Journal of Experimental Child Psychology 150 (2016) 252–271

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

The integration of visual context information in facial emotion recognition in 5- to 15-year-olds

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ARTICLE INFO

Article history:
Received 6 June 2015
Revised 3 June 2016

Keywords:
Emotion
Facial expression
Visual context
Development
Children
Context integration

ABSTRACT

The current study investigated the role of congruent visual context information in the recognition of facial emotional expression in 190 participants from 5 to 15 years of age. Children performed a matching task that presented pictures with different facial emotional expressions (anger, disgust, happiness, fear, and sadness) in two conditions: with and without a visual context. The results showed that emotions presented with visual context information were recognized more accurately than those presented in the absence of visual context. The context effect remained steady with age but varied according to the emotion presented and the gender of participants. The findings demonstrated for the first time that children from the age of 5 years are able to integrate facial expression and visual context information, and this integration improves facial emotion recognition.

Introduction

The recognition of basic facial expressions of emotion (e.g., joy, sadness, anger, fear) is crucial for the development of emotion understanding and successful social interaction (Matsumoto, Keltner,

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http://dx.doi.org/10.1016/j.jecp.2016.06.004

Shiota, O'Sullivan, & Frank, 2008). In daily life, facial emotional expressions are experienced mainly in contextualized situations, but the developmental time course of emotional face–context integration remains unclear. The current study focused on the issue of whether and when visual context information starts to play a role in the visual recognition of basic emotions.

The ability to recognize facial expressions emerges early with infants' capacities to discriminate between facial expressions at around the age of 7 months (for a review, see Bayet, Pascalis, & Gentaz, 2014). These early recognition abilities improve considerably with age throughout childhood and (pre)adolescence (for a review, see Gosselin, 2005). According to the dimensional view (Russell, 1997), children begin by classifying facial expressions into two broad categories on the basis of the positive and negative dimensions of valence and arousal before categorizing them into specific emotional categories as adults do. In contrast, according to the discrete category assumption (Ekman, 1992; Izard, 1991), very young infants already recognize and respond to different specific emotions conveyed via facial expressions.

To understand the development of facial expression recognition during childhood, researchers have designed different tasks (e.g., free labeling of facial expressions, facial expression matching, forced choice between multiple emotion labels for a single expression item; Markham & Adams, 1992; Vicari, Reilly, Pasqualetti, Vizzotto, & Caltagirone, 2000). Taken together, the results of such studies provide a general consensus regarding the developmental trajectory of facial expression recognition: Overall, kindergarten children (4 and 5 years old) performed as well as grade school children (6–9 years old) for happiness, but they performed significantly worse for (in ascending order of difficulty) sadness, anger, and fear (Boyatzis, Chazan, & Ting, 1993; Camras & Allison, 1985; Widen & Russell, 2008b). The recognition of surprise and disgust seems to develop later, between 6 and 10 years of age (Widen & Russell, 2013). This consensus is challenged, however, by the variety of experimental procedures used by researchers for assessing the ability to recognize facial expression. Indeed, methodological choices may influence experimental settings by either favoring or precluding the use of certain cues, and the importance of these cues can vary as a function of children's age and the type of emotion being recognized. For instance, the emotion labeling performance of 3-year-olds was lower when they were shown a facial expression than when they were given the cause or consequence of an emotion (Balconi & Carrera, 2007; Widen & Russell, 2004, 2010). This *face inferiority effect* was particularly strong for fear and disgust (Camras & Allison, 1985; Widen & Russell, 2004), two later-emerging emotions, and remained strong from childhood to early adulthood (Widen, Pochedly, & Russell, 2015). In addition, children as young as 6 years understand that facial expressions are sometimes produced according to display rules to mask embarrassing emotions or to simulate emotions in order to obtain social reactions from interlocutors, for instance, and that facial expression might not systematically reflect actual emotional states (Saarni, 1979). These results suggest that the strongest cues to categorize emotion may change as children's understanding of emotion increases.

In real-life situations, one rarely encounters faces in an isolated fashion; facial expressions are generally experienced within a context that influences the interpretation of these expressions. Researchers who consider facial expressions as discrete categories have minimized the role of context in emotion perception, suggesting that basic facial expressions are unambiguous signals that should be read from the face configuration regardless of the context in which it appears (e.g., Ekman, Friesen, & Ellsworth, 2013; Ekman & O'Sullivan, 1988). However, more recent studies suggest that facial expressions include features that convey both unambiguous and ambiguous information. Indeed, whereas certain features of an expression (i.e., activation of specific facial muscles) might be relatively unique to it (e.g., wrinkled nose in disgust), other features (e.g., furrowed brows) are shared with other expressions (Smith, Cottrell, Gosselin, & Schyns, 2005). Computerized analysis of physical similarities between facial expressions and human errors (Susskind, Littlewort, Bartlett, Movellan, & Anderson, 2007) showed that facial expressions are ambiguous to varying degrees with other facial expressions with which they share physical features. For example, expressions of disgust were classified as being most similar to those of anger, as less similar to sad faces, and as even less similar to fear faces.

Because facial expressions can be considered ambiguous, some studies investigated the role of context information in the processing of facial expressions in adults. These studies reported that recognition of facial expression improves (both accuracy and speed) when presented with congruent body posture, voices, or emotional scenes (for a review, see Wieser & Brosch, 2012). In contrast, an incongruent context has the potential power to shift the classification of facial expression from one category to another (for a review, see de Gelder & Van den Stock, 2011). The "emotional seeds" model put forward by Aviezer, Hassin, Bentin, and Trope (2008) proposed that because facial expression may be highly ambiguous with respect to some physically similar expressions, the specific combination of facial expression and context would determine the occurrence and magnitude of context effects. Context effects depend on the physical characteristics (the emotional seeds) shared by the facial displays of the emotion conveyed by the background and the emotion displayed in the face. Moreover, Aviezer, Hassin, Bentin, et al. (2008) proposed that an attentional bias underlies contextual effects: Context can influence the perception of facial expressions by guiding the viewer's attention to features in the face that correspond to the emotion suggested by the context. Indeed, the integration of context information seems to occur automatically before full structural encoding of the stimulus and conscious awareness of the emotional expression are fully elaborated (Aviezer, Bentin, Dudarev, & Hassin, 2011; Mumenthaler & Sander, 2015).

