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The conscious awareness of time distortions regulates the effect of emotion on the perception of time

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ABSTRACT

This study examined how the awareness of emotion-related time distortions modifies the effect of emotion on time perception. Before performing a temporal bisection task with stimulus durations presented in the form of neutral or emotional facial expressions (angry, disgusted and ashamed faces), some of the participants read a scientific text providing either correct or incorrect information on the emotion–time relationship. Other participants did not receive any information. The results showed that the declarative knowledge allowed the participants to regulate (decrease) the intensity of emotional effects on the perception of time, but did not trigger temporal effects when the emotional stimuli did not automatically induce emotional reactions that distorted time.

1. Introduction

The last decade has seen a huge growth in research into the effect of emotions on the perception of time, and especially that of the emotional facial expressions currently used for measuring people's emotions (for a recent review, see Droit-Volet, Fayolle, Lamotte, & Gil, 2013). Most of the studies that have used facial expressions as emotional stimuli have employed the temporal bisection task (e.g., Doi & Shinohara, 2009; Droit-Volet, Brunot, & Niedenthal, 2004; Gil, Niedenthal, & Droit-Volet, 2007; Tipples, 2008, 2011). In this task, participants are trained to recognize a short and a long standard duration. They are then presented with comparison durations, including the two standards and intermediate stimulus durations. Their task is to judge whether these comparison durations are more similar to the short or the long anchor duration. However, in studies involving emotions, the standard durations are presented in the form of a neutral stimulus (pink oval), while the comparison durations are presented as emotional stimuli, namely faces expressing different emotions. The results systematically show that the bisection functions shift toward the left, with a lowering of the bisection point (BP) (i.e., point of subjective equality), for faces expressing high-arousal emotions (i.e., anger, fear) compared to neutral faces, with the result that participants respond long more often for emotional facial expressions than for neutral expressions, even though both are presented for the same duration. Consequently, the perception of negative high-arousal emotional stimuli has been demonstrated to produce distortions in time judgment consistent with a lengthening effect.

This lengthening effect has been explained in terms of the perception of negative high-arousal emotional stimuli which increases the level of activation of the central nervous system and thus causes a speeding up of the internal clock system underlying the representation of time. According to the internal clock models, which are the models most frequently invoked

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in order to account for behavioral data (Gibbon, 1977; Gibbon, Church, & Meck, 1984; Treisman, 1963), the subjective measurement of durations depends on the number of pulses emitted by a pacemaker-like clock system and accumulated during the stimulus duration to be timed. When the clock runs faster, more pulses are accumulated and time is judged to last longer. The speeding-up of the internal clock system in threatening conditions would result from an automatic survival mechanism which prepares the organism to act as quickly as possible when confronted with a potential danger, e.g. to attack or flee when faced with an aggressive person (Droit-Volet & Meck, 2007). Indeed, there is ample evidence that threatening situations automatically trigger innate defense responses in both humans and animals (LeDoux, 1998, 2000). In threatening conditions, individuals are therefore ready to act quickly because their internal clock runs faster and they experience the passage of time as lasting longer than normal. However, human time judgments in an emotional context cannot be reduced to an automatic process of action readiness. As suggested by theories of the appraisal of emotion, the behavioral expression of emotions also depends on people's cognitive appraisal of their emotional state and of the events that have induced this emotional state (Lazarus, 1991; Scherer, 2001). Introspective awareness of an emotional reaction that is too intense for a given situation can, for example, lead individuals to reduce the behavioral expression of emotion (Sanders & Scherer, 2009).

The aim of the present study was to examine how the declarative knowledge of emotion-related time distortions modulates the effect of emotional stimuli on time perception. No study of the role of individual awareness of emotion-related time distortions has investigated the effect of emotion on the judgment of time. However, a recent study has examined how subjects' awareness of the fluctuation of the passage of time in their everyday lives affects their time judgments in a laboratory situation (Lamotte, Izaute, & Droit-Volet, 2012). In this study, the participants were required to estimate stimulus durations in a single temporal task and a dual-task in which they had to process both temporal and non-temporal information. The results replicated those found in numerous studies and showed that the stimulus durations were judged shorter in the dual-task than in the single temporal task (e.g., Coull, Vidal, Nazarian, & Macar, 2004; Fortin, Rousseau, Bourque, & Kirouac, 1993; Macar, Grondin, & Casini, 1994). However, the extent of this shortening effect was smaller in the participants who were more conscious of being subject to time distortions in their everyday lives. In this study, the degree of consciousness was assessed through subjects' responses to the statement "the more I focus attention on time, the slower time goes". The results thus revealed a significant correlation between agreement with this statement and temporal accuracy: The more the participants agreed with the statement, the smaller the distortion of their time judgments in the dual-task was. Based on metacognitive studies, the authors argued that the participants' individual knowledge of time distortion caused them to monitor the attentional resources they allocated to time processing. The participants thus developed a cognitive control strategy allowing them to compensate for their tendency to shorten time when they performed a secondary non-temporal task. In conclusion, people's individual consciousness of their temporal abilities also contributes to their time judgments.

