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Skin conductance activity measurements for exploring emotional processing and emotional regulatory capacities in normative populations: An integrated review.

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Abstract

Emotional regulation is defined as the processes responsible for monitoring, evaluating, and modifying emotional responses in order to accomplish one's goal. Abnormalities in emotional regulation capacities are the hallmark of mood and anxiety disorders where the abnormal persistence of subjective, mostly negative, affective states are associated with the development and maintenance of these conditions. Psychophysiological recordings provide a complimentary objective measurement of emotional regulatory capacities independent of subjective reports. Psychophysiological variables of major scientific interest during affective picture processing have been electrodermal activity, more specifically skin conductance changes as indexes of autonomic nervous system activity. The present integrative literature review presents a critical synthesis of the literature findings so far aiming to delineate further the possible effects of visually presented stimuli on skin conductance activity correlates of emotional processing and emotional regulatory capacities in normative populations. Further investigation of clinical populations across acute or remitted mood states (e.g. bipolar disorder) is critically urged since it could provide valuable insight into the cognitive and neural underpinnings of emotion regulatory processes in different clinical disorders and healthy populations.

Keywords: psychophysiology, emotional processing, emotional regulation, skin conductance, electrodermal activity, emotion.

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Introduction

Emotional regulation is defined as "the processes responsible for monitoring, evaluating, and modifying emotional responses in order to accomplish one's goal" (Gross & Thompson, 2007). Abnormalities in emotional regulation are the hallmark of mood and anxiety disorders where the abnormal persistence of subjective, mostly negative, affective states is incorporated in the operational diagnostic criteria for these conditions (APA, 1994; ICD-10, 1994). In addition, the persistence of negative subjective responses may represent a risk factor for sub-threshold psychopathology in healthy individuals (Beevers & Carver, 2003; Bolger, DeLongis, Kessler, & Schilling, 1989).

Psychophysiological recordings have been increasingly employed in recent years in order to provide a complimentary objective measurement of emotional regulatory capacities independent of subjective reports (Ochsner & Gross, 2005). Psychophysiological variables of major scientific interest during affective picture processing have been electrodermal (EDA) activity, more specifically skin conductance (SC) changes as indexes of autonomic nervous system (ANS) activity. The discovery that SC activity can be sensitive to emotionally meaningful stimuli (e.g., Bradley, 2000; Bradley & Lang, 2000; Vrana, 1995) has increasingly led to a widespread use of these psychophysiological measures in studies of emotional regulation. Such measurements provide a simple and easy method for exploring emotional processing and have been widely used in both healthy and clinical populations.

Scope of this review

There is a comparative lack of empirical studies examining the possible effects of stimuli properties (i.e., valence and arousal) or specific thematic contents (e.g., fearful

versus sad images) on emotional regulatory capacities in large normative samples. Similarly, not enough data yet exists on normative psychophysiological correlates of such capacities whilst findings still remain tentative due to vast methodological limitations and heterogeneity of outcome measures used amongst studies.

Therefore, the present integrative literature review aims to delineate further the possible effects of visually presented stimuli on SC activity correlates of emotional processing and emotional regulatory capacities in normative populations. This study presents an overview and critical synthesis of the literature findings so far aiming to discuss research limitations and offering areas for future research.

Methodology

Literature search and inclusion criteria

Studies were initially identified by searching the major databases (PsychINFO, Medline, Embase and Cambridge Journals Online) using the terms *emotional processing*, *emotional regulation*, *skin conductance*, *psychophysiology* and *emotion*. All available years generated through the databases were examined. The titles and abstracts of the articles identified were examined and those that appeared to fulfill our inclusion criteria were retrieved. The references of the retrieved articles were searched for additional studies not previously identified. Only studies written in English were retrieved.

All identified articles were scanned to ensure reference to emotional processing or emotional regulation processes. Only studies employing SC measurements were included. Finally, articles were included if they met the following criteria: (a)

publication before 31/12/12 (b) included adult normative populations (aged 16–65) as a distinct group, (c) provided clear descriptive information about the psychophysiological techniques employed.

Experimental tasks

All identified studies employed two distinct types of experimental tasks, namely emotion induction and regulation tasks.

During a 'typical' emotion induction task, participants are passively exposed to a series of visual stimuli (presented in a random or pseudorandom order). The picture viewing context encourages a passive, perceptual intake of cues with no demand for response output aside from affect evaluation so that the effects of emotional processing can be efficiently enhanced (Bradley, Codispoti, Cuthbert, & Lang, 2001).

During a 'typical' emotion regulation task, participants are exposed to a series of visual stimuli (again, presented in a random or pseudorandom order). During or shortly after the presentation of visual stimuli, participants are asked to suppress their emotional responses elicited by the stimuli. In such instances, emotional "down-regulation" techniques are initiated after the onset of stimuli, aiming thus at decreasing the quality, intensity or duration of elicited emotional experiences.

Static pictures used in the above tasks are often taken from databases with (a) standardized images for arousal and valence ratings such as the International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert, 1995a, 1995b, 1999) or (b) images of facial expressions depicting affective states which differ in quality and intensity such as the library produced by Ekman and Friesen (Ekman & Friesen, 1976). Pictures are

presented for several seconds (usually 6 seconds) and subjective as well psychophysiological responses are being recorded.

Results

From the computerized search, 673 studies were obtained. Of those, only 33 studies met the criteria and were included in the review, summaries of which are encapsulated in Table 1 below.

Findings from emotion induction tasks

Many studies have shown orderly relationships between SC measures and arousal qualities of the presented stimuli. For instance, Bradley and colleagues (Bradley et al., 2001) assessed the effect of 72 IAPS pictures comprising of 18 different emotional contents of varying intensity in a large sample of volunteers. Substantial increases in SC amplitude were only obtained for the most highly arousing pictures depicting threat, violent death and erotic scenes. Consistent with the motivational hypothesis (Lang, 1994), the authors argued that a certain threshold of motivational activation is necessary to be reached first before sympathetic activity covaries with increases in affective arousal judgments (i.e. inferred motivational engagement) of the picture contents.

In Bernat and colleagues (Bernat, Patrick, Benning, & Tellegen, 2006), participants watched 54 pleasant, neutral and unpleasant IAPS images representing again specific thematic contents of varying affective intensity. Pleasant contents were erotic and adventure scenes; unpleasant contents were scenes of victimization and threatening images while neutral contents were either neutral human faces or household objects. In agreement with Bradley and colleagues (Bradley et al., 2001), images depicting erotic and threat scenes elicited the largest SC responses; most importantly,

significant positive correlations between intensity and SC amplitude were only evidenced for highly arousing erotic and threat content adventure or victim scenes. In a similar study, Codispoti and colleagues (Codispoti, Surcinelli, & Baldaro, 2008) asked psychology students to watch three films depicting surgery, landscape and erotica themes. Results again showed that although the two valenced films elicited larger SC responses than the neutral film, within the pleasant picture category, erotica prompted significantly larger SC activity compared to other pleasant and neutral contents.