Recently, studies in children (Mondloch, 2012; Mondloch, Horner, & Mian, 2013) showed adult-like context congruency effects; children were more accurate in congruent face–context trials than in incongruent ones when sad expressions were contrasted with fearful expressions (tested in 6- and 8-year-olds) but not when sad expressions were contrasted with happy expressions (from the age of 4 years). The congruency effect was lower in adults than in children (6- and 8-year-olds). The authors interpreted their results as providing support for both the emotional seeds model (Aviezer, Hassin, Bentin, et al., 2008) and the dimensional model (Russell, 1997). Indeed, the latter predicts a positive context effect when the emotion conveyed by the face and the contextual information are similar in arousal (low vs. high) and in valence (pleasant vs. unpleasant) and vice versa. Moreover, the congruency effect was higher in aligned patterns (i.e., when the body and face were aligned) than in misaligned patterns (i.e., when the face was detached from the body stimulus and shifted to the left), suggesting holistic processing of faces and bodies.

Regarding the context effect for congruent multiple cues, Nelson and Russell (2011) showed that, unlike the case in adults, accuracy in 3- to 5-year-old children in the multiple-cues condition (face + body + voice) was not higher than in the face-only condition. Other studies observed no increase in the accuracy of children's recognition of emotion when congruent facial expression and context were presented together than when one cue was presented alone (Gnepp, 1983; Reichenbach & Masters, 1983). However, this lesser benefit of multiple cues in young children could not be attributed to limited abilities in intermodal emotion perception because infants as young as 6.5 months are able to match emotional static body postures to vocalizations (Zieber, Kangas, Hock, & Bhatt, 2014). Thus, these results seem to conflict with those of previous studies showing adult-like congruency effects of context in children.

Although recent studies clearly demonstrate the influence of context information on facial expression recognition in adults, the relative strength of context information in facial expression recognition during child development is not well established. Throughout the course of middle childhood into adolescence, many structural and functional brain changes occur (e.g., Giedd et al., 1999), some of which are related to the development of mental state understanding and emotion expression recognition (Gweon, Dodell-Feder, Bedny, & Saxe, 2012; Kobayashi, Glover, & Temple, 2007; Saxe, Whitfield-Gabrieli, Scholz, & Pelphrey, 2009). Connectivity among distant regions of the brain, such as the prefrontal cortex and the amygdala, strengthens from middle childhood to adolescence (Tottenham, Hare, & Casey, 2009). Functional communication throughout the brain and maturation of the frontal lobes result in the development of attention and high-level cognitive functions (Hughes, 2011). Hemispheric specialization also develops during middle childhood and results in refined and more efficient performance in school-age children (Groen, Whitehouse, Badcock, & Bishop, 2011). The development of the corpus callosum, which connects the two cerebral hemispheres and supports integration of perception (Thompson et al., 2000), allows children and adolescents to become more efficient in diverse cognitive skills, including the capacity to integrate information and to regulate cognition and emotion (Blakemore & Choudhury, 2006; Lenroot & Giedd, 2006). The integration of context information in facial expression recognition, thus, may depend on the brain structures that develop from middle childhood to adolescence. However, the small number of studies examining these face–context integration abilities throughout this period, as well as the methodological discrepancies, limits interpretations about the development of the integration of context information in facial expression recognition.

In the current study, 5-, 8-, 12-, and 15-year-old children and adolescents were presented with facial expressions of emotion (anger, disgust, happiness, fear, and sadness) that were manipulated in two experimental conditions: a *context* condition, with congruent scenes that included a character interacting with a peer or with meaningful objects, and a *no-context* condition, with scenes that included a character but in the absence of any peers or meaningful objects. From the emotional seeds model and the underlying mechanism of attentional bias proposed by Aviezer, Hassin, Bentin, et al. (2008), we expected a congruent visual context to help disambiguate facial expression by guiding the viewer's attention to features in the face that correspond to the emotion suggested by the context. First, we expected performance to be more accurate in the context condition than in the no-context condition. Second, we expected context information to be more beneficial for younger children, as observed by Mondloch and colleagues (Mondloch, 2012; Mondloch et al., 2013). Indeed, although Nelson and Russell (2011) showed that 3- to 5-year-old children did not benefit from multiple cues, we expected the younger children in our study to benefit from context information because they are able to process multiple emotional cues holistically (Mondloch & Longfield, 2010). Finally, we expected that context information would be more beneficial for later-emerging emotions, such as fear, than for emotions identified earlier in the course of development.

Method

Participants

A total of 226 children in four age groups (5, 8, 12, and 15 years) participated in the experiment. Approximately 3% of the sample (n = 7: 4 5-year-olds, 2 8-year-olds, and 1 15-year-old) was excluded from the analyses after statistical analysis of outliers. Our final sample consisted of 219 children (128 girls and 91 boys) in the following age groups: 5 years (n = 45, mean age = 5;6 [years;months], range = 5;0–5;10, 29 girls and 16 boys), 8 years (n = 54, mean age = 8;5, range = 7;5–9;6, 36 girls and 18 boys), 12 years (n = 63, mean age = 12;5, range = 11;10–13;9, 34 girls and 29 boys), and 15 years (n = 57, mean age = 15;5, range = 14;5–16;5, 29 girls and 28 boys). Participants were recruited within the same school from the region of Rhone Alpes, France, on a voluntary basis of the academic personnel of the school. The current study was conducted in accordance with the Declaration of Helsinki and with the ethics convention between the academic organizations (LPNC-UPMF and FPSE-UNIGE) and the educational organization of France. Written parental consent was obtained for each child.

Materials

We used a computer game that showed child characters in 650 × 522 pixel illustrated scenes. Throughout the task, the characters (a girl and a boy) portrayed five facial expressions of emotion (anger, disgust, happiness, fear, and sadness) that were selected from the Radboud Faces Database (Langner et al., 2010). The size of the facial expression and the location of the facial stimuli on the screen remained identical across conditions and trials, that is, between emotions and in conditions with or without context. Fig. 1 presents the five facial expressions (anger, disgust, happiness, fear, and sadness) for the male character.

Two types of scenes were built for the experiment. Child characters were presented in scenes either in the presence of a visual context that was congruent with their facial emotional expressions (context condition) or in the absence of any contextual information (no-context condition) (see Fig. 2). For the context condition, four scenes were designed for each of the five facial emotional expressions (see Appendix A for more details of context scenes). The choice of scenarios was based on prior work on emotion recognition with stories (Barisnikov, Van der Linden, & Catale, 2004; Camras & Allison, 1985; Widen & Russell, 2010). For the current study, we tested our context scenes in a sample of

Fig. 1. Facial expressions of emotions selected from the Radboud Faces Database (Langner et al., 2010) of the male character in this experiment (from left to right: anger, disgust, happiness, fear, and sadness).