In the emotion-related domain, no studies have investigated the effect of individual knowledge on the perception of time. Using an extensive series of questions, Lamotte, Chakroun, Droit-Volet, and Izaute (2014) assessed individuals' explicit knowledge and beliefs about factors that may affect how time is perceived. Factorial analyses allowed the authors to extract two discriminant factors: one related to attention and the other to emotion. However, as far as emotion was concerned, there was individual variability in the consciousness of time distortions in the presence of happiness and sadness, but not in response to the high-arousal emotions of anger or fear, even though these emotions have a considerable impact on time perception. As reported above, this may be due to the temporal effects produced by these basic emotions, which derive directly from automatic unconscious mechanisms. Consequently, to examine the effect of individual knowledge of emotion-related time distortions, we decided to compare angry faces and neutral faces, and to manipulate the knowledge provided to the participants before they performed the temporal bisection task. To do this, we provided some of the participants with a text which they had to read before performing the temporal task and which contained either correct or incorrect information about the effect of emotion on time perception. More specifically, the text stated that the perception of an angry face produces a lengthening of time (true information) or a shortening of time (false information) compared to that of a neutral face. Certain other participants did not receive any information. Our hypothesis was that declarative knowledge of emotion-related time distortions would modulate the basic effects of emotional stimuli on the perception of time in bisection.

2. Experiment 1

2.1. Method

2.1.1. Participants

Fifty-two women students ($M = 19.35$, $SD = 1.37$) from Blaise Pascal University (Clermont-Ferrand, France) took part in this study in return for course credits after signing a consent form to participate in the experiment.

2.1.2. Materials

The participants were tested individually in a quiet room in the laboratory of the Psychology department. They were seated in front of a PC computer that controlled the experiment and recorded the data via an E-prime program (1.2. Psychology Software Tools, Pittsburgh, PA). They gave their responses by pressing the *D* ("*Short*") and *K* ("*Long*") keys on the computer keyboard and the button-press assignment was counterbalanced across subjects. The stimuli to be timed were an oval with a mottled texture (white, gray, black) in the training phase and the faces of 3 different women in the testing phase, all presented at the center of the computer screen against a black background. These faces were taken from a validated set of facial expressions (Ekman & Friesen, 1976). Two emotional expressions were used: an intense expression of anger and a neutral expression.

2.1.3. Procedure

Participants were randomly assigned to one of the 3 groups as a function of the information received before performing the temporal bisection task: true information, no information, and false information. In the true information group, a text informed participants that, according to time research, angry faces cause a subjective lengthening of time in humans, with the result that the presentation time of angry faces tends to be overestimated compared to that of neutral faces. In the false information group, the text wrongly informed the participants that angry faces cause a subjective shortening of time, with the result that the presentation time of angry faces tends to be underestimated compared to that of neutral faces. In the no-information group, the participants did not read any text before the temporal bisection task.

In all the experimental groups, the participants were given a temporal bisection task consisting of a training and a testing phase. In the training phase, the short (400-ms) and the long (1600-ms) standard duration was presented five times each, in a random order, in the form of an oval and the participants were trained to press the corresponding button on the keyboard to respond "*Short*" or "*Long*". In the testing phase, they were presented with 7 comparison durations which took the form of facial expressions. Two of these were identical to the short and the long standard (400, 1600-ms) and five had intermediate values (600, 800, 1000, 1200 and 1400-ms). The participants had to judge whether these comparison durations were more similar to the short or to the long standard duration. Each participant was given 126 trials, i.e. 9 trials for each of the 2 emotional expressions (neutral *vs.* anger) for the 7 comparison durations. The 9 trials consisted of 3 trials for the 3 different women. The trials were randomly presented within each block of 42 trials (3 women $\times$ 2 emotions $\times$ 7 durations) and the inter-trial interval was between 1 and 2 s.

