Time perception in response to ashamed faces in children and adults

SANDRINE GIL and SYLVIE DROIT-VOLET

1University of Poitiers, Poitiers, France
2Clermont University, Clermont-Ferrand, France


The present study investigated the effect of the perception of faces expressing shame on time perception in children aged 5 and 8 years, as well as in adults, as a function of their ability to recognize this emotional expression. The participants’ ability to recognize the expression of shame among faces expressing different emotions was tested. They were then asked to perform a temporal bisection task involving both neutral and ashamed faces. The results showed that, from the age of 8 years, the participants who recognized the facial expressions of shame underestimated their presentation time compared to that of neutral faces. In contrast, no time distortion was observed in the children who did not recognize the ashamed faces or in those younger children who did not recognize them. The results are discussed in terms of self-conscious emotions which develop to involve an attentional mechanism.

Key words: Time perception, emotional development, facial expression, shame.

INTRODUCTION

Emotional facial expressions are considered to be the most powerful way that humans have to communicate their emotions to others (Ekman, 1982; Frijda & Tcherkassof, 1997; Keltner & Ekman, 2000; Keltner & Haidt, 2001). Recent studies have revealed that the presentation duration of faces expressing primary emotions (anger, fear, sadness or happiness) is systematically judged to last longer than that of a neutral face (for reviews, see Droit-Volet & Gil, 2009; Droit-Volet & Meck, 2007). According to the researchers involved, this overestimation of time reveals a fundamental function of the perception of emotions in others, namely to prepare to respond rapidly and efficiently to them. When time appears to run faster, this effectively means that individuals are prepared to act more quickly, for example, to respond to aggression or to help someone in need. The question raised in the present study is: Is this temporal overestimation also observed in the case of secondary emotions which we refer to as “moral” or “self-conscious” emotions (Tracy, Robins & Tangney, 2007).

The dominant idea in the time perception literature is that there is a central system – an internal clock – that allows humans to measure time accurately (for recent reviews, see Grondin, 2010; Meck, Penney & Pouthas, 2008). According to the internal clock models, this clock system consists of a pacemaker that gates pulses through a switch to an accumulator, the contents of which represent subjective elapsed time (Gibbon, 1977; Gibbon, Church & Meck, 1984; Treisman, 1963). However, the time distortions, that is, the temporal over- and underestimations, are explained in terms of two major sources that are located within this very clock system. The first source of time distortion is located at the pacemaker level which is arousal-driven (Maricq, Roberts & Church, 1981; Meck, 1983; Treisman, 1963). In response to an arousing stimulus, the frequency of pulses emission in the pacemaker should increase. More pulses are therefore accumulated and the stimulus duration is judged to be longer. The second source of time distortion is located at the level of the switch or an attentional gate that is thought to be under attentional control (Block & Zakay, 1996; Lejeune, 1998; Zakay & Block, 1996). When attentional resources are diverted away from the processing of time, the switch closes later or the attentional gate is more fully closed, thus allowing fewer pulses to enter the accumulator. Whatever the case may be, fewer pulses are accumulated, and time is judged shorter. Many experimental studies have provided data validating the predictions made on the basis of the internal clock models, with the result that these two kinds of time distortion – arousal-based overestimation and attention-based underestimation – are now considered to be the most robust phenomena in the time perception field (for a review, see Coull, Vidal, Nazarian & Macar, 2004; Wittman & van Wassenhove, 2009).

As suggested above, the recent studies that have examined the effect of facial expressions of primary emotions on the perception of time have systematically found a temporal overestimation (Doi & Shinohara, 2009; Droit-Volet, Brunot & Niedenthal, 2004; Effron, Niedenthal, Gil & Droit-Volet, 2006; Mondillon, Niedenthal, Gil & Droit-Volet, 2007; Tipples, 2008). In these studies, the participants were asked to perform a bisection task in which they were initially trained to discriminate between two standard durations, that is, a short (400 ms) and a long (1600 ms) duration, presented in the form of a pink oval. In the subsequent testing phase, they were asked to categorize as more similar to the short or the long standard duration a series of comparison durations (the two standard durations and five intermediate probe durations), which were presented in the form of faces expressing an emotion and neutrality. Results showed that, for any given objective stimulus duration, the participants systematically responded “long” more often for emotional faces than for neutral faces, although this response was observed more frequently for anger and fear than for sadness and happiness. In addition, this temporal distortion has been shown to occur in a similar manner at different levels of the ontogenic scale, and at least from the age of 3 years (Gil, Niedenthal & Droit-Volet, 2007). Consequently, as argued by Droit-Volet and Gil (2009), the overestimation of the presentation...
duration of faces expressing a primary emotion compared to neutral faces is probably an indication of an automatic, unconscious program of arousal responses which is associated with a speeding up of the internal clock. The function of this clock acceleration would be to enable organisms to prepare to respond as quickly as possible to their social environment.