Similarly, Sarlo and colleagues (Sarlo, Palomba, Buodo, Minghetti, & Stegagno, 2005) asked participants to watch 20 images split into two pleasant (scenes of extreme sports/adventure, erotica) and two unpleasant (threat, blood) categories. A neutral category was also included as a control condition (household objects). Although valenced images had comparable normative arousal ratings, images depicting erotic scenes, threat and blood were again considered the most arousing ones and therefore produced the largest SC changes compared to other thematic contents. Similarly, in an earlier study, Houtveen and colleagues (Houtveen, Rietveld, Schoutrop, Spiering, & Brosschot, 2001) asked participants to passively watch two sets of images, each split into threatening, erotic and neutral emotional thematic contents. Again, SC responses were significantly larger in response to pictures depicting erotic scenes than those depicting threatening or neutral ones.

In Frazier and colleagues (Frazier, Strauss, & Steinhauer, 2004), undergraduate students watched 9 film segments (three positive, three neutral, and three negative), each 120sec in length. Findings showed that increased SC activity was associated with arousal independent of valence whereas no gender differences were found on SC activity. Similarly, in Norris and colleagues (Norris, Larsen, & Cacioppo, 2007), students watched 66 pleasant, unpleasant and neutral images and thought about how

they made them feel. Again, SC was greater in response to unpleasant and pleasant images when compared to neutral ones while SC reactivity did not differ between unpleasant and pleasant pictures, replicating again the typical arousal pattern of skin conductance (e.g. Bradley, 2000).

A number of studies have also examined the effects of stimuli exposure time on affective reactivity. For instance, in Armhein and colleagues (Amrhein, Mühlberger, Pauli, & Wiedemann, 2004), participants chose the length of time they would spend watching a series of positive, negative and neural images (self-paced image presentation). SC amplitude was again higher for emotionally valenced images relative to the neutral ones, although viewing time was significantly longer for positive compared to negative images. The authors interpreted the SC findings as an arousal effect and argued that as viewing time was not directly influenced by arousal but it might have also been affected by a combination of variables, specifically subjective interest and picture valence.

McManis and colleagues (McManis, Bradley, Berg, Cuthbert, & Lang, 2001) asked participants to watch passively for as long as they wanted to (self-paced image presentation) 60 IAPS images, equally split into positive, negative and neutral valence categories. Viewing time and SC amplitude varied with emotional content, with enhanced SC responses during exposure to unpleasant pictures, compared to pleasant and neutral pictures. The authors argued that their selection of low arousal positive images might have failed to activate strong or reliable emotional reactions from the participants. In Ribeiro and colleagues (Ribeiro, Pompéia, & Bueno, 2006), participants watched 32 IAPS images divided into four categories: eight highly pleasant-arousing pictures (sexual content and adventures), eight highly pleasant relaxing pictures (landscapes, flowers or babies), eight neutral on both valence and arousal pictures and

eight highly unpleasant arousing ones. In agreement with MacManis and colleagues (McManis et al., 2001) above, the pleasant relaxing images failed to elicit as large SC responses as those elicited by the unpleasant images.

Results were replicated in few more studies where participants were exposed to the presentation of (a) three video clips depicting feelings of fear, disgust and joy (Palomba, Sarlo, Angrilli, Mini, & Stegagno, 2000) and (b) 100 IAPS images equally split into unpleasant and neutral categories (Caseras et al., 2007); both studies showed that unpleasant images depicting feelings of disgust elicited the largest SC responses as compared to other valenced categories. Lane and colleagues (Lane et al., 1997) asked 20 female participants to watch 60 IAPS images which were split into pleasant, unpleasant and neutral categories and depicted varying thematic contents; in agreement with the above, enhanced SC activity was elicited in response to the unpleasant images as compared to both other categories.

Cuthbert and colleagues (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000) asked participants to watch pleasant (e.g. attractive infants, opposite sex nudes), unpleasant (e.g. spiders, mutilations) and neutral (e.g. household objects) IAPS images and maintain the image of each slide in their minds after its presentation and until they could hear a soft tone which would allow them to stop. Again, the presentation of emotionally valenced categories elicited enhanced SC activity compared to neutral images. However, although both emotional categories prompted similar arousal ratings, pleasant pictures did evoke significantly greater SC activity than the unpleasant ones. In line with the above, the authors argued that SC differences might have resulted from an augmented affective arousal of pleasant images in this particular picture sample.

In Sierra and colleagues (Sierra, Senior, Phillips, & David, 2006) participants viewed images displaying spontaneous happy or disgusted facial expressions. Images

were presented for only 3 seconds and were followed by a blank screen interval which lasted for 30 seconds; during this interval, subjects were asked to give verbally their emotional intensity ratings. Although no differences were found in intensity ratings between the two thematic contents, SC amplitude to happy facial expressions was significantly larger compared to facial expressions depicting disgust. Nevertheless, the stimuli used in this study had been developed and validated by authors, making the results less comparable with the other studies.

Another study wished to investigate whether brief presentations of emotionally valenced images may also be able to elicit same patterns of autonomic responding to those observed during longer picture presentations. Specifically, Codispoti and colleagues (Codispoti, Bradley, & Lang, 2001) asked participants to watch 54 briefly presented IAPS images (duration of 500 ms) equally split into pleasant, unpleasant and neutral categories. Again, larger increases in SC were elicited when subjects watched emotional pictures compared to neutral pictures, although no differences were found in SC when participants were watching pleasant, compared to unpleasant pictures. The authors explained the findings as an arousal effect and argued that shorter presentations of visual stimuli can thus effectively activate similar response patterns to those observed during longer presentations of valenced stimuli (usually 6 seconds).

Vrana and colleagues (Vrana & Gross, 2004) reached the same findings by examining, however, the effects of longer (8 seconds) exposure to images depicting angry, joyful and neutral facial expressions (Ekman & Friesen, 1976). SC amplitude was again significantly larger for positive as compared to both other facial expressions whilst the angry and neutral facial expressions elicited similar patterns of SC activity. Interestingly, the authors argued that neutral images were depicting a more difficult

thematic content for participants to decode and thus indexed enhanced orienting processes which in turn, resulted in greater psychophysiological activity.

Smith and colleagues (Smith, Bradley, & Lang, 2005) examined the effects of sustained exposure to consecutive presentations of 108 images selected from IAPS split into positive (n=36), negative (n=36) and neutral (n=36 x 2) categories presented during four long lasting image series. A greater number of SC responses were again elicited when viewing blocks consisting of unpleasant images as compared to pleasant and neutral ones suggesting again that the highly arousing qualities of unpleasant stimuli might have had significant modulatory effect on the elicited SC responses. Finally, SC level significantly decreased across series presentation: the authors argued that this might have been reflecting overall habituation in electrodermal measures as the task context became more familiar and the orienting processes were therefore less enhanced (Montagu, 1963; Sokolov, 1963). In line with Vrana and colleagues (Vrana & Gross, 2004), the authors suggested that differences in the engagement of orienting processes may therefore underlie the modulatory effects of stimulus arousal on SC response systems.

