

BRIEF REPORT

Perception of the duration of emotional events

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Participants were trained on a temporal bisection task in which visual stimuli (a pink oval) of 400 ms and 1600 ms served as short and long standards, respectively. They were then presented comparison durations between 400 ms and 1600 ms, represented by faces expressing three emotions (anger, happiness, and sadness) and a neutral-baseline facial expression. Relative to the neutral face, the proportion of long responses was higher, the psychophysical functions shifted to the left, and the bisection point values were lower for faces expressing any of the three emotions. These findings indicate that the duration of emotional faces was systematically overestimated compared to neutral ones. Furthermore, consistent with arousal-based models of time perception, temporal overestimation for the emotional faces increased with the duration values. It appears, therefore, that emotional faces increased the speed of the pacemaker of the internal clock.

Despite renewed interest in the role of emotion in cognitive processes, little research has systematically examined the way in which emotion affects time perception. An older, scattered literature on the topic remains inconclusive due to the inconsistency of findings across studies. For example, in his review of the literature, Orme (1969) concluded that pain and stress are associated with an underestimation of subjective time. However, a number of studies demonstrated the opposite effect, suggesting that the duration of affective events is overestimated (e.g., Thayer & Shiff, 1975; Watts & Sharrock, 1984). Still other studies demonstrated no effects of affect on the estimation of duration (Fraisse, 1967; Shiff & Thayer, 1968). Thus, based on this earlier literature, little can be said about the effect of emotion on time perception, the generalisability of the effects across emotions, or, most critically, about the mechanism by which such an influence might occur.

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Extant models of time estimation appeal largely to two different mechanisms: attention and arousal. And emotions are known to influence both of these. For example, subjective duration is directly related to the amount of attentional resources allocated to time processing itself such that the fewer attentional resources are allocated to the passage of time, the shorter the time estimate is (Thomas & Weaver, 1975; Zakay, 1989). This is explained by a loss of internal clock pulses accumulated in the cognitive timer. The fewer pulses accumulated, the shorter the duration perceived (see Lejeune, 1998, for a discussion). If emotional events detract attention away from the processing of time, as suggested by past literature (e.g., Öhman, Lundqvist, & Esteves, 2001), then, according to attentional models, such events should be underestimated relative to neutral ones. However, emotional events are also inherently arousing (Russell & Mehrabian, 1977), and arousal has been shown to increase the speed of the pacemaker that provides the raw material to time perception (e.g., Maricq, Roberts, & Church, 1981; Meck, 1983; Wearden & Penton-Voak, 1995). This in turn increases the number of pulses emitted per unit of time by an "internal clock" and, consequently, subjective time increases. In other words, when individuals are in an aroused state, they tend to overestimate the passage of time. Models of time perception based in the mechanism of arousal therefore predict that emotional events should be overestimated compared to neutral ones.

In one of the few systematic analyses of the effect of emotion on time perception. Angrilli, Cherubini, Pavese, and Manfredini (1997) presented participants with slides that depicted scenes that were fully crossed for their valence and intensity. Thus, participants saw scenes that were high intensity-pleasant (e.g., kissing couple), high intensity-unpleasant (e.g., baby with eye tumour), low intensity-pleasant (e.g., smiling baby), and low intensity-unpleasant (e.g., large spider). Participants performed a time reproduction and a verbal estimation task. Analyses revealed no main effects of valence or arousal. Rather, an interaction was observed such that for low arousal slides, the duration of unpleasant slides was more underestimated than that of pleasant slides, whereas for high arousal slides, the duration of unpleasant slides was more overestimated than that of pleasant slides.

Angrilli et al. (1997) concluded that both attentional and arousal mechanisms are required to account for their findings, with attentional mechanisms being more important in low arousal conditions. However, in their study, the participants not only produced inaccurate temporal judgements, but also systematically *underestimated* the real durations. No clear temporal overestimation relative to real time was therefore observed. According to Angrilli et al. (1997), this underestimation of the real durations can in part be explained by the complexity of the tasks used, which attracted attention away from the passage of time and attenuated any potential arousal effect. Furthermore, the stimulus duration values used (i.e., 2, 4, 6 s) may not have been sensitive to an arousal effect. Indeed, the relative overestimation of time induced by the high arousal stimulus obtained in the shortest interval (2 s) progressively shifted to an underestimation at 4 s and 6 s (Angrilli et al., 1997).