In addition, after the bisection task, the participants assessed the arousal level of the angry and neutral expressions of the 3 different female faces using the 9-point scale of the Self-Assessment Manikin (SAM) (Lang, Bradley, & Cuthbert, 2008). The presentation duration of the facial expressions was at the mid-point between the short and the long standard durations, i.e. 600 ms. In each group, the participants therefore rated 6 different emotional stimuli presented in a random order (3 faces $\times$ 2 emotions).

2.2. Results

Fig. 1 shows the proportion of "long" responses (p(long)) plotted against the comparison durations for the neutral and the angry facial expressions in the 3 information groups (true information, no-information and false information). An examination of Fig. 1 shows that the psychophysical functions were shifted toward the left, consistent with a lengthening effect, for the angry faces compared to the neutral faces, except in the false information group. This finding was confirmed by the statistical analyses run on the Bisection Point (BP). Statistical analyses were initially run on p(long) but are not reported because they provided results similar to those obtained for the BP. The BP is the point of subjective equality at which the stimulus duration is judged long as often as it is short ($p(\text{long}) = .50$). This temporal parameter was derived from the significant fit of the individual data with the pseudo-logistic function which provided good fits for the bisection data in the different conditions. A second parameter, the Weber Ratio (WR), was also calculated. This is the difference limen $(D(p(\text{long}) = .75) - D(p(\text{long}) = .25))/2$, divided by the BP. It is an index of time sensitivity: The lower the WR, the steeper the psychophysical function and the higher the sensitivity to time.

However, the statistical analyses on the WR (Table 1) did not reveal any significant effect (all $p > .05$). In line with the results of numerous studies of emotions (for reviews, see Droit-Volet, 2013; Droit-Volet et al., 2013), this indicated that the perception of emotional facial expressions did not change the sensitivity to time. In contrast, the ANOVA run on the BP with faces as within-subjects factor and information as between-subject factor revealed a significant main effect of faces, $F(1,49) = 4.58$, $p = .04$, $\eta^2_p = .09$, while the main effect of information, $F(2, 49) = 0.45$, $p = .64$, and the faces $\times$ information interaction, $F(2,49) = 1.89$, $p = .16$, did not reach significance. This suggests that the BP was systematically lower for the angry than for the neutral faces. The emotion-related lengthening effect on the perception of time thus tended to emerge with the omnibus analysis of variance using 3 information conditions whose 2 conditions with lengthening-based instructions. However, as suggested by several researchers in statistics (Furr & Rosenthal, 2003; Judd, 2000; Rosenthal & Rosnow, 1985), in order to evaluate our theoretical predictions efficiently (a priori hypothesis), we decided to run a one-way ANOVA on PB for each information groups taken separately. The analyses revealed that the difference in the BP between the neutral and the emotional faces, $F(1,17) = 5.55$, $p = .03$, $\eta^2_p = .25$, was significant in the no-information and the true information conditions, $F(1,16) = 8.31$, $p = .01$, $\eta^2_p = .34$. Nevertheless, the differences in the BP between the neutral and the emotional faces did not reach significance between these two conditions, although the leftward shift of the bisection function seemed to be greater in the true information than in the no-information condition ($p > .05$). In addition, in the false condition, in which the participants received incorrect information about the effect of emotion on time perception, the significant difference in the BP between the neutral and the angry faces was no longer observed, $F(1,16) = 0.07$, $p = .81$.

The ANOVA on the subjective assessment of the arousal level (Self-Assessment Manikin) induced by the perception of faces confirmed a significant main effect of faces (Angry faces: $M = 5.54$, $SE = .25$; Neutral faces: $M = 2.56$, $SE = .16$, $F(1,48) = 114.87$, $p = .0001$, $\eta^2_p = .71$), whereas the effect of information and the information x faces interaction failed to reach

