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Negative Emotionality Influences the Effects of Emotion on Time Perception

Jason Tipples
University of Hull

In this study I used a temporal bisection task to test if greater overestimation of time due to negative emotion is moderated by individual differences in negative emotionality. The effects of fearful facial expressions on time perception were also examined. After a training phase, participants estimated the duration of facial expressions (anger, happiness, fearfulness) and a neutral-baseline facial expression. In accordance to the operation of an arousal-based process, the duration of angry expressions was consistently overestimated relative to other expressions and the baseline condition. In support of a role for individual differences in negative emotionality on time perception, temporal bias due to angry and fearful expressions was positively correlated to individual differences in self-reported negative emotionality. The results are discussed in relation both to the literature on attentional bias to facial expressions in anxiety and fearfulness and also, to the hypothesis that angry expressions evoke a fear-specific response.

Keywords: emotion, time perception, temperament

Unpleasant events can seem to “last a lifetime.” In support of this everyday experience, psychological research (Angrilli, Cherubini, Pavese, & Manfredini, 1997; Droit-Volet, Brunot, & Niedenthal, 2004; Effron, Niedenthal, Gil, & Droit-Volet, 2006; Gil, Niedenthal & Droit-Volet, 2007; Thayer & Schiff, 1975; Watts & Sharrock, 1984) has shown that the temporal perception of emotionally arousing events is typically distorted compared to the duration of neutral events. The current research was designed to establish whether temporal bias due to angry and fearful expressions is enhanced in individuals who consistently report high levels of negative emotional arousal. In addition, the research extends previous studies by examining the effects of fearful facial expressions on time perception.

Droit-Volet and colleagues (2004) used a temporal bisection task to investigate the effect of viewing another person’s facial expression on time perception. The experiment consisted of a training and test phase. During training, participants learnt to recognize standard short (400 ms) and long (1,600 ms) stimulus durations. During the test phase, angry, happy, neutral, and sad female facial expressions were presented for a range of stimulus durations (from 400 to 1,600 ms). The results showed that participants (all women) overestimated the duration of emotional expressions. Specifically, they produced a higher proportion of “long” responses for the emotional compared to neutral expressions. Moreover, overestimation was greatest for the more arousing angry expressions compared to the less arousing happy and sad expressions. Further analyses showed that the bisection point (comparison duration giving rise to 50% of the long responses) was reached sooner for emotional expressions compared to the neutral expressions. A later study conducted by Effron et al. (2006) used the same method to test the hypothesis that embodied emotional states are necessary for the bias in temporal processing due to emotion. The results supported this hypothesis—overestimation due to emotion (again, greatest for angry expressions) was eliminated when participants placed a pen in their mouth and consequently, imitation was inhibited. Overestimation for angry relative to neutral expressions has also been recorded in children aged 3, 5, and 8 years (Gil et al., 2007).

It is possible to interpret the above findings within the context of internal clock theories of time processing (Gibbon, Church, & Meck, 1984; Treisman, 1963; Wearden, 2004; Zakay & Block, 1996). In general, these models included an arousal-sensitive pacemaker that sent pulses (or units of elapsed time) to a counter (or accumulator). Attending to nontemporal information (e.g., a secondary task) is thought to reduce the number of units sent to the counter resulting in an underestimation of time. Increased arousal is thought to accelerate the rate of the pacemaker leading to a greater number of counted units of time thus resulting in overestimation of time. In support of these predictions, a number of studies (e.g., Burle & Casini, 2001) reported both underestimation and overestimation of time following the manipulation of attention and arousal, respectively.

Several aspects of the data reported by Droit et al. (2004) and Effron et al. (2006) support the operation of arousal rather than attentional processes on time perception. First, both studies recorded an overestimation of the presentation duration of faces rather than underestimation. Second, overestimation was greatest for faces typically rated as appearing more highly aroused (angry expressions) compared to faces rated as appearing less aroused (e.g., happy and sad expressions). In other words, the effects of facial expressions on time perception appear to reflect the arousal level of the person expressing the emotion (the sender).