No study published to date has examined the effect of a secondary emotion on the perception of time. First of all, the efficiency of emotional communication depends on the perceiver’s ability to recognize emotional expressions in faces. There is now ample evidence that young children are able to process facial expressions of primary emotions, that is, of anger, disgust, fear, happiness, sadness. As of the first month of age, they imitate (Melzoff & Moore, 1977, 1983) and are able to distinguish between these facial expressions (Kuchuk, Vibbert & Bornstein, 1986; Striano, Brennan & Vanman, 2002). Moreover, there is evidence of an early ability to recognize and understand these expressions (Camras & Allison, 1985; Gosselin, 2005; Gosselin, Roherbe & Lavallée, 1995; Izard, 1971; Kirouac, Doré & Gosselin, 1985). To expand on Darwin’s theories (1998 [1872]), the expression and the recognition of basic emotions are universal, and humans have a genetic predisposition to process them in order to adapt their behavior to their physical and social environments. Similarly, Harris (1990) considers that by the age of one year, children do not just react to facial expressions, but also attribute a sense to them and use them in order to guide their actions. This explains why the temporal overestimation of faces expressing primary emotions occurs at an early age in childhood (Gil et al., 2007; Gil & Droit-Volet, in press). Children’s ability to understand and recognize the secondary emotions, which are also referred to as “moral”, “social” or “self-conscious” emotions (embarrassment, guilt, pride, shame), has been generally neglected. However, the few studies devoted to this issue have reported an improvement in the ability to recognize these facial expressions from the preschool years through to the early teens (Lewis, 2007; Lewis, Sullivan, Stanger & Weiss, 1989; Tangney & Dearing, 2002; Tracy, Robins & Lagattuta, 2005). As the effect of a facial expression may depend on the participants’ ability to recognize the expressed emotion, we may suppose that the effect of a secondary emotion on the perception of time is more likely to occur in adults than in young children.

Among the secondary emotions, it is now well established that shame is a characteristic facial expression (Izard, 1971; Tracy & Robins, 2004; Tracy, Robins & Schriber, 2009) which appears to be very efficiently recognized by adults (Tracy & Robins, 2008). We therefore decided to examine the specific facial expression of shame. Lewis (2007) claimed that this negative emotion emerges from the complex social judgment of oneself, and requires thus introspection and self-awareness. It is the result of “a comparison of our action against a set of standards, rules and goals (SRGs) that are inventions of culture and transmitted to the child” (p. 137). The failure of our action relative to these SRGs results in a state of shame when the responsibility for this failure is attributed to oneself (Lewis, 2000; Tracy & Robins, 2004). In this way, the expression of shame would serve a social appeasement function which makes it possible for the individual in question to preserve a certain social status (e.g., Keltner, 1995; Ohman, 1986; Young, Keltner & Linswiler, 1996).

The effect on time perception of the perception of shame in other individuals has never been tested. However, shame is neither a primary basic emotion nor an arousing emotion. We may thus assume that the expression of shame will not produce an overestimation of time. On the contrary, if this secondary emotion involves self-examination concerning the cause of shame and an attribution of the fault to the individual, greater attention should be devoted to these activities, consequently resulting in an impaired processing of time and a temporal underestimation. However, as shame develops later than the basic emotions, we may not observe any effect of the expression of shame on the perception of time in young children if they are indeed unable to recognize this facial expression. In the present study, we therefore measured children’s ability to recognize the expression of shame. Then, the participants were presented with a temporal bisection task involving neutral and ashamed faces.

METHOD

Participants

The sample consisted of 95 participants: 40 five-year-old children (Mean age = 5.68, SD = 0.39), 38 eight-year-old children (Mean age = 8.48, SD = 0.29), and 14 adults (Mean age = 20.23, SD = 1.01). The children were recruited from schools and the adults were undergraduate students at Blaise Pascal University, Clermont-Ferrand, France.