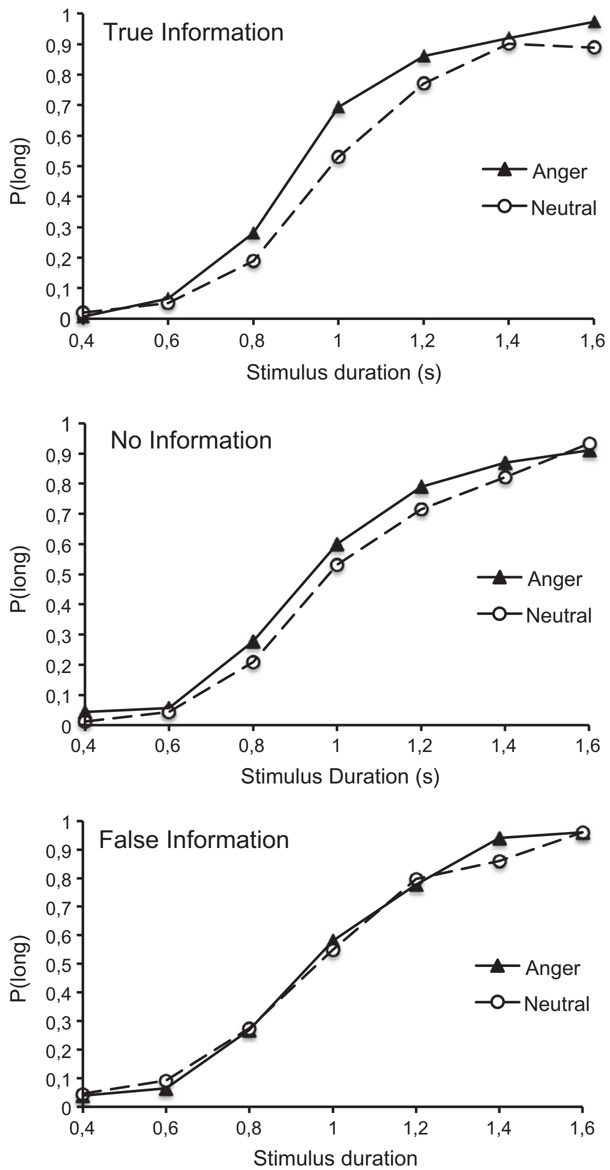

Fig. 1. Proportion of long responses (*p*(*long*)) plotted against stimulus durations (s) for the angry and the neutral facial expressions when the participants received true information, no-information or false information.

significance (all $p > .05$). Consequently, in each information condition, the angry faces were always judged to be more arousing than the neutral faces.

In summary, the results of Experiment 1 suggest that the effect of emotional faces (angry faces) on the perception of time tended to emerge in all experimental conditions. However, when the participants received information that contradicted observed behavior, the emotional effect did not reach significance. The false information thus suppressed/reduced the time distortion initially induced by the emotional stimuli. Our results also suggest that this knowledge is not in itself capable of producing a time distortion in bisection. Indeed, the incorrect information did not produce a temporal effect on time judgment in the opposite direction (shortening) to that originally observed in the no-information condition. Although the participants received information indicating that the perception of angry faces produces a shortening effect, they did not judge the period of presentation of the angry faces to be shorter than that of the neutral faces. Consequently, explicit information about the nature of the emotional effect on time perception seems to modulate the basic emotional effect on time judgment, rather than produce an effect by itself. In order to verify the role of false information in time judgments, we decided to conduct a second experiment examining the effect of different types of false information on the time judgment of faces expressing different emotions: namely anger, disgust and shame. As confirmed by Experiment 1, the facial

Table 1
Mean and standard error of bisection points and Weber ratios for the neutral and anger faces in the groups receiving true information, no-information and false information.

	Bisection point		Weber ratio	
	M	SE	*M*	SE
True information				
Neutral	975	43.25	0.17	0.11
Anger	903	40.61	0.14	0.06
No-information				
Neutral	1014	42.03	0.17	0.12
Anger	953	39.47	0.18	0.11
False information				
Neutral	934	43.25	0.19	0.16
Anger	945	40.61	0.16	0.09

expression of anger produces a lengthening effect in the no-information context. Some studies have found that, in contrast to the expression of anger, the perception of disgusted and ashamed faces did not produce lengthening effects on the perception of time in bisection (Droit-Volet & Meck, 2007; Gil & Droit-Volet, 2011a,b). Consequently, in order to examine whether explicit information can produce a temporal effect that is not dependent on the task (emotional context), two opposing types of false information were given to the participants. For the angry and the disgusted faces judged as arousing, the participants were informed that the perception of angry/disgusted faces shortens time estimates (shortening effect), and, for the ashamed faces judged as non-arousing, that the perception of shameful faces lengthens time estimates (lengthening effect). Our hypotheses was that the false information would only have a significant effect on time judgment when the perception of emotional faces originally produced a time distortion in the no-information condition, i.e., in the case of the angry faces but not the disgusted and the ashamed faces.

3. Experiment 2

3.1. Participants

One hundred and nineteen new female students ($M = 19.77$, $SD = 1.52$) from Blaise Pascal University participated in this experiment in return for a course credit and after signing a consent form.

