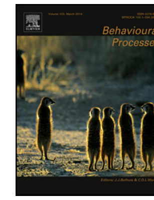
Behavioural Processes 120 (2015) 135–140

Contents lists available at ScienceDirect

Behavioural Processes

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



Fear and time: Fear speeds up the internal clock

Sophie Fayolle[a], Sandrine Gil[b], Sylvie Droit-Volet[a,*]

[a] Université Clermont Auvergne, CNRS (LAPSCO UMR 6024), France
[b] Université de Poitiers, CNRS (CeRCA UMR 7295), France

ARTICLE INFO

Article history:
Received 3 June 2015
Received in revised form
28 September 2015
Accepted 28 September 2015
Available online 9 October 2015

Keywords:
Time perception
Timing
Emotion
Fear
Internal clock

ABSTRACT

We tested time perception in a bisection task featuring a wide range of durations (from 0.2 to about 8.0 s) and highly arousing stimuli (delivery of an electric shock). In addition, self-report questionnaire responses and skin conductance responses were assessed to measure emotional reactivity. Results clearly demonstrated emotion-related time distortion, as stimulus durations were judged to be longer in the trials with an electric shock than in those without one. In addition, this lengthening effect increased with the length of durations. These findings are consistent with the hypothesis of an arousal-induced speeding up of the internal clock system.

1. Introduction

When we compare episodes of our everyday lives that we experienced in different emotion states, we have the strange impression that time is either speeded up or slowed down. While time seems like an eternity when we are waiting for a loved one, it suddenly seems to fly by once that person has arrived (Droit-Volet, 2014). Time no longer exists! The judgment of time therefore seems to change pace with our emotional states. The past decade has seen an explosion in the number of laboratory studies yielding empirical data on the effects of emotion on time perception (for a review, see Droit-Volet et al., 2013), but the mechanisms underlying these effects remain the subject of debate. One reason why the debate is proving difficult to settle is that the effects of emotion on time perception in humans have mainly been tested with paradigms involving the temporal processing of emotional stimuli, forcing researchers to use short durations in the hundreds of milliseconds, because the emotional state induced by the perception of emotional stimuli are extremely transient. The aim of the present study was thus to examine the effect of one particular emotion on time perception with a wider range of durations, from hundreds of milliseconds to several seconds, using highly arousing stimuli (electric-shock procedure) to induce a fearful state in participants.

Studies of the effects of emotion on the perception of short durations have used a variety of stimuli, including emotional faces (e.g., Bar-Haim et al., 2010; Doi and Shinohara, 2009; Droit-Volet et al., 2004; Gil and Droit-Volet, 2011; Tipples, 2008, 2011), emotional scenes (e.g., Angrilli et al., 1997; Buetti and Lleras, 2012; Gil and Droit-Volet, 2012; Grommet et al., 2011; Smith et al., 2011), and sounds (e.g., Mella et al., 2011; Noulhiane et al., 2007). Despite the diversity of these emotional stimuli, they have generally found that high-arousal emotional stimuli are judged to last longer than either low-arousal emotional stimuli or neutral stimuli, consistent with a lengthening effect. However, researchers have yet to explain the mechanisms underlying this emotion-related effect on time perception.

According to the models derived from the most popular theory of timing, namely scalar expectancy theory (SET; Gibbon, 1977; Gibbon et al., 1984), the internal clock is composed of a pacemaker, a switch and an accumulator. At the onset of the stimulus to be timed, the attention-controlled switch closes and the pulses emitted by the pacemaker enter the accumulator. At the stimulus offset, the switch re-opens, thus interrupting the pulse transfer. The judgment of a stimulus duration therefore depends on the number of pulses that have been accumulated: the more pulses, the longer the duration is judged to be. There is thus a linear relationship between subjective duration and actual stimulus duration, in that the longer the stimulus duration, the greater the number of pulses that are accumulated.

According to SET, an emotion-related lengthening effect can be obtained via two main mechanisms: (1) an attention-switch mechanism and (2) an arousal mechanism that speeds up the pacemaker

* Correspondence author at: Laboratoire de Psychologie Sociale et Cognitive, CNRS (UMR 6024), Université Clermont Auvergne, Université Blaise Pascal, 34 avenue Carnot, 63037 Clermont-Ferrand, France. Fax: +33 4 73 40 64 82.
E-mail address: sylvie.droit-volet@univ-bpclermont.fr (S. Droit-Volet).

http://dx.doi.org/10.1016/j.beproc.2015.09.014
0376-6357/

system. The distinction between the two is quite clear (see Burle and Casini, 2001). According to the attention-switch hypothesis, the emotion effect is added to the duration effect. More specifically, the attentional switch closes earlier, under the effect of emotion, and a constant number of pulses is added to the number of pulses accumulated during the processing of the stimulus duration. As the number of these early additional pulses is the same for all stimulus durations, irrespective of their length, the combined effect of emotion and stimulus duration is equal to the sum of their separate effects (i.e., additive effect). According to the clock-speed hypothesis, the pacemaker rate increases with arousal and so the emotion effect multiplies the duration effect, such that the number of additional pulses increases with the length of the stimulus duration. In other words, there is a multiplicative interaction between the effects of emotion and stimulus duration (i.e., multiplicative effect). In short, if we wish to test these two hypotheses concerning the mechanisms behind the effects of emotion on time perception, we have to examine several duration ranges (Droit-Volet and Meck, 2007).