In an attempt to separate contributions of stimulus arousal due to novelty from those due to emotional valence, Bradley (Bradley, 2000) presented students with a selection of 54 IAPS images split in pleasant, unpleasant and neutral categories; each photograph was shown twice in a row. The argument was that during the second presentation, the picture was no longer novel to the participants and effects due to emotional arousal alone should therefore be accentuated. Although SC responses to unpleasant images remained similar across the two presentations, responses to pleasant images decreased significantly from the first to the second presentation, suggesting

therefore that pleasant images may be more related to stimulus novelty than to emotional arousal.

A number of studies have also examined the possible modulatory effects of stimulus size on SC responding. For example, Sánchez-Navarro and colleagues (Sánchez-Navarro, Martínez-Selva, & Román, 2006) asked undergraduate students to watch 54 IAPS images split into positive, negative and neutral categories. Students were randomly assigned to two experimental conditions: one condition consisted of large images and the other of small ones. Analysis showed significant SC differences between emotionally valenced and neutral pictures, but not between pleasant and unpleasant pictures suggesting again a modulatory arousal effect on autonomic reactivity. No significant differences were however found between image size conditions, suggesting no such effect on SC responses. On the other hand, Codispoti and colleagues (Codispoti & De Cesarei, 2007) asked participants to watch 106 IAPS images representing a much wider range of thematic contents split into seven categories: erotic couples, opposite sex nudes, babies, neutral people, contamination, animal attack, and mutilated bodies. Each picture was small, medium or large. Although more pronounced SC activity was elicited for erotic couples and mutilated bodies, thematic content modulation on SC was more pronounced for large images whereas decreased linearly with stimulus size; the authors argued that stimulus size might have modulated stimulus relevance and consequently, sympathetic changes related to high activation of strategic motivational response systems and action preparation (Bradley et al., 2001).

Brown and colleagues (Brown, Bradley, & Lang, 2006) asked students to watch IAPS images depicting members of the same or different to them ethnic groups in order to examine possible modulatory effects of ethnicity on SC activity. African American and European American participants were therefore recruited and exposed to images

depicting (a) black people, (b) white people and (c) animals and objects. Although all participants showed larger SC responses when viewing pleasant or unpleasant images as compared to neutral ones, African American participants had lower SC activity than European American participants supporting earlier findings suggesting that darker skin has less electrodermal conductivity than lighter skin (Korol & Kane, 1978). European American participants also showed higher arousal ratings in response to unpleasant and pleasant pictures of white people than African Americans suggesting that European American participants might have showed heightened emotional reactivity due to increased group identification or personal relevance.

Finally, a recent study aimed to develop a new emotional paradigm to examine whether autonomic activation patterns could also be organized around social dimensions of emotion. Specifically, Britton and colleagues (Britton, Taylor, Berridge, Mikels, & Liberzon, 2006) used film segments in order to induce socially and non-socially generated emotions. SC responses to social positive stimuli (i.e. comedy) were greater than those to non social positive stimuli (i.e. pizza scenes) although SC responses to social negative stimuli (i.e. bereavement) were smaller than those to non social negative ones (i.e. wounded bodies). More interestingly, for non social stimuli, SC responses to negative stimuli was greater than responses to positive or neutral ones; conversely, for social stimuli SC responses to valenced stimuli were greater than SC responses to neutral stimuli suggesting that the social dimension may be an additional important characteristic of emotional processing that can produce distinctive psychophysiological responses.

Table 1: Psychophysiological studies that have used skin conductance activity as index of emotional processing and emotional regulation

Author, date	Sample	Design	Stimuli	Technical	Measures	Results	Comments / Interpretation
Bradley et al., 2001	N =95 (50F) N=47 (24 F) coloured images N=48 (26 F) black and white images	Emotion induction task	72 IAPS images (positive, negative and neutral) had varied normative valence & arousal ratings and were presented for 6 s (pseudorandom order)	Coulbourn S71-22 coupler Sensormedic electrodes 5% NaCl Unibase paste SR: 20 Hz	SC amplitude measured within 1-4 s after image onset log-transformed values reported	<u>SC:</u> unpleasant > pleasant, neutral <u>Between thematic contents:</u> threat, violent death, erotica > other categories	SC modulated by arousal SC amplitude in men > women when viewing positive pictures SC amplitude in women > men when viewing negative stimuli
Sierra et al., 2006	N =15 (7 F) Mean age: 33.2 ± 7.2	Emotion induction task	12 blocks x disgust and happy facial expressions; images alternated in gender Images presented for 3 s each. Blocks followed by 30 s intervals	Contact Precision Electrodes 0.5cm SR: 100 Hz	SC amplitude measured as the maximum change initiated 1- 4 s after image onset and exceeding 0.04 μS log-transformed values reported	<u>SC:</u> happiness > disgust <u>Arousal:</u> No differences reported	Stimuli were developed and validated by one of the authors (CS) as part of his PhD dissertation

Amrhein et al., 2004	N =16 (6 F) Mean age 29.5±7.9	Emotion induction task	54 IAPS images (positive, negative and neutral) Valenced images had similar arousal ratings Self-paced image presentation (random order of presentation)	Vitaport-I system SR:400 Hz	SC amplitude measured within 1.5 - 6.5 s after image onset log-transformed values reported	<u>SC amplitude:</u> Neutral < pleasant, unpleasant pictures <u>SC Latency:</u> NS differences <u>Arousal:</u> Unpleasant > pleasant > neutral images <u>Viewing time:</u> pleasant > unpleasant > neutral images	SC modulated by arousal Viewing time not directly related to arousal but influenced by a combination of variables (e.g. valence, subjective interest) Valence and arousal ratings were comparable to normative IAPS values Small sample size
Cuthbert et al., 2000	N =37 (14 F) Age range: 18-24 years	Emotion induction task	54 IAPS images (positive, negative and neutral) Valenced images had similar arousal ratings; images presented for 6 s; random order of image presentation. Participants "maintained the image in their minds" until they heard a tone.		SC amplitude measured as the change score deviated from baseline (1 s before image onset) log-transformed values reported	<u>SC:</u> neutral < unpleasant <pleasant pictures <u>Valence:</u> pleasant > unpleasant > neutral images <u>Arousal:</u> Unpleasant, pleasant > neutral images	SC modulated by arousal

Norris et al., 2007	N =61 (61F)	Emotion induction task	66 IAPS images (positive, negative and neutral) SC averaged over the first and last 3 s of image presentation as well as the 3 s following picture offset	Biopac GSR100C 8mm Ag/Ag-Cl electrodes SR:1000 Hz Low-pass filter: 10-Hz	SC amplitude measured as the difference between each epoch and baseline (1 s before picture onset) square-root transformed values reported	SC: Neutral < unpleasant, pleasant pictures	All subjects were right-handed, undergraduate students
Vrana & Gross, 2004	N = 19 High fear: Mean age 19.7 ± 1.4 Low fear: Mean age 21.7 ± 1.8)	Emotion induction task	24 slides equally split into anger, neutral, joy categories (Ekman & Friesen, 1976) Slides presented for 8 s; pseudorandom order of image presentation	Coulbourn bioamplifier /coupler electrodes (4 mm) Unibase paste SR:20 Hz	SC amplitude measured as the change score deviated from baseline (1 s before image presentation)	SC: Neutral & anger expressions: SC decreased from baseline Only joyful expressions: SC increase from baseline	SC modulated by arousal 1 s of baseline physiology just prior to slide onset was used as a covariate for all physiological analyses. Lower SC activity during neutral expressions interpreted as the result of increased attentive processing NS gender differences