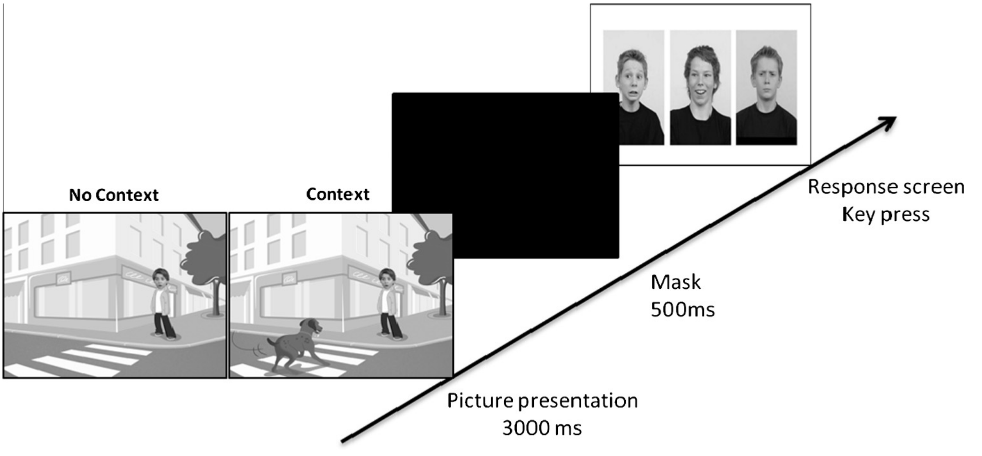


Fig. 2. Visual depiction of the experimental procedure. In this example, the picture presentation shows the no-context condition (left) and the context condition (right) of fear. After a 500-ms mask, the target emotion fear (left) was presented among two alternative options: joy (middle) and anger (right).

72 adults aged 20 to 35 years (mean age = 27.2 years) and 73 children aged 9 to 11 years (mean age = 10.2 years). Details of this control study are available in Appendix A. All scenes (context and no context) were designed with a character of each gender. The experiment was designed with emotion (anger, disgust, happiness, fear, or sadness) and context (context or no context) as within-participant factors. All participants were indeed presented with all facial emotional expressions in a context and in the absence of a context. However, items were counterbalanced across the characters' genders, so that the illustration scenes (two for each emotion) were presented with a male character for half of the participants and with a female character for the other half of the participants and vice versa. In sum, each child saw 30 illustration scenes showing the five emotions six times: four times in a context and two times in the absence of context (15 with a male character and 15 with a female character).

Procedure

Children were tested individually in a quiet room of their school. A 15-min experimental session started with the participant being comfortably seated in front of a computer and receiving the following instructions: "You will see drawings showing a little character in different situations. You must carefully watch these drawings. Then you will see three faces of other children, and you must choose which one of these children feels the same way as the character in the drawings." When the participant was ready, the experimenter started the game by pressing the space bar.

Each illustration scene included a background (either with context information or with no context). A character (boy or girl) expressing a facial emotion (anger, disgust, happiness, fear, or sadness) was presented, in random order, to the participant for 3000 ms, then masked by a black screen for 500 ms, followed by the response display (E-Prime 2.0; Schneider, Eschman, & Zuccolotto, 2001) (Fig. 2). The response display showed three facial expressions of emotion portrayed by three different children (also selected from the Radboud Faces Database) of the same gender as the child character of the scene shown previously: the emotion expressed by the character in the script, one alternative emotion of positive valence (happiness), and one alternative of negative valence (fear, sadness, anger, or disgust).[1] The position of the correct response on the screen and the position and emotion of the alternatives were counterbalanced across participants. The participant's task was to choose, from among these three facial expressions of emotion, the one that corresponded to the emotion shown in the previous scene. To respond, the participant needed to press the 1, 2, or 3 button of the keyboard according to the position of the facial expression of his or her choice. Only two alternatives (distractors) were used to reduce working memory load, as recommended by Székely et al. (2011), thereby making the task suitable for the youngest children in our experiment (5 years). The experiment ended after the participant had been presented with 30 illustration scenes depicting the five facial expressions of emotion six times: four times in a context and two times in the absence of context.

To test the occurrence of a context effect with this specific experimental procedure in an adult population, this experiment was tested on a control group of 25 adults (19 women and 6 men) aged 25 years 9 months on average (range = 19–42 years). Results are presented in Appendix B.

Data coding

Given the results of the first control study (Appendix A), the data recorded for two anger contexts (Anger-1 and Anger-3) and on one sadness context (Sadness-1) were removed from subsequent analyses. Correct identification rates were calculated for the remaining 27 items. An analysis of variance (ANOVA) was carried out on the mean correct recognition rates (%) of facial expression of emotion, with age (5, 8, 12, or 15 years) and gender (male or female) as between-participant factors and emotion (anger, disgust, happiness, fear, or sadness) and context (context or no context) as within-participant factors. Tukey's HSD (honestly significant difference) test was used to test significant comparisons when appropriate (post hoc analyses).

To better understand children's performance in the facial emotion recognition task, we also calculated errors of recognition. The percentage of incorrect responses was computed as the number of errors for an emotion divided by the number of times it was presented as a response choice × 100.

Results

Table 1 presents the mean correct identification rates for each age group as a function of emotion and context. Recognition performance (82.04%) was largely above chance level (33%) and increased with age from 5 years (72.87%) to 15 years (87.47%). Results revealed a significant effect of context, $F(1,211) = 95.28$, $p < .001$, partial $\eta^2 = .31$.[2] Emotions presented in a context ($M = 87.00\%$, $SD = 11.12\%$) were recognized more accurately than emotions presented in no context ($M = 77.08\%$, $SD = 15.01\%$).

The context effect significantly interacted with emotion, $F(4,844) = 4.77$, $p < .001$, partial $\eta^2 = .02$. Performance increased more when emotions were presented in context than when they were presented in the no-context condition for disgust (92.92% and 85.39%, respectively, $p < .05$), happiness (87.90% and 94.75%, respectively, marginal significance, $p = .06$), fear (68.04% and 84.25%, respectively,

[1] Because only one positive emotion was tested in our experiment, it was not possible to contrast happiness, as the target, with two alternatives of different valence. Because knowledge of other positive emotions occurred later and did not represent strong competitors, we chose to contrast happiness with two different negative emotions.

[2] Partial eta-square is defined as the proportion of total variation attributable to the factor, partialling out (i.e., excluding) other factors from the total non-error variation (Cohen, 1973; Haase, 1982; Kennedy, 1970). From information reported in an ANOVA summary table, partial eta-square is computed as follows: partial η^2 = SS factor/(SS factor + SS error). Values of .01, .06, and .14 indicate small, medium, and large effects, respectively (Richardson, 2011).