Material

A Power Macintosh computer controlled the stimulus presentation and recorded the data by means of PsyScope software. The participants responded to each stimulus by pressing one of two keys (“d” or “k”) on the computer keyboard. In the bisection task, the stimulus to be timed was a pink oval (12 × 16 cm) for the training phase, and a picture of a woman’s face for the testing phase. There were three different women, each expressing shame and neutrality. The same set of women’s faces was used in the task requiring the recognition of emotional expressions. Each of the pictures represented an emotional expression: anger, sadness

---

Fig. 1. An example of female faces displaying anger, shame and sadness.
or shame. All the pictures of faces were selected from Beaupré and Hess (2005). As in Camras and Allison (1985) and Tracy et al. (2005), these pictures were presented in the form of a triptych (Fig. 1). For the training phase, triptychs consisting of pictures of animal were used: a cow, a horse and a dog.

Procedure

The participants performed two tasks, the bisection task followed, 2–4 hours later, by the facial recognition task. The facial recognition task was similar to the standardized procedure used by Camras and Allison (1985) and by Tracy and coworkers (2005). During a training phase, the children were presented with the animal triptych four times, with the position of the animal pictures changing between trials. Their instructions for each trial were to point to the picture of an animal (either the cow, horse or dog) if they saw it. In addition, in order to make sure that the children had understood the instructions, they were asked to point to the picture of another animal, that is, a duck, in one trial. In the subsequent testing phase, the subjects were presented with the triptychs of faces (anger, sadness and shame). They were told to point to one emotion from among the three facial expressions. There were 12 trials (3 × 4), i.e. 4 trials for each emotion. As in Tracy et al.’s study (2005), each emotion was placed in each position of the triptych four times and each position corresponded to the correct answer four times.

The bisection task consisted of a training phase with the short and the long standard durations (400 and 1600 ms), a test phase with five intermediate probe durations (600, 800, 1000, 1200, 1400) and the two standard durations. In the training phase, the participants were presented with the two standard durations in the form of the pink oval, and blocks of 10 trials (5 short, 5 long) were used to train them to press one key in response to the short and the other key in response to the long stimulus. The key-press assignment was counterbalanced. The trial was presented in a random order and the inter-trial interval was also randomly selected between 1 and 2 s. If the participants were correct on ≥ 75% of the trials, training terminated and was immediately followed by the test phase. The test phase used the same procedure as the training phase except that we used the seven comparison durations and the emotional facial expressions. The experimenter said, “It’s the same task, but now you’ll see faces instead of the pink oval.” Each participant completed 126 trials, 9 trials for each kind of facial expression (shame vs. neutral) and for each comparison duration. The trials within the session were presented in a random order.

RESULTS

Recognition task

Figure 2 shows the mean percentage of correct recognitions for the three emotional facial expressions in the 5-year-olds, the 8-year-olds and the adults. One-sample t-tests revealed that the participants in all the age groups were able to recognize anger (5 years, \( t(39) = 45.64 \); 8 years, \( t(37) = 53.05 \); adults, \( t(16) = 33 \)), and sadness (5 years, \( t(39) = 12.49 \); 8 years, \( t(37) = 9.55 \); adults, \( t(16) = 4.12 \)) at a level above chance (all \( p < 0.001 \)). Kruskal-Wallis tests revealed that there was no significant effect of age for the recognition of anger and sadness (\( H(2) = 0.17 \), \( H(2) = 2.75 \), respectively, both \( p > 0.05 \)). Indeed, the mean percentage of correct responses for these two emotions was particularly high as of the age of 5 years (i.e. ≥ 75%). In contrast, in the case of shame, the level of recognition was always above chance for the 8-year-olds, \( t(37) = 2.54 \), \( p < 0.05 \), and the adults, \( t(16) = 9.67 \), \( p < 0.05 \), but fell below chance level in the 5-year-olds, \( t(39) = -3.01 \), \( p < 0.01 \). Unlike the case of anger and sadness, there was thus an age-related improvement in the ability to recognize the facial expression of shame, \( H(2) = 31.25 \), \( p < 0.001 \). The percentage of correct responses was lower in the 5-year-olds than in the 8-year-olds (Mann-Whitney U tests, \( U = 409.5 \), \( p < 0.001 \)) and in the 8-year-olds than in the adults (\( U = 177.5 \), \( p < 0.001 \), with the 5-year-olds also producing a lower level of correct responses than the adults (\( U = 56.5 \), \( p < 0.001 \)).

