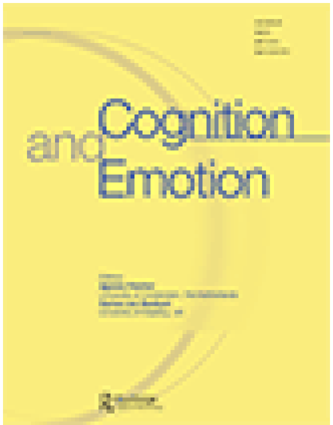

Cognition and Emotion

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/pcem20

The emotional body and time perception

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Published online: 30 Mar 2015.

COGNITION AND EMOTION, 2015
http://dx.doi.org/10.1080/02699931.2015.1023180

Routledge
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(Received 1 December 2014; accepted 22 February 2015)

We examined the effects of emotional bodily expressions on the perception of time. Participants were shown bodily expressions of fear, happiness and sadness in a temporal bisection task featuring different stimulus duration ranges. Stimulus durations were judged to be longer for bodily expressions of fear than for those of sadness, whereas no significant difference was observed between sad and happy postures. In addition, the magnitude of the lengthening effect of fearful versus sad postures increased with duration range. These results suggest that the perception of fearful bodily expressions increases the level of arousal which, in turn, speeds up the internal clock system underlying the representation of time. The effect of bodily expressions on time perception is thus consistent with findings for other highly arousing emotional stimuli, such as emotional facial expressions.

Keywords: Timing; Time perception; Emotional body; Bodily expression; Emotion.

The ability to understand the emotions expressed by others is an important aspect of human social cognition, not least because it allows people to predict others' actions and to adapt their own behaviour accordingly (Frijda, 1988; Levenson, 1994). Regarding the critical role of emotion in adaptive actions, studies conducted in the past decade have revealed a tight coupling between the emotionality of stimuli and their apparent duration (Droit-Volet & Meck, 2007). Timing ability in humans is often attributed to an internal clock-like system that provides the raw material (time units) for making accurate time judgments (Allman, Teki, Griffiths, & Meck, 2014; van Rijn, Gu, & Meck, 2014). However, when they are exposed to emotionally charged stimuli, people exhibit distorted time judgments. In this so-called *time-emotion paradox* (Droit-Volet & Gil, 2009), even though individuals possess a sophisticated mechanism for processing time accurately, their time judgments are biased by the perception of emotional stimuli. This emotional distortion in the subjective estimation of time is assumed to reflect the automatic processing of emotional stimuli by the organism for readiness of action (Droit-Volet, Fayolle, Lamotte, & Gil, 2013). Given that emotional bodily expressions can be regarded as a raw and efficient channel of emotional information (de Gelder, 2006, 2009), we investigated for the very first time whether they can trigger the time distortion effect.

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Researchers examining emotional time distortion in humans have made extensive use of emotional facial expressions (e.g., Bar-Haim, Kerem, Lamy, & Zakay, 2010; Doi & Shinohara, 2009; Droit-Volet, Brunot, & Niedenthal, 2004; Fayolle & Droit-Volet, 2014; Gil & Droit-Volet, 2011b; Tipples, 2008, 2011). Consistent with the literature on emotion, they have regarded facial expressions as primary signals of emotion in social interactions (de Gelder & Hortensius, 2014). However, as Darwin (1872/2002) suggested long ago, individuals use multiple emotional cues in their social interactions, including not just facial expressions, but prosody and bodily expressions, too. Investigating these different emotional cues can therefore give us a broader and more comprehensive view of emotion processing. Several studies have shown that bodily expressions are recognised by individuals as easily as facial expressions (e.g., de Gelder, Snyder, Greve, Gerard, & Hadjikhani, 2004), and event-related potential studies have revealed that they are processed as quickly as facial expressions (e.g., Van Heijnsbergen, Meeren, Grezes, & de Gelder, 2007). However, despite the similarities between facial and bodily expressions in the communication of emotion, there is one fundamental difference. As stated by de Gelder (2009, p. 3478), "focusing on facial expressions tends to make us refer to a person's mental state. But focusing on bodily expressions directs attention to a person's actions". Bodily expressions therefore represent the major action component of emotion. Indeed, the whole human body and its motion indicate to the observer the individual's intended action. Consequently, if action readiness is a critical factor in emotion-related time distortion, it is important to examine the effects of emotional postures on the perception of time.