Jason Tipples, Department of Psychology, University of Hull.
Correspondence concerning this article should be addressed to Jason Tipples, Department of Psychology, University of Hull, Hull, England HU6 7RX. E-mail: j.tipples@hull.ac.uk

The current research was designed to investigate the possible influence of individual differences in self-reported negative emotional arousal (negative emotionality) on time perception. The influence of individual differences on overestimation due to emotion has been recorded in one study (Watts & Sharrock, 1984) in which spider stimuli were presented for 45 s. In comparison to the control group, spider-phobic individuals overestimated the time that had passed while viewing a spider. Although the presentation of negative facial expressions such as those used by Droit-Volet et al. (2004) is likely to invoke a weaker emotional response, a number of studies have shown that individual differences in aspects of negative emotionality such as fearfulness (Tipples, 2006) and anxiety (Fox, Russo, Bowles, & Dutton, 2001; Georgiou et al., 2005) are linked to various forms of cognitive bias induced by computer-presentation of angry and fearful facial expressions. In light of these findings, the current study investigated the influence of individual differences in negative emotionality on the effects of facial expressions on time perception. Factor analytic studies (Naerde, Roysamb, & Tambs, 2004) show that the EAS Temperament Survey for Adults (Buss & Plomin, 1984) measures differences in negative emotionality, activity, and sociability in adults. Individual differences in negative emotionality are indexed by scores on subscales of the EAS designed to measure fearfulness, anger, and distress. The prediction made here is that overestimation due to negative facial expressions will be linked to individual differences in negative emotionality.

In addition, the current study was an attempt to extend previous research by examining the effects of fearful facial expressions on time perception. Replication using fearful expressions is important because previous studies (Droit-Volet et al., 2004; Effron et al., 2006; Thayer & Schiff, 1975) have not compared angry expressions with other negative, highly aroused expressions. Fearful expressions are a suitable for this purpose because they are typically rated as appearing high aroused (Calder, Burton, Miller, Young, & Akamatsu, 2001). Specifically, fearful and angry expressions are given similar ratings of pleasantness and arousal as angry expressions. Therefore, if the effect of facial expressions on time perception reflects an arousal-sensitive mechanism, we might expect similar levels of overestimation for both angry and fearful expressions. In the present study, the temporal bisection task described by Droit-Volet et al. (2004) was used to examine the influence of facial expressions and individual differences in negative emotionality on time perception.

Method

Participants

Forty-two psychology students from the University of Hull took part in the study in return for a course credit. There were 8 men (*M* age = 22, age range 18 to 35) and 34 women (*M* age = 20, age range 18 to 39).

Materials and Apparatus

Sixteen digitized photographs from the Ekman and Friesen (1976) pictures of faces were used in the experiment. The photographs were those of two males (JJ, WF) and two females (MO, MF), each displaying an angry, fearful, happy, and neutral facial expression. In a previous study (Calder et al., 2001) all pictures except the happy expressions for the female posers were rated for pleasantness and arousal (scores ranged from 1 to 9) using the Affect Grid (Russell, Weiss, Mendelsohn, 1989). These ratings show that the angry and fearful expressions used in the current study were perceived as appearing similarly aroused (angry, $M = 6.25$, $SD = .41$; fearful, $M = 7.15$, $SD = .26$) and furthermore, both were perceived as more arousing than either happy ($M = 5.25$, $SD = .92$) or neutral ($M = 3.23$, $SD = .49$) facial expressions.

When presented in the center of the computer screen, the faces measured 17° of vertical visual angle. The stimuli were presented on a 17-inch computer monitor (1,024 × 768, 60Hz) connected to a 1 GHz Pentium computer. Stimulus presentation and data collection were controlled by E-Prime software (Schneider, Eschman, & Zuccolotto, 2002).

Procedure

The procedure was similar to that described in earlier research (Droit-Volet et al., 2004). Participants were initially trained to discriminate "short" (400 ms) from "long" (1,600 ms) stimulus durations. On the first eight trials, a pink oval appeared for either a short or long duration in a fixed sequence (e.g., long–short–long–short, etc.). Participants were informed that the oval would appear in this sequence and were asked to indicate whether the stimulus appeared for either a short or long stimulus duration by pressing one of two labeled keys on a QWERTY keyboard (the "z" and "m" keys were used). The response mapping (e.g., z for short durations and m for long durations) was counterbalanced across participants. Following a response, participants were presented with visual feedback for both correct ("yes") and incorrect ("no") decisions. The feedback appeared in the center of the screen for 2 s and was followed by an intertrial interval that could vary (according to a uniform random distribution), on each trial, in duration from 1 s to 3 s. After the initial training phase, there was a short break followed by a test session during which the pink oval was presented for a further eight trials in a new random order for each participant. During this phase participants continued to indicate whether the oval appeared for either a short or long stimulus duration. Participants continued to receive feedback in this phase. After this phase there was a short break. During the main test phase, each angry, fearful, happy, and neutral expression was presented for each of the standard (400 ms and 1,600 ms) durations and also, a range of intermediate durations (600, 800, 1,000, 1,200, and 1,400 ms). Each picture was presented at each of the durations resulting in four trials for each expression-duration combination. Participants were asked to (a) look at the face and (b) indicate whether the face appeared for a duration that was closer to either the short or long durations that they had learnt earlier. Feedback was not given during the main test phase. Finally, after the main test phase participants completed the EAS Temperament survey for Adults (Buss & Plomin, 1984).

