International Journal of Psychophysiology 80 (2011) 173–181

Contents lists available at ScienceDirect

International Journal of Psychophysiology

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

Emotional scenes and facial expressions elicit different psychophysiological responses

Georg W. Alpers [a,b,d,*], Dirk Adolph [b,c], Paul Pauli [b]

[a] School of Social Sciences, Department of Psychology, Chair of Clinical and Biological Psychology, Germany
[b] University of Würzburg, Department of Psychology, Germany
[c] University of Bochum, Department of Psychology, Germany
[d] Otto-Selz-Institute, University of Mannheim, Germany

ARTICLE INFO

Article history:
Received 15 June 2010
Received in revised form 29 December 2010
Accepted 19 January 2011
Available online 26 January 2011

Keywords:
Affect modulated startle
Emotional facial expressions
Emotional scenes
Autonomic responses
Valence and arousal ratings

ABSTRACT

We examined if emotional faces elicit physiological responses similar to pictures of emotional scenes. Forty one students viewed emotional scenes (negative, neutral, and positive) and emotional faces (angry, neutral, and happy). Heart rate, orbicularis oculi and electrodermal activity were measured continuously, and the startle reflex was elicited. Although the patterns of valence and arousal ratings were comparable, physiological response patterns differed. For scenes we replicated the valence-specific modulation of the startle response, heart rate deceleration, and the arousal-related modulation of the electrodermal response. In contrast, for faces we found valence-specific modulation only for the electrodermal response, but the startle and heart rate deceleration were modulated by arousal. Although arousal differences may account for some differences in physiological responding this shows that not all emotional material that is decoded similarly leads to the same psychophysiological output.

1. Introduction

Emotions are thought to be part of two basic motivational systems (Lang, 1995) where the appetitive system activates approach behavior when consummation, procreation or nurturance is the goal and the defensive system activates defense behavior in order to protect the organism from threat. These two systems modulate reflex responses that are compatible or incompatible with the required behavior. Within this framework, emotional reactions to external cues are modulated by two dimensionally organized stimulus features: valence and arousal. Judgments of valence, i.e., pleasure or displeasure, relate to the active motivational system and judgments of arousal relate to the intensity of motivational activation (Bradley et al., 2001). Pictures of emotional scenes (Lang, 1995) and emotional facial expressions (Russell and Bullock, 1985) can be described by ratings on these two dimensions. Evidence for this motivational theory of emotion comes from an impressive number of studies using the picture viewing paradigm to elicit approach and avoidance motivation (Bradley et al., 2001; Lang et al., 1997).

1.1. Emotional scenes

To document activation of the defensive or appetitive system, several physiological variables, including the affective modulation of the startle reflex are typically used. It has been well demonstrated that the amplitude of the eyeblink startle reflex elicited by a loud noise varies with emotional valence of the background stimulus viewed simultaneously. The response is potentiated when viewing slides with negative content, and reduced when viewing positive pictures (Vrana et al., 1988). In addition, measures of autonomic activity covary with the level of arousal or with the valence of the presented stimulus (Bradley et al., 2001). The typical pattern of defensive motivation is an initial heart rate deceleration which indicates orientation towards a meaningful stimulus (Graham, 1997; Graham and Clifton, 1966).

The electrodermal response seems to be an unspecific measure of arousal. A significant rise of the skin conductance level can be found for both positive and negative stimuli when compared to neutral ones (e.g., Azevedo et al., 2005; Bradley et al., 2001, 2005).

Other valence-specific responses can be measured with the facial EMG: the corrugator supercilii muscle, which causes frowning, is more strongly activated when watching negative scenes and the zygomatic major (Lang et al., 1993), as well as the orbicularis oculi muscle (as a part of the so called Duchenne smile, Wolf et al., 2005) are engaged while watching positive slides.

In the central nervous system, the emotional responses observed in the picture viewing paradigm are probably orchestrated by the amygdala (LeDoux, 2000; Whalen, 1998). Several studies have shown

* Corresponding author at: University of Mannheim, Chair of Biological and Clinical Psychology, School of Social Sciences, 68131 Mannheim, Germany. Tel.: +49 621 181 2106; fax: +49 621 181 2107.
E-mail address: alpers@uni-mannheim.de (G.W. Alpers).

0167-8760/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.ijpsycho.2011.01.010

that significant amygdala activations can be observed when the responses to emotional scenes and neutral scenes are contrasted (e.g., Hariri et al., 2002; Lee et al., 2004; Müller et al., 2003) (for a review see Phan et al., 2004).

1.2. Emotional facial expressions

Because the picture viewing paradigm has been so prolifically used with complex emotional scenes, it is surprising that there are so little published data on physiological reactions to emotional facial expressions. While emotional faces have been shown to be processed similar to emotional scenes in many ways, e.g., they both predominate perceptually in binocular rivalry (Alpers and Gerdes, 2007; Alpers and Pauli, 2006), direct comparisons of physiological or behavioral output are rare.

Emotional facial expressions should be particularly well suited to elicit evolutionarily grounded motivational responses. While the meaning of most scenes can only be deciphered when several elements are integrated, faces are processed holistically (Farah et al., 1998). Moreover, facial expressions are generally thought to be biologically rooted (Dimberg et al., 2000), comparable across cultures (Ekman et al., 1969), and they clearly evoke emotional responses in everyday life (Dimberg, 1982). Similar to pictures of emotional scenes (e.g., Alpers, 2008), emotional expressions have been shown to capture attention in visual search tasks (Hansen and Hansen, 1988; Öhman et al., 2001) and in the dot-probe deployment paradigm (Bradley et al., 1997; Mogg and Bradley, 2002). Within the framework of the somatic marker hypothesis it has been argued that the perception of an emotional expression involves the simulation of the emotional state within the relevant cortical circuitry of the observer (Adolphs, 2002). Several brain imaging studies have shown that both positive and negative emotional facial expressions strongly activate the amygdala (for a review see Zald, 2003) and this activation can be found even when the faces are not consciously visible due to masking (Whalen et al., 1998, 2004).