Few studies of emotion and timing in humans have included the different ranges of stimulus duration needed to examine SET's hypotheses and identify the mechanisms behind the effects of emotion on time perception. In addition, where different duration ranges have been used, they have often been shorter than 2 s, that is, in a narrow temporal window restricting the detection of emotional effects. In the hundreds of milliseconds duration range, results appear to be inconsistent, with some data supporting a multiplicative effect (clock speed; e.g., Droit-Volet et al., 2004; Mella et al., 2011) and others an additive effect (attention; e.g., Grommet et al., 2011; Lui et al., 2011). Some results even support both, depending on the durations that are tested (Gil and Droit-Volet, 2012; Smith et al., 2011). Each researcher nevertheless finds justification for his/her findings in the literature on emotion, insofar as threatening stimuli have been shown to increase arousal, but also capture attention (Anderson and Phelps, 2001; Scherer, 2013). The few studies to have used several duration ranges, including durations of more than 2 s, have shown that the emotion-related lengthening effect decreases, rather than increases, for these longer durations (Angrilli et al., 1997; Bar-Haim et al., 2010). Although this would appear to undermine the SET hypothesis that arousal speeds up the internal clock, it has been suggested that this decrease in the lengthening effect with long durations nonetheless reflects an arousal-based mechanism, given that the attention effect is assumed to be constant, irrespective of duration length (Bar-Haim et al., 2010). Finally, the major problem with studies up to now is that they have used emotional stimuli (e.g., pictures) that induce only short-lived emotions. In other words, participants' arousal level in response to emotional stimuli quickly decreases. In addition, certain characteristics of these stimuli (picture color, sound rhythm) may interfere with time processing, thus modifying the effect of the induced emotion (Droit-Volet et al., 2013). It has been shown, for example, that colors contribute to the emotional charge of the most widely used emotional pictures (Cano et al., 2009). The color red, for instance, which is often presented in high-arousal emotional scenes, signals danger and dominance (for a review, see Elliot, 2015). By definition, therefore, the processing of emotional stimuli involves both ephemeral and variable effects.

The best way to verify the SET hypotheses of a multiplicative (clock speed) versus additive (attention-switch closure) effect is to examine the effect of emotion per se on temporal judgments of neutral stimuli, using emotions that are sufficiently arousing to affect the processing of even long durations (>2 s). Droit-Volet et al. (2011) recently tested the effects of different moods on the perception of neutral stimuli by immersing participants in threatening films (e.g., *The Shining*) for 10 min before administering a temporal bisection task. However, in their temporal tasks, they only used stimulus durations shorter than 2 s (0.2–0.8 s, 0.4–1.6 s), in order to avoid a decrease in mood level during the temporal processing. When Droit-Volet et al. (2010) used an aversive sound (50-ms burst of 95-dB white noise), judged to be highly arousing, in a temporal bisection task, they observed a multiplicative effect between emotion and duration, consistent with the clock-speed hypothesis. Once again, however, the durations they tested lasted less than 2 s. Two early studies (Falk and Bindra, 1954; Hare, 1963) tested longer intervals (>5 s) using electric shocks, which are currently employed in studies of the fear emotion (e.g., LaBar et al., 1998; Phelps et al., 2004). Obviously, the intensity level of the electric shocks was adjusted to make them bearable for participants. These early authors found that participants overestimated the length of durations in the electric shock condition, compared with the no electric shock condition. However, Falk and Bindra (1954) only tested one duration (15 s) in their temporal production task, and Hare (1963) only tested two (5 s and 20 s). Consequently, their experimental procedure did not allow them to test the SET hypotheses about the mechanisms behind the effect of emotion on time perception.

The aim of the present study was to systematically test the effect of fear, induced by an electric shock delivered during the stimulus, in a temporal bisection task featuring four duration ranges (durations longer and shorter than 2 s), all with the same ratio of short (*S*) to long (*L*) anchors (1:4): 0.2–0.8, 0.4–1.6, 1.2–4.8, and 2.0–8.0 s. In this investigation, we included both self-report (i.e., Self-Assessment Manikin (SAM) scale; Bradley and Lang, 1994) and physiological (i.e., electrodermal activity, EDA) indices of arousal (for a review, see Kreibig, 2010). We hypothesized that if fear speeds up the internal clock, then the difference in lengthening effect between trials with and without electric shocks should increase linearly across the duration ranges.

2. Material and methods

2.1. Participants

Participants were 60 (48 women and 12 men) psychology undergraduates (mean age = 19.41 years, SD = 4.8) from Clermont Auvergne University (Clermont-Ferrand, France). They received course credits in exchange for their participation. All the participants provided their written informed consent to taking part in this experiment, which was conducted in accordance with the Declaration of Helsinki. One participant decided to withdraw from the study, and one decided not to participate.

2.2. Apparatus

The participants were tested individually in a quiet laboratory room, where they were seated in front a computer with a 15" square screen. E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA, United States) generated the experimental events and recorded the data. The stimulus to be timed was a blue circle displayed in the center of the computer screen. The participants responded either "short" or "long" by pressing the *S* or *L* key of the computer keyboard with their dominant hand. In addition to recording participants' EDA, two finger electrodes were placed on the index and middle finger of their nondominant hand. These electrodes were connected to the FE116 amplifier (ADInstruments, Colorado Springs, CO, United States), a fully insulated galvanic skin response amplifier with low-voltage 75 Hz AC excitation and automatic zeroing. We chose a common 1–4 s latency window (i.e., between 1 and 4 s following stimulus onset) and a minimum amplitude criterion of 0.05 μs (Dawson et al., 2007; Levinson and Edelberg, 1985). For the purpose of the analyses, participants' EDA