Results

Prior to data analyses, indexes of emotional bias were calculated following a number of steps. First, the proportions of long re-

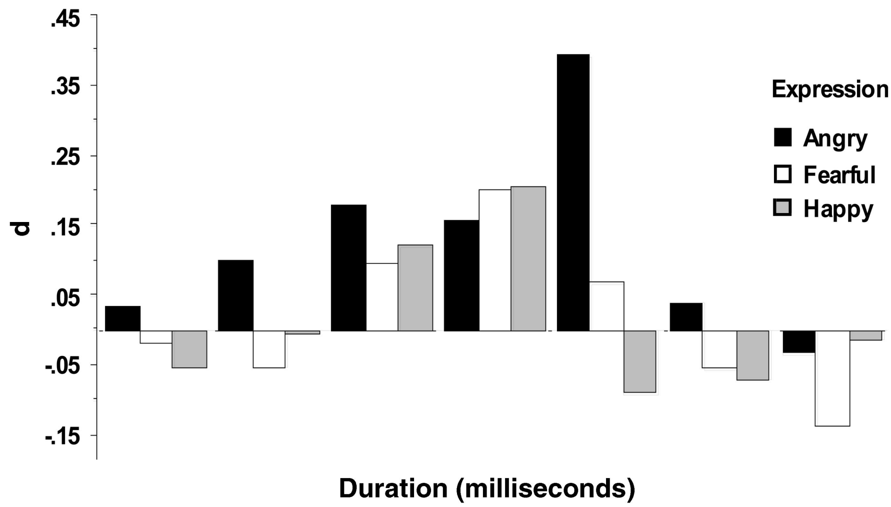

Figure 1. Indexes of overestimation due to emotion (d' scores) as a function of duration (milliseconds) and expression (angry, fearful, happy).

sponses for each condition were transformed into z scores. Second, d' (Macmillan & Creelman, 1991) was calculated by subtracting the z score for the neutral facial expression from the z score for the angry, happy, and fearful expressions, separately. This led to the creation of 21 d' scores. Positive values of the index reflect overestimation, and negative values reflect underestimation relative to the neutral expression. In addition, the bisection point (BP) and Weber ratio (WR) were calculated for each participant and each emotion, separately. The BP refers to point of subjective equality (.5 point on the psychometric function) and was calculated from the intercept and slope parameters of regression of p(long) onto stimulus duration. The WR measures temporal sensitivity and is calculated by dividing half the difference between the upper difference limen (*plong*[.75]) and the and lower difference limen (*plong*[.25]) by the BP.

A 7 (duration) × 3 (expression) within-subjects analysis of variance (ANOVA) was used to analyze the d' scores. The mean d' scores for each expression separately, are plotted in Figure 1 as a function of duration. Post hoc analyses (using the Tukey-Kramer formula) of the main effect of expression, $F(2, 82) = 5.33$, $p = .006$, $\eta_p^2 = .12$, showed that d' scores were higher (averaged across duration) for angry expressions ($M = .13$, $SEM = .03$) compared to both fearful ($M = .02$, $SEM = .04$) and happy expressions ($M = .02$, $SEM = .05$). To establish whether the specific expressions consistently lead to overestimation the d' scores for each expression were averaged across the seven durations and subsequently compared to zero using one-sample t tests. These analyses showed that duration of angry, $t(41) = 4.22$, $p < .001$, but not fearful, $t(41) = .32$, $p = .74$, or happy, $t(41) = .26$, $p = .80$ expressions were consistently overestimated relative to neutral expressions.[1]