The aim of the present study was to test two competing and plausible mechanisms underlying the effect of emotion on time perception, by using a temporal bisection task (Allan & Gibbon, 1991). Short durations of less than 2 s were used in order to both prevent spontaneous counting strategies, and to limit the decrease of any potential arousal effect over time. In the bisection task, the participants were trained to recognise a short and long standard duration, which were represented by the same neutral stimulus. They

then classified a range of comparison stimulus durations, including the two standards as well as intermediate stimulus durations, on the basis of their similarities to the short or the long standard. The critical stimuli presented during the test phase were faces that expressed different emotions: neutral-baseline, angry, happy, and sad. Since all three of these facial expressions can be correctly identified by 50 ms, there was no concern that the stimuli could not be fully processed well within the parameters of the presentations (e.g., Kirouac & Dore, 1983).

Since emotional stimuli are more arousing than neutral, arousal methods predict that the perceived duration of emotional stimuli will be longer than that of neutral stimuli. Furthermore, anger and joy are high arousal emotions, whereas sadness is a lower arousal emotion (Russell & Mehrabian, 1977). Thus the duration of angry and happy faces would also be expected to be more overestimated than sad. In contrast, attention models predict an underestimation of the duration of facial expressions of emotion compared to that of the neutral-baseline expression. Furthermore, this would be more apparent for the negative facial expressions, which should detract attention away from temporal processing more than positive facial expressions (e.g., Öhman et al., 2001; Pratto & John, 1991).

METHOD

Subjects

The sample consisted of 37 first-year female psychology undergraduates at Blaise Pascal University in Clermont-Ferrand, France.

Material

The experiment was presented on PowerMacintosh computers, which controlled the presentation of the experimental stimuli and recorded the participants' responses with Pyscope (Cohen, McWhinney, Flatt, & Provost, 1993). Responses were made on the computer keyboard. The stimuli used for the representation of duration were a pink oval (12 × 16 cm) and photos of the faces of three different women (see Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001). For each of the women there were photos of four different facial expressions (i.e., neutral, angry, happy, sad, see Figure 1 for an example), which had been pretested for the purity of the expression displayed (Niedenthal et al., 2001).

Procedure

Participants performed a bisection task composed of two successive phases: training and testing. In the training phase, participants were shown the short and the long standard stimulus durations, represented by the pink oval stimulus. The short standard stimulus duration (S) was 400 ms and the long one (L) 1600 ms. Each standard was initially presented five times in alternation. Participants pressed keys labelled "short" and "long" on the computer keyboard after the short and the long standard durations, respectively. The left-right response position was counterbalanced across participants. Then each participant performed a block of eight trials, and S and L had a 50% probability of appearance on each trial. The intertrial interval was randomly chosen between 1 s and 3 s. Accuracy feedback, positive ("yes") or negative ("no"), was presented for 2 s in the centre of the computer screen.



Figure 1. Example of faces with neutral, sad, happy, and angry expressions.

The testing phase maintained the conditions of training except that the feedback was discontinued, and the comparison stimulus durations were represented by faces rather than the oval. There were nine blocks of 28 trials, on which the three emotional faces and the neutral face were presented seven times each, in random order (for a total of 252 trials in all). Each stimulus was presented once at each of the two standard durations (S and L), and at five intermediate comparison durations (600, 800, 1000, 1200, and 1400 ms).

RESULTS

Figure 2 shows the mean proportion of “long” responses plotted against the stimulus durations.¹ Each panel shows responses for an emotional expression compared to the neutral one. Proportions of long responses for each participant were transformed to *z*-scores. Then, *d'* was calculated by taking the difference between the *z*-score of the emotional faces and the *z*-score of the neutral faces that were presented for the same amount of time (Macmillan & Creelman, 1990).

¹ The task of the participants was so undemanding when the duration presentation was identical to one of the two standards, that there was no variance in the responses for these two duration conditions. They were thus dropped from the analysis. It should be noted, however, that the results did not change significantly when the standard durations were included in the analyses.