Table 1
Mean identification rates (and *SD*s) as a function of context (no context or context), emotion (happiness, anger, sadness, fear, or disgust), and age (5, 8, 12, or 15 years).

	5 years	8 years	12 years	15 years
No context	68.22 (15.71)	76.67 (14.14)	77.46 (13.91)	84.04 (12.94)
Anger	56.67 (31.26)	69.44 (32.82)	75.40 (33.45)	89.47 (22.63)
Disgust	76.67 (31.26)	84.26 (27.17)	88.10 (23.27)	90.35 (22.04)
Happiness	77.78 (29.30)	88.89 (20.98)	89.68 (20.40)	92.98 (19.91)
Fear	60.00 (34.71)	73.15 (33.24)	60.32 (36.10)	78.07 (31.36)
Sadness	70.00 (35.99)	67.59 (32.44)	73.81 (33.43)	69.30 (36.30)
Context	77.52 (13.74)	87.96 (9.05)	89.42 (8.83)	90.91 (8.59)
Anger	65.56 (33.41)	77.78 (33.18)	77.78 (28.08)	85.96 (22.67)
Disgust	85.56 (20.29)	93.52 (13.02)	95.24 (10.87)	95.61 (9.59)
Happiness	90.00 (18.00)	95.37 (9.80)	96.03 (9.21)	96.49 (9.95)
Fear	69.44 (24.36)	87.96 (18.65)	84.92 (19.33)	91.67 (13.64)
Sadness	77.04 (26.42)	85.19 (23.05)	93.12 (16.02)	84.80 (21.89)

$p < .01$), and sadness (70.32% and 85.70%, respectively, $p < .01$). The context effect was not significant for anger (context: 73.74%; no context: 77.40%; $p = .83$), but it significantly interacted with gender, $F(1,211) = 6.33$, $p < .05$, partial $\eta^2 = .03$. Girls ($M = 78.52$, $SD = 14.09$) performed better than boys ($M = 75.05$, $SD = 16.08$) in the no-context condition ($p < .05$), whereas no significant difference was observed in the context condition ($M_{\text{girls}} = 86.46$, $SD = 11.46$; $M_{\text{boys}} = 87.76$, $SD = 10.63$; $p = .62$). Finally, the effect of context did not interact with age, $F(3,211) = 1.51$, $p = .21$. Fig. 3 presents the amplitude of the context effect (i.e., the difference between the context and no-context conditions) according to emotion (Panel A), age (Panel B), and gender (Panel C).

Results also showed that the age factor was significant, $F(3,211) = 19.07$, $p < .001$, partial $\eta^2 = .21$, revealing that the 5-year-olds performed significantly worse ($M = 72.87\%$, $SD = 10.77\%$) than the 8-year-olds ($M = 82.31\%$, $SD = 9.86\%$), the 12-year-olds ($M = 83.44\%$, $SD = 9.09\%$), and the 15-year-olds ($M = 87.47\%$, $SD = 8.65\%$). The gender factor was not significant, $F(1,211) = 2.25$, $p = .13$. The emotion factor had a significant effect, $F(4,844) = 31.45$, $p < .001$, partial $\eta^2 = .13$, with happiness ($M = 91.32\%$, $SD = 13.29\%$) and disgust ($M = 89.16\%$, $SD = 15.82\%$) being recognized more accurately than sadness ($M = 78.01\%$, $SD = 22.11\%$), fear ($M = 76.14\%$, $SD = 22.66\%$), and anger ($M = 75.57\%$, $SD = 24.35\%$). No significant differences were observed between happiness and disgust, anger, fear, and sadness. Emotion significantly interacted with age, $F(12,844) = 2.83$, $p < .001$, partial $\eta^2 = .04$. The 5-year-olds performed

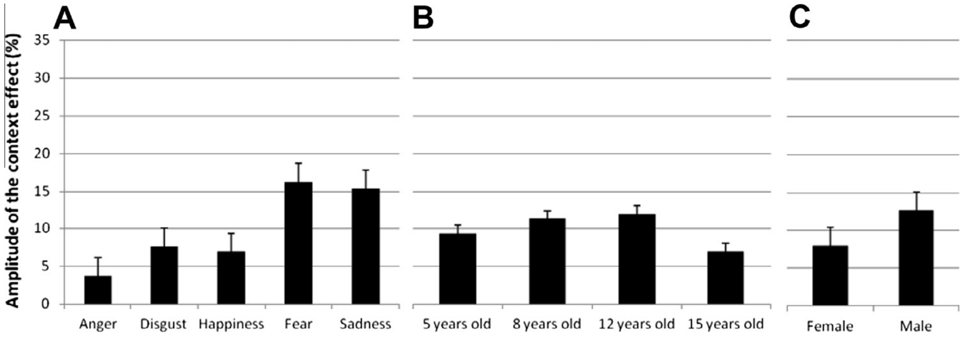


Fig. 3. Amplitude of the context effect as a function of emotion (anger, disgust, happiness, fear, or sadness) (A), age (5, 8, 12, or 15 years) (B), and gender (female or male) (C). The error bars correspond to 1 standard error. The amplitudes of the context effect in the recognition rates correspond to the difference between the context and no-context conditions. Positive amplitude means an occurrence of context effect.

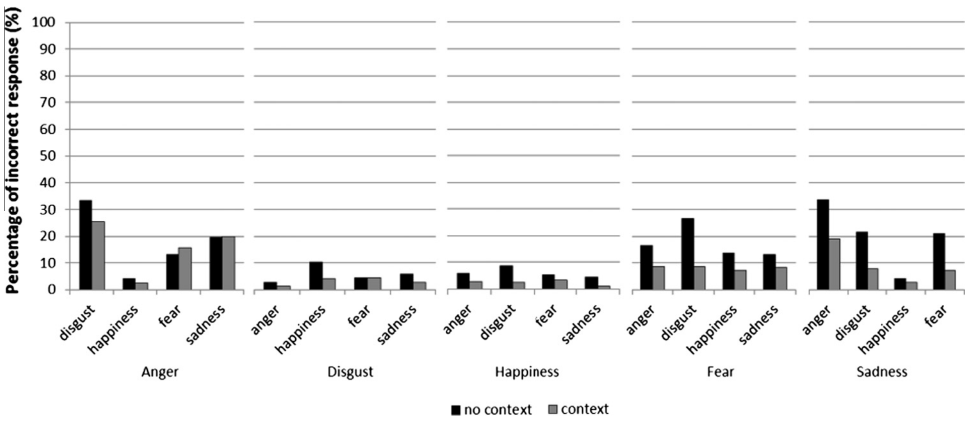


Fig. 4. Percentages of incorrect responses for each target emotion as a function of alternative choice and context.

worse than the other age groups for anger and fear. Other comparisons were not significant. Other interactions were not significant (all *F*s < 1). To test whether the amplitude of the context effect was linked to children's performance in the emotion attribution task (Appendix A), correlations between emotion attribution performance for each context scene and the amplitude of the context effect of each context scene were calculated for each age group. Results revealed that the amplitude of the context effect did not correlate with emotion attribution performance among 5-year-olds ($r = .15$, $p = .51$), 8-year-olds ($r = -.24$, $p = .31$), 12-year-olds ($r = -.01$, $p = .95$), and 15-year-olds ($r = -.05$, $p = .82$).