Action readiness is nevertheless governed by the perception of discrete emotions (Frijda, 1988). It is at its strongest in threatening situations. Facial expressions of fear in conspecifics signal the presence of some kind of threat (e.g., Adolphs, Russell, & Tranel, 1999; Ledoux, 2014; Morris et al., 1996). Their perception therefore automatically triggers a series of physiological changes in the observer so that he/she is able to react as quickly as possible (i.e., to flee). Functional magnetic resonance imaging (fMRI) studies have shown that the perception of facial expressions activates the amygdala, a basal ganglia structure involved in the processing of threatening stimuli (Ledoux, 2007; Phelps & Ledoux, 2005). The first fMRI study to feature bodily expressions of fear, conducted by Hadjikhani and de Gelder (2003), revealed activation of the same structure. Facial and bodily expressions therefore both activate a brain region involved in the avoidance motivation system for action (Cacioppo & Berntson, 1994; Lang, Bradley, & Cuthbert, 1997; Ledoux, 2012). There are thus similarities in the physiological and neural changes that take place in individuals when they see the face or the whole body of a conspecific expressing the emotion of fear (e.g., de Gelder, 2006; Tamietto & de Gelder, 2010; Tamietto et al., 2009). We can therefore assume that the perception of bodily expressions of fear produces distortions in time judgment just as the perception of facial expression of fear has been found to do.

Time distortions induced by facial expressions have mainly been investigated in studies featuring a temporal bisection task (e.g., Droit-Volet et al., 2004; Gil & Droit-Volet, 2011a; Tipples, 2008, 2011). In bisection, participants are initially shown a neutral oval form for a short (400 ms) and a long (1600 ms) standard duration. They are then shown emotional faces for durations that are either equal to the short or long standard durations or of intermediate durations and asked to judge whether these comparison durations are more similar to the short standard duration or to the long one. The results of bisection tasks have systematically shown that angry or fearful faces are judged to be displayed for longer than happy, sad or neutral faces (e.g., Droit-Volet et al., 2004; Fayolle & Droit-Volet, 2014; Gil & Droit-Volet, 2011a; Tipples, 2008, 2011). However, the magnitude of this lengthening effect is smaller for angry/fearful versus happy faces than it is for angry/fearful versus sad or neutral faces, the latter two facial expressions, characterised by a low arousal value, producing similar temporal results. As further explained in the general discussion, a high level of arousal speeds up the internal clock system, meaning that more time units (internal clock ticks) are emitted and time is judged to be longer. Consequently, the perception of angry/fearful faces, that is assumed to be more highly arousing than the perception of faces expressing other emotions, produce the greatest lengthening effect. In our study, participants were administered a temporal bisection task featuring bodily expressions of fear, happiness and sadness. We thus examined for the first time whether the lengthening effect observed for fearful/angry faces is also observed when people are shown bodily expressions of fear (emotion characterised by high arousal) versus bodily expression of a low-arousal emotion (i.e., sadness). The temporal perception of sad bodily expressions was also compared to that of another high-arousal but positive emotion (i.e., happiness). One can note that neutral stimuli were not used in our study because neutral body expressions by *definition* involve no action tendency. Moreover, as discussed below, in order to consider the underlying mechanisms, we investigated the effects of bodily expressions on temporal bisection judgments for different duration ranges (Experiment 1: 200–800 versus 400–1600 ms; Experiment 2: 200–800 versus 400–1600 versus 600–2400 ms).

EXPERIMENT 1

Method

Participants

Eighty psychology undergraduates (*mean age* = 20.37, *SD* = 1.37) from Blaise Pascal University, Clermont-Ferrand (France), took part in this experiment in return for course credits. Given that both gender of participants and gender of stimuli are known to influence emotional processes, including bodies' pictures (Kret, Pichon, Grèzes, & de Gelder, 2011b), only females were recruited (i.e., female participants viewing posture of female actors). They all provided their written informed consent to participate in this experiment, which was conducted in accordance with the Declaration of Helsinki.