Although the main effect of duration failed to reach statistical significance, $F(6, 246) = 1.67$, $p = .12$, there was an Expression × Duration interaction, $F(12, 492) = 1.91$, $p < .03$, $\eta_p^2 = .04$. Simple main effect analyses of the effect of duration for each emotion separately, showed that the effect of duration was largest (but not linear; see Figure 1) in magnitude for angry expressions, $F(6, 246) = 2.08$, $p = .05$, $\eta_p^2 = .05$, compared to happy, $F(6, 246) = 1.68$, $p = .13$, $\eta_p^2 = .04$, and fearful expressions, $F(6, 246) = 1.45$, $p = .20$, $\eta_p^2 = .03$. As can be seen in Figure 1, overestimation due to angry faces grew in magnitude from the 400 ms ($d' = .03$) to a peak at the 1,200 ms ($d' = .39$) duration.

One-way within subjects ANOVA on the BP and WR indexes revealed an effect of emotion on the BP indexes, $F(3, 123) = 3.67$, $p = .01$, $\eta_p^2 = .087$. Post hoc analyses of the BP indexes showed that the BP was reached sooner for angry ($M = 964$ ms, $SEM = 15$ ms) compared to fearful ($M = 1{,}022$ ms, $SEM = 25$ ms) neutral ($M = 1{,}016$ ms, $SEM = 18$ ms) and happy expressions ($M = 995$ ms, $SEM = 21$ ms) although the latter difference (and all other differences) failed to reach significance, $p > .05$. The As expected by the nonsignificant effect of emotion on the WR indexes, $F(3, 123) = 0.74$, $p = .53$, the WR indexes were similar for each emotion (angry, $M = .37$, $SEM = .01$; fearful, $M = .37$, $SEM = .01$; happy, $M = .34$, $SEM = .04$; neutral $M = .37$, $SEM = .01$).

Negative Emotionality

Scores on each of the subscales of the EAS are presented in Table 1. Intercorrelations between scores on each of the subscales is presented in Table 2. As reported in previous research using self-report versions of the EAS in adults (Lusk, MacDonald & Newman, 1998) scores on the EAS Distress and Fearfulness subscales were positively correlated but neither Distress nor Fearfulness scores were correlated with scores on the anger subscale. In

[1] An anonymous reviewer noted that the imitation of emotions, notably anger, varies as a function of the sex of the individual to be imitated and sex of the participant. Although the current study was not designed to test this prediction, the pattern of data support it—female participants more frequently responded "long" to female angry faces (52%) compared to male angry faces (48%) and conversely, male participants more frequently responded "long" to male angry faces (51%) compared to female angry faces (49%). Such sex differences are similar to those reported elsewhere (Chambon & Droit-Volet, 2004 as cited in Effron et al., 2006) and are in keeping with the embodiment hypothesis.

light of these findings, an index of negative emotionality was created by averaging across the four items of the EAS distress scale and the four EAS fearfulness scale. Age of participant did not correlate with the index of negative emotionality, $r(40) = -.08$, $p = .62$. To test the hypothesis that negative emotionality moderates temporal bias due to negative emotion, correlation coefficients were calculated between the indexes of temporal bias due to each facial expression type and negative emotionality scores. There was a significant positive correlation between negative emotionality and temporal bias due to both anger, $r(40) = .34$, $p < .05$; and fear, $r(40) = .32$, $p < .05$; but not happiness, $r(40) = .27$, $p = .18$. In other words, overestimation due to negative emotional stimuli (fearful and angry expressions) increased with negative emotionality.

Discussion

In line with the predictions for this study, individual differences in negative emotionality were linked to increased levels of overestimation due to both angry and fearful expressions but not happy expressions. The pattern of overestimation due to emotion replicates that reported in recent research (Droit-Volet et al., 2004; Effron et al., 2006) and can be accounted for in terms of arousal rather than attention-based processes. In support of the arousal account there was clear overestimation due to angry expressions.