Temporal bisection

One goal of the present study was to examine the effect of ashamed faces on bisection performance as a function of the participants’ ability to recognize this emotion. We therefore selected the participants who exhibited a low (≤ 25%) or high (≥ 75%) percentage of correct recognition (no-recognition vs. recognition groups). This resulted in a sample of 80 participants: 35 aged 5 years (9 in the recognition and 26 in the no-recognition group), 32 aged 8 years (22 in the recognition and 10 in the no-recognition groups) and all the adults (13, all in the recognition group).
Since none of the adults failed to recognize the expression of shame, we conducted statistical analyses for the adults separately from the children.

Figure 3 indicates the proportion of long responses (p(long)) plotted against the comparison durations for the ashamed and the neutral faces in the adults. An analysis of variance (ANOVA) was performed on p(long), with the intermediate durations (600, 800, 1000, 1200, 1400) and emotion (shame vs. neutral) as within-subject factors. This ANOVA revealed a significant main effect of emotion, $F(4, 48) = 212.61$, $p < 0.05$, which indicates that p(long) increased with the duration value. There was also a significant main effect of emotion, $F(1, 12) = 15.74$, $p < 0.05$, and there was no significant emotion $\times$ duration interaction, $F(4, 48) = 1.20$, $p > 0.05$. The adults thus responded “long” less often for the ashamed faces (0.51) than for the neutral faces (0.58). This indicates that the presentation duration of faces was under-estimated by the adults when these faces expressed shame compared to neutrality. Furthermore, the magnitude of this temporal under-estimation appeared to be constant whatever the duration values. This observation is consistent with the additive effect required by the attention-based hypothesis (see discussion).

For the children, the ANOVA run on p(long) with emotion and duration as well as age and recognition group as between-subject factors revealed significant main effects of age, $F(1, 63) = 9.34$, $p < 0.05$, and of duration, $F(4, 252) = 256.95$, $p < 0.05$, as well as a significant duration $\times$ age interaction, $F(4, 252) = 5.52$, $p < 0.05$. These results revealed that the psychophysical functions were flatter for the 5-year-olds than for the 8-year-olds, a finding which is consistent with the results found in all studies using the temporal bisection task in children (e.g., Droit-Volet & Izaute, 2009; Droit-Volet & Wearden, 2001). In addition, the main effect of emotion was not significant, $F(1, 63) = 1.28$, $p > 0.05$, but there was a significant three-way interaction between emotion, age and recognition group, $F(1, 63) = 4.15$, $p < 0.05$, with the other effects not reaching significance (all $p > 0.05$). The significant effect of emotion as a function of age and recognition was thus independent of the duration values, a finding that is consistent with the emotion effect observed in the adults. Consequently, for each age and recognition group, we used paired sample t-tests to examine the difference in p(long) between the ashamed and the neutral faces on the averaged five comparison durations. As Fig. 4 suggests, the difference between the ashamed and the neutral faces among 5-year-old children did not reach significance either when the children did not recognize the expression of shame or when they did recognize it, $t(25) = 1.95$, $t(8) = 1.03$, respectively, both $p > 0.05$). At the age of 8 years (Fig. 5), when children did not recognize the expression of shame, there was also no significant difference in the proportion of long responses between the ashamed and the neutral faces, $t(9) = 0.37$, $p > 0.05$. However, among the children who did recognize the expression of shame at this age, there were significantly fewer long responses for the ashamed than for the neutral faces, (0.51 vs. 0.60, $t(21) = 2.31$, $p < 0.05$). These children therefore underestimated the presentation duration of faces expressing shame in the same way as the adults.

To go further in explaining this shame-neutral difference in temporal bisection performance, we calculated differences between p(long) for the ashamed and p(long) for the neutral faces for each comparison duration (for the method, see Effron et al., 2006, Mondillon et al., 2007). Since the previous statistical analyses had not shown any significant effect of duration, we averaged this difference score ($d$) across the different comparison durations. Figure 6 indicates the $d$ scores obtained in this way for the 5-, the 8-year-olds and the adults in each recognition group. A $d > 0$ indicates that the presentation duration of the ashamed faces was overestimated, while a $d < 0$ indicates that it was underestimated compared to the neutral faces. The one-sample t-tests revealed that the magnitude of the shame-neutral difference ($d$ score) was significantly lower than zero in the adults, $t(12) = -3.17$, $p < 0.05$, thus indicating that the presentation duration of faces was judged shorter when they expressed shame compared to neutrality. For the children, the ANOVA on the $d$ score with age and recognition as between-subjects factors revealed a significant interaction between age and recognition, $F(1, 63) = 3.82$, $p < 0.05$, while the main effects of age and recognition did not reach significance (all $p > 0.05$). At both 5 and 8 years of age, the $d$ score among children who did not recognize the expression of shame did not significantly differ from zero ($t(25) = -1.95$, $t(9) = -0.35$, all $p > 0.05$). In contrast, among the children who did recognize this expression, the $d$ score remained close to zero in the youngest children, $t(8) = 1.06$, $p > 0.05$, whereas it was significantly lower than zero in the 8-year-olds, $t(21) = -2.04$.
Time perception in response to ashamed faces