3.1.1. Material and procedure

The material and the procedure were the same as those used in Experiment 1, except for the emotional material to be timed which took the form of faces expressing 4 different emotions: anger, disgust, shame and a neutral emotion. The angry and disgusted faces were selected from Ekman's battery (Ekman & Friesen, 1976) and the ashamed faces from that compiled by Beaupré and Hess (2005) as also used in Gil and Droit-Volet's study (2011b). The participants were assigned to the angry ($N = 40$), the disgust ($N = 39$) or the shame ($N = 40$) group. In each group, there were two sub-groups of participants that differed as a function of the information received (false information *vs.* no-information). In the false information group, the text incorrectly informed the participants that ashamed/disgusted/angry faces cause a subjective lengthening/shortening/shortening of time, so that ashamed/disgusted/angry faces tend to be overestimated/underestimated/underestimated compared to neutral faces. In the no-information groups, the participants did not read any text before performing the temporal bisection task.

3.2. Results

Fig. 2 shows the bisection functions for the anger, disgust and shame groups when the participants received no information or false information. Overall Analyses of Variance were performed on BP and WR with two between-subjects factor (emotional group, information group) and one within-subjects factor (emotional faces *vs.* neutral faces). The BP and WR were derived from the significant fits of individual data obtained with the pseudo-logistic function (Table 2). As in Experiment 1, the analyses on WR did not show any significant effect (all $p > .05$), suggesting that sensitivity to time remained constant in the different experimental conditions. More interestingly, the ANOVA on BP revealed a 3-way interaction between emotional group, information group and faces, $F(2,113) = 5.58$, $p = .005$, $\eta^2_P = .09$, with a significant main effect of faces, $F(1,113) = 6.55$, $p = .01$, $\eta^2_P = .06$. Subsequently, an ANOVA was run on BP for each emotional group taken separately. For the anger group, there was a significant main effect of faces, $F(1,38) = 9.98$, $p = .003$, $\eta^2_P = .21$, and a significant faces $\times$ information interaction, $F(1,38) = 12.25$, $p = .001$, $\eta^2_P = .24$, with the main effect of information being non-significant ($p > .05$). This interaction indicated that the difference in the BPs between the angry and the neutral faces was significant in the no-information group, $t(19) = 5.98$, $p = .001$, whereas it did not reach significance in the false information group, $t(19) = 0.21$, $p = .84$. Unlike the anger group, for the disgust group and the shame group there were no significant main effects of faces ($F(1,37) = .39$,