McManis et al., 2001	N = 30 (15F)	Emotion induction task	27 IAPS images (positive, negative and neutral) Valenced images had similar arousal ratings Self-paced duration of image presentation (up to 30 s) Pseudorandom order of image presentation	Coulbourn coupler 5% Unibase paste SR:20 Hz	SC amplitude measured as the change score deviated from baseline (1 s before image presentation)	SC: Unpleasant > pleasant, neutral pictures Viewing time: unpleasant > pleasant, neutral Arousal: unpleasant > pleasant, neutral	SC modulated by arousal NS gender differences
Codispoti et al., 2001	N=51 (23F)	Emotion induction task	54 IAPS images (positive, negative and neutral) Valenced images had similar normative arousal ratings; images were presented for 500 ms each	Coulbourn S71-22 coupler Sensormedic electrodes 5% NaCl Unibase paste	SC amplitude measured as the change score deviated from baseline (1 s before image presentation) and 1- 4 sec after image onset	SC: neutral < unpleasant, pleasant images	SC modulated by arousal Affective reactions were similar for briefly presented pictures as found in studies using longer, e.g. 6 s presentations Same images were also used in Bradley et al., 1993

Houtveen et al., 2001	N = 41 (27F) Repressors (N=14) Low anxious (N=14) High anxious (N=14)	Emotion induction task	Two sets x 27 IAPS images (positive, negative and neutral)	Ag/AgCl electrodes 5% NaCl Unibase paste	SC amplitude scored as the largest value compared to baseline (10 s before image onset) 1-5 s after picture onset	SC: erotica > threatening > neutral pictures Reduced SC activity found during the second image set	NS differences between repressors, truly low anxious and moderately-high anxious groups in self-reports or SC
Smith et al., 2005	N = 37 (23F)	Emotion induction task	Consecutive presentation of three blocks of 108 IAPS images (positive, negative and neutral) Blocks of 12 same valence images (90 s long) Pictures presented for 6 s each, followed by 1.5 s intervals	Coulbourn S71-22 coupler Sensormedic electrodes %5 NaCl Unibase paste	SCRs > 0.05 µS STAI	SCRs: Unpleasant > pleasant, neutral STAI: Individuals with higher anxiety ratings showed more SCRs	SC modulated by arousal
Palomba et al., 2000	N = 50 (35F) Mean age 23.8 ± 1.7	Emotion induction task	Three video clips depicting threat scenes (fear), operation (disgust) and landscape (joy) Clips were 132 s long Unpleasant clips had similar arousal ratings	150/160 LTD Digitimer amplifier S71-22 SC coupler Ag/AgCl electrodes SR:10 Hz	SCL data reduced to 0.5 s bin criterion. SC analyzed by dividing the 132-s stimulus period into four 33-s epochs. Differences between epochs and the last 15 s of baseline were reported.	SCL: disgust > threat > joy	All participants were undergraduate students

Sarlo et al., 2005	N = 46 (21F) Mean age 23.5 ± 2.9	Emotion induction task	20 IAPS images (6 s each) equally split into two positive (erotica, sport), two negative (threat, blood) and one neutral categories Variable intervals: 15–20 s Valenced images equal in arousal normative ratings	150/160 LTD Digitimer amplifier Coulbourn S71-22 coupler Ag/AgCl electrodes SR: 20 Hz	SC amplitude measured as the change score between 3 s before picture onset (baseline) and for 6 s during picture viewing	<u>SC:</u> erotic > threat, blood > sport > neutral stimuli	All participants were undergraduate students NS gender differences
Bernat et al., 2006	N = 48 (48M) Mean age 19.8 ±2.52	Emotion induction task	54 IAPS images (6 s each) equally split into positive (erotic, adventure), negative (victimisation, threatening images) and neutral categories Valenced images equal in arousal ratings	Coulbourn amplifier / coupler Ag/AgCl (1 cm) electrodes 5% NaCl Unibase paste SR:20 Hz	SC amplitude measured from the onset to peak response within 0.9–4-s following picture onset	Positive relationships between arousal and SC for erotic and threat contents only	Male participants only

Codispoti & De Cesarei, 2007	N = 50 (25M) Mean age 21.48±1.87	Emotion induction task	105 IAPS images split into: erotic couples, opposite sex nudes, babies, neutral people, contamination, animal attack and mutilation. Three different picture sizes: large, medium, small	Coulbourn S71-22 coupler Ag/AgCl (7-mm) electrodes 5% NaCl Unibase paste SR: 20 Hz	SC amplitude scored as the maximum response between 1 - 4 s from picture onset log-transformed values reported	<u>SC:</u> largest picture size, highly arousing images > low arousing and neutral ones larger, medium > smaller pictures erotic couples, mutilated bodies > all others categories neutral pictures, contamination < sex nudes, animal attacks and babies	Picture size reduction was associated with a decrease in SC affective modulation.
Ribeiro et al., 2006	N = 24 (12F)	Emotion induction task	4 sets x 32 IAPS images: 8 highly pleasant-arousing (sexual, adventures) 8 highly pleasant- relaxing (landscapes, flowers or babies), 8 neutral & 8 highly unpleasant-arousing pictures	I-410 Physiological Monitoring System Ag/AgCl electrodes	SC amplitude scored by subtracting 3-s before picture onset from the last 3-s of picture viewing	<u>SC:</u> Unpleasant > pleasant, relaxing images (tended to do so also in relation to pleasant arousing and neutral images)	

Caseras et al., 2007	N = 34 (17 F) Mean age Males: 29.06±7.3 Females: 29.88± 9.04	Emotion induction task	100 IAPS images (6 s each) split into unpleasant (disgust; n=50) and positive or neutral (n=50) categories	Coulbourn S71-22 coupler Ag/AgCl (7-mm) electrodes 5%NaCl Unibase paste SR: 20 Hz	SCRs > 0.01μS and > 500 ms rise time When no SCRs, 0 was recorded for that block	<u>SCRs:</u> disgust > neutral images	NS gender differences Females > males in disgust sensitivity scores and subjective discomfort
Hubert & de Jong-Meyer, 1991	N = 20 (20 M) Mean age 22.7 range 21-24	Emotion induction task	2x 10 min films (amusing, suspense) presented on 2 consecutive days. Counterbalanced order of images presentation	Beckman Ag/AgCl electrodes (8 mm) Natic EDA coupler 5% NaCl Unibase electrode paste SR:10 Hz	SCL values averaged for 60-s periods and subtracted from the last 2 min of the baseline period SCL ≥ 0.1 μS	<u>SC:</u> SCL initially increased for min 1 SCL increased for min 3 and 6 during suspense scenes SCL decreased for min 5 to 10 for the amusing film	Participants got more irritated during the second part of the suspense segment while during the amusing film this trend was weaker towards the end. All participants were males
Cobos, Sánchez, Garcia, Nieves Vera, & Vila, 2002	N = 19 (7 F) Age range 21-53	Emotion induction task	30 IAPS images (6 s) (unpleasant, pleasant and neutral) Random order of image presentation	Sensormedic electrodes Isotonic electrolyte paste (0.29g) NaCl per 100 ml water. Constant current: 10 A	SC change between stimulus onset to maximum increase during the 6 s slide presentation	<u>SC amplitude:</u> Unpleasant > pleasant, neutral images	Patients with spinal cord injuries were also included in the study