For more details on children's performance on the facial emotion recognition task, Fig. 4 presents the percentages of incorrect responses (alternative choices) as a function of target emotion and context.

Errors of recognition were made, with emotions sharing high levels of physical similarity (Susskind et al., 2007). For example, according to Susskind et al. (2007), expressions of anger are classified as very similar to those of disgust, as less similar to sad faces, and as even less similar to fear faces. In our experiment, errors of recognition showed exactly the same pattern; facial expressions of anger were mainly confused with (in descending order) disgust faces, sad faces, and fear faces. Regarding the effect of context, we observed that context reduced errors of recognition by diminishing confusion between emotions sharing high levels of similarity. This reduction of confusion (i.e., lower rate of incorrect responses in the context condition than in the no-context condition) appeared to be more accentuated for fear (reduction of 16.32%) and sadness (15.30%) expressions than for anger (3.20%), disgust (7.53%), and happiness (7.08%) expressions.

Discussion

The main finding in this experiment was that children between 5 and 15 years of age recognized emotions more accurately when presented with congruent visual context information than in the absence of context. Thus, congruent contextual and expressive information allowed more accurate judgment than emotional expressive cues alone, at least for certain emotions. Results are in line with those from recent studies in adults showing that facial expression recognition improves with context information (for a review, see de Gelder et al., 2006), but they contradict the results of previous studies in children (Gnepp, 1983; Reichenbach & Masters, 1983) showing no increase in the accuracy of emotion recognition when congruent facial expressions and situations were presented together. We discuss below the assumption that context information helps to disambiguate the signals of facial expression (Aviezer, Hassin, Bentin, et al., 2008) and whether this context effect depends on age and on the emotion being recognized.

Context information integration disambiguates facial expressions of emotion

The current experiment revealed that adding congruent visual context information increases emotion recognition performance. This effect was observed in children as young as 5 years, with performance improvement of approximately 10% with context information (performance of 5-year-olds in context was equivalent to that of 12-year-olds without context). This result appears to be somewhat contradictory to that of previous studies testing emotion recognition with multiple cues in children (Gnepp, 1983; Nelson & Russell, 2011; Reichenbach & Masters, 1983). However, several methodological discrepancies can explain these conflicting results (facial expression stimuli, number of emotions, age, and incongruent vs. congruent information), as in the case of the study by Nelson and Russell (2011). First, they used dynamic cues, whereas emotional cues were presented statically in the current experiment. A recent study reported that children recognized static expressions slightly better than dynamic expressions (Nelson & Russell, 2012). Processing of multiple dynamic cues may have increased visuospatial working memory load and affected higher level processes of integration and decision making. In addition, the selected expressions in the study by Nelson and Russell (2011) were based on a single actor, but in our study they were based on two actors. Second, these researchers tested the integration of body and vocal cues, whereas we investigated the integration of visual context information depicted by daily situations because it was easier to interpret than body postures or vocal intonations. In another study, Nelson and Russell (2011) used a free-labeling task, whereas we used a forced-choice task. As claimed by these authors, the test they used examined "children's spontaneous, rather than forced interpretation of cues," which probably made it easier than our task.

Even though some biological predisposition for attending to faces or preexisting knowledge about discrete emotions exists (Bayet et al., 2014), our results support the idea that children as young as 5 years use both facial expressions and visual contexts to recognize and understand the meaning of facial expressions. This result is consistent with the idea that context can help to disambiguate the signals of facial expression (Aviezer, Hassin, Bentin, et al., 2008), as proposed by the emotional seeds model. Errors of recognition are consistent with this model (Aviezer, Hassin, Bentin, et al., 2008). Indeed, context helps to reduce the confusion between emotions that share high levels of physical similarity (Susskind et al., 2007). Larger context effects are also observed for the two emotions that were less well recognized without context in our study (sadness and fear). This result may be attributable to the slow development of adult-like categorization of sadness and fear (Gao & Maurer, 2009; Vicari et al., 2000), making the recognition of these emotions in faces more sensitive to context. Thus, affective information conveyed by the visual scene is a powerful cue for recognizing facial expression when abilities to recognize the latter are still limited. Again, error analysis supports this function of context in revealing that context reduces the confusion among emotions that may share a high level of common features and, thus, be more easily confused with one another.

Given that children first perceive emotions at the level of valence and only later discriminate among negatively valenced emotions with adult-like sensitivity, we predicted that context information might be more beneficial for younger children. However, contrary to our predictions, we found that context effects remain stable with age. This result seems to conflict somewhat with that of previous studies (Mondloch, 2012; Mondloch et al., 2013) showing that perception of facial expressions was more susceptible to contextual information in younger children. However, comparisons were made with an adult group in those studies. In our experiment, older children were 15 years old; evidence from previous studies has suggested that underlying dimensions of emotions are not fully adult-like after the age of 10 years for some emotions (Gao, Maurer, & Nishimura, 2010). Results of the control group of adults presented in Appendix B revealed that adults presented an amplitude of context effect of 6% on average. Considering that the same amplitude is observed in 15-year-olds, this suggests that the magnitude of context effects becomes adult-like at 15 years only. However, regarding the amplitude of the context effect for specific emotions, perfect symmetry between adults and 15-year-olds was not found. For instance, the amplitude of the context effect for fear is 13% in 15-year-olds versus 3% in adults. Future studies are needed to determine more precisely when the magnitude of context effects becomes adult-like.

