Cardiac responses associated with affective processing of unpleasant film stimuli

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Abstract

The autonomic basis of cardiac reactions to unpleasant film stimuli was investigated. Film clips depicting major surgery, threats of violence, and neutral material were presented to 46 subjects. Self-report measures of emotion were obtained, as well as heart rate, respiration rate, respiratory sinus arrhythmia, T-wave amplitude and skin conductance level. Resting vagal tone was estimated in a paced breathing task prior to film viewing. Spontaneous blink rate was also taken as a measure of visual engagement during film viewing. Coherent increases in sympathetic activation accompanied the film containing violent threats, whereas the surgery film yielded greater electrodermal activation, as well as heart rate deceleration and T-wave increase. These data support the hypothesis of differential autonomic response patterns to specifically unpleasant material. As compared with threat and neutral films, greater blink rate inhibition was observed during the surgery film. Individual differences in parasympathetic cardiac control measured at rest were able to discriminate cardiac response patterns during film viewing. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Unpleasant emotions; Film stimuli; Heart rate; Autonomic influences; Blink rate

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1. Introduction

In human research, the induction of unpleasant emotions has been widely used to investigate the cardiac response to aversive material. Differences in experimental settings and eliciting stimuli (i.e., social induction, facial action task, imagery, perception) still account for most controversial findings (Wagner, 1989; Levenson, 1992; Zajonc and McIntosh, 1992; Cacioppo et al., 1993; Lang et al., 1993; Palomba, 1993; Philippot, 1993). During imagery or social induction tasks, sympathetic activation is often associated with cardiac acceleration, which is presumably partly evoked by the task demands; moreover, the heart rate increase seems to be influenced by the intensity of emotion and, to a lesser extent, by its affective content (Vrana et al., 1988; Gollnisch and Averill, 1993; Witvliet-vanOyen and Vrana, 1995). Emotional and perceptual stimuli, e.g., slide or film viewing, have been widely used across different studies on emotion. In emotional picture perception, subjects are passively exposed to visual stimuli, such that the effects of affective processing are enhanced. In general, it has been shown that when normal subjects view affective scenes, sustained cardiac deceleration ensues, the largest decelerations occurring during the viewing of unpleasant scenes (Bradley et al., 1993; Lang et al., 1993; Angrilli et al., 1994; Palomba et al., 1997). Those studies which investigated specific negative emotions (e.g., sadness, fear, anger, disgust) showed that unpleasant stimuli evoking sadness and disgust provoke larger heart rate decrease as compared with anger or fear (Sternbach, 1962; Ekman et al., 1983; Bradley et al., 1993; Palomba and Stegagno, 1993), fear occasionally yielding HR increase (Lazarus et al., 1962; Thyer et al., 1984). In particular, sustained HR deceleration is the systematic reaction to the sight of stimuli depicting mutilations, injuries or blood (Bradley et al., 1993; Gross and Levenson, 1993; Angrilli et al., 1994). This phenomenon has been repeatedly observed in normal subjects as well as in blood phobics exposed to films depicting the feared situation (Korman et al., 1977; Kleinkecneht, 1988; Steptoe and Wardle, 1988; Lumley and Melamed, 1992). The specific cardiac response induced by blood-related stimuli has been interpreted in different ways.

In several studies, such stimuli often evoked self-reports and/or facial expressions of disgust (Davidson et al., 1990; Lumley and Melamed, 1992; Gross and Levenson, 1995; Kaviani et al., 1999); on the other hand, in most research in which disgust is the target emotion, surgical operations, bleeding wounds and similar contents were used as visual elicitors (e.g., Webb and Davey, 1992; Gross and Levenson, 1995; Alvarado, 1997). In addition, research investigating the autonomic physiology of the disgust reaction have used almost exclusively blood, surgery or injury contents. In a study from our laboratory (Sarlo et al., 1997a), stimuli depicting blood and other kinds of disgusting material (namely, body products and garbage) were separately presented, thus evoking differential autonomic patterns: whereas in front of blood-related stimuli a marked increase in electrodermal activity is associated with heart rate deceleration, the exposure to disgusting stimuli, still evoking a similar heart rate decrease, does not yield a large sympathetic response. Thus, the reaction to stimuli depicting blood, although often associated with a feeling of disgust, seems to be sustained by a specific autonomic pattern.