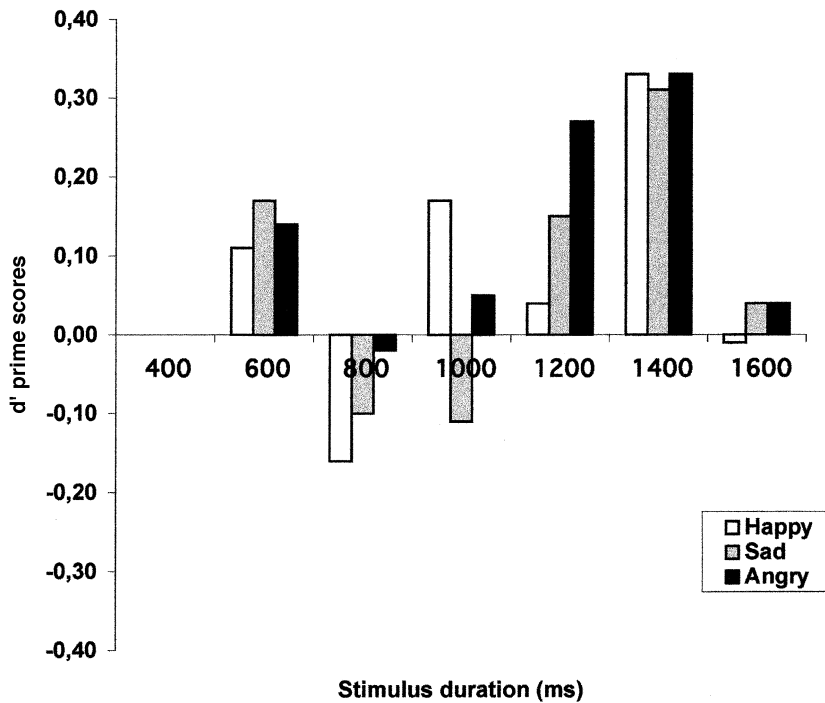


Figure 2. Proportion of “long” responses plotted against stimulus durations for the neutral, angry, happy, and sad facial expressions.

The scores express the extent to which the duration of a facial expression was over- or underestimated relative to the neutral expressions. Positive d' 's reflect overestimation, and negative d' 's reflect underestimation. Average d' 's broken down by type of emotion and stimulus duration are shown in Figure 3.

The d' 's were treated as the dependent variable in subsequent analyses. For each type of facial expression, we averaged the scores for different durations, and tested whether the average d' was significantly greater than 0. This was indeed the case for happy: ($M = 0.07$, $SD = 0.21$, $t(36) = 2.02$, $p = .05$), and angry expressions: ($M = 0.15$, $SD = 0.18$), $t(36) = 5.14$, $p < .001$, and marginally so for sad expressions: ($M = 0.06$, $SD = 0.20$, $t(36) = 1.92$, $p = .06$). Thus, participants overestimated the durations of all three emotional faces relative to neutral ones.

In order to explore participants' responses further, we conducted an overall ANOVA on d' 's with two within-subject factors: type of emotion (angry, happy, sad) and stimulus duration (600, 800, 1000, 1200, 1400 ms). There was a main effect of emotion, $F(2, 72) = 3.97$, $p < .02$. Student's t -tests for repeated measures revealed that the effect was due to the angry faces for which duration was more overestimated than those of happy and sad faces, $t_s(36) = 2.67$ and 2.62 , $p_s < .01$, respectively (effect sizes were $d = 0.45$ and 0.47). No significant difference was obtained between the latter two faces, $t(36) = 0.12$, $p = .90$ (effect size was $d = 0.03$).