DISCUSSION

The present study demonstrated that, when the facial expression of shame affected the perception of time, it produced a shortening rather than a lengthening effect. Indeed, the participants responded long less often for the ashamed than for the neutral faces and the difference in the proportion of long responses ($d$ score) was lower than zero. The perception of shame in other individuals thus produced an underestimation of time. Previous studies have shown that the perception of emotional as opposed to neutral facial expressions does not produce an underestimation but an overestimation of time (e.g., Doi & Shinohara, 2009; Droit-Volet & Gil, 2009; Gil et al., 2007). As set out in the introduction, within the framework of the internal clock models, authors explain this overestimation in terms of an arousal-related effect according to which the perception of emotional expressions speeds up the internal clock: More pulses are accumulated and time is judged longer. However, the emotional expressions studied in the past have consisted of primary emotions such as anger, sadness and happiness. In our study, the investigated emotion was not primary but instead self-conscious. An underestimation of time under emotional conditions has already been observed by Angrilli, Cherubini, Pavese, and Manfredini (1997) in temporal estimation and reproduction tasks which made use of low-arousal pictures from the International Affective Pictures system (IAPS, Lang, Bradley & Cuthbert, 2008). These authors explained their results in terms of an attention-related effect. Indeed, it has been widely reported that the less attention participants pay to time, the more they underestimate stimulus durations. The attentional version of the internal clock models (Block & Zakay, 1996; Zakay & Block, 1996) suggests that a certain number of pulses that represent elapsed time in the accumulator are lost when attentional resources are diverted away from the processing of time. In addition, these models successfully distinguish between an arousal-based and an attention-based effect on time perception when a number of different durations are used. The first of these effects, which triggers an acceleration of the internal clock, produces a multiplicative effect with the duration values, whereas the latter produces an additive effect (Maricq et al., 1981; Meck, 1983). Our data clearly show that the shortening effect observed in the present study represented an additive rather than a multiplicative effect, with the reduction being constant for different duration values. Overall, these results suggest that the perception of shame distracts attention away from time processing, thus producing a temporal underestimation.

The remaining question is why does the perception of facial expressions of shame distract attention away from the processing of time? Lewis (1971) has argued that the feeling of shame involves focusing attention on our own thoughts about the self or the causes of the shame. As far as the perception of emotion in others is concerned, a considerable body of literature is now available concerning the role of facial mimicry (e.g., Adolphs, Damasio, Tranel, Cooper & Damasio, 2000; Decety & Chaminade, 2003). According to this literature, individuals spontaneously mimic the emotions expressed by others (e.g., Dimberg, Thunberg & Elmehed, 2000). In its turn, this mimicry induces the same emotional state in the perceiver, although to a lesser extent (Hess, Kappas, McHugo, Lanzetta & Kleck, 1992; Strack, Martin & Stepper, 1998; for a review, see McIntosh, 1996). Two studies

$p < 0.05$). It was therefore only as of the age of 8 years that the perception of ashamed face produced an underestimation of time compared to neutral faces.

---

Fig. 5. Proportion of “long” responses plotted against stimulus durations for ashamed and neutral faces in the 8-year-old children, (upper panel) who did not recognize the ashamed faces, (lower panel) who correctly recognized the ashamed faces.