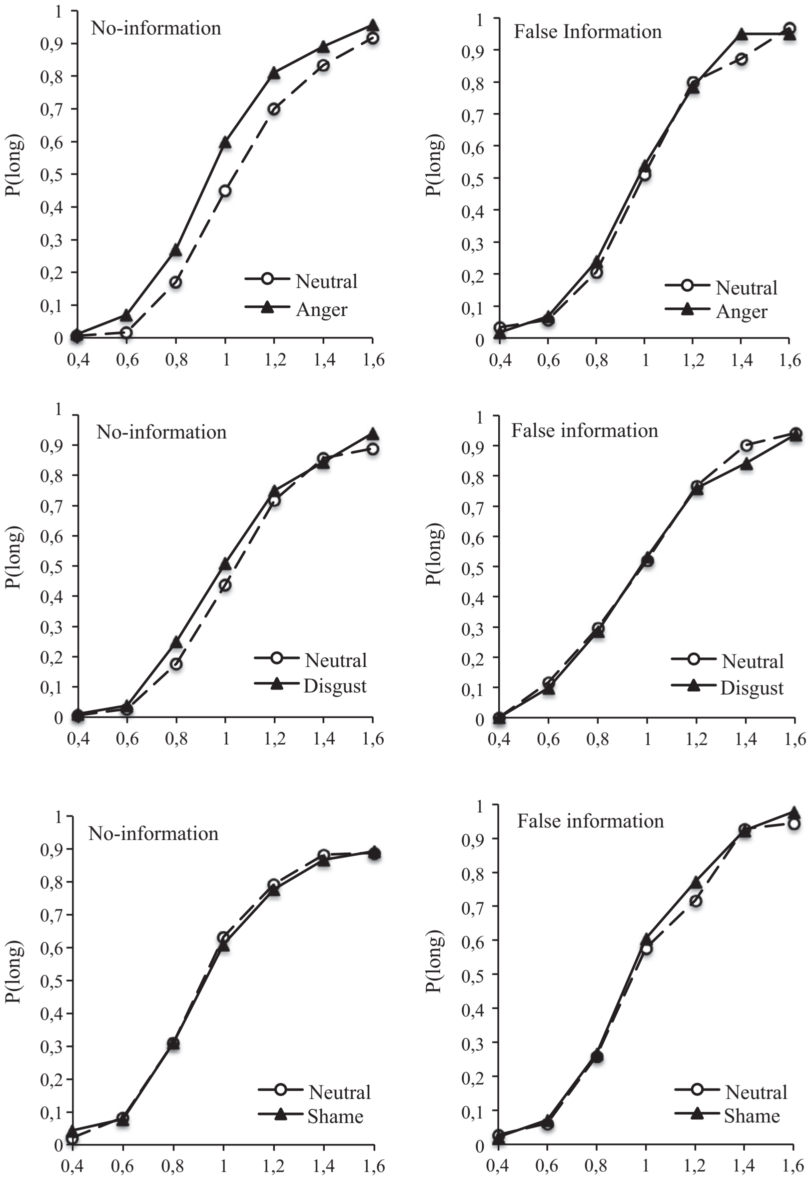

Fig. 2. Proportion of long responses ($p(long)$) plotted against stimulus durations (s) for the neutral and the emotional facial expressions (anger, disgust and shame) when the participants received no-information or false information.

$F(1,38) = .64$, respectively) or information group ($F(1,37) = .99$, $F(1,38) = .25$), and no significant interaction involving these two factors ($F(1,37) = .74$, $F(1,38) = 2.87$) (all, $p > .05$).

The ANOVA on the self-assessment Manikin scores for arousal with the faces and the information as factors showed that the participants judged the disgusted faces to be more arousing than the neutral faces (5.02 *vs.* 2.95), regardless of information condition (only a significant main effect of faces, $F(1,37) = 39.19$, $p = .0001$ $\eta^2_p = .52$), whereas the ashamed faces were judged to be as low arousing as the neutral faces (3.43 *vs.* 3.23) (all effects, $p > .05$). To summarize, the results of Experiment 2 confirmed that explicit information that described an erroneous relationship between time and emotion reduced the temporal effect that was automatically produced by emotional faces in the no-information condition (anger groups), but was not powerful enough to produce either a shortening or lengthening temporal effect when no emotional effect was originally observed in the no-information condition (disgust and shame groups).

4. General discussion

The present study examined how declarative knowledge modulates the effect of emotional stimuli (facial expression) on time judgments in a bisection task. First of all, the results found in the no-information groups replicated those found in

Table 2
Mean and standard error of bisection points and Weber ratios in the anger, the disgust and the shame condition for the neutral and emotional faces in the no-information and the false information group.

	Bisection point		Weber ratio	
	M	SE	*M*	SE
Condition: Neutral-anger				
No-information				
Neutral	1063	38.2	0.17	0.02
Anger	923	38.6	0.18	0.02
False information				
Neutral	1010	38.2	0.17	0.02
Anger	1017	38.6	0.13	0.02
Condition: Neutral-disgust				
No-information				
Neutral	1024	34.2	0.16	0.01
Disgust	985	42.8	0.17	0.02
False information				
Neutral	953	35.0	0.19	0.02
Disgust	959	43.9	0.21	0.02
Condition: Neutral-shame				
No-information				
Neutral	921	36.7	0.20	0.02
Shame	936	38.1	0.22	0.03
False information				
Neutral	974	36.7	0.16	0.02
Shame	932	38.1	0.15	0.03

numerous studies showing a lengthening of perceived durations in response to negative high-arousal emotional stimuli compared to neutral stimuli. Indeed, the psychophysical function in bisection was shifted toward the left and the BP was significantly lower for the angry faces than for the neutral faces. Even though emotional reactions are always a difficult material to work with (Fayolle & Droit-Volet, 2014), this finding indicates that the distortion of time in response to the effect of a high-arousal emotion is robust.