Frazier et al., 2004	N= 56 (28F) Mean age 19.1±1.53 Age range 18-26	Emotion induction task	9 films (3 x positive, 3 x neutral, 3 x negative) (120 s each)	Biopac TSD103A amplifier Bandpass DC-1 Hz 5%Unibase paste NaCl. SR:1000 Hz.	SCRs >0.05 µS computed by subtracting baseline values preceding and following films from values during each film	<u>SCRs:</u> Unpleasant, pleasant > neutral images	Undergraduate students NS gender differences
Sánchez-Navarro et al., 2006	N = 61 (38 F) Mean age 19.75±2.95 N=31 viewed large images N=30 viewed small images	Emotion induction task	54 IAPS images (unpleasant, pleasant and neutral) Inter-trial intervals: 18-30 s Valenced pictures had similar arousal ratings (> 6) Participants controlled image duration by keypress	AD Instruments ML132 bioamplifier Ag/AgCl (7-mm) electrodes with isotonic electrolytic paste	SC amplitude > 0.05 µS in a 0.9-4 s window after picture onset. log-transformed values reported	<u>SC:</u> pleasant, unpleasant > neutral images <u>Viewing time:</u> Pleasant, unpleasant > neutral images <u>Arousal ratings:</u> Females: unpleasant > pleasant > neutral images Males: unpleasant, pleasant > neutral images	NS differences or interactions found in SC or viewing time for picture size or gender

Britton et al., 2006	N = 40 (21F) Mean age 19.3±1.2	Emotion induction task	Short films (2 min) varying in sociality (social or non social) and valence (positive, neutral, negative or blank) After each film, participants had to maintain the emotions evoked	BioPac MP100 bioamplifier Ag/AgCl electrodes with NaCl Unibase paste	The peak SC amplitude during the first 30 s of each film was compared to a 25 s baseline period prior to each film	SC: Social positive > non social positive Non social negative > social negative Non social stimuli: negative > positive Social stimuli: positive, negative > neutral	All participants were males

Brown et al., 2006	N = 87 (46 F)	Emotion induction task	56 IAPS images of (1) black people (2) white people (3) animals and objects	Coulbourn S71-22 bioamplifier /coupler Vivo Metric E224 8 mm electrodes 5% NaCl Unibase paste	SC amplitude calculated by subtracting the baseline activity (1 s before picture onset) from each half s following picture onset.	SC: European American participants had larger SC when viewing unpleasant or pleasant pictures of White targets > African American participants Viewing time: African Americans looked at Black targets > White targets. No ethnicity differences in viewing time for unpleasant pictures.	All participants were undergraduate students from different ethnic backgrounds
Lane et al., 1998	N = 20 (20F)	Emotion induction task	60 IAPS images (6 s) (unpleasant, pleasant and neutral)	Biopac amplifier / electrodes SR:1000 Hz signals reduced to 12 half s bins	SC amplitude scored as the largest half-s value during picture viewing. log-transformed values reported	SC: unpleasant > pleasant > neutral images	All participants were female volunteers

Neiss, Leigland, Carlson, & Janowsky, 2007	N = 102 Older adults age range 65-85 Younger adults age range 24-40	Emotion induction task	70 IAPS images (2 s) (unpleasant, pleasant, neutral) All image categories had similar arousal ratings	Biopac MP100A amplifier GSR100C transducer module (sensitivity =.7 nS) Low pass filter:1.0 Hz High pass filter: 0.05Hz Ag/AgCl (6 mm) electrodes 5% saline electrode paste	SC amplitude scored as the highest peak within 6-s following stimulus onset and ≥0.1μS log-transformed values reported	SC did not differ across valence categories Younger women < younger men towards pleasant and unpleasant stimuli Young and old did not differ in SC SC correlated to subjective arousal ratings in the young group only	SC activity correlated with subjective arousal ratings in the young group only, suggesting a disconnection between older participants' conscious awareness and physiologic arousal
Codispoti et al., 2008	N=60 (33F) mean age: 23.12 range 19–37	Emotion induction task	Practice film clip (120 s) and then 3 films (surgery, landscape and erotica) with variable interval (6–8 min) between presentations. 2-min baseline was recorded	Coulbourn S71-22 coupler Sensormedic Ag/AgCl electrodes 5% NaCl Unibase paste Signal calibrated in 0–40 μS.	SCL computed by subtracting activity in 60 s before film presentation from that occurring at each 60s interval after film onset	<u>SCL:</u> emotional films > neutral film first interval> second interval	Psychology students NS gender differences

Gross, 1998	N = 120 (60F) Mean age: 21±4.1 N=40 emotion induction condition N=40 emotion regulation condition	Emotion regulation <u>Suppression:</u> Participants behaved in such a way *"that an observer would not know what they were feeling"* <u>"Watch condition"</u> as control	Three silent films (Ekman & Friesen, 1976): 2 films depicting disgust (55 & 64 s long) &1 neutral emotion (1 min long)	Beckman electrodes NaCl Unibase paste	SCL measured as the change score between baseline (1 min before image onset) from film period	<u>SCL:</u> Suppression vs. induction: larger SCL <u>Subjective ratings:</u> NS differences between conditions	The ethnic composition of the sample was mixed
Kunzmann et al., 2005	N = 95 N=48(24F) Age range 18-28 N= 47(23F) Age range: 60-85	Emotion regulation <u>Suppression:</u> Participants behaved in a way *"that an observer would not know what they were feeling"* <u>"Watch condition"</u> as control	5 films (Ekman & Friesen, 1976): 1 neutral film (58 s long) 3 disgust films (eye operation 58 s; burn victim 55 s; arm amputation 62 s) 1 positive film (contentment)	Beckman electrodes NaCl Unibase paste	SCL measured as the change score between pre film and film period	<u>SCL:</u> Suppression vs. induction: larger SCL <u>Subjective ratings:</u> NS differences between conditions. Young participants greater disgust during medical films > old ones	The order of the film presentations counterbalanced Each condition consisted of 23 older (11 F) and 24 younger (12 F) healthy volunteers NS effect of age