Fig. 6. Mean $d$ scores (shame-neutral difference) in the 5-year-olds, the 8-year-olds and the adults as a function of their performances in the recognition of ashamed faces (recognition vs. no recognition).
have already indicated the critical role of simulations of other people’s facial expressions in the perception of time by testing the effect of suppressing this mimicry or its relevance in terms of adaptation (Efron et al., 2006; Mondillon et al., 2007). It is therefore justifiable to assume that perceiving an ashamed face might, via a kind of “mirror” process, produce the feeling of shame with its associated thoughts concerning the self. This cognitive activity would thus consume additional resources which would be distracted away from the processing of time. Nevertheless, the exact function of the emotion of shame remains unclear. Another alternative interpretation has been suggested. This relates to the fact that the display of shame involves appeasement both for the transmitter and the perceiver (for a review, see Keltner & Harker, 1998). This appeasement would decrease the level of arousal and therefore slow down the internal clock. A number of studies have shown that a slowing down of the internal clock also produces an underestimation of time (e.g., Chambon, Droit-Volet & Niedenthal, 2008; Misani, Anderson, Christianson, Collins, Goodhart, Rushanan & Hindeliter, 2002; Wearden, Philpott & Win, 1999). However, as reported above, any such clock-related speed effect would have produced a multiplicative effect rather than the additive effect found in our experiment. Further studies will be required in order to investigate the conditions under which shame captures attention or slows down the level of arousal.

Another finding of our study resides in the fact that younger children were not able to recognize the facial expression of shame. Our study revealed an age-related improvement in the ability to recognize this facial expression. Indeed, in a standard recognition task, a large percentage of children did not, unlike adults, recognize the expression of shame at 5 or even at 8 years of age. These results are consistent with the proposal that shame is a complex emotion that emerges later in development. In line with Lewis’s (2007) idea which is reported above, the development of this emotion depends upon both the development of the concept of the self and the acquisition and the understanding of standards and moral norms (Lagattuta & Thompson, 2007; Lewis, 2000; Niedenthal, Krauth-Gruber & Ric, 2006).

More specifically, our results revealed that the underestimation of time in response to ashamed faces is dependent on children’s ability to understand this emotional expression. We use the word “understand” instead of “recognize” because our data suggests that the shame-related underestimation of time occurs in children who recognize the emotion of shame but only as of a certain age, that is, 8 years. In the case of the very young children, no time distortion was observed even when they exhibited a “good” level of recognition of ashamed faces. What do these contrasting findings suggest about emotional development? First, it is possible to question the efficiency of the recognition task. The children who performed this task may have chosen the ashamed face through a process of elimination. However, as argued by Tracy et al. (2005), the inclusion of a “don’t see” option in the training phase when the participants are asked to point to an animal that is not present in the triptych may overcome this methodological criticism. Whatever the case, we can suppose that young children do not have a conceptual understanding of shame even though they are able to recognize this emotion. This idea is consistent with the work of Harter and Whitesell (1989), which showed that there is a gradual development in the emergence of a genuine understanding of the emotion of shame, with children not being able to illustrate what it means to be ashamed until the age of 8.

Finally, the original feature of our study, which involved children of different ages and of different levels in their ability to recognize facial expression, lies in the fact that it has demonstrated that the effect of emotional expressions on time perception depends, to a large extent, on their meaning for the perceiver in terms of adaptation to the social or physical environment. In this vein, Mondillon and coworkers (2007) showed that when participants do not feel any empathy for the other person or desire to associate with him or her, the effect of the facial expression of anger on time perception is reduced or even absent. Other authors have shown that the perception of an angry face produces a greater time distortion when the face is looking at the participant straight-on rather than being averted because the former posture is more significant for humans (Doi & Shinohara, 2009). Finally, Bar-Haim, Kerem, Lamy & Zakay (2010) and Tipples (2008) have shown that a series of inter-individual differences, for example anxiety, modulate the effect of emotions on the perception of time as a function of their meaning for individuals. To summarize, within a developmental perspective, our work provides data about the perception of the facial expression of shame and the attentional mechanisms responsible for its processing. It also shows that the perception of time is highly sensitive to the emotional context and its meaning for individuals.

We are grateful to our child and adult subjects for their invaluable participation in this research project. We naturally also wish to thank the various schools in Clermont-Ferrand (e.g., the Edouard Herriot, Victor Duruy, and Bellerive sur Allier (e.g., Jean Zay, and Jean-Baptiste Burlot schools), for providing us with excellent conditions in which to conduct our study. Finally, we extend our thanks to Laëtitia Barthomeuf, Aurelle Villelegier and Pierre Baduel for their help with data collection. This research was supported by an ANR Grant from the National Center of Scientific Research, CNRS, France, Blan06-2-1450908.

NOTES

1 As was only one adult who failed to recognize the facial expressions of shame at a level equal to or higher than 75%, this subject was excluded from the subsequent statistical analyses.

2 All the reported probability levels have been adjusted using the Greenhouse-Geisser correction.

REFERENCES


Received 21 September 2010, accepted 24 October 2010