As in response to scenes, the facial EMG activity response corresponds with the valence of an emotional expression: the corrugator supercilii muscle is more strongly activated when negative facial expressions are attended to, and the zygomatic major muscle is more strongly activated when positive facial expressions are observed (Dimberg, 1982; Dimberg and Petterson, 2000; Vrana and Gross, 2004). More specifically, the so called Duchenne smile has been found as a response to positive, rather than to negative facial expressions (Hess et al., 1998).

Contrary to the results including facial EMG, studies on physiological responses to faces are rare and revealed less consistent results as for emotional scenes. Concerning the electrodermal response some studies found comparable reactions to angry and happy facial expressions (Dimberg, 1982; Merckelbach et al., 1989) or even stronger electrodermal responses to happy expressions than to angry ones (Vrana and Gross, 2004). Concerning heart rate, at least two studies found the expected heart rate deceleration to angry facial expressions, but heart rate acceleration to happy expressions (Johnsen et al., 1995; Vrana and Gross, 2004). However, in Vrana and Gross (2004) study deceleration was also observed for neutral faces, and an earlier study did not find any differences in deceleration between angry and happy expressions (Dimberg, 1982).

Published data on the startle response to emotional facial expressions is also rather limited and shows contradictory results. There is one study demonstrating that the affective modulation of the startle reflex to angry and happy expressions can be found in 5 month old infants (Balaban, 1995), while a recent study did not find affect modulated startle responses to neutral and angry facial expressions in four to eight year old children (Waters et al., 2008). In adults, one study with pictures of negative infant emotional faces (crying babies) did not find the expected startle modulation (Spangler et al., 2001). Another study found a startle potentiation to threatening adult facial expressions (i.e., fearful and angry expressions, Anokhin and Golosheykin, 2009). Finally, a study by Hess et al. (2007) reported startle reflex potentiation to angry emotional faces but the expected potentiation was only found when the actors were males, whereas results by Springer et al. (2007) suggest that startle amplitudes may be potentiated while viewing angry facial expression regardless of the sex of the expresser. To our knowledge, no study to date found the expected inhibition of the startle reflex to appetitive (e.g. happy) emotional facial expressions.

However, few studies have directly compared the responses to faces and to scenes. Two recent experiments (Britton et al., 2006; Hariri et al., 2002) demonstrated within the same experimental paradigm that emotional scenes and faces activate similar brain structures, including those directly engaged in emotion processing like the amygdala. However, faces were superior in eliciting stronger activations in the amygdala (Hariri et al., 2002) or activations in more extended regions beyond it (Britton et al., 2006). In spite of the similarities in brain activations, it is not resolved, whether this reflects the decoding of emotional cues or whether it also corresponds with comparable physiological output. That physiological responses to emotional facial expressions emotional and scenes may differ has been demonstrated by one of the imaging studies mentioned above: electrodermal responding to negative facial expressions was more pronounced than that to comparable scenes (Hariri et al., 2002). However, other responses, such as the startle modulation were not examined in that study.

1.3. Aims

The aim of the present experiment was to directly compare the psychophysiological effects of emotional facial expressions and emotional scenes in order to clarify whether emotional facial expressions and emotional scenes induce comparable appetitive and defensive motivation. On the one hand, we assumed that comparable or even greater amygdala activity observed in response to emotional facial expressions should lead to comparable activation of the defensive and appetitive motivational system, and hence to comparable patterns of physiological responses. On the other hand, the evidence we accumulated from different studies suggest that despite comparable activation patterns in significant emotion related brain areas, the physiological output to emotional facial expressions, but not for emotional scenes, is inconsistent. The strongest argument as to why differences in physiological output to scenes and faces should be expected is based on the finding that the modulation of physiological output is dependent on the level of arousal a stimulus induces. For example, the emotional modulation of the startle response can typically only be observed in pictures that elicit relatively high levels of arousal (Cuthbert et al., 1996), and the fact that emotional facial expressions often only elicit relatively low levels of arousal (e.g., Alpers and Gerdes, 2007). In order to address this question, we examined the influence of differences in the perceived level of arousal between scenes and facial expressions on the psychophysiological responses measured in an analysis of covariance.

Therefore, we presented a block of happy, neutral, and angry faces and a block of positive, neutral, and negative scenes. To assess the activation of defensive and appetitive motivational systems in response to the scenes and faces, we measured heart rate deceleration and electrodermal responding to picture onset and the modulation of the startle reflex elicited by a loud noise while participants viewed the pictures. In addition to these classic measures we also explored the usefulness of the EMG from the orbicularis oculi muscle (which is typically recorded for the startle response) as a continuous measure of facial expressiveness indexing the Duchenne smile.[1] The EMG is thought to reflect a valence-specific response (Wolf et al., 2005). Also, we collected ratings of picture valence and arousal.

[1] As mentioned above, the so-called Duchenne smile consists of simultaneous activation of the zygomaticus major and the orbicularis oculi muscle. Within the scope of this work we assessed the latter component only.