Gross & Levenson, 1997	N = 180 Healthy controls	Emotion regulation Suppression: Participants behaved in a way *"that an observer would not know what they were feeling"* "Watch condition" as control	4 films (Ekman & Friesen, 1976): films were neutral (3.5 min, soundless), amusing (3.5 min, with sound) or sad (3.5 min, with sound); a neutral film used as baseline (1.5 min, soundless)	Grass Model 7 (Astro-Med, Inc)	SCL measured as the change score between pre-film and film period.	SCL: Suppression vs. induction: larger SCL during sad condition Subjective ratings: NS differences between two conditions	All female undergraduate students In all conditions, the order of film presentations was counterbalanced
Gross & Levenson, 1993	N = 85 43M: mean age 19.3 (range 18-23) 42F: mean age 19.2 (range 17-23)	Emotion regulation Suppression: Participants behaved in a way *"that an observer would not know what they were feeling"* "Watch condition" as control	3 silent films (Ekman & Friesen, 1976): 1 film was neutral (113 s) 2 films depicting disgust (burn victim 55 s & arm amputation 64 s)	Grass Model 7 (Astro-Med, Inc) Beckman electrodes NaCl Unibase paste	SCL measured as the change score between pre-film and film period.	SCL: Suppression vs. induction: larger SCL Subjective ratings: NS differences between two conditions	NS gender differences found during suppression

Demaree et al., 2006	N=69 (36F) Mean age 19.32±1.57	Emotion regulation <u>Suppression:</u> Participants were asked to *''show no emotional response''* <u>"Watch condition"</u> as control	Participants saw either a disgusting clip or a neutral clip (2 min each)	Biopac Systems GSR100C amplifier TSD203 transducers Biopac Electrode Paste Low-pass filter: 10 Hz SCRs>0.05 μS	SCRs averaged over 2 min within conditions	<u>SCRs:</u> Negative films vs. neutral: more SCRs Suppression vs. induction: fewer SCRs <u>Subjective ratings:</u> NS differences between conditions	
Ohira et al., 2006	N=10 (10F) Mean age: 24.22±1.72 range: 22–27	Emotion regulation <u>Suppression:</u> Participants had to *"suppress emotional responses and remain calm"* <u>"Attending condition"</u> as control	2 sets x (10 positive, 10 neutral, 10 negative) colour IAPS photos Positive, neutral, and negative blocks randomly presented Each block: 10 photos presented for 10 s at 2-s intervals	BioPac Systems MP-100 Ag/AgCl electrodes NaCl unibase electrolyte	SC amplitude measured in 10 s time window during image presentation SC amplitude averaged during each block and during a 1-min baseline period	<u>SC:</u> Negative>positive during suppression <u>Arousal:</u> negative > positive, neutral stimuli	All female undergraduate & graduate students The order of the tasks not counterbalanced

Eippert et al., 2007	N=24 Healthy controls (24F) Mean age: 23.3 (range: 18–28)	Emotion regulation <u>View:</u> Participants viewed pictures *"without altering emotional reactions"* <u>Decrease:</u> Participants *"became detached observers"*	2 sets: neutral (12 images, low arousal) & negative (36 images, high arousal) Instructions appeared on images for 500 ms asking participants to regulate their emotions accordingly Images presented for 6 s	Varioport, Becker Meditec Ag/AgCl electrodes NaCl Unibase electrolyte Low - pass filter: 16 Hz	View: largest SC difference between a max and a preceding min in the induction phase (1-3.5 s after stimulus onset) Decrease: SC differences between a max in the induction phase (1-3.5 s after stimulus onset) and a max in the regulation phase (4-10 s after stimulus onset)	<u>SC amplitude:</u> View: SC amplitude negative > neutral pictures Suppression vs. induction: NS differences <u>Subjective ratings:</u> NS between two conditions	All participants were females
Lazarus & Alfert, 1964	N=69 (69M)	Emotion regulation Participants watched films whilst i) listening ii) or not to a denial commentary	Presentation of sub-incision film (17 min) without commentary Denial commentary condition (17min)	Fels dermohmmeter Esterline-Angus recorder	SCL averaged at 15 s intervals	<u>SCL:</u> Compared with the no-soundtrack condition, participants who heard the soundtrack showed lower SC levels	All participants male students Compared with the no-soundtrack condition, participants who heard the soundtrack also showed more pleasant mood ratings
Key: SC=Skin Conductance; IAPS= International Affective Picture System; F=females; s=seconds; SR=sampling rate; μS=micro Siemens; NS= no significant; STAI= State-Trait Anxiety Inventory; SCRs= number of SC responses							

Findings from emotion regulation tasks

A growing number of studies has been examining the effects of down regulating emotional responses as a common form of emotional response modulation. Lazarus (Lazarus, 1966, 1969; Lazarus & Alfert, 1964) provided some of the first evidence in an influential series of studies. In a seminal study, Lazarus and Alfert (Lazarus & Alfert, 1964) showed participants a filmed operative procedure while manipulating the accompanying soundtrack. More specifically, some participants heard a soundtrack designed to minimize the negative emotional impact of the film by denying the pain involved in the surgery and emphasizing the joyful aspects of the procedure instead. Other participants heard no soundtrack at all. Compared with the no-soundtrack condition, participants who heard the soundtrack showed lower SC levels and more pleasant mood ratings. The authors argued that leading participants to watch the film less negatively had decreased the stressfulness of what otherwise would have been a stressful experience. As a result, they showed attenuated SC activity.

Gross (Gross, 1998) randomly assigned a large sample of healthy volunteers to watch a disgust-eliciting film (Ekman & Friesen, 1976) either passively or suppress their expressive emotional behaviours so that "an observer would not know that they were feeling anything". Although the suppression condition was effective at diminishing expressive behavior, it had no significant effect on subjective emotional responses whilst leading to increased SC responses. Most interestingly, although in an attenuated form, this effect continued into the post-film period. Kunzmann and colleagues (Kunzmann, Kupperbusch, & Levenson, 2005) asked participants of varying age groups to watch a neutral and a disgust-eliciting film; they were then randomly assigned to either watch passively or suppress their expressive behavior in response to

the presentation of a different disgust-eliciting film. Consistent with the above, the suppression instruction although effective at diminishing expressive behavior, had no impact on subjective experience while SC levels increased in response to the negative film relative to the passive condition; furthermore, no age effects were found in participants' expressive behavior, subjective experience or SC responses.

A series of studies have replicated these findings while extending the thematic content of positively valenced images to depict a variety of emotions, such as amusement. In order to examine the effects of inhibiting both negative and positive emotion, Gross & Levenson (Gross & Levenson, 1997) asked female college-aged participants to watch sad, neutral, and amusing films (as used in Gross & Levenson, 1995). Although suppression led participants to successfully inhibit their expressive behaviours elicited by the films, this again had no impact on subjective experience. Moreover, an asymmetry between negative and positive emotions emerged: when subtracting pre-film from film period scores, the negative film elicited greater SC activity during the suppression relative to the attending condition. Nevertheless, the amusement film didn't reveal any significant differences between the two conditions.