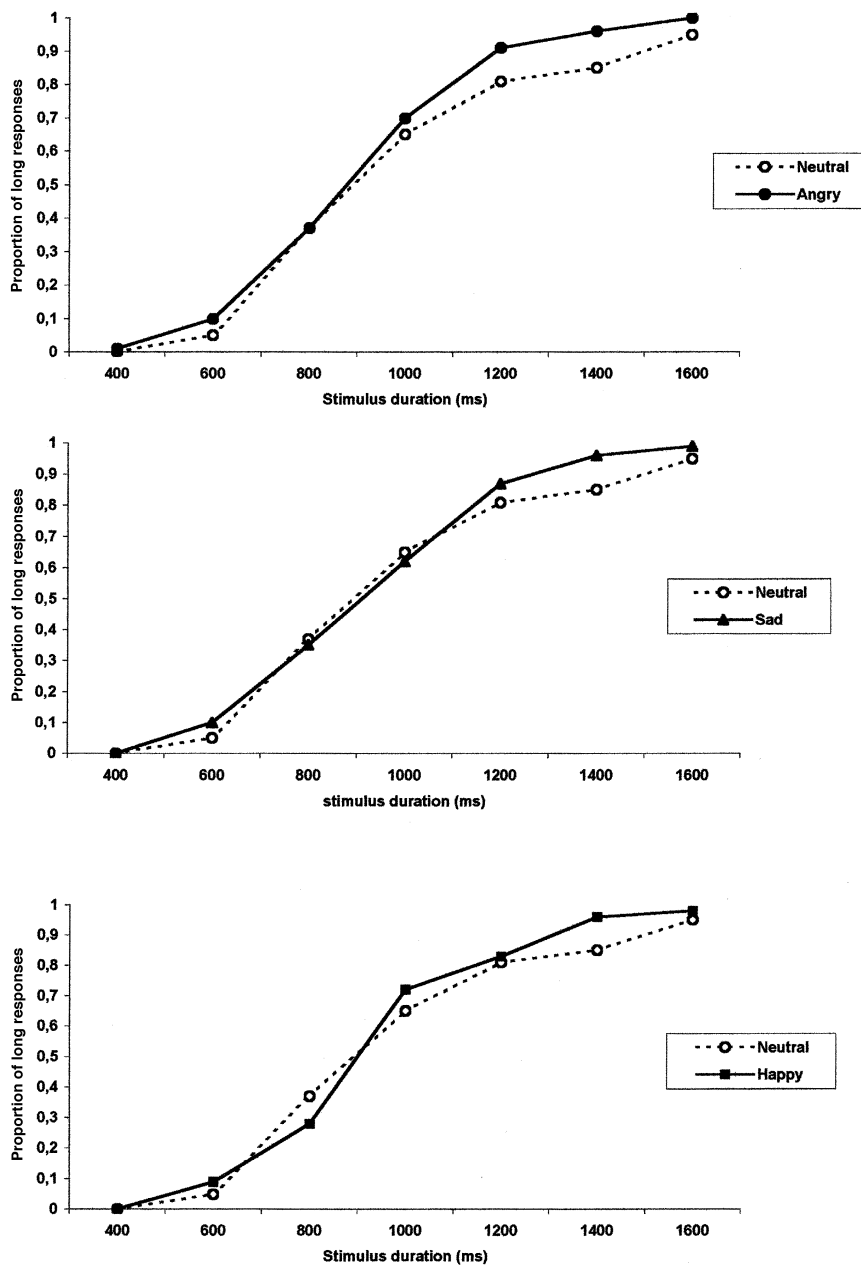


Figure 3. Proportion of “long” responses plotted against stimulus durations. Upper panel: Results for the neutral-baseline and the angry facial expressions. Centre panel: Results for the neutral and the happy facial expressions. Lower panel: Results for the neutral to the sad facial expressions.

There was also a significant main effect of stimulus duration, $F(4, 144) = 5.84, p < .0001$, indicating that overestimation did not occur uniformly across the durations. Polynomial contrast analyses revealed a significant linear trend showing that overestimation increased with stimulus duration, $F(1, 36) = 10.63, p = .002$ [the quadratic trend was also significant, $F(1, 36) = 12.45, p < .01$, but the cubic trend was not $F(1, 36) = 2.99, p > .05$]. As shown in Figures 2 and 3, overestimation occurred largely at longer durations. The interaction between the type of emotion and the stimulus duration was also significant, $F(8, 288) = 3.92, p < .0001$, indicating that the extent to which emotional expressions were overestimated relative to the neutral one was moderated by emotion type. Student's t -test for repeated measures on the d 's averaged over the longer durations (i.e., 1000, 1200, 1400 ms) revealed that the difference between the neutral and emotional faces tended to be greater for anger (0.22) and happiness (0.18) than for sadness (0.09): $t(36) = 2.51, p = .02, t(36) = 1.36, p = .07$, respectively, whereas the difference between anger and happiness was not significant, $t(36) = 0.85, p = .40$.

Similarities and differences between the psychophysical functions produced with the different facial expressions were also examined by calculating the bisection point from the individual psychophysical functions. The bisection point is the comparison stimulus duration giving rise to 50% of "long" responses. Bisection points were calculated from the slope and intercept parameters obtained in the individual linear regressions (see Table 1). There was a significant overall effect of facial expression: Kendall's W -test, $\chi^2(3) = 23.82, p = .0001$. Two-by-two comparisons using Wilcoxon tests revealed significant differences between the neutral face and each of the three expressive faces (anger, $Z = 4.08$, happiness, $Z = 3.44$, sadness, $Z = 2.05, p < .05$). Thus, the bisection points were lower with the presentation of the expressive faces than with the neutral face, as indicated by the left-shift of the psychophysical functions and a bias toward responding "long". These findings are consistent with those reported above in that they demonstrate an overestimation of the duration of emotional stimuli. However, as can be seen in Table 1, the bisection point values were lower for anger and happiness than for sadness, but this only reached significance in the comparison between anger and sadness ($Z = 2.69, p = .007$).