In general, these data indicate that unpleasant emotions, although commonly associated with a pure sympathetic defense reaction (D.R.), may also evoke mixed (sympathetic and parasympathetic), or even prevailing parasympathetic autonomic reactions. Indeed, in emotion research, there is growing evidence that co-activation of both branches of the autonomic nervous system occurs during the defense response, with parasympathetic and sympathetic effects being dominant at different stages and in different contexts (see Berntson et al., 1993, 1994; Reyes del Paso et al., 1993). Nevertheless, the autonomic basis of these differential cardiac responses to different unpleasant material has not been fully explored.

Studies conducted with clinical samples, interpreted the HR reduction during blood-related stimuli as a part of diphasic cardiac reaction, modulated by an abrupt shift from a sympathetically mediated pattern to an opposing increase in
parasympathetic activity (Graham et al., 1961; Öst et al., 1984). They also suggested that sustained parasympathetic cardiac tone may be associated with an autonomic predisposition toward developing blood phobia (Vingerhoets, 1984; van Lieshout et al., 1991; Angrilli et al., 1997; Sarlo et al., submitted). The diphasic cardiac reaction is reliably displayed across time when long-lasting visual stimuli are employed (Öst et al., 1984; Step-toe and Wardle, 1988). Instead, when slides are used as visual stimuli, no reliable diphasic pattern is observed (Klorman et al., 1977; Hamm et al., 1997).

A third line of interpretation is based on the general assumption that heart rate deceleration to visual stimuli is associated with enhanced disposition to stimulus intake (Graham and Clifton, 1966; Lacey and Lacey, 1970). In this view, the cardiac pattern observed in passive exposure to unpleasant visual material might be interpreted in terms of the perceptual–attentional requirements of such emotional stimuli. In fact, in emotional research sustained cardiac deceleration is consistently observed when subjects focus their attention on high-arousal unpleasant stimuli, and seems to be associated with a parasympathetic dominance in the autonomic nervous system (Lang et al., 1997). This notion is also sustained by animal research, in which ‘fear bradycardia’ has been reported to occur during pre-avoidance of a noxious stimulation (Zanchetti, 1976): under these conditions, heightened attention to the noxious event may strengthen the animal’s chances of avoidance (see Campbell et al., 1997).

One major aim of the present study was to compare cardiac response patterns associated with passive exposure to various unpleasant film stimuli and their development across time. Indeed, several studies indicate that, compared with other visual stimuli (e.g. slides), film stimuli evoke patterned psychophysiological responses which may help to identify autonomic nervous system changes in emotions (Sternbach, 1962; Adamson et al., 1972; Carruthers and Taggart, 1973; Hubert and de Jong-Meyer, 1990, 1991; Gross and Levenson, 1993, 1995; Palomba and Stegagno, 1993). Indeed, compared with still pictures, films are dynamic media which contain more information relevant to the development of integrated and sustained emotional responses (Lazarus, 1972; Davis et al., 1987).

On the basis of the reviewed literature, two unpleasant films depicting either threat or surgery were selected, presumably able to evoke differential autonomic response patterns. Similar contents were used in other film studies in which startle modulation measures were taken (Jansen and Frijda, 1994; Kaviani et al., 1999). In these studies startle probe showed a defense-potenti- ated response during threat film presentation (Jansen and Frijda, 1994; Kaviani et al., 1999) and a lack of potentiation to the blood-related content (Kaviani et al., 1999).

In order to investigate the autonomic basis of emotional cardiac responses, two measures of autonomic influence on the heart were considered: respiratory sinus arrhythmia (RSA) and T-wave amplitude. The former has been widely proposed as a non-invasive index of parasympathetic cardiac control (McCabe et al., 1984; Grossman and Svebak, 1987), whereas the latter reflects sympathetic β-adrenergic influences on the heart (see Furedy and Heslegrave, 1983; Rau, 1991). Respiratory sinus arrhythmia was investigated both at rest, during a paced respiration test, and during film viewing. Based on previous research on blood phobia (Vingerhoets, 1984; van Lieshout et al., 1991; Angrilli et al., 1997), subjects high in blood fear do exhibit heightened parasympathetic tone at rest. T-wave amplitude, which is inversely related to sympathetic activation, was expected to be smaller during the threat film than during mutilation.

A second aim of the study was to identify spontaneous measures of affective processing of perceptual stimuli. Spontaneous eyeblink rate inhibition during visual tasks has been assumed to preserve input information processing, thus reflecting attentional engagement. A reduction in blink rate is commonly observed during tasks involving visual engagement, or requiring external information processing (Stern et al., 1984; Fogarty and Stern, 1989). Spontaneous eyeblink rate inhibition during film viewing was taken as a measure of attentional disposition toward the affective stimuli. This measure is less affected by ex-
perceptual instructions or task requirement, as compared with free viewing times, an index of interest often applied in studies on affective processing of visual emotional material (e.g. Bradley et al., 1993; Lang et al., 1993; Hamm et al., 1997).

2. Method

2.1. Subjects

Fifty undergraduate students (35 female, 15 male), aged 22–29 years (mean = 23.8, S.D. = 1.7), participated as part of a class requirement. To increase homogeneity in the population sample, only non-phobic subjects were selected (see Section 2.5); four women were thus omitted (final n = 46).

2.2. Stimulus materials

Two unpleasant and one neutral film clip, each 132 s long, were selected, and edited in order to preserve the scene integrity (the scene continuity was maintained within the period of presentation). A second selection criterion required that only dialogue and no music score (to avoid music-related responses) were present in the clips. Audio level was kept approximately equal across the films. The first unpleasant scene was drawn from The Hitcher (Harmon et al., 1986) and depicted a boy threatened by a man armed with a knife. This clip was labeled ‘threat’. The second film clip, excerpted from a medical documentary (Franzini et al., 1993), depicted the early phases of a thoracic operation and was labeled ‘surgery’. The control scene was drawn from Switzerland — The Alpine Wonderland (Scro et al., 1989), a landscape documentary of urban areas and artistic buildings. It was labeled ‘landscape’.

These film segments were selected among a large number of clips on the basis of affective ratings obtained from a previous pilot study. According to these evaluations, the unpleasant scenes had comparable ratings, in the unpleasant/high arousal quadrant, using the dimensional representation of the International Affective Picture System (see Lang et al., 1997). In order to show different psychophysiological patterns elicited by two aversive, high-arousal stimuli, it would be necessary to keep both valence and arousal affective dimensions under control, these factors being responsible for most psychophysiological emotional variance (Lang et al., 1993). If not controlled, they may confound the results. In most studies using films, the control or measure of valence and arousal dimensions have been neglected. Moreover, the threat, surgery, and landscape clips were classified as producing specific emotional states such as fear, disgust and moderate joy, respectively, on a nominal scale including six discrete emotions (joy, surprise, fear, disgust, anger, sadness). According to Bradley et al. (1993), the dimensional and specific state view of emotion are considered complementary methods to control different factors influencing emotional responses. The films were also equivalent with respect to subject ratings of action/movement units.

Films were presented on a 24-inch color TV monitor positioned 2 m in front of the subject.

2.3. Self-report measures

Valence, arousal and dominance ratings were obtained using the paper-and-pencil version of the Self-Assessment Manikin (SAM; Lang, 1980), which consists of a nine-point rating scale for each dimension. Six basic emotional states (happiness, surprise, fear, anger, disgust and sadness; e.g. Ekman et al., 1982) describing the reaction to the films were also evaluated on a six-point scale for each category (0–5 score).

2.4. Apparatus and physiological recordings

Electrocardiogram (ECG) was recorded by placing Ag/AgCl surface electrodes on the subject’s chest in a modified Lead II configuration. Heart rate (HR), T-wave amplitude (TWA) and respiratory sinus arrhythmia (RSA) were derived from the raw signal. The ECG was recorded with a time constant of 1 s (to avoid distortions of the T-wave signal) and a low-pass filter set at 100 Hz. Skin conductance level (SCL) was recorded with Ag/AgCl electrodes attached to the palmar sur-
face of the middle phalanges of the second and third fingers of the non-dominant hand. A Coulbourn S71-22 skin conductance coupler provided a 0.5-V constant voltage across electrodes.

The DC recording of the respiration signal was obtained using a piezoelectric transducer placed on a belt stretched around the subject’s chest. Eyelid closures (blinks) were obtained by recording vertical electrooculogram (EOG) through Ag/AgCl surface electrodes placed on the supra- and infra-orbital ridges in the vertical axis of the right pupil. The signal was filtered with a time constant of 100 ms and a low-pass filter set at 100 Hz.

Physiological signals were amplified and filtered on a Digitimer Ltd amplifier system, fed into an A/D board (NB-MIO-16L-25; sampling rate: 500 Hz for ECG and vertical EOG, 10 Hz for SCL and respiration), and stored on a Macintosh Quadra 700 computer. Data acquisition and analyses were implemented by LabVIEW 3 software (National Instruments, Austin, TX, USA) according to Angrilli (1995).

2.5. Procedure

Upon arrival, subjects were given general information about the experiment, and their written consent was obtained.

Prior to the experimental session, a reduced, 18-item Fear Survey Schedule (FSS-III; Wolpe and Lang, 1964) was administered in order to screen and discard highly fearful subjects. Subjects were excluded from the study if their scores were ≥ 3 on items concerning blood and/or weapons (0–4 score).

Participants were then seated in a comfortable reclining chair in a dimly lit room, and physiological sensors were attached.

Following an initial 10-min adaptation period, instructions for a 1-min paced respiration task were given; subjects were required to pace their breathing at eight cycles/min (cpm) with the aid of a rhythmic trace displayed by an oscilloscope.

Before starting the presentation of the three emotional films, a practice film clip was projected in order to acquaint subjects with the experimental procedure. Next, subjects were again directed to rest quietly for approximately 5 min, and then the three films (landscape, threat, and surgery) were presented. At the end of each clip, subjects were asked to assign valence, arousal and dominance ratings and to rate the specific emotions they had experienced during film viewing. A variable interval (4–6 min) lapsed between film presentations. A cross subjects, films were viewed in one of three varied orders.

2.6. Data reduction and analysis

A digital trigger detecting R-waves was applied to the ECG signal to obtain interbeat intervals. Beat-to-beat R–R intervals were then reduced to heart rate in 0.5-s bins, as described by Graham (1978). SCL data were reduced according to the same 0.5 s bin criterion. The SCL data from one subject were lost due to technical problems.

The T-wave amplitude was computed as the difference in μV between the maximum value included in a 100–300-ms window after the R-wave and the mean value of the 40-ms isoelectric line included between P-wave and Q-wave (Rau, 1991).

Respiratory sinus arrhythmia was quantified as the difference in ms between the largest interbeat interval measured during expiration and the lowest measured during inspiration, according to the peak-valley estimation (Fouad et al., 1984; Grossman et al., 1990; Grossman, 1992).

For the above-described physiological measures, the time course of each response was analyzed by dividing the 132-s stimulus period into four 33-s epochs. Difference scores between each epoch and the last 15 s of baseline were considered. For each measure, mean values were entered in separate repeated measures analyses of variance (ANOVAs) with Film (landscape, threat, surgery) and Time (four 33-s epochs) as factors.

Respiratory rate (RR) in cycles per minute was quantified using a digital trigger detecting signal zero-crossing.
Spontaneous eyeblink identification was based on slope, amplitude and temporal criteria of the vertical EOG (e.g., Stern et al., 1984). Blink rate (in blinks/min) was then computed for baseline and film viewing intervals. Blinking data from two subjects wearing contact lenses were excluded from analysis. For both respiration and blinking, change scores were calculated by subtracting the mean activity measured during the 60-s baseline from the average response during the 132-s film interval. Mean values were then entered in repeated measures ANOVAs with Film as a factor.

To examine individual differences in parasympathetic cardiac control, subjects were divided into two groups on the basis of their mean respiratory sinus arrhythmia at rest (vagal tone). The 75th and 25th percentiles of respiratory sinus arrhythmia values measured during paced respiration were used as separation criteria: 11 subjects above the 75th percentile (high vagal tone) and 12 below the 25th (low vagal tone) were obtained. In this respect, the design also involved a between-subjects factor (Group).

Valence, arousal, and dominance mean ratings were entered into ANOVAs containing Film as a factor. Similarly, separate ANOVAs were performed on mean ratings of each of the six specific emotions with Film as a factor.

The Greenhouse–Geisser correction has been used to adjust the P-values for repeated measures factors with more than two levels. Post hoc means comparisons (Newman–Keuls) and simple effects analyses were employed to further examine significant effects (using a P < 0.05 criterion for significance).

### 3. Results

#### 3.1. Self-report measures

Highly significant Film effects were obtained for the dimensions of valence \((F_{2,30} = 54.45, P = 0.0001)\); arousal \((F_{2,30} = 114.78, P = 0.0001)\); and dominance \((F_{2,30} = 31.78, P = 0.0001)\). The landscape scene was rated as significantly more pleasant, more dominant, and less arousing than the unpleasant films, whereas subjects showed comparable valence, arousal and dominance ratings for the two unpleasant films (Table 1). As assessed by post hoc tests, no significant difference was found between the latter.

Subjects’ mean ratings of fear, disgust, anger, surprise, and happiness were significantly affected by film type, whereas no significant effect was found for sadness (mean values and standard deviations per film type for each emotion are reported in Table 2, along with a summary of statistical effects). Subjects reported significantly higher fear and anger for the threat clip as compared with the other two conditions, with the surgery film inducing higher fear than the landscape. The surgery clip was rated as significantly more disgusting than the threat and the landscape films and significantly more surprising than the threat scene. Disgust ratings for the threat and the landscape films and surprise ratings for the landscape and the surgery films did not differ significantly. The landscape clip obtained significantly higher happiness ratings than did the other two films, which did not differ from each other.

<table>
<thead>
<tr>
<th>Film clips</th>
<th>SAM ratings</th>
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<tbody>
<tr>
<td></td>
<td>Valence</td>
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<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Landscape</td>
<td>6.66</td>
</tr>
<tr>
<td>Threat</td>
<td>3.64</td>
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<tr>
<td>Surgery</td>
<td>3.36</td>
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</tbody>
</table>

*The three dimensions were rated on separate scales ranging from 1 to 9 (paper-and-pencil version of Self-Assessment-Manikin, SAM; Lang, 1980).
<table>
<thead>
<tr>
<th>Basic emotions</th>
<th>Film clips</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Landscape</td>
<td>Threat</td>
<td>Surgery</td>
<td>F_{2,90}</td>
<td></td>
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<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Fear</td>
<td>0.00</td>
<td>0.00</td>
<td>1.78</td>
<td>1.34</td>
<td>0.41</td>
<td>0.79</td>
</tr>
<tr>
<td>Disgust</td>
<td>0.01</td>
<td>0.07</td>
<td>0.31</td>
<td>0.69</td>
<td>1.25</td>
<td>1.29</td>
</tr>
<tr>
<td>Anger</td>
<td>0.08</td>
<td>0.31</td>
<td>0.18</td>
<td>0.43</td>
<td>0.15</td>
<td>0.54</td>
</tr>
<tr>
<td>Sadness</td>
<td>0.65</td>
<td>0.93</td>
<td>0.24</td>
<td>0.73</td>
<td>0.95</td>
<td>0.83</td>
</tr>
<tr>
<td>Surprise</td>
<td>0.90</td>
<td>0.92</td>
<td>0.09</td>
<td>0.41</td>
<td>0.16</td>
<td>0.60</td>
</tr>
</tbody>
</table>

**The emotional states were rated on separate scales ranging from 0 to 5.**

**P < 0.001.**

***P < 0.0001.**

***Not significant.

3.2. Physiological measures

3.2.1. Heart rate

HR data showed a significant main effect for Film (F_{2,90} = 3.7, P = 0.03), whereas Time effect was found to be very close to significance (F_{3,135} = 2.81, P = 0.056). Post hoc analyses indicated that the threat film produced a larger HR increase compared with the surgery and landscape films, which did not differ from each other. HR reductions were recorded during the last interval of film presentations compared to the first interval. The Film × Time interaction was highly significant (F_{6,270} = 6.49, P = 0.0001), revealing an increased HR during the threat film, whereas a significant HR reduction between the first and the last interval characterized the surgery film (Newman–Keuls, P = 0.005), indicating a slow late deceleration (Fig. 1). Instead, the landscape film showed a significant HR decrease between the first and the second epoch (Newman–Keuls, P = 0.0008), thus evoking an early fast deceleration. Post hoc tests showed significant differences between the threat and the remaining films at epoch 2, 3 and 4; the surgery and landscape films were not different from each other in any of the considered epochs.

3.2.2. T-wave amplitude

T-wave amplitude showed a significant main effect for Film (F_{2,90} = 4.81, P = 0.01). Time effect proved to be close to significance (F_{3,135} = 2.86, P = 0.057). T-wave amplitude was progressively larger from the first to the last interval. As assessed by post hoc tests, T-wave was significantly larger during the neutral and surgery films (lower sympathetic cardiac control) compared with the threat film, which indeed induced a decreased T-wave amplitude (higher sympathetic cardiac control). The surgery and landscape films were found to be comparable to each other. The Film × Time interaction was highly significant (F_{6,270} = 6.09, P = 0.0003): as revealed by post hoc tests, starting from the second epoch a significantly lower T-wave amplitude, indicating an augmented cardiac sympathetic activity, characterized the
Fig. 2. Mean T-wave amplitude changes across time during three experimental conditions. Epoch 1 = 1–33 s; 2 = 34–66 s; 3 = 67–99 s; and 4 = 100–132 s.

viewing of the threat scene compared with the other films, which both induced an increased T-wave amplitude and did not differ from each other in any of the recorded epochs (Fig. 2).

3.2.3. Respiration
All of the films induced an increase in respiration rate compared with baseline, the largest changes being recorded during the threat film. A significant main effect for Film was obtained ($F_{2,90} = 3.71, P = 0.032$). Post hoc analyses showed a larger respiration rate increase to the threat compared with the neutral film (means = 2.36 vs. 1.31 cpm, respectively). No significant respiration differences were found between the two unpleasant stimuli.

3.2.4. Respiratory sinus arrhythmia
Analysis of respiratory sinus arrhythmia during film viewing revealed no significant Film effect nor Film $\times$ Time interaction. The only significant effect concerned Time ($F_{3,123} = 3.27, P = 0.033$), showing that respiratory sinus arrhythmia generally decreased during the central phases of film viewing. Post hoc analyses indicated significant decreases from the first (1–33 s) to the second (34–66 s) and third (67–99 s) epochs.

3.2.5. Skin conductance level
Results indicated reliable main effects of Film ($F_{2,88} = 23.85, P = 0.0001$) and Time ($F_{3,122} = 11.05, P = 0.0002$) on skin conductance level, which increased after the first epoch and then progressively decreased. A larger increase was observed during the surgery film compared with the threat film, and during the latter compared with the landscape, which induced a slight decrease. The highly significant Film $\times$ Time interaction ($F_{6.264} = 9.53, P = 0.0001$) indicated that the surgery evoked maximal sympathetic activation during the second epoch (34–66 s), and this activation then decreased in the following two intervals (Fig. 3). Except between the surgery and threat films at the first epoch, analyses by post hoc tests revealed a complete differentiation among films along time.

3.2.6. Blink rate
A significant Film effect was found for blink rate ($F_{2,86} = 4.91, P = 0.012$); as confirmed by post hoc tests, a larger blink rate inhibition, reflecting greater attentional engagement, was observed during exposure to the surgery film, compared with the remaining films, which did not differ from each other (Fig. 4).

3.2.7. Individual differences in vagal tone
Subjects previously identified as high or low in vagal tone, on the basis of the RSA values measured during the paced respiration task, displayed distinct HR response patterns during the films. The ANOVA revealed a significant main effect for Group ($F_{1,22} = 4.37, P = 0.048$), as well as a significant Film $\times$ Group interaction ($F_{2,44} = 5.1$, $P = 0.048$). Post hoc tests indicated a larger HR increase to the threat film compared with the neutral film in the high vagal tone group, but not in the low vagal tone group.
Fig. 4. Mean blink rate changes from baseline during surgery, threat, and control films. Blink rate inhibition corresponds to increased attention toward stimuli.

P = 0.013). Low vagal tone subjects showed overall HR increases, whereas high vagal tone subjects generally displayed HR decreases. A clearcut cardiac deceleration was found during the surgery film only in high vagal tone subjects, whereas low vagal tone subjects showed an acceleratory response to this film (Fig. 5). As revealed by post hoc comparisons, the two groups' HR differed only in this specific scene (Newman–Keuls, P = 0.018).

No other significant Group effects or Film × Group interactions were found for the other variables.

4. Discussion

The results of the present study indicate differential cardiac and autonomic response patterns in viewing subjects, as a function of the specific content of unpleasant films. The threat film evoked a coherent sympathetic response characterized by cardiac acceleration, decreased T-wave amplitude and increased skin conductance. These results support and extend previous findings of relative cardiac activation during threat compared with other unpleasant material (Levenson, 1992; Bradley et al., 1993; Palomba and Stegagno, 1993).

The surgery film evoked a more complex autonomic response. T-wave amplitude increased during the surgery film, indicating decreased β-adrenergic sympathetic activity, whereas skin conductance, an index of cholinergic sympathetic activation (Venables and Christie, 1980), reached the highest levels compared with the other films (see Fig. 4). Moreover, heart rate showed an increase in the first minute of film presentation, followed by a reduction which became significant during the last stage. With respect to the surgery, the neutral film highlighted a cardiac decrease with a significantly different development across time; moreover, it did not evoke either increased skin conductance level or blink rate inhibition. A mixed autonomic pattern (namely, large skin conductance increase associated with HR decrease) to blood-related material, has been reported in previous studies using similar stimulus contents (Carruthers and Taggart, 1973; Steptoe and Wardle, 1988). T-wave data add further evidence to the notion of mixed autonomic influences on the cardiac response to this emotional material.

The different reactions elicited by the two unpleasant films indicate that the threat pattern is consistent with a purely sympathetic activation, which may be interpreted as a typical defense response induced by fearing stimuli; instead, the surgery pattern is consistent with a mixed autonomic activation marked by decreased β-adrenergic and increased cholinergic sympathetic activity.

One explanation for such a mixed autonomic response pattern to the blood content might be...
that this film induced a multiple affect state characterized by a high-arousal condition associated with less clear-cut unpleasant feelings. In fact, self-report data showed comparable arousal, valence and dominance ratings to the threat and surgery films, along with different combinations of basic emotions. The threat film mainly evoked fear, with much lower ratings assigned to the other emotional states, whereas the surgery film was classified as evoking a multi-component emotional state made up by disgust, surprise, fear and other emotional states.

This result is also in agreement with previous research on autonomic response patterns to blood stimuli in both normal and blood-phobic subjects (Steptoe and Wardle, 1988; Lumley and Melamed, 1992). Heart rate reduction during the second part of the surgery film was paralleled by decreased skin conductance and increased T-wave amplitude, indicating that the observed heart rate decrease was the result of sympathetic cardiac withdrawal. In the present study, the role of parasympathetic cardiac control during film viewing was less clear cut. Respiratory sinus arrhythmia was not significantly different among the three conditions. The lack of a significant film effect is presumably due to the large inter-subject RSA variability, which greatly increased the overall variance. It is also possible that differences in breathing rate contributed to the large response variability; as a matter of fact, the need to control respiratory parameters (respiratory rate and tidal volume) has been strongly recommended when using RSA as an index of cardiac vagal activity (Grossman et al., 1991). Instead, the prediction that subjects with high respiratory sinus arrhythmia at rest would also react with larger HR decrease to the films was confirmed, indicating that basal differences in vagal tone influenced the cardiac emotional response. It is noteworthy that basal vagal tone influenced HR but not other autonomic responses, indicating specific modulation of the cardiac response system. Moreover, vagal tone at rest predicted the HR response to the surgery film only. Thus, individual differences in parasympathetic cardiac control exert their influences in a specific response-system (heart) and in specific stimulus conditions (surgery). This result is also consistent with the concept that specific responses to blood/injury stimuli may predispose individuals with autonomic/constitutional specificity (i.e. increased basal vagal tone) toward developing blood phobia (Connolly et al., 1976; Friedman et al., 1993; Angrilli et al., 1997; Sarlo et al., submitted).