Even though the context effect remains stable with age, it appears to be modulated by gender. Indeed, although girls performed better than boys in the no-context condition, these differences disappeared with context. Results observed in the no-context condition confirmed those of previous studies showing that as early as 3 years of age, girls have greater ability than boys in perceiving facial expressions of emotion (e.g., McClure, 2000; Montagne, Kessels, Frigerio, de Haan, & Perrett, 2005). However, boys appear to benefit more than girls from the contextual information provided by the scenes. This result seems to conflict with that of a previous study showing that girls generally pay more attention to facial and situational cues than do boys (DePaulo, Jordan, Irvine, & Laser, 1982). Nevertheless, in contexts where male and female participants rate others' emotions in realistic and dyadic interactions, studies have shown no gender differences in empathic accuracy (Ickes, Stinson, Bissonnette, & Garcia, 1990; Levenson & Ruef, 1992). Although girls appear to have better abilities in recognizing emotions from facial cues, gender differences seem to disappear when context is added and emotion is presented in a more naturalistic context. More studies are needed to better understand the gender effect in the perception of emotions in the context of visual scenes. Indeed, numerous parameters need to be taken into account when studying the gender effect in emotion perception (for a review, see Brody & Hall, 2008).

Although visual context information appears to be a powerful cue in recognizing facial expression from 5 to 15 years of age, the context effect did not permit us to disambiguate anger. We address this issue in the following section.

Anger recognition did not benefit from visual context information

Although adding visual context information increased the recognition rate for most emotions tested in this experiment, context did not influence performance related to anger. When examining the literature on facial expression recognition in the context of scenes, we observed that no study has tested this effect in adults (for a review, see de Gelder et al., 2006). Some studies also did not test anger in children (Mondloch, 2012; Mondloch et al., 2013), but when they did no effect of context on anger was reported (Nelson & Russell, 2011; Reichenbach & Masters, 1983). Concerning the absence of a significant effect of context in the recognition of anger, it is possible that anger is more difficult to convey in a cartoon image. However, cartoon images should have interfered with the recognition of other negative emotions and not only anger. The identification rates collected in adults and children (Appendix A) showed that after removing the three contexts that were ambiguous, the emotional contexts of anger were recognized, as were the fear and sadness contexts for which we observed strong context effects. Moreover, correlational analyses revealed that the amplitude of the context effect did not correlate with children's performance in the emotion attribution task (Appendix A). However, cartoon images possibly included a "positive bias." Indeed, participants more often confused happiness and negative emotions (see Fig. 4), which is commonly observed in the literature (e.g., Widen & Russell, 2003).

The fact that a visual scene does not improve the recognition of the facial expression of anger could also be explained by the fact that anger can result from other negative emotions, so that it is an ambiguous emotion per se and, in consequence, more difficult to disambiguate. Indeed, according to Berkowitz and Harmon-Jones (2004), cognitive factors assumed to be causes of anger may simply intensify existing anger caused by other things, including pain, displeasure, and aversive conditions that do not require interpretation or attribution. Moreover, anger has a particular functional relationship with other negative emotions such as fear (Carver & Harmon-Jones, 2009) because these affects co-occur with high frequency in daily situations. In this case, the visual scene could have conveyed other negative emotions such as fear and sadness as causes of anger. The visual context of anger appears to be too ambiguous to guide participants' attention to facial features and then reduce confusion with emotions that share a high level of physical similarity. Error analysis supports this idea because it revealed that, in contrast to the case for other emotions, context did not decrease confusion with other negative emotions. To better understand the absence of the context effect on anger, researchers should systematically test each basic emotion and integrate complex emotions in future studies.

An additional contribution of this study lies in the extended developmental range considered in the current experiment. Because emotional abilities have rarely been investigated throughout a decade of development, we address the issue of the developmental timeline of facial emotion recognition from childhood to adolescence in the final section of the Discussion.

Development of facial expression recognition from childhood to adolescence

Studies that have explored normal emotional development during middle and later childhood have tended to focus on restricted age ranges such as the preschool period or the period between 7 and 10 years of age. Furthermore, different methodologies used by different studies make comparisons across findings and age groups difficult (see Gross & Ballif, 1991; Vicari et al., 2000). The current study provides data about the continued development of facial expression recognition over the full childhood and adolescence range, linking development across these age ranges.

We observed that the recognition rate for basic emotions increased significantly between 5 and 15 years of age, with happiness being more accurately recognized than (in descending order) disgust, fear, sadness, and anger. Regarding the ranking of emotion recognition, happiness and disgust were the best recognized emotions regardless of age and context, followed by (in descending order) sadness, anger, and fear. Even though this result conflicts with previous evidence of poor labeling performance for disgust in children (Herba et al., 2008; Jones et al., 2011; Pochedly, Widen, & Russell, 2012), it corroborates previous results obtained with a matching face paradigm that reported disgust as the best recognized emotion after happiness (Markham & Adams, 1992; Vicari et al., 2000). This result may be explained by the fact that, contrary to other emotions that require integration of contracted units from both the upper and lower face, these two emotions can be distinguished by a unique face pattern (smile for happiness and raised upper lip for disgust). Confusion between disgust and happiness is consistent with this assumption. However, it should be noted that Nelson and Russell (2011) revealed that past studies that used our paradigm may have overestimated children's expression knowledge because two tasks—choice from array and free labeling—that were often used to assess emotion knowledge produced illusory recognition by a mechanism of elimination strategies. Thus, our results should be replicated by using a different experimental paradigm.

Recognition of the other emotions (anger, fear, and sadness) depends on the context of presentation. In the no-context condition, fear was the least accurately matched facial expression at all ages, consistent with previous findings placing fear among the latest-emerging emotions (Calvo & Lundqvist, 2008; Durand, Gallay, Seigneuric, Robichon, & Baudouin, 2007; Gao & Maurer, 2009; Vicari et al., 2000; Widen & Russell, 2003). The confusion observed between negative emotions is in line with the literature, which reported that children's errors are often based on the similarity of stimuli along pleasure/displeasure dimensions because discrimination between specific negative emotions develops later (Gao & Maurer, 2009; Markham & Adams, 1992; Thomas et al., 2001). This confusion between emotions of negative valence was previously observed in the literature (e.g., between anger and sadness: Kirouac, Dore, & Gosselin, 1985; Widen & Russell, 2008a; between anger and disgust: Gosselin & Laroque, 2000; Widen & Russell, 2010). The rank orders of emotion recognition, as well as the pattern of error confusion according to context, appear to remain stable with age. The pattern of error confusion in our study is consistent with the emotional seeds model (Aviezer, Hassin, Bentin, et al., 2008); confusion occurred with emotions that shared a high level of physical similarity (Susskind et al., 2007).