Material

Participants were tested in a quiet laboratory room, where they were seated in front of a computer. The experiment was controlled by E-Prime software (1.2. Psychology Software Tools, Pittsburg, PA, USA), which also recorded all the data. Participants gave their *short* and *long* responses by pressing the corresponding key (D or K) on the computer keyboard. The neutral stimulus was a dark grey circle (diameter 12 cm) displayed in the centre of the computer screen (21 × 17 cm) against a light gray background. The emotional stimuli consisted of the whole bodily expressions of three different emotions: fear, happiness and sadness. For each emotion, we selected the pictures of four female actors (F05, F14, F28 and F30) from the validated database of the bodily expressive action stimulus test (de Gelder & Van den Stock, 2011; see Figure 1). As extensive empirical works show multimodal emotional processing (e.g., de Gelder & Van den Stock, 2011; Scherer & Ellgring, 2007), this dataset consists in face-blurred stimuli in order to only examine body expression language. These pictures were displayed in the centre of the computer screen against the same light grey background as that used for the neutral stimulus.

Procedure

Participants were assigned to 1 of 4 groups (20 participants per group) as a function of stimulus duration (200–800 versus 400–1600 ms) and bodily expression (fear/sadness versus happiness/sadness). In the 200–800-ms condition, the short standard duration (S) was 200 ms and the long standard duration (L) 800 ms. The comparison durations were 200, 300, 400, 500, 600, 700 and 800 ms. In the 400–1600-ms condition, S and L were 400 and 1600 ms, respectively, and the comparison durations 400, 600, 800, 1000, 1200, 1400 and 1600. In each group, the participants performed a bisection task in two phases: training and testing. In the training phase, participants were initially shown the neutral stimulus, once with S and once with L. They then underwent six training trials (three S and three L) to practice responding *short* or *long* by

Figure 1. *Examples of bodily expressions (fear, sadness, happiness) selected from the validated database of the bodily expressive action stimulus test (de Gelder & Van den Stock, 2011).*

pressing the corresponding button. The order of S and L was randomised across these six trials. Each trial started when the participant pressed the space bar after the word "*prêt*/ready" appeared in the centre of the computer screen, following a random intertrial interval lasting 500–1000 ms. The testing phase, which came immediately afterwards, had the same experimental procedure as the training phase, except for the comparison durations and the stimuli (two different bodily expressions) that had to be timed. As in most bisection studies based on the bisection procedure initially adapted by Wearden (1991) to human adults from the procedure used in animals (Church & Deluty, 1977), each participant completed 10 trials for each stimulus duration, divided into 10 blocks of 14 trials (7 comparison durations × 2 bodily expressions). The blocks, and the trials within each block, were presented randomly. Each block featured pictures of a single actor. As there were four actors, this made two occurrences of each of the four actors, with one additional occurrence for two other actors randomly selected.

In addition, after the temporal bisection task, the participants assessed the bodily expressions in terms of arousal (from very calm to very excited) and valence (from very unpleasant to very pleasant) on the 9-point Self-assessment Manikin scale (Bradley & Lang, 1994). They also assessed the emotion (happiness, sadness, fear and angry) they saw in the bodily expressions on a 9-point scale from "not at all agree" to "strongly agree". The presentation duration of the bodily expressions was at the mid-point between the short and the long standard duration for each duration condition, i.e., 500 and 1000 ms. In each group, the participants therefore rated eight different emotional stimuli presented in a random order (four actors × two emotions).