At first blush, the link between individual differences in negative emotionality and the effects of emotion on time perception are surprising given that a number of researchers have reported a link between anxiety (e.g., Bradley, Mogg & Millar, 2000; Fox et al., 2001; Yiend & Mathews, 2001), fearfulness (Tipples, 2006) and attentional bias in response to negative emotional stimuli. For example, studies have shown that anxiety is associated with a tendency to dwell longer on both angry (Fox et al., 2001) and fearful (Georgiou et al., 2005) expressions compared to both neutral and happy facial expressions. The authors interpreted such effects as delayed disengagement of attention in anxiety. How are these and other findings reconciled with those reported here, whereby it is argued that arousal rather than attention-based effects were recorded? To reiterate, attentional effects are indexed by underestimation (e.g., Burle & Casini, 2001) not the overestimation recorded in the current study. One possibility is that the attentional effects reported in previous research are mediated by emotional arousal via a common neurotransmitter. Noradrenaline affects the operation of both attentional and time processes. The release of noradrenaline is also thought to both facilitate orienting and lead to slower disengagement of attention (Posner & Raichle, 1994). Blocking the release of noradrenaline in rhesus monkeys eliminates the facilitatory effects of alerting cues on covert orienting (Witte & Marrrocco, 1997). With respect to time perception, substances such as caffeine[2] increase the release of noradrenaline and lead to similar biases in time perception as those reported here (Gruber & Block, 2005). In short, both the effects reported here and the influence of anxiety on attention may be mediated by a common, arousal-based process linked to release of the neurotransmitter noradrenaline.

One unexpected finding was that angry facial expressions led to a greater overestimation of time (relative to neutral facial expressions) compared to both fearful and happy expressions. Although other researchers (Droit-Volet et al., 2004; Effron et al., 2006; Thayer & Schiff, 1975) have shown that the duration of angry facial expressions is typically overestimated relative to neutral and other facial expressions they did not compare the effects of angry expressions with other highly aroused negative facial expressions. The current findings show that the emotional responses and the subsequent effects on time perception are not solely due to the perceived arousal of the sender. Fearful faces are typically rated as appearing more aroused than angry faces (see Materials section). If the effects of facial expressions on time perception vary solely as a function of the aroused state of the sender (the facial expression) then fearful and angry expressions should have led to similar levels of overestimation. Instead, overestimation was markedly greater for angry expressions. Greater overestimation due to angry expressions may reflect the operation of a fear-specific response system (Öhman & Mineka, 2001). Throughout evolutionary history a strong arousal response to threatening stimuli such as angry facial expressions may have facilitated a rapid adaptive response and survival. In other words, angry facial expressions may have a particularly potent effect on time perception because they can indicate intent to attack and therefore, are more directly relevant to human survival than other expressions. Other human experimental research supports a stronger emotional response to angry expressions. For example, compared to happy and neutral expressions, fear-conditioned angry faces show greater resistance to extinction and lead to higher fear ratings, increased heart rate and enhanced

Table 1
Mean and Standard Deviation of the Ratings on Each of the Subscales of the EAS for Men and Women, Separately

	Mean Rating			Standard Deviation		
Subscale	Women	Men	Total	Women	Men	Total
Activity	10.41	11.50	10.62	2.71	3.93	2.95
Anger	9.50	11.75	9.93	2.84	3.65	3.10
Distress	9.82	10.75	10.00	3.47	2.12	3.25
Fear	10.71	11.75	10.90	3.94	2.25	3.68
Sociability	12.97	13.38	13.05	3.10	5.13	3.50

Note. EAS Temperament Survey (Buss & Plomin, 1984).

Table 2
Intercorrelations Between the Scores on Each of the Subscales of the EAS

Subscale	1	2	3	4	5
1. Activity	—	.18	.15	.19	.14
2. Anger		—	−.26	.05	−.20
3. Distress			—	.68**	−.31*
4. Fearfulness				—	−.24
5. Sociability					—

* $p < .05$. ** $p < .0$.

[2] Caffeine also has cholinergic effects (for a review see Fredholm, Battig, Holmen, Nehlig, & Zvartau, 1999). Moreover, the neurotransmitter acetylcholine affects visual spatial attention (Bentley, Husain, & Dolan, 2004).

corrugator muscle activity (Dimberg, 1987; for a review, see; Dimberg & Öhman, 1996). In summary, one explanation for greater overestimation for angry faces relative to other expressions is that such effects reflect the operation of fear-specific response system (Öhman & Mineka, 2001).

In summary, the current research shows that overestimation of time due to emotion is moderated by individual differences in negative emotionality. Furthermore, the effects of facial expressions on time perception were largest in response to angry faces and therefore, may reflect the operation of a fear-specific response system.

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