might have a larger role to play in errors made during disgust recognition compared to that of fear. It is also possible that the interaction between perceptual and conceptual factors varies over time throughout childhood, perhaps with discrimination errors becoming less of an issue as children's visual analysis system fully develops.

It is also important to take into consideration the limits of our discrimination paradigm. Asking participants to tell which of two expressions is the most similar to a target expression is only one possible method for assessing perceptual abilities. Some previous studies have taken a detailed look at these perceptual abilities using different methods. For example, Gosselin and Simard (1999) showed participants a series of fear–surprise

contrasts that they had manipulated in terms of the amount of common facial action units. Their results suggested that, between 5 and 10 years of age, the likelihood of confusions between expressions of fear and surprise increased as a function of common facial action units. The fact that such results contrast with the perfect scores observed in our discrimination task attests to the need for further studies.

The pattern of results observed in both of our studies seem to fit best with those previously observed by Russell and Widen (Russell and Widen 2002; Widen and Russell 2003, 2004, 2008). According to these authors, emotional categories such as disgust and fear start off as semantically broad and gradually narrow over the years. As a guiding model for this incremental process, Widen and Russell (2003) found that the disgust label emerges around the sixth year of life, and the fear label around the fourth and fifth. They also explain that the acquisition of a verbal label by the child does not imply a complete understanding of the conceptual category referred to by this label. Instead, labels and concepts are thought to develop gradually together (Widen and Russell 2008). Therefore, children may refer to, or be familiar with, the verbal label of a concept while still having difficulty understanding what this category entails, notably in terms of its facial display. An example of such a phenomenon is given by Widen and Russell (2003) where a group of 3- and 4-year-olds who all had access to disgust as part of their lexicon, only applied this label to the correct expression in 13% of the cases. That prototypical facial expressions are only gradually included within their relative category is also apparent in a series of studies showing a label superiority effect in recognition (Widen and Russell 2004) and categorization tasks (Russell and Widen 2002). The first such study reported that verbal labels were more efficient than facial expressions in tapping 3–4 year olds' knowledge of the causes of a host of emotions including fear and disgust. The latter found the same effect even in 7-year-olds when participants included more correct faces in the appropriate boxes for happiness, anger and sadness when such categories were presented in the form of verbal labels compared to facial expressions.

According to Russell and Bullock's (1986) model, facial displays of affective states similar in terms of valence and arousal would be more likely confused with each other, as children have a natural tendency to process facial expressions in terms of those two broad dimensions. Since disgust and anger expressions share the same valence and degree of arousal, the younger children in our study would have a harder time associating them with distinct conceptual categories. Older children would have developed a more complete and narrow concept of disgust over time and could more easily distinguish it apart from anger, even in terms of their respective facial expressions. Note that the same explanation can be called upon to account for the difficulties children experienced recognizing fear facial expressions when they were presented along with surprise ones.

Finally, we would like to point out the limitation of our approach regarding the process underlying the recognition of facial emotional expressions. Although participants in Study 1 were quite accurate in choosing the expressions for the labels of fear and disgust, it is not clear which process was responsible for their performance of the task. One possibility is that they chose the right expressions because they had accurate internal representations of fear and disgust facial expressions and were able to match them with the stimuli of fear and disgust they were shown. However, we cannot exclude the possibility that they made their choice by exclusion, first rejecting the alternative choice (anger, sadness, or surprise), and then pointing to the anger or disgust expression. Furthermore, they could have used both strategies to perform the task. The fact that performance in the recognition task was good in 5- and 6-year olds for five of the seven contrasts is interesting with respect to the exclusion strategy because it means they were able to exclude several type of expressions

(anger, sadness, and surprise). Furthermore, their performance for the contrast fear–anger, fear–sadness, fear–disgust, and disgust–sadness could not be made on the basis of the valence because all of these emotions were negatively valenced.

In conclusion, the two studies reported in this paper indicate that limitations in the quality of visual analysis play a fairly limited role in the difficulties that school-age children experience when recognizing disgust and fear facial expressions. It seems more likely that 5- and 6-year-olds' difficulty in recognizing fear and disgust facial expressions results instead from their imperfect conceptualization of these emotions.

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