Results and discussion

Subjective emotional assessment. For each group (fear/sadness versus happiness/sadness), the responses for the different actors were averaged and analyses of variance (ANOVAs) were run on emotional assessments with the bodily expression and the duration group as factors. For the fear/sadness group, the ANOVA[1] on the subjective assessment of the arousal level confirmed a significant main effect of bodily expression (fear: M = 3.95, SE = 0.3; sadness: M = 2.68, SE = 0.24, $F(1, 35) = 26.94$, $p = .0001$, $\eta^2 = .44$), indicating that the bodily expression of fear was judged more arousing than that of sadness. The main effect of duration and the duration × bodily expression interaction was not significant (all $p > .05$). The fearful postures were also judged more pleasant than the sad postures (fear: M = 3.26, SE = 0.23; sadness: M = 2.49, SE = 0.21, $F(1, 36) = 19.78$, $p = .0001$, $\eta^2 = .36$), with no effect involving the duration ($p > .05$). The emotion of fear was also recognised in the bodily expression of fear, $F(3, 108) = 17.76$, $p = .0001$, $\eta^2 = .33$, and the emotion of sadness in the bodily expression of sadness, $F(3, 108) = 40.20$, $p = .0001$, $\eta^2 = .53$, with no significant duration-related effect ($p > .05$). The participants thus agreed that these postures expressed more the emotion of fear/sadness than another emotion (happiness, sadness/fear and angry; Bonferroni, $p < .05$). For the happiness/sadness group, there was also a main effect of bodily expression for the assessment of arousal (happiness: M = 4.34, SE = 0.24; sadness: M = 3.28, SE = 0.26, $F(1, 36) = 13.70$, $p = .0001$, $\eta^2 = .28$) and valence (happiness: M = 5.72, SE = 0.21; sadness: M = 3.21, SE = 0.18, $F(1, 36) = 128.05$, $p = .0001$, $\eta^2 = .78$), with no other significant effects. The participants thus judged more arousing and pleasant the happy than the sad postures. The happiness and the sadness were also clearly identified in the specific bodily expressions [$F(3, 108) = 53.59$, $\eta^2 = .60$; $F(3, 108) = 29.76$, $\eta^2 = .45$, respectively, both $p = .0001$] compared to other emotions ($p < .05$), with no effect involving the duration factor.

Temporal performance. Initial ANOVAs were performed on the proportion of long responses, but the results are not reported here because they were similar to those obtained with the bisection point (BP). The BP is the point of subjective equality, that is, the stimulus duration for which participants respond *long* as often as they do *short* (*percentage of "long" responses = .50*). A lower BP value for one stimulus than for another one suggests a lengthening effect, with participants responding *long* more often for the former than for the latter, even though they are of the same duration. The BPs were derived from the fitting of individual bisection functions with the pseudologistic model (Killeen, Fetterman, & Bizo, 1997). This model fitted our individual data well, with a mean R^2 of .94 (SE = 0.008), no difference in R^2 being found between the experimental conditions ($p > .05$). The Weber ratio (WR) was also derived from this pseudologistic fit. This is the difference limen (half the difference between the stimulus duration giving rise to 75% "long" responses and that giving rise to 25% "long" responses) divided by the BP. This is a measure of time sensitivity (time variability): The lower the WR, the greater the sensitivity to time. The BP and WR values we obtained are set out in Table 1.

For each of the two emotional groups, we ran an ANOVA on the WR, with bodily expression as the within-participants factor and duration group as the between-participants factor. These ANOVAs did not yield any significant results (all $p > .05$). This demonstrated that the scalar properties of the temporal discrimination (constant WR for different duration ranges) were maintained in the different conditions we tested, with the same

[1] For technical reasons, the subjective emotional assessment of some pictures on the 9-point scales was not recorded for a few number of participants: arousal and valence assessment: fear/sadness groups: one participant in the 400/1600-ms condition, one participant in the 600/2400-ms and two participants in the 200/800-ms condition; happiness/sadness groups: one participant in the 400/1600-ms and one in the 600/2400-ms condition; discrete emotion assessment: fear/sadness groups: one participant in the 400/1600-ms, one participant in the 600/2400-ms condition; happiness/sadness groups: two participants in the 400/1200-ms condition.

Table 1. *Mean and standard error of bisection point and Weber ratio in the different duration ranges for the bisection tasks with two different bodily expressions: fear versus sadness and happiness versus sadness*

	200/800		*400/1600*		*600/2400*	
	M	*SE*	M	*SE*	M	*SE*
			Bisection point			
Fear/sad bisection						
Fear	527	39	938	39	1436	48
Sadness	530	36	996	36	1522	53
Happy/sad bisection						
Happiness	518	39	1038	39	–	–
Sadness	525	36	1057	36	–	–
			Weber ratio			
Fear/sad bisection						
Fear	0.22	0.03	0.18	0.03	0.17	0.03
Sadness	0.22	0.03	0.23	0.03	0.17	0.03
Happy/sad bisection						
Happiness	0.21	0.03	0.17	0.03	–	–
Sadness	0.22	0.03	0.19	0.03	–	–

sensitivity to time for different bodily expressions and different duration ranges.

For the fear/sadness group, the ANOVA we ran on the BP, using the same factor design as for the WR, revealed a significant main effect of bodily expression, $F(1, 38) = 6.45$, $p = .02$, $\eta^2 = .15$, indicating that the BP was lower for bodily expressions of fear than for those of sadness (732 versus 763 ms), consistent with a lengthening effect for fearful versus sad bodily expressions. However, there was also a significant main effect of duration, $F(1, 38) = 107.92$, $p = .0001$, $\eta^2 = .74$, as well as a significant duration × bodily expression interaction, $F(1, 38) = 5.20$, $p = .03$, $\eta^2 = .12$. This suggests that the lowering of the BP for fearful bodily expressions compared with sad ones was greater in the 400–1600-ms duration group than in the 200–800-ms one (Figure 2). The difference between the BPs for the fearful and sad bodily expressions reached significance in the 400–1600-ms group, $F(1, 19) = 6.91$, $p = .02$, $\eta^2 = .27$, but not in the 200–800-ms group, $F(1, 19) = 0.11$, $p = .75$. In contrast to the fear/sadness group, the ANOVA we ran on the BP for the happiness/sadness group did not reveal any significant effects [bodily expression, $F(1, 38) = 0.98$, bodily expression × duration, $F(1, 38) = 0.17$, both $p > .05$], except for a significant main effect of duration,

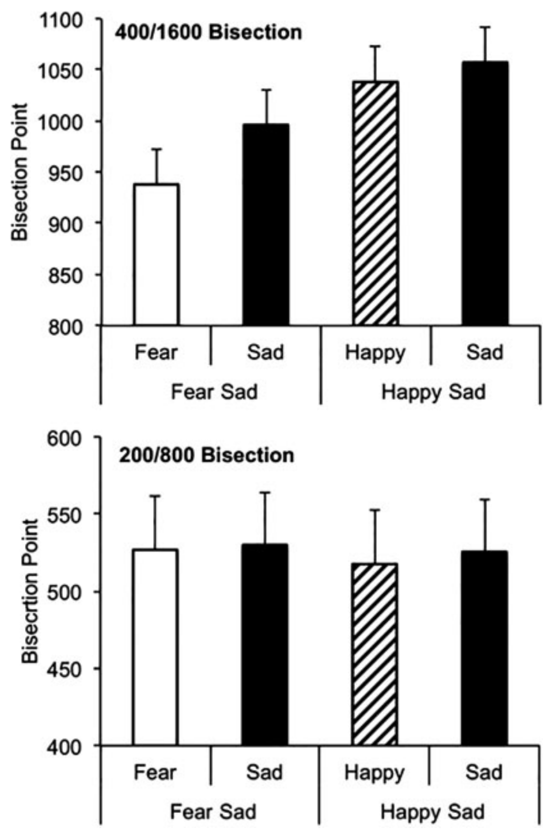

Figure 2. *Mean bisection point in the bisection task with two bodily expressions (fear versus sadness and happiness versus sadness) for the 400/1600 and the 200/800-duration conditions.*

F(1, 38) = 104.37, p = .001, η^2 = .73, showing that the BP was higher in the 400–1600-ms duration group than in the 200–800-ms one.

In summary, our results revealed that the perception of fear signals in the bodily expressions was the major source of distortions in time judgment. However, the comparison of BPs between the fearful and sad bodily expressions did not reach significance in the 200–800-ms duration group in contrast to the 400–1600-ms one. This probably stemmed from the duration ranges used in our study, where there were only small differences between the anchor durations. We therefore decided to conduct a second experiment featuring a range of longer durations (600–2400 ms) in the fear/sadness bisection condition to see whether the magnitude of the lengthening effect observed for fear increased with the length of the durations we tested. This longer range of durations had the same ratio as that used in the other bisection tasks Experiment 1 (1:4) in order to keep constant time discrimination difficulty. The anchors durations were thus 3 times and 1.5 times larger than those used in the 200/800-ms and the 400–1600-ms bisection task, respectively, with the same ratio of 1:4 between the two anchor durations. The results obtained with this new duration condition were compared with those obtained with the conditions using shorter durations (200–800 and 400–1600 ms).

EXPERIMENT 2

Method

Participants

Fifty new students (*mean age* = 19.81, *SD* = 1.78, all females) took part in this experiment in exchange for course credits. As in Experiment 1, they all gave their written informed consent.

Material and procedure

The material and procedure were similar to those used in Experiment 1, with pictures of bodily expressions of fear and sadness. Only the stimulus durations were different, with a short standard duration of 600 ms and a long standard duration of 2400 ms. The comparison durations were 600, 900, 1200, 1500, 1800, 2100 and 2400 ms.

Results and discussion

Subjective emotional assessment. The ANOVA[1] on the affective assessment showed a significant main effect of bodily expression for the arousal level (fear: M = 4.08, SE = 0.26; sadness: M = 2.95, SE = 0.21, F(1, 48) = 22.32, p = .0001, η^2 = .32) and the valence (fear: M = 3.47, SE = 0.20; sadness: M = 2.69, SE = 0.19, F(1, 49) = 23.35, p = .0001, η^2 = .32), with no duration and duration × bodily expression effects (p > .05). This confirmed that the fearful bodily expressions were judged not only more arousing, but also more pleasant, that the sadness bodily expression. The emotions expressed in the fearful and sad postures were also recognised among different emotions [F(3, 141) = 19.07, η^2 = .29; F(3, 141) = 40.53, η^2 = .46; p = .0001], with no effect of the duration. Consequently, the postures of fear and those of sadness were judged as representing more the emotion of fear and sadness than another emotion (Bonferroni, p < .05).

Temporal performance. As in Experiment 1, we calculated the BP and WR values by fitting the pseudologistic model to individual data (mean R^2 = .96, SE = 0.009) (see Table 1). An initial ANOVA was run on both the BP and the WR (Table 1), with bodily expression (fear versus sadness) as factor. The ANOVA on the BP showed a significant effect of bodily expressions, F(1, 14) = 6.99, p = .01, η^2 = .34, indicating that the BP was significantly lower for the bodily expressions of fear than for those of sadness. No effect of bodily expression was found for the WR (p > .05).

Then, a cross-experimental comparison was conducted with an ANOVA on the BP and the WR with the bodily expression as the within-participants factor, and the duration group as the between-participants factor [data for the new 600/2400-ms duration group (15 participants) were

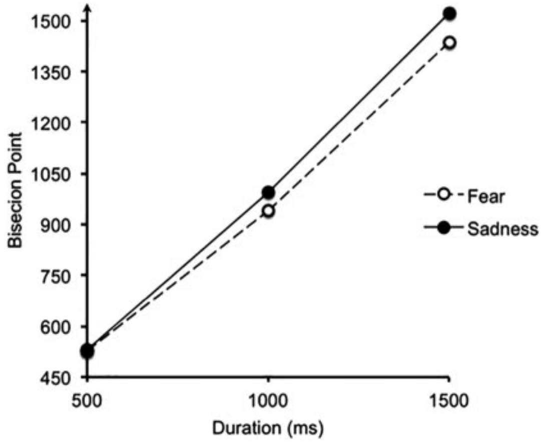

Figure 3. *Mean bisection point for the fearful and the sad bodily expressions in the bisection task for the 3 duration groups: 200/800, 400/1600, 600/2400.*

compared with those for the 200–800-ms duration group (20 participants) and the 400–1600-ms duration group (20 participants) studied in Experiment 1]. The ANOVA on the WR did not reveal any significant effect, confirming that the perception of bodily expressions did not disrupt time discrimination, regardless of bodily emotion (all *p*s > .05). The ANOVA on the BP showed a clearly significant main effect of bodily expression, $F(1, 52) = 15.25$, $p = .0001$, $\eta^2 = .23$, demonstrating that the BP was lower for bodily expressions of fear than for those of sadness (966.96 versus 1016.02). In addition, there were a significant main effect of duration, $F(2, 52) = 108.43$, $p = .0001$, $\eta^2 = .81$, and a significant bodily expression × duration interaction, $F(2, 52) = 3.73$, $p = .03$, $\eta^2 = .13$. As illustrated in Figure 3, this interaction revealed that the magnitude of the difference in BP between the expressions of fear and sadness increased with duration range. The follow-up linear contrast test showed a significant effect of linearity on this interaction, $F(2, 52) = 3.73$, $p = .03$, $\eta^2 = .13$. In summary, the longer the bisection durations, the greater the lengthening effect when fearful and sad bodily expressions were compared.

GENERAL DISCUSSION

The purpose of this study was to investigate the impact of the perception of bodily expressions of emotion on time perception. It was thus the first study to examine whether the perception of bodily expressions produces temporal distortions consistent with those already observed with other emotional stimuli. Moreover, we used several duration ranges in the temporal bisection task to try and deepen our understanding of the mechanisms involving in emotion-related time distortion.

In Experiment 1, two groups of participants were administered a bisection task in which expressions of happiness (for the first group) and fear (for the second group) were contrasted with expressions of sadness. Results revealed a significant lengthening effect, but only in the fear/sad group, with a significantly lower BP for fearful bodily expressions than for sad ones. This result is entirely consistent with those of previous studies using other kinds of emotional stimuli, including facial expressions (e.g., Bar-Haim et al., 2010; Gil & Droit-Volet, 2011a), emotional scenes (e.g., Angrilli, Cherubini, Pavese, & Manfredini, 1997; Gil & Droit-Volet, 2012; Grondin, Laflamme, & Gontier, 2014; Lui, Penney, & Schirmer, 2011), sounds (e.g., Mella, Conty, & Pouthas, 2011; Noulhiane, Mella, Samson, Ragot, & Pouthas, 2007) and aversive stimuli (e.g., Droit-Volet, Mermillod, Cocenas-Silva, & Gil, 2010; Langer, Wapner, & Werner, 1961). Irrespective of emotional stimulus, these studies have systematically shown that negative high-arousal emotional stimuli are judged to be longer than either negative low-arousal emotion stimuli or neutral stimuli.

As mentioned in the Introduction, for most researchers, this lengthening effect in a threatening context can be explained by the critical role played by arousal in speeding up the internal clock system. According to the models of scalar expectancy theory (SET; Gibbon, 1977; Gibbon, Church, & Meck, 1984), the internal clock is composed of an accumulator, which collects pulses emitted by a pacemaker. Consequently, when the pacemaker rate increases with the increase in arousal, more pulses are collected, and more time is judged to have elapsed. However, a lengthening effect can be explained not only by an arousal-related increase in the pacemaker rate, but also by an increase in the amount of attentional resources allocated to time processing in the case of a faster onset detection for arousing stimuli. When the switch connecting the pacemaker to the accumulator closes earlier, more pulses are transferred to the accumulator and the time is judged to be longer (Zakay & Block, 1996, 1998). SET dissociates these two mechanisms. An attention-based mechanism is assumed to produce an additive effect between emotion and duration, such that the number of pulses accumulated as a result of early switch closure remains constant regardless of duration. By contrast, a pacemaker-based mechanism has a multiplicative effect, with the number of pulses accumulated as a result of the acceleration in the pacemaker rate increasingly proportionally with duration. The testing of the attention (additive effect) and clock-speed (multiplicative effect) hypotheses therefore requires different duration ranges to be examined (Droit-Volet & Meck, 2007). Experiment 2 was specifically conducted to test the predictions of these hypotheses, using a wider range of durations with three different anchor durations in bisection (200–800, 400–1600 and 600–2400 ms). In Experiment 2, the lengthening effect for fearful versus sad bodily expressions increased linearly with duration range, being greater for the long anchor duration (600–2400 ms) than for two the shorter ones (200–800 and 400–1600 ms). Our results were therefore consistent with the hypothesis that fear increases the arousal level which, in turn, speeds up the internal clock system. Consequently, the perception of bodily expressions of fear automatically increases the internal clock rate, as do other highly arousing emotional stimuli. This is consistent with the literature on the emotional body, which describes the processing of threatening bodily expressions as being rapid and automatic, relatively independent of attentional control (van Heijnsbergen et al., 2007). Nevertheless, even if the observed pattern of results provides support for the clock-speed hypothesis, the attention-related hypothesis cannot be dismissed as emotion literature highlights that arousal and attention are closely related (e.g., Vuilleumier, 2005)

The present findings can be also interpreted within the framework of the theory of embodied cognition (Barsalou, 2008) that suggests that the automatic simulation of another person's bodily expression allows observers to feel the other person's emotion and to produce adaptive behavioural responses. Indeed, studies have shown that individuals imitate other people's postures just as they imitate their facial expressions (Magnée, Stekelenburg, Kemner, & de Gelder, 2007). Our results on the effects of bodily expression on the perception of time might thus provide support for the theory of embodiment of time (Droit-Volet, 2014; Droit-Volet & Gil, 2009; Droit-Volet et al., 2013; Schirmer, 2011; Wittmann, 2014). However, bodily expressions of emotion are characterised by motion: avoidance body posture for fearful and sluggishness for sadness. Several studies have reported the same time dilation as that observed in our study when people are exposed to nonemotional bodily motion presented either statically (posture resulting from motion) or dynamically (Nather, Bueno, Bigand, & Droit-Volet, 2011; Orgs, Bestmann, Schuur, & Haggard, 2011; Sgouraini & Agiro, 2014; Wittmann, Van Wassenhove, Craig, & Paulus, 2010). Recently, Zhang, Jia, and Ren (2014) even observed that the duration of words and expressions associated with rapid movements (e.g., *gallop*, *run like the wind*) was overestimated compared with those associated with slow movements (*sluggish*, *limp*). The speed of motion involved in bodily expressions is therefore likely to play a critical role in time distortions. Fleeing in response to a threat is necessarily faster than remaining prostrate, overwhelmed by sadness. The distortion of time with bodily expressions can therefore be indirectly linked to the dynamics of emotional action. For a long time now, the subjective experience of time has been associated with dynamic movements in space (Piaget, 1946).

Although speculative at this point, findings of Experiment 1 allow us partially to disentangle what results from motion (i.e., the perceptive shape of postures) and what results from emotion (i.e., the emotional action tendency). Indeed, compared with the postures of sadness, those of happiness and fear were relatively similar, with marked bodily motion and arms raised in every posture (Figure 1). However, unlike the comparison between bodily expressions of fear and sadness, the comparison between bodily expressions of happiness and sadness failed to reach significance in temporal bisection judgment. Consequently, it seems that it was not so much the shape of the posture but the emotion expressed in the whole body that affected participants' time judgements. This provides additional confirmation of studies of the emotional body pointing out a processing of the actual emotion expressed by the body (de Gelder & Hortensius, 2014). Indeed, the perception of bodily expressions of fear activates not only the motor areas involved in the perception of human motion (i.e., superior temporal sulcus), but also the amydala involved in the processing of threatening situations (Grèzes, Pichon, & de Gelder, 2007; Hadjikhani & de Gelder, 2003; Kret, Pichon, Grèzes, & de Gelder, 2011a). Finally, regarding possible limitations of our study, the limited number of emotions investigated, the cross-experimental comparisons in timing performance, and the exclusive female population, may be considered. Further experiments are therefore required to identify the role of speed of motion in the effect of emotional body postures on time perception.

Our study on emotional bodily expressions opens up a new avenue of research on the role of action in the perception of time. First, however, we must investigate whether or not bodily expressions produce similar time distortions to facial expressions. As reported in the Introduction, recent studies have shown that bodily and facial expressions of emotions share the same characteristics (de Gelder et al., 2004; Reed, Stone, Bozova, & Tanaka, 2003; van Heijnsbergen et al., 2007). However, despite these similarities, the authors also assume that bodily expressions are more primary expressions of emotion, in that they are much older from a phylogenetic evolutionary perspective than emotional faces and can be recognised from a greater distance than faces. Taken as a whole, these studies suggest that emotions expressed by the body are more arousing than emotions expressed by the face, because of the fundamental nature of the former, where the motion of emotion is added to the meaning of emotion (i.e., action readiness). Consequently, the speed the internal clock may be greater for the perception of bodily expressions of fear than for the perception of fearful facial expressions. This issue will have to be addressed in future research.

Acknowledgment

The authors would like to thank Laétitia Bartomeuf (research assistant) and Guillaume Blanc (MA student) for collecting data from the students.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This study was funded from the French National Research Agency (ANR) [grant number ANR-11-EMCO-01201] and from the European Commission [Project: TIMESTORM], Horizon 2020 research and innovation action [grant number H2020-FET-PROACT-2014].

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