DISCUSSION

The present findings revealed an overestimation of the perceived duration of faces expressing emotion compared to neutral expression. This was demonstrated in several ways. First, the differences between the proportions of long responses for the emotional faces and those for the neutral faces were positive for all emotional expressions. Second,

TABLE 1
Means (and standard deviations) of individual regression bisection points (ms) for the 4 facial expressions: Neutral, Angry, Happy, and Sad

	<i>Neutral</i>	<i>Angry</i>	<i>Happy</i>	<i>Sad</i>
<i>Mean</i>	950	873	887	914
<i>(SD)</i>	(171)	(146)	(135)	(167)

the emotional faces lowered the bisection point and shifted the psychophysical function towards the left, indicating a bias towards long responses. This tendency to overestimate the duration of emotional stimuli is consistent with the prediction of arousal-based models and inconsistent with attentional models, which predict underestimation of the duration of emotional events. According to the former models, an increase in the level of arousal acts on the internal clock by increasing the pacemaker speed. The pacemaker produces more pulses per unit of time than without increased arousal and time seems longer.

Another finding suggestive of arousal as the mechanism of greatest import in modelling the influence of emotion on the perception of time was that the overestimation of the duration of emotional faces varied by type of expression. Anger and happiness are considered higher arousal emotions than sadness, although this is sometimes less marked for happiness (e.g., Russell, 1983). Our results showed that the duration of faces expressing anger was more overestimated than the duration of faces expressing sadness. Specifically, the bisection point was significantly lower for anger than for sadness, and the overestimation of the longest durations was also more marked for anger than for sadness. Thus, the duration of the higher arousal emotion was overestimated more than the lower arousal emotion.

The present finding is consistent with a small literature on the perception of the duration of crime scenes that were assumed to be highly arousing. That literature shows quite consistently that crime scenes are perceived to have lasted longer than they did in reality (Buckhout, 1977; Buckhout, Figueroa, & Hoff, 1975). The present findings provide further evidence both for the general lengthening of subjective time and for the probable role of arousal in this effect.

However, even if the overestimation of duration is consistent with an arousal interpretation, the precise changes in the internal clock are not unequivocally revealed by the present study. In fact, pacemaker-accumulator internal clock theories suggest two ways in which the clock might be affected by arousal (Gibbon, 1977). One of these, that already discussed, is an increase in pacemaker speed. An alternative, however, is a change in the functioning of the switch of the internal clock that relates the pacemaker to the accumulator (Church, 1984). For example, emotional stimuli may make the switch open later or close earlier than normal. Either one or both of these effects (i.e., changes in pacemaker speed or influences on the opening and closing of the switch) would increase the number of pulses accumulated during the event to be judged.

The mathematics of the internal clock model suggest that a distinction can be made between the clock speed and the latency switch interpretations, however (for a discussion, see Burle & Casini, 2001; Droit-Volet & Wearden, 2002). Pacemaker speed is multiplicative with real time. So if the pacemaker is speeded up by an increase in arousal, the effect should be absolutely greater at longer times than at shorter times. Switch effects, on the other hand, are independent of the durations judged and are additive in nature. Thus, they are constant whatever the duration values employed. We did not examine different ranges of duration in the present study, nevertheless we did examine several stimulus durations (between 400 ms and 1600 ms). In this range, extent of temporal overestimation of emotional faces relative to the neutral face increased with stimulus duration values. This duration $\times$ emotion interaction is precisely the result required by the clock speed interpretation, and one that has been demonstrated by other studies in which arousal was manipulated, for example, by the administration of drugs (e.g., Maricq et al., 1985; Meck,

1983). Thus, it seems reasonable to conclude that the arousal induced by the perception of emotional stimuli affects pacemaker speed.

Of course, the present research does not rule out the possibility that attentional processes play some role in the perception of the duration of emotional events and stimuli in different tasks. For example, it is possible that at longer durations than those examined in the present experiment, findings consistent with an attentional model would be observed. Furthermore, time judgements depend not only on a clock system, but also on memory and decision processes. Thus, although our data argue clearly in favour of an arousal mechanism, they also do not rule out the possibility that other mechanisms operate across a range of circumstances. Future work will need to address the boundary conditions for the present findings.

