

## Galvanic Skin Response in Mood Disorders: A Critical Review

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### ABSTRACT

To critically review the literature on Galvanic Skin Response (GSR) within Mood Disorder populations. GSR profiles were examined for the various types of Mood Disorder and their association with comorbidity, suicidality and predispositions. This review examined studies with emotional and non-emotional stimuli whilst aiming to identify a Mood Disorder GSR profile by comparisons with healthy controls and other psychological or physical disorders. A systematic search for relevant literature was conducted using PsychINFO, CINAHL and MEDLINE databases. Studies using emotional stimuli to measure GSR in mood disorder patients were included. Some studies did not use emotional stimuli, however were included as GSR measures were conducted separately from stimuli presentation. A greater proportion of studies reported results in support of a specific GSR profile for mood disorders as well as indicating GSR variation depending on type of disorder. Distinguishing the GSR profile from other psychological or physical disorders was more challenging, as it is less clear if pathology causes differences in GSR when issues such as comorbidity are present. Bilateral GSR differences, GSR differences between the left and right hand, were also reported in a number of studies. Results indicated mood disorder patients have low or flat GSR profiles, consistent with review expectations. Bilateral analysis also indicated a common left-hand bias among mood disorder patients.

*Key words:* galvanic skin response, electrodermal activity, mood disorders, affective disorders.

### Novelty and Significance

*What is already known about the topