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Physiological Responses Induced by Emotion-Eliciting Films

Cristina Fernández · Juan C. Pascual · Joaquim Soler · Matilde Elices · Maria J. Portella · Enrique Fernández-Abascal

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Abstract Emotion-eliciting films are commonly used to evoke subjective emotional responses in experimental settings. The main aim of the present study was to investigate whether a set of film clips with discrete emotions were capable to elicit measurable objective physiological responses. The convergence between subjective and objective measures was evaluated. Finally, the effect of gender on emotional responses was investigated. A sample of 123 subjects participated in the study. Individuals were asked to view a set of emotional film clips capable to induce seven emotions: anger, fear, sadness, disgust, amusement, tenderness and neutral state. Skin conductance level (SCL), heart rate (HR) and subjective emotional responses were measured for each film clip. In comparison with neutral films, SCL was significantly increased after viewing fear films, and HR was also significantly incremented for anger and fear films. Physiological variations were associated with arousal measures indicating a convergence between subjective and objective reactions. Women appeared to display significantly greater SCL and HR responses for films inducing sadness. The findings suggest that physiological activation would be more easily induced by emotion-eliciting films that tap into emotions with higher subjective arousal such as anger and fear.

Keywords Emotional films · Physiological response · Arousal · Valence · Gender differences

C. Fernández · J. C. Pascual (✉) · J. Soler · M. Elices · M. J. Portella
Department of Psychiatry, Santa Creu i Sant Pau Hospital, Av. St. Antoni M[a] Claret 167, 08025 Barcelona, Spain
e-mail: jpascual@santpau.es

C. Fernández · J. C. Pascual · J. Soler · M. Elices · M. J. Portella
Centro de Investigación Biomédica en Red de Salud Mental, CIBERSAM, Institut d'Investigació Biomèdica-Sant Pau (IIB-SANT PAU), Universitat Autònoma de Barcelona (UAB), Barcelona, Spain

C. Fernández · E. Fernández-Abascal
Departamento de Psicología Básica, UNED Universidad Nacional de Educación a Distancia, Madrid, Spain

Introduction

In the last decades, the study of emotions has achieved importance due to the increasing interest to determine the neurobiological processes underlying healthy versus pathological emotion-related states (Kring 2010). A large range of techniques has been developed to elicit emotions in experimental settings. Some of these techniques are: images with emotional content (Lang et al. 1995; Schaefer et al. 2009), sounds or music (Bradley and Lang 2000; Zentner et al. 2008), facial expressions (Ekman and Friesen 1979; Guitart-Masip et al. 2009), autobiographic recollection (Brewer et al. 1980; Schaefer and Philippot 2005), scripted and unscripted social interactions (Harmon-Jones et al. 2007; Roberts et al. 2007) and films (Gross and Levenson 1995; Hagemann et al. 1999; Philippot 1993; Schaefer et al. 2010).

At present, emotion-eliciting films are one of the most commonly used techniques to induce emotions under laboratory conditions (Kreibig 2010, for a review). This technique has several advantages in comparison to other emotional-inducing methods (Westermann et al. 1996). Firstly, emotion-eliciting films allow the recreation of dynamic situations, combining visual and auditory stimuli, and increasing the ecological validity of the procedure (Rottenberg et al. 2007; Schaefer et al. 2010). Secondly,

compared with other techniques such as autobiographic memories, emotion-eliciting films can be standardized and therefore, results can be replicated (Gross and Levenson 1995; Rottenberg et al. 2007). Finally, in contrast to other methods that only evoke negative or positive valences, and high arousal (e.g. sounds or music), film clips can induce discrete emotions. This latter advantage allows the analysis of the differences between basic emotions with similar valence or level of arousal such as anger, fear or sadness (Hagemann et al. 1999). Indeed, its capacity of eliciting discrete emotions has already been demonstrated in previous studies (Gross and Levenson 1995; Hagemann et al. 1999; Hewig et al. 2005; Philippot 1993; Schaefer et al. 2010). However, this technique has only tested subjective emotional responses measured with self-reported instruments. By using self-reported measures other components of emotional responses (i.e. physiological, behavioural or cognitive) are dismissed. Some works have pointed out the need to examine other basic components of emotional response, which should be evaluated by means of objective measures (Gross and Levenson 1995; Schaefer et al. 2010). In fact, all these components should be evaluated simultaneously in order to ascertain the convergence among them. To date, studies that have examined the convergence among the measurement of different emotional elements, however, have reported discrepant results (Cacioppo et al. 2000; Mauss and Robinson 2009, for a review).

Within the objective components, autonomous nervous system (ANS) and central nervous system (CNS) responses have been measured. Those studies using ANS measures related to emotions have utilized indexes of sympathetic and parasympathetic activity, which are generally associated with activation and relaxation respectively (Mauss and Robinson 2009). Different measures have been used to assess cardiovascular, electrodermal and respiratory activity. Among these measures heart rate (HR), skin conductance level (SCL) and respiratory rate are the most used (Kreibig 2010, for a review). Whether these measures reflect primarily sympathetic or parasympathetic activity is not clear. However, results of previous studies showed that SCL predominantly reflects sympathetic activity and HR reflects a combination of both (Mauss and Robinson 2009, for review). Finally, gender differences have also been explored, and some works suggest that women generally display more intensive subjective emotional reactions (Lasa Aristu et al. 2007). However, such differences are less clear regarding physiological reactivity (Chentsova-Dutton and Tsai 2007).

The aim of the present study was to investigate whether a set of emotion-eliciting films, previously validated in a Spanish-speaking sample (Fernández et al. 2011), was able to induce physiological changes in SCL and HR. The convergence between subjective responses and physiological measures was determined. Finally, the effect of gender on emotional responses was investigated.

Method

Participants

A total of 123 healthy subjects (91 women and 32 men) without history of mental disorders, psychotropic treatment or drug use participated in the study, all of whom were Spanish native speakers. The mean age was 29.2 years ($SD = 12.4$). Participants were recruited from the student population and their relatives and friends to assure other participants of the community. Participation was voluntary and subjects did not obtain any type of retribution.

Stimuli and Procedure

We employed a set of emotion-eliciting film clips previously validated in a Spanish-speaking sample. This battery included some of the scenes used in other standardized sets (Gross and Levenson 1995; Schaefer et al. 2010). Results of subjective emotional responses in healthy volunteers can be found elsewhere (Fernández et al. 2011).

Each participant watched on average 10 film clips in which seven emotions of interest were elicited: anger, fear, sadness, disgust, amusement, tenderness and neutral state. The length of the experimental session was approximately 1 h. Participants were randomly assigned to a different subset of films. These subsets were designed to counterbalance order effect, so that film clips of the same affective valence (negative or positive) were not shown consecutively, but the assignment also assured that each participant would watch all the emotions to be studied. The mean length of clips was 158 s (range = 24–364 s). Films were displayed on a 15″-screen laptop computer, in a dimly lit room of approximately 10 m^2 and the experimenter stayed in the room with the participant during the entire session. Before starting the experiment, a brief but clear explanation was provided about experimental procedures, and participants were told that the study aimed to obtain a deeper insight into emotional response. Following the same procedure as in previous studies (Rottenberg et al. 2007; Schaefer et al. 2010), it was explained to them that there were no right or wrong answers, and that they only had to report whatever they had felt while watching that scene, discerning it from their general mood state throughout that day. Subjects could end their participation at any time and all their answers remained anonymous. After receiving instructions and signing informed consent, the researcher put the SCL and HR sensors in place. For each film clip, participants followed the same sequence: (1) baseline in

which participants were told to stay in calm while baseline physiological measures were taken for 1 min; (2) presentation of the film clip (while *being* physiologically monitored); and (3) completion of self-reported questionnaire. After each film clip, room lights were turned on, subjects filled the questionnaires out and waited calmly until the next film clip. According to the study of Fredrickson and Levenson (1998), the interval between two film clips was set up approximately at 3 min, so as to return to baseline levels and to minimize any carryover effect.

Electrophysiological Response Measures

SCL and HR were taken as indexes of physiological reactivity because both measures are the most used by previous studies (Kreibig 2010 for a review). Recordings were performed during the minute prior to watching the film clips and this was considered the baseline measurement. Subsequently, physiological variables were recorded continuously during the presentation of the stimuli.

- Skin conductance level (SCL) was recorded with a "Dermback" LE-538 (Letica Inc.) fitted with two electrodes for finger surfaces, which measures SCL in microSiemens, with a frequency of four times per second. The instrument provides a sum-up of values during a given period, which includes *mean*, maximum and minimum scores. Baseline levels were established as the *mean* score within the last minute before start watching each film. SCL variations were calculated with respect to the maximum SCL score during the watching of films, since emotional response can appear at different moments for each film-clip, and it can also occur suddenly or progressively, depending on the film.
- Heart rate (HR) was registered with a 'Polar 600' pulse counter, which consists of a sensor (fixed to the chest via an adjustable strap), which emits the heart beat frequency via radio waves to a computerized receptor interface. Variations in HR were calculated with the maximum HR score, *corresponding to the shortest inter-beat-interval registered during the watching of films.*

Subjective Response Measure

For the study of subjective response, the Self Assessment Manikins (SAM; Bradley and Lang 1994) was used. It is a quick and simple tool to measure emotional reactions from a dimensional perspective. The original questionnaire and its validated Spanish version have optimal psychometric properties (Moltó et al. 1999). The SAM evaluates three different dimensions: (a) Affective valence, ranging from a smiley, happy figure (maximum score, 9) to a frowning, unhappy figure (minimum score, 1); (b) Arousal or activation, ranging from an excited, wide-eyed figure (maximum score, 9) to a relaxed, sleepy figure (minimum score, 1); (c) Dominance or emotion control, which ranges from a small human-like figure with minimum control (minimum score, 1) to a large, impassive figure (maximum score, 9).

Statistical Analyses

Data were analyzed using the SPSS 18.0 statistical package for Windows. In light of the results from our previous study, film clips were classified into seven basic emotions: anger, fear, sadness, disgust, amusement, tenderness and neutral state. In order to analyze the capacity of these films to induce electrophysiological changes in SCL and HR, we performed ANOVA contrasts with discrete emotions as factor to examine the variations in SCL and HR induced by the emotional scenes as compared to neutral ones. To study the convergence between the subjective emotional responses and electrophysiological changes, we tested the Pearson correlations between SAM subscale scores and variations in SCL and HR. Subsequently, we used a linear regression analysis to examine the predictive capacity of the subjective variables over changes in the electrophysiological response. Finally, gender effect on physiological responses to emotional films was examined, by means of partial correlation analyses.

Results

Physiological Reactivity to Emotion-Eliciting Films

Table 1 displays SCL and HR delta scores for each discrete emotion. Regarding SCL, ANOVA results showed that fearful films induced significantly greater responses as compared to neutral films ($p = 0.014$; see Fig. 1, left side). There was also a tendency towards significance in films inducing more intensive SCL variations in amusement ($p = 0.07$) and tenderness ($p = 0.06$).

As can be observed in Fig. 1, right side, the ANOVA results of HR variations showed significant differences between neutral scenes and those inducing anger ($p = 0.022$) or fear ($p = 0.027$). Sad films evoked higher HR changes but without reaching significance ($p = 0.07$).

Convergence Between Subjective Responses and Electrophysiological Measures

Table 2 shows the emotion ratings based on SAM subscales (Valence, Arousal and Dominance) after the watching of films. Correlation analysis displayed a significant association between variations in SCL and variations in HR ($r = 0.509$, $p < 0.001$), showing that both measures

Table 1 Skin conductance level (SCL) and heart rate (HR) changes after viewing a set of film clips for eliciting different emotions

Variables	SCL increase		HR increase	
	M	*SD*	*M*	*SD*
Neutral	1.63	1.22	5.57	1.45
Anger	2. 93	0.96	8.51	2.49
Fear	3.78	2.29	8.52	2.2
Sadness	2.65	1.37	7.91	2.12
Disgust	2.88	1.32	7.02	2.86
Tenderness	3.19	1.2	7.49	1.69
Amusement	3.17	0.8	7.51	0.89

Values represent means and SD

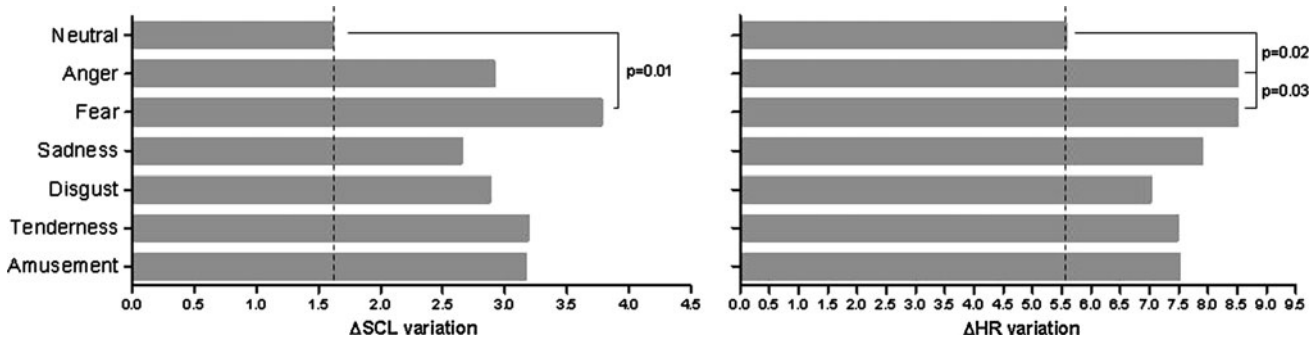

Fig. 1 Skin conductance level (SCL) and Heart rate (HR) changes after viewing a set of film clips for eliciting different emotions. *Gray bars* represent the increment of electrophysiological reactions per emotion; *dot line* indicates the increment of SCL and HR for neutral emotion, which was set as a comparer for the ANOVA contrasts (represented are *p* values of the significant contrasts)

Table 2 SAM subscales (valence, arousal and dominance) scores after the watching of films

Variables	SAM valence		SAM arousal		SAM dominance	
	M	*SD*	*M*	*SD*	*M*	*SD*
Neutral	4.94	0.36	3.07	0.37	7.49	0.41
Anger	2.3	0.75	6.04	0.54	5.19	1.15
Fear	3.09	0.9	6.18	0.85	4.9	0.6
Sadness	3.46	0.87	5.36	0.74	5.53	1.06
Disgust	2.44	0.51	4.94	0.64	6.05	0.75
Tenderness	6.14	1.3	4.9	0.92	5.88	0.61
Amusement	6.81	0.53	4.45	0.52	6.65	0.67

Values represent means and SD

assessed pretty similar physiological responses. In terms of convergence analyses, variations in SCL were statistically correlated with Arousal subscale scores of the SAM ($r = 0.385$, $p = 0.003$); but not with Affective valence or Dominance scores. Variations in HR showed a significant correlation with Arousal scores ($r = 0.412$, $p = 0.001$) and with Dominance scores ($r = -0.299$, $p = 0.024$). By contrast, no association was either observed between HR and Affective valence scores.

The lineal regression model showed that Arousal scores significantly predicted changes in SCL ($\beta = 0.504$, $SE = 0.16, p = 0.003$), although this only explained a 15% of the variance ($R = 0.38, F = 9.55, df = 1,16.15, p = 0.003$). With regard to changes in HR, the model showed that Arousal scores were significantly predictive ($\beta = 0.828$, $SE = 0.24$, $p = 0.001$), and explained a 17% of the variance ($R = 0.41$, $F = 11.22, df = 1,43.55, p = 0.001$).

Gender Differences in Emotional Response

Variations in SCL were significantly different between males and females for sad films, where women had more

intense SCL scores than men ($p = 0.021$). With regard to HR, the differences between males and females appeared to be significant for films inducing sadness ($p = 0.013$) and disgust ($p = 0.048$), being the females more reactive than males.

For most films (neutral, amusement, anger, sadness, or disgust) partial correlation analyses (controlling for gender) between electrophysiological responses and SAM scores did not show any significant correlation ($p <$ NS). In contrast, for films eliciting fear, there seemed to be a significant partial correlation between arousal and SCL changes ($r = 0.36$, $p = 0.003$) and between dominance and variations on SCL ($r = -0.28$, $p = 0.02$). These associations were also observed for changes in HR ($r = 0.24$, $p = 0.05$; $r = -0.27$, $p = 0.03$, respectively). In tenderness films, dominance scores were associated to changes in SCL ($r = -0.32$, $p = 0.003$) and variations in HR ($r = -0.31$, $p = 0.004$), after controlling for gender.

Discussion

Our findings show that within the set of emotion-eliciting films tested herein, only those fear and anger films are able to induce a significant change in physiological responses. Variations in SCL and HR were associated with measures of alertness, indicating a fair convergence between subjective and objective reactions to emotional stimuli. This is further confirmed with the regression model, although the results do not explain a great amount of variance. Interestingly, gender would seem to have only a partial effect on electrophysiological responses when viewing emotional stimuli, although sadness appears to induce a greater reaction in females.

The use of objective parameters overcomes some of the limitations of self-reported data, since emotional responses go further than subjective awareness, i.e. involve unconscious reactions, often overlooked by individuals (Rosenthal et al. 2008). In this regard, previous studies of emotion-eliciting film sets only evaluated their capacity to provoke a subjective emotional response (Gross and Levenson 1995; Hagemann et al. 1999; Philippot 1993; Schaefer et al. 2010) Significant increases in SCL and HR were only observed for scenes eliciting fear and anger, consistent with previous studies (Kreibig 2010, for a review). Possibly, this is due to the fact that feeling anger and fear constitutes an initial step towards a more active behavioral response, accounting for a greater sympathetic activation and arousal. In contrast, other emotions such as tenderness and sadness often have the function of communicating (and influencing) to others (Linehan 1993) and therefore would not embed such intensive sympathetic responses (characterized by α- and β-adrenergic stimulation). In any case, physiological variables seem to reflect the degree of alertness and its relation with emotion intensity, rather than indicate specific reactions to discrete emotions (Bradley et al. 2001; Cacioppo et al. 2000; Greenwald et al. 1989; Lang et al. 1993). It has to be taken into account that in our study only two physiological measures (HR and SCL) were taken, this can explain why we *failed* in detect more complex and differentiated response patterns for discrete emotions. Indeed, some studies (Kreibig 2010, for a review) have recently suggested that each discrete emotion would present a certain pattern of experience, physiology and behavior, congruent with the proposal of James at the end of the XIX century (James 1884; Mauss and Robinson 2009; Stephens et al. 2010). Therefore, in order to investigate these specific patterns a combination of multiple cardiovascular, electrodermal and respiratory measures ought to be examined.

Emotions can be defined as a multifaceted response which involves changes in subjective felling, physiological activation, brain activation and expressive behavior (Mauss and Robinson 2009, for review). A priori, we could hypothesize that components of emotion should converge as if they were following an "affect program", that when activated all body systems would be involved in the same way. Accordingly, we observed a convergence between subjective arousal and physiological changes in HR and SCL. However, previous studies have reported conflicting or inconclusive results regarding such synchronicity among response systems, highlighting that those subjective changes can be observed without physiological changes, and vice versa (Mauss and Robinson 2009, for a review).

Regarding the effect of gender on physiological responses, our results show that women react more intensively to sadness and disgust elicitation. When analyzing the possible gender effect on our results, the results of partial correlations showed no influence of gender, indicating that subjective and objective parameters of emotion are somehow independent of this factor. Other studies which have analyzed differences in emotional response between males and females have only looked at subjective responses, suggesting that women present a more intense subjective response than men, especially on negative emotions such as sadness, fear or guilt (Brody and Hall 2000; Gross and Levenson 1995; Hagemann et al. 1999; Schaefer et al. 2010). Our results are only based in SCL and HR, so it cannot be ruled out that with other objective measures, differences between males and females would have been found. Regarding gender differences, effects of socio-cultural stereotypes should also be considered (Brody and Hall 2000; Feldman-Barret et al. 1998), as well as possible differences related to the inhibition or suppression of emotional response and neurobiological differences in emotional systems between genders (Cahill et al. 2004).

There are some limitations that should be considered with caution. First, the generalizability of the results would be restricted by the fact that not all the participants saw all the films. Second, the two electrophysiological variables included in the study were raw measures of sympathetic system, but they might be not enough to represent complex physiological patterns of activation. Lastly, since emotion-eliciting techniques are different, our results may not be directly comparable to other studies which have used different methods for emotional elicitation (e.g. pictures, sounds, or autobiographical memories; Christie and Friedman 2004). In any case, this set of emotion-eliciting films seems to be a useful instrument to elicit both subjective and objective emotional responses particularly in relation to anger and fear. Future studies should address the complexity of emotional reactions by including other techniques that cover the majority of body systems involved in emotional processes. Furthermore, the analysis of emotional responses among subjects with psychiatric disorders in whom their emotional response may be dysregulated would be appropriate.

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Conflict of interest None.

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