In a much earlier study conducted by the same research group (Gross & Levenson, 1993), participants were randomly assigned to watch a neutral and a short disgust-eliciting film whilst either inhibiting the expression of their emotional responses (suppression condition) or watching it passively (no suppression condition). Similarly, suppression was effective at diminishing expressive behavior and had no effect on subjective experience; again, when subtracting pre-film from film period scores, greater increases in SC activity were elicited in the suppression group relative to participants who attended passively to the same stimuli.

A more diverse picture emerged however when Demaree and colleagues (Demaree et al., 2006) randomly assigned undergraduate students to either suppress or exert no control over their facial responses while watching a (2 minute long) disgust-eliciting or neutral film by following the screen instructions preceding each clips presentation. Again, response modulation had no effect on subjective emotional experience; similarly, the suppression task elicited greater SC activity in response to the disgust eliciting film relative to the passive condition although the difference was not statistically significant. The authors argued that the highly arousing nature of the film might have created a ceiling effect that would have been difficult for participants to exceed. Indeed, the participants who modulated their responses evidenced significant SC recovery during the post-film period whereas the attending group did not.

Another study explored the effect of regulating internal emotional experience to images as a conscious effort to alter their emotional impact. Particularly, Ohira and colleagues (Ohira et al., 2006) asked female participants to complete two series of experiments. During one of them, participants had to react normally to positive, negative and neutral images with varied arousal ratings. Then, participants had to watch another set of images with similar valence and arousal ratings while at the same time trying to voluntarily suppress their subjective emotional responses. Indeed, during the suppression condition, although there was again no effect on subjective experiences, SC amplitude in response to all image categories was significantly larger relative to the attending task. In terms of self-report data, attending to negative pictures induced unpleasant emotional states compared to baseline whereas during the suppression task, emotional states did not significantly change after viewing stimuli of any valence, suggesting that although negative stimuli had a stronger impact (than positive and

neutral ones), participants were successful in attenuating their emotional experiences during the suppression task.

Finally, Eippert and colleagues (Eippert et al., 2007) asked female participants to watch two sets of neutral and highly arousing threat-related images and follow instructions preceding each picture presentation; the instructions requested participants to either view the pictures passively (mood induction task) or decrease their emotional reactions (suppression) by distancing themselves from the pictures. During the suppression condition, although SC amplitude increased in comparison to the passive condition, this failed to reach significant difference. According to the authors' interpretation of the results, these may add weight to an early study on emotional down regulation of emotional responses (Lazarus & Alfert, 1964), which demonstrated that changes in SC activity were greater when instructions were given well before than during a threatening film presentation. It was therefore postulated that reversing the direction of an emotional response that is already under way may require more conscious effort than doing so well before an emotional response unfolds.

Discussion

The present review provided an overview and critical synthesis of the existing literature examining SC activity correlates of emotional regulatory capacities in normative populations. Findings are discussed qualitatively rather than quantitatively.

Pleasant and unpleasant pictures consistently elicited larger SC activity than neutral images whereas no significant differences were consistently found between pleasant and unpleasant categories, suggesting that SC activity covaries with subjective affective arousal only when participants are exposed to highly arousing stimuli that is, regardless of valence. When exploring the possible effects of distinct thematic contents

of stimuli on SC activity, images depicting erotica, violence/blood and disgust appear to elicit consistently larger SC responses compared to other ones (e.g. fear, joy). SC activity also appeared to be affected by other factors such as ethnicity, personal relevance, subjective interest, social context, valence and the novelty of stimuli whereas with repeated presentations of the same images, SC activity appeared to decrease. Similar arousal patterns of skin conductance were observed using varying exposure times to stimuli whereas larger sizes of stimuli seemed to elicit enhanced SC activity, although results remain less consistent (Sánchez-Navarro et al., 2006).

SC activity is closely associated with the activation of the sympathetic branch of the autonomic nervous system. Increases from baseline activity are considered a component of the orienting reflex (Graham & Clifton, 1966), which aims at facilitating the perceptual processing of information regarding the state of the external environment (Lacey, 1967). Indeed, the preferential processing of high-priority stimuli in the environment is an essential function of selective attention. In such a way, highly arousing contents can prompt greater orienting, sustained attention, and action preparation, as reflected by enhanced SC activity (Bradley et al., 2007; Codispoti et al., 2006). In line with the above, findings discussed in this review showed that highly arousing pleasant stimuli (e.g. erotica) were more effective in capturing attentional resources whereas stimulus-specific aversive responses for negatively valenced stimuli (e.g. blood, violence-related) also resulted in enhanced autonomic activity (Bradley et al., 1999; Codispoti & De Cesarei, 2007; Schupp et al., 2007).

Emotional "down-regulation" or suppression appears to be associated with increased SC activity as compared to passive emotion induction tasks, although there were less significant effects of task demands on subjective emotional experiences. It is possible that the level of autonomic arousal plays a rather limited role in participants'

subjective evaluations of intensity of their emotional experiences; conversely, cognitive appraisal of the emotional experience may be a more complex function, which may utilize far more sources of information than the level of physiological arousal alone (e.g. motivation, social context, subjective interest) (Stefanopoulou & Hunter, 2013a, 2013b). The above formulation is further supported by a growing number of neuroimaging studies (e.g. Garrett & Maddock, 2006; Hariri, Bookheimer, & Mazziotta, 2000; Patterson, Ungerleider, & Bandettini, 2002; Williams et al., 2001) suggesting some degree of functional specialization in ventral medial PFC-amygdala versus ventral lateral PFC-hippocampal systems: specifically, reflective evaluation of emotional experiences is considered to be associated with hippocampal-lateral PFC activity whereas the amygdala-medial PFC network is considered to process primarily visceral information concerning autonomic arousal. However, future neuroimaging and psychophysiological studies are warranted in order to delineate further such complex processes.

Participants' effort to actively regulate their responses to neutral images had no effect on SC or subjective responses, suggesting that inhibiting non emotional states cannot produce changes in either subjective or physiological activation: the physiological impact of active emotional regulation grows out of the counterpoising of attempts to inhibit expression against strong impulses to express. Nevertheless, in the absence of a stimulus that can produce such impulses to express, inhibition of ongoing behavior may only have little physiological or behavioural impact (Gross & Levenson, 1993).

Another controversial issue in emotional regulation studies concerns the presence of gender differences in emotional response. Existing findings support that men and women are mostly similar in their physiological reactions to pleasant and unpleasant

stimuli. Indeed, many studies using adjunct physiological measures in assessing emotional arousal, such as respiratory sinus arrhythmia (RSA), EMG activity and heart rate have also failed to find significant gender differences (Frazier et al., 2004; Kreibig et al., 2007; Sanchez-Navarro et al., 2006; Codispoti et al., 2008). They are also consistent with recent functional imaging studies (Caseras et al., 2007; Hamann et al., 2004; Sabatinelli et al., 2004; Wrase et al., 2003) showing that although gender differences were shown in amygdala and extrastriate visual cortex activation in reaction to emotional stimuli (pictures or films), such differences were not observed in terms of autonomic changes. Taken together, it might thus be possible that gender differences in evaluative judgments might be due to cultural factors and reinforcement, but more studies are needed to better clarify disconcordance between subjective self reports and SC changes.