As indicated in the introduction, attentional dispositions (which are enhanced in passive confrontation with noxious events) have been considered in the interpretation of differential autonomic changes to unpleasant visual stimuli. Spontaneous blink rate inhibition was considered an index of increased attention during visual tasks (Stern et al., 1984; Fogarty and Stern, 1989). Larger blink rate decrease was observed during the surgery as compared with the threat and neutral films, indicating greater attentional engagement. In some studies, arousal level has also been shown to affect blink rate (the higher the arousal, the higher the blink rate). However, the decreased blink rate observed during the surgery film in the present study is not dependent on arousal level: the surgery film did reveal the greatest skin conductance response (a measure that is highly correlated to emotional arousal; Lang et al., 1993) together with the largest blink rate decrease. Further support in favor of the attentional interpretation of present data derives from those studies investigating reaction times during unpleasant picture viewing (Sarlo et al., 1997b). Reaction times to an acoustic probe presented after picture onset were significantly slower for pictures depicting disgusting objects and mutilations as compared with threat. This effect is consistent with the hypothesis that these classes of unpleasant percepts demand more attentional resources.

Although sensory facilitation and attentive disposition associated with HR slowing have been repeatedly emphasized (Graham and Clifton, 1966; Lacey and Lacey, 1970; Lang et al., 1997), the lack of correlation between HR reduction and blink rate inhibition and the failure to find differences in blink inhibition between the high and low vagal tone groups led us to hypothesize the relative independence between cardiac changes and this behavioral measure of attention. The
large HR deceleration found in high vagal tone individuals to the surgery film, rather than attentional, seems to be mainly related to a stimulus-specific autonomic reactivity.

In conclusion, these results show the existence of distinct cardiac patterns during the viewing of specific unpleasant material: the typical defense patterns during the viewing of specific response marked by HR increase and T-wave reduction, sustained by coherent sympathetic activation, and a more complex autonomic reaction characterized by psychophysiological fractionalization: HR reduction and T-wave increase, associated with sympathetic cardiac withdrawal, increased cholinergic sympathetic activity, or even increased parasympathetic cardiac control. It may be suggested that distinct autonomic patterns are observed as a function of the specific nature of negative events. Clearly threatening stimuli are able to evoke the classic fight-flight reaction, supported by clear-cut sympathetic activation. Blood, injuries and mutilations evoke a cardiac response which is likely to be related to conservative (trophotrophic) changes, thus activating the parasympathetic branch of the autonomic nervous system. The reaction is similar to that observed in front of disgusting stimuli; nevertheless blood/injury conditions still maintain their specificity, due to the sympathetic/parasympathetic concurrent opposing control over the cardiac response. In clinical contexts, this autonomic co-activation has been assumed to eventually lead to emotional fainting (Graham et al., 1991; Öst et al., 1984; Steptoe and Wardle, 1988). The link between parasympathethic predisposition and HR decrease supports the clinical evidence that blood phobia is associated with heightened parasympathetic cardiac control, which produces an altered cardiac response to the phobic stimulus (Vingerhoets, 1984; van Lieshout et al., 1991; Angrilli et al., 1997).

Data on attentional engagement also indicate distinct behavioral dispositions toward specific unpleasant contents. It is likely that blood-related stimuli are not automatically rejected in view of a motivationally important action; rather, attention is allocated to processing them in detail, due to the lack of a clear-cut action disposition.

Future research is required to extend these findings and systematically explore the relationship between the behavioral/attentional dispositions and the physiological response patterns to unpleasant material.

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References


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