Conclusion and perspectives

Our results provide the first evidence that visual context improves emotion recognition in children and that this context integration helps to disambiguate facial expressions at least from 5 years of age. However, although this study provides initial support for the integration of context information and its effect on facial expression recognition in children, the underlying processes remain unclear. Specifically, it would be interesting to determine whether context scenes direct children's face-scanning patterns as they do in adults (Aviezer, Hassin, Bentin, et al., 2008) or to identify when face-scanning patterns become adult-like. Future studies should implement eye-tracking technology to address these questions. In addition, future studies should determine whether there is a gradual shift during childhood from effortful and deliberate face–context processing to automatic and more efficient integration, as observed in adults (Aviezer et al., 2011; Righart & de Gelder, 2008). Future studies may address this issue by using a concurrent working memory task (Aviezer et al., 2011) or subliminal contextual cues (Mumenthaler & Sander, 2015).

A limitation of this study is that children's verbal ability was not measured. However, there is growing evidence of the role of verbal ability in children's ability to recognize emotions. Correlational studies showed that, irrespective of age, the level of emotion understanding is correlated with language ability in typically developing children (Cutting & Dunn, 1999; Pons, Lawson, Harris, & De Rosnay, 2003). Moreover, some studies showed that although children with language impairment could identify the facial expressions of emotion (Spackman, Fujiki, & Brinton, 2006; Trauner, Ballantyne, Chase, & Tallal, 1993), they had significantly more difficulty in inferring what emotion a character might experience given a specific social scenario (Ford & Milosky, 2003). These results should lead future studies to take into account how language abilities might impact the context effect in children's emotion recognition.

Consistent with the results of previous work, our findings suggest that inefficient use of contextual information available in daily social situations could play a role in difficulties with emotion and mental state understanding (e.g., Green, Waldron, Simpson, & Coltheart, 2008). These findings highlight the importance of training abilities in the integration of social contextual information in order to promote facial expression recognition, especially for children (for example, see Theurel & Gentaz, 2015).

Appendix A. Control study: Emotion attribution in the context of visual scenes in adults and children

The main goal of this experiment was to control the contextual scenes of our main experiment. More specifically, we aimed at determining whether emotions attributed to contextual scenes by children and adults matched the emotion we expected for each context.

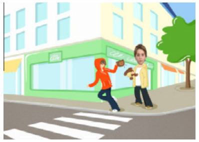
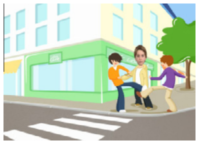
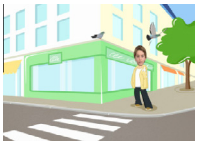
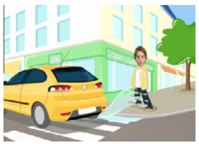
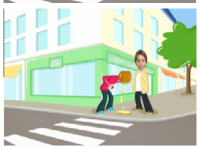
A total of 72 adults aged 20 to 35 years (mean age = 27.2 years) and 73 children aged 9 to 11 years (mean age = 10.2 years) participated in this experiment. Context scenes were color printed on A4 (approximately letter size) paper and presented in random order to participants. Participants watched each context scene (20 pictures; for details, see Table A1) and were asked to determine what emotion the character should feel in this situation by using the following label response choices: anger, disgust, happiness, surprise, fear, and sadness. In this experiment, the character's facial expression was neutral.

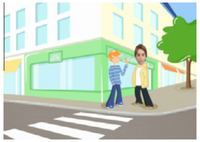
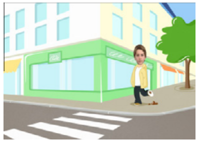
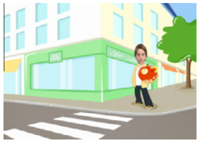
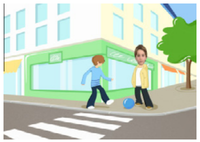
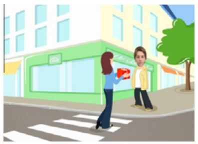
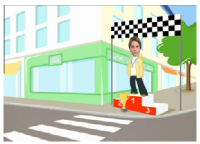
Contexts were correctly identified as making the character feel the specific emotion that we expected at a rate of 74.56% in adults on average (anger = 47.92%, disgust = 90.28%, happiness = 98.26%, fear = 79.98%, sadness = 56.25%) and 74.04% in children on average (anger = 51.03%, disgust = 83.22%, happiness = 96.23%, fear = 76.71%, sadness = 63.01%). Table A1 presents the percentage of responses in children and adults observed by emotion in each context scene. A multivariate analysis of variance (MANOVA) was performed on the percentage of correct responses (correctly identified as making the character feel the specific emotion that we expected), considering age (adults or children) as the between-participant factor. Post hoc analyses were performed by using Tukey's HSD test when appropriate. Table A2 presents the mean percentages of correct recognition as a function of age group and statistical significances of differences between groups (Tukey's HSD test).

Results revealed a significant difference between age groups, $F(20,119) = 3.747$, $p < .01$. Tukey's HSD test revealed significant differences between age groups for one context scene of anger (Anger-2), $p < .01$, one of disgust (Disgust-2), $p < .01$, one of happiness (Happiness-1), $p < .05$, one of fear (Fear-3), $p < .05$, and one of sadness (Sadness-3), $p < .05$ (see Table A2). To control for potential age differences in performances within the group of children, we decided to rerun a MANOVA, considering age as a continuous predictor. Results revealed no significant effect of age, $F(20,52) = 1.43$, $p = .15$.

Results of this experiment showed that all context scenes were correctly identified at an above-chance level in adults and children. No significant differences were observed between children and adults regarding overall performances. However, some context scenes did not convey the same emotion in children and adults. Finally, in accordance with the results presented in Table A1, an emotion other than the one we expected occurred mostly with some contexts, particularly in the context of Anger-1, Anger-3, and Sadness-1 in children. This result suggests that these contexts should not be

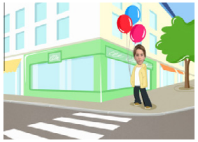
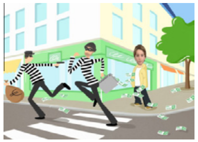
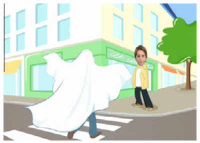
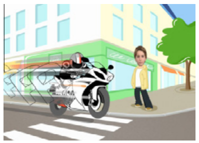
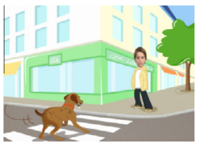
Table A1
Percentages of children's and adults' responses observed by emotion in each context scene.

Emotion	Context	Percentage of responses									
		Children					Adults				
		Anger	Disgust	Happiness	Fear	Sadness	Anger	Disgust	Happiness	Fear	Sadness
Anger-1		34.25	0.00	4.11	0.00	61.64	45.83	0.00	0.00	4.17	50.00
Anger-2		57.53	0.00	0.00	31.51	10.96	33.33	4.17	0.00	56.94	5.56
Anger-3		24.66	68.49	2.74	0.00	4.11	29.17	68.06	1.39	0.00	1.39
Anger-4		84.93	10.96	0.00	1.37	2.74	84.72	12.50	1.39	0.00	1.39
Disgust-1		0.00	97.26	0.00	1.37	1.37	0.00	100.00	0.00	0.00	0.00

Disgust-2		31.51	57.53	2.74	2.74	5.48	0.00	95.83	4.17	0.00	0.00
Disgust-3		10.96	87.67	0.00	0.00	1.37	23.61	75.00	0.00	0.00	1.39
Disgust-4		4.11	91.78	2.74	1.37	0.00	1.39	87.50	5.56	1.39	4.17
Happiness-1		8.22	0.00	87.67	2.74	1.37	2.78	0.00	97.22	0.00	0.00
Happiness-2		0.00	0.00	100.00	0.00	0.00	0.00	0.00	98.61	0.00	1.39
Happiness-3		0.00	0.00	98.63	0.00	1.37	0.00	0.00	100.00	0.00	0.00

(*continued on next page*)

Table A1 (*continued*)

Emotion	Context	Percentage of responses									
		Children					Adults				
		Anger	Disgust	Happiness	Fear	Sadness	Anger	Disgust	Happiness	Fear	Sadness
Happiness-4		1.37	0.00	98.63	0.00	0.00	0.00	0.00	97.22	0.00	2.78
Fear-1		8.22	0.00	4.11	86.30	1.37	2.78	1.39	4.17	90.28	1.39
Fear-2		6.85	1.37	15.07	76.71	0.00	0.00	0.00	33.33	66.67	0.00
Fear-3		27.40	0.00	20.55	52.05	0.00	20.83	0.00	8.33	70.83	0.00
Fear-4		0.00	0.00	4.11	94.52	1.37	0.00	1.39	11.11	87.50	0.00

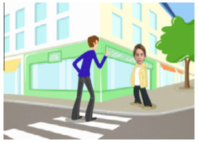
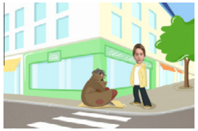
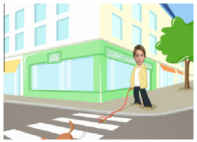
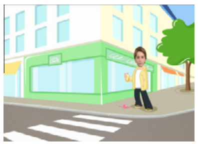
Sadness-1		46.58	2.74	1.37	21.92	27.40	34.72	0.00	1.39	41.67	22.22
Sadness-2		0.00	6.85	1.37	10.96	80.82	1.39	4.17	1.39	6.94	86.11
Sadness-3		17.81	0.00	16.44	0.00	65.75	8.33	1.39	1.39	44.44	44.44
Sadness-4		17.81	2.74	2.74	0.00	76.71	16.67	5.56	4.17	0.00	73.61

Table A2
Mean percentages and standard deviations of correct recognition as a function of age group (adults or children) and statistical significance of differences between groups.

	Adults		Children		Significance
	M	*SD*	*M*	*SD*	
Anger-1	45.83	50.18	36.99	48.61	.44
Anger-2	33.33	47.47	57.53	49.77	<.01
Anger-3	28.17	45.30	24.66	43.40	.49
Anger-4	83.33	37.53	84.93	36.02	.82
Disgust-1	100.00	0.00	97.26	16.44	.17
Disgust-2	95.83	20.12	57.53	49.77	<.01
Disgust-3	77.14	42.29	86.30	34.62	.18
Disgust-4	87.50	33.30	91.78	27.66	.65
Happiness-1	97.22	16.55	87.67	33.10	<.05
Happiness-2	98.61	11.79	100.00	0.00	.30
Happiness-3	100.00	0.00	98.63	11.70	.34
Happiness-4	97.22	16.55	98.63	11.70	.51
Fear-1	90.28	29.83	86.30	34.62	.56
Fear-2	66.67	47.47	76.71	42.56	.21
Fear-3	70.42	45.96	53.42	50.23	<.05
Fear-4	93.06	25.60	90.41	29.65	.43
Sadness-1	21.13	41.11	28.77	45.58	.28
Sadness-2	86.11	34.83	80.82	39.64	.36
Sadness-3	44.44	50.04	65.75	47.78	<.05
Sadness-4	72.86	44.79	76.71	42.56	.50

taken into account in the data analysis of the main experiment. We tested significant differences between emotions when these three contexts were removed. An ANOVA was run on the percentage of correct recognition on this task of emotion attribution, considering emotion as the within-participant factor. Results revealed that emotion was significant. Tukey's HSD test revealed that happiness contexts (96.23%) and disgust contexts (83.22%) were recognized more accurately than other contexts, $p < .01$. Nevertheless, no significant differences were observed between anger context (71.23%), sadness context (74.43%), $p = .91$, and fear context (76.71%), $p = .59$.

Appendix B. Results of the context effect study (main experiment) in a sample of adults

Table B1 presents the mean correct identification rates as a function of emotion and context in a sample of adults. Adults correctly recognized emotions at a rate of 92.1% on average. An analysis of variance (ANOVA) was performed on the mean correct recognition rates (%) of facial expression of emotion, with emotion (anger, disgust, happiness, fear, or sadness) and context (context or no context) as within-participant factors. Results revealed a significant effect of context, $F(1,24) = 13.16$, $p < .01$. Emotions presented in a context ($M = 95.4\%$, $SD = 5.19\%$) were recognized more accurately than emotions presented with no context ($M = 88.8\%$, $SD = 8.33\%$). The amplitude of the context effect was 6.6% on average. The context effect did not interact with emotion, $F(4,96) < 1$, $p = .52$. The amplitude of the context effect was 3% for anger, 8% for disgust, 5% for happiness, 3% for fear, and 14% for sadness.

Table B1
Mean identification rates (and *SD*s) as a function of context (no context or context) and emotion (happiness, anger, sadness, fear, or disgust).

	Anger	Disgust	Happiness	Fear	Sadness	Total
No context	86 (22.91)	90 (20.41)	94 (16.58)	92 (18.71)	82 (31.89)	88.8 (8.33)
Context	89 (16.27)	98 (10.00)	99 (5.00)	95 (10.21)	96 (9.35)	95.4 (5.19)
Total	87.5 (14.88)	94 (10.90)	96.5 (8.48)	93.5 (10.90)	89 (17.05)	92.1 (5.24)

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