Similarly, there were no evident modulatory effects of age on SC correlates of emotional responding (e.g. Kunzmann et al., 2005). The possible effects of ageing on emotional regulation nevertheless warrants further investigation. A few studies have examined age differences in subjective but not physiological responses during similar tasks; for example, Malatesta-Magai and colleagues (Malatesta-Magai, Jonas, Shepard, & Culver, 1992) reported that older people showed greater emotional expressivity when compared with young adults suggesting therefore that the basic capacity to react spontaneously to emotion-arousing events on a subjective and behavioral level remains intact in old age (Lawton, 2001; Lawton, Kleban, Rajagopal, & Dean, 1992). Only a few studies have investigated emotion regulation in adults of different ages (Gross et al., 1997; Lawton et al., 1992); however, these studies examined beliefs about emotion regulation rather than measuring SC correlates of emotion regulatory skills. In Gross and colleagues' study (Gross et al., 1997), older adults saw themselves as more

successful in regulating their inner feelings and overt emotional expressions than younger adults did. Similarly, in Lawton and colleagues' study (Lawton et al., 1992), older adults reported higher levels of emotion regulation (control of inner feelings and behavior) than younger adults. Although these two studies provide some indication that emotion regulation might improve in older age groups, they are based on questionnaire data and not on observed physiological activity.

Clinical implications

Most interesting are also the clinical implications of these findings. Particularly, there has been very little direct empirical investigation of the use of maladaptive emotion regulation strategies in the development and/or maintenance of clinical or subclinical symptomatology, such as anxiety or depression. Although clinical improvement has often been associated with at least partial reversal of the above abnormalities, the question of whether the observed psychophysiological changes are state or trait related still remains unresolved. Further investigation of clinical populations across acute or remitted mood states (e.g. bipolar disorder) is therefore critically urged since it might provide valuable insight into the cognitive and neural underpinnings of emotion regulatory processes in different clinical disorders and healthy populations.

Future directions

Although there are multiple points of convergence across studies, there are also many confounding factors (e.g. social context, personal relevance) which may distort our understanding of the psychophysiological mechanisms involved in emotional regulation.

Many arguments have also been raised suggesting that common recording, classification and correction methods of measuring psychophysiological responses are

critically urged in order to eliminate possible methodological differences between studies (Alexander et al., 2005; Dawson, Schell, & Filion, 2000; Lynn, 1966). Moreover, it was recently argued that longer recording time-periods during and after-stimulus presentation are needed in order for the emotional suppression to become more effective in modulating both subjective and psychophysiological responses (Eippert et al., 2007; Garrett & Maddock, 2001).

Furthermore, despite the importance of examining subjective and psychophysiological responses to different categories of stimuli in terms of valence and arousal, few studies have systematically examined distinct thematic concepts within each category (e.g. mutilation versus adventure images). Additionally, it has been argued that although pleasant images are depicting only one thematic content (i.e. happiness), unpleasant images are depicting many different ones (e.g. sadness, disgust, fear, threat etc); therefore, unless unpleasant images are depicting one thematic content only (e.g. fear), it is difficult to reliably compare between these two image categories (i.e. pleasant versus unpleasant). Finally, almost all existing studies have examined young healthy populations (i.e. students): it is difficult therefore to generalize existing findings to a normative sample of a wider age range.

Finally, no study so far has provided information on the nature, duration and strength of emotional responses elicited by differently valenced or arousing stimuli in a large normative sample. As a result, no normative data yet exist on the psychophysiological and behavioral correlates of such responses. Future studies exploring the above issues further may therefore be of great theoretical and clinical significance.

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Ψυχοφυσιολογικές μετρήσεις συναισθηματικών διεργασιών και ρυθμιστικών ικανοτήτων του συναισθήματος σε υγιείς πληθυσμούς: Ποιοτική ανασκόπηση της βιβλιογραφίας.

Ευγενία Στεφανοπούλου[8]

Περίληψη

Η ικανότητα ρύθμισης των συναισθημάτων αναφέρεται στις διεργασίες που είναι υπεύθυνες για την αποτελεσματική παρακολούθηση, αξιολόγηση και τροποποίηση των συναισθηματικών αντιδράσεων, προκειμένου να επιτευχθεί ένας στόχος. Οι διαταραχές στην ικανότητα ρύθμισης των συναισθημάτων είναι το σήμα κατατεθέν διαταραχών της διάθεσης και αγχωδών διαταραχών, όπου η παθολογική εμμονή υποκειμενικών, ως επί το πλείστον αρνητικών, συναισθηματικών αντιδράσεων συνδέεται με την εκδήλωση αλλά και τη διατήρηση αυτών των καταστάσεων. Οι ψυχοφυσιολογικές μέθοδοι αξιολόγησης του συναισθήματος παρέχουν αντικειμενικές μετρήσεις της ικανότητας ρύθμισης των συναισθημάτων, οι οποίες συμπληρώνουν τις υποκειμενικές αναφορές. Η ψυχοφυσιολογική μεταβλητή που έχει προσελκύσει μεγάλο επιστημονικό ενδιαφέρον σε ό,τι αφορά στην ικανότητα ρύθμισης του συναισθήματος είναι η καταγραφή της ηλεκτροδερμικής δραστηριότητας, και πιο συγκεκριμένα η μεταβολή της αγωγιμότητας του δέρματος, η οποία αποτελεί δείκτη της λειτουργίας του αυτόνομου νευρικού συστήματος. Η παρούσα εργασία ανασκόπησης της βιβλιογραφίας αποτελεί μία κριτική σύνθεση των μέχρι στιγμής ερευνητικών ευρημάτων που εστιάζουν στην αξιολόγηση της σχέσης ανάμεσα στη διαδικασία της αισθητηριακής επεξεργασίας οπτικών ερεθισμάτων και τον τρόπο με τον οποίο σχετίζεται με την ηλεκτροδερμική δραστηριότητα, ως δείκτη διεργασιών ρύθμισης του συναισθήματος σε υγιείς πληθυσμούς. Η περαιτέρω διερεύνηση κλινικών πληθυσμών κατά τη διάρκεια οξέων επεισοδίων ή περιόδων ύφεσης (π.χ., διπολική διαταραχή) κρίνεται απαραίτητη, καθώς μπορεί να παράσχει πολύτιμες πληροφορίες σχετικές με τις γνωστικές και νευροβιολογικές διαδικασίες που είναι υπεύθυνες για τη ρύθμιση του συναισθήματος σε διάφορες διαταραχές αλλά και σε υγιείς πληθυσμούς.

Λέξεις κλειδιά: ψυχοφυσιολογία, συναισθηματική ρύθμιση, ηλεκτροδερμική δραστηριότητα, συναίσθημα.

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