More interestingly, our results revealed the important role played by declarative knowledge in the effect of emotional stimuli on the judgment of time. Indeed, when the participants were told either that the perception of angry faces produces a lengthening effect (true information) or that it leads to a shortening effect (false information), the effects of corresponding facial expression on the judgment of time were amplified and reduced, respectively. Nevertheless, in our study, the down-regulation of emotional effects on time perception seemed to be more significant than their up-regulation. As expected, our results were thus entirely consistent with the appraisal theories of emotion, which hold that an individual's focus on affect and/or emotional context may change his or her expression of emotion (for a review, see Grandjean & Scherer, 2009). However, our results also demonstrated that the declarative knowledge modulated, i.e. reduced, the emotional effects on the perception of time, but did not trigger a temporal effect. Indeed, in Experiment 1, the false information about a shortening effect reduced the lengthening effect originally observed in the no-information condition, with the result that the significant temporal difference between the angry and the neutral faces was no longer observed. However, this false information did not lead to a shortening effect consistent with the description of emotion–time relationships presented in the information text seen by the participants. Similarly, in Experiment 2, the false information about a shortening effect in the case of disgusted faces and a lengthening effect in the case of ashamed faces did not result in any effect, either shortening or lengthening, on time judgments. In particular, in the no-information group, these emotional facial expressions did not spontaneously induce an emotional reaction that significantly altered the judgment of time in bisection (see also, Droit-Volet & Meck, 2007; Gil & Droit-Volet, 2011a,b). To summarize, when emotional effects automatically occurred in response to emotional stimuli (angry faces), knowledge modified the intensity of this effect on the perception of time. However, when emotional effects did not automatically occur in response to emotion stimuli, the declarative knowledge did not cause this effect to emerge. Consequently, our study demonstrates that declarative knowledge seems to regulate rather than trigger the effects of emotional stimuli on time judgment. In other words, emotional knowledge inhibits and, to a lesser extent, enhances the emotional effects on the perception of time, but is not in itself able to generate a temporal effect. Overall, our results are consistent with appraisal models of emotion that argue that although emotions are triggered by emotional stimuli, cognitive appraisal nevertheless permits a certain flexibility in emotional responses (Grandjean & Scherer, 2009). As explained by Scherer (2001), the role of conscious processes lies in the cognitive regulation of emotion.

We can thus assume that the internal clock system speeds up automatically in response to the perception of threatening stimuli (Droit-Volet et al., 2013). However, the question that can be raised now is: at what level of time processing does cognitive regulation act to modify the distortion of time triggered by emotion? Fig. 3 illustrates different hypotheses. In his attentional theory, Zakay (1992) referred to the level of relevance and importance of time in a given context. His idea is that the level of temporal relevance will increase the level of temporal awareness which should, in turn, modify the amount of attention devoted to time. This interpretation therefore supports the idea that temporal awareness acts as an attentional control. If this is indeed the case, we can assume that participants pay less attention to emotional stimuli that are considered as less relevant. This is the case, for example, of an angry friend whose anger has less of an effect on you when you consider him or her to be completely hysterical. The significance of his/her anger in terms of behavior is thus reduced. A first hypothesis (panel 1, Fig. 3) is therefore that participants divert attention away from the emotional stimuli and try, for example, to ignore their hysterical friend. According to the internal clock models, attention acts at an early stage of time processing via an attentional gate mechanism or an attention-controlled switch that connects the pacemaker-like system to the accumulator (Lejeune, 1998; Thomas & Weaver, 1975; Zakay & Block, 1996, 1998). Following this line of argument, Lamotte et al. (2012) explained that participants' knowledge of their subjective time distortions leads them to use attention monitoring strategies that reduce these time distortions in an experimental context. We can therefore assume that, when people allocate fewer attentional resources to emotional stimuli that are considered as less significant, the attentional gate between the pacemaker and the accumulator is less open and that the number of pulses entering the accumulator is therefore reduced.

However, the control of attention can also act at a later stage of time processing, i.e. not before but after the accumulator. The volume of pulses produced by an automatic acceleration of the internal clock rate in a threatening situation could thus automatically enter the accumulator (Droit-Volet, 2013). The second hypothesis (panel 2, Fig. 3) is therefore that the control of attention consists in inhibiting, or erasing, in memory the temporal content that automatically enters the accumulator.

The third hypothesis is that judging emotional stimuli to be irrelevant reduces the level of arousal induced by these emotional stimuli, which in turn reduces the speed of the internal clock (panel 3, Fig. 3). This approach considers that the participants themselves down-regulate the physiological reactions induced by the emotional stimuli. In a recent study, Peira, Fredrikson, and Pourtois (2014) showed that healthy participants can efficiently use detectable biofeedback (heart rate) to reduce their emotional reactions in response to visual emotional stimuli. In the domain of timing, Meissner and Wittmann (2011) measured participants' awareness of heart rate by asking them to attend to their own heartbeats and count them silently. These authors found that the more aware subjects were of their heartbeat, the more accurately they performed in a duration reproduction task. In sum, it is possible that the participants used bodily information to consciously down-regulate their emotional reaction, thus attenuating the speeding-up of the internal clock. In the theories of embodied time it has been suggested that the self-awareness of bodily information contributes to time judgment (e.g., Craig, 2009; Droit-