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REFERENCES

- Allan, L., & Gibbon, J. (1991). Human bisection at the geometric mean. *Learning and Motivation*, 22, 39–58.
- Angrilli, A., Cherubini, P., Pavese, A., & Manfredini (1997). The influence of affective factors on time perception. *Perception & Psychophysics*, 59, 6, 972–982.
- Buckout, R. (1977). Eyewitness identification and psychology in the courtroom. *Criminal Defense*, 4, 5–100.
- Buckout, R., Figueroa, D., & Hoff, E. (1975). Eyewitness identification: Effects of suggestion and bias in identification from photographs. *Bulletin of the Psychonomic Society*, 6, 71–74.
- Burle, B., & Casini, L. (2001). Dissociation between activation and attention effects in time estimation: Implication for internal clock models. *Journal of Experimental Psychology: Human Perception and Performance*, 27, 1, 195–205.
- Church, R. M. (1984). Properties of the internal clock. *Annals of the New York Academy of Sciences*, 423, 566–582.
- Cohen, J., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: An interactive graphic system for designing and controlling experiments in the psychology laboratory using Macintosh computers. *Behavior Research Methods, Instruments, & Computers*, 25, 257–271.
- Droit-Volet, S., & Wearden, J. (2002). Speeding up an internal clock in children? Effects of visual flicker on subjective duration. *The Quarterly Journal of Experimental Psychology*.
- Fraisse, P. (1967). *Psychologie du temps*. Paris: PUF.
- Gibbon, J. (1977). Scalar expectancy theory and Weber's law in animal timing. *Psychological Review*, 84, 279–325.
- Kirouac, G., & Dore, F. Y. (1983). Accuracy and latency of judgment of facial expressions of emotions. *Perceptual and Motor Skills*, 57, 683–686.
- Lejeune, H. (1998). Switching or gating? The attentional challenge in cognitive models of psychological time. *Behavioural Processes*, 44, 127–145.
- Macmillan, N. A., & Creelman, C. D. (1990). Response bias: Characteristics of detection theory, threshold theory, and "nonparametric" indexes. *Psychological Bulletin*, 107, 401–413.
- Maricq, A. V., Roberts, S., & Church, R. M. (1981). Metamphetamine and time estimation. *Journal of Experimental Psychology: Animal Behavior Processes*, 7, 18–30.
- Meck, W. H. (1983). Selective adjustment of the speed of the internal clock and memory processes. *Journal of Experimental Psychology: Animal Behavior Processes*, 9, 171–201.

- Niedenthal, P. M., Brauer, M., Halberstadt, J. B., & Innes-Ker, A. H. (2001). When did her smile drop? Contrast effects in the influence of emotional state on the detection of change in emotional expression. *Cognition and Emotion*, 15, 853–864.
- Öhman, A., Lundqvist, D., & Esteves, F. (2001). The face in the crowd revisited: An anger superiority effect with schematic stimuli. *Journal of Personality and Social Psychology*, 80, 381–396.
- Orme, J. E. (1969). *Time experience and behaviour*. Amsterdam: Elsevier.
- Pratto, F., & John, O. (1991). Automatic vigilance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology*, 61, 380–391.
- Russell, J. A. (1983). Pancultural aspects of the human conceptual organization of emotions. *Journal of Personality and Social Psychology*, 39, 1281–1288.
- Russell, J. A., & Mehrabian, A. (1977). Evidence for a three-factor theory of emotions. *Journal of Research in Personality*, 11, 273–294.
- Shiff, W., & Thayer, S. (1968). Cognitive and affective factors in temporal experience: Anticipated or experienced pleasant and unpleasant sensory events. *Perceptual and Motor Skills*, 26, 799–808.
- Thayer, S., & Shiff, W. (1975). Eye-contact, facial expression, and the experience of time. *The Journal of Social Psychology*, 95, 117–124.
- Thomas, E. A. C., & Weaver, W. B. (1975). Cognitive processing and time perception. *Perception & Psychophysics*, 17, 363–367.
- Watts, F. N., & Sharrock, R. (1984). Fear and time estimation. *Perceptual and Motor Skills*, 59, 597–598.
- Wearden, J., & Penton-Voak, I. (1995). Feeling the heat: Body temperature and the rate of subjective time, revisited. *Quarterly Journal of Experimental Psychology*, 48B, 129–141.
- Zakay, D. (1989). Subjective and attentional resource allocation: An integrated model of time estimation. In I. Levin & D. Zakay (Eds.), *Time and human cognition* (pp. 365–397). Amsterdam: North-Holland.

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