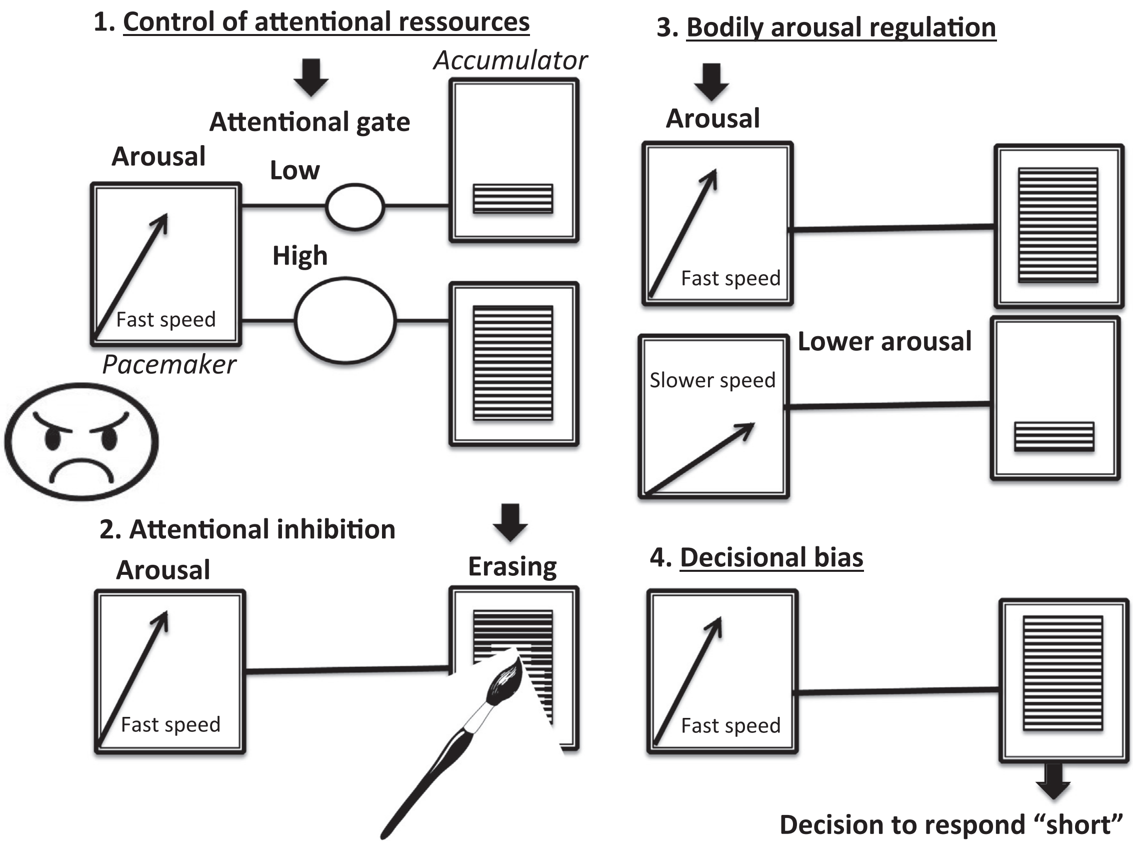

Fig. 3. Hypotheses about the level of time processing at which cognitive regulations act to modify the distortion of time triggered by emotion: (1) control of attentional resources, (2) attention inhibition, (3) bodily arousal regulation and (4) decisional bias.

Volet, 2014; Droit-Volet & Gil, 2009; Droit-Volet et al., 2013; Wittmann, 2014). However, in our study, the scores on the self-assessment of arousal level in response to the perception of angry faces did not change with the nature (false or true) of the explicit information received.

A fourth hypothesis relates to decision-making bias. This holds that participants would respond "short" more often because they are aware of their tendency to respond long in emotional conditions. Such a tendency would mask the lengthening effect at the behavioral level. However, the modeling of individual bisection data demonstrates that changes in decisional processes only affect the proportion of responses in the middle of the bisection curve, i.e. in the case of "ambiguous" durations when the participants do not know whether the durations are more similar to the short or the long standard (Droit-Volet & Wearden, 2001; Wearden & Jones, 2013). In particular, this bias in the middle of the psychophysical functions was not observed in our false information groups.

Finally, there is a series of hypotheses concerning the mechanisms that mediate the effects of knowledge on emotion-induced time distortions that require the conduction of further experiments before they can be validated. Regardless of the mechanisms involved, the original contribution of our study is to reveal the important role of temporal awareness in determining the extent of subjective time dilation under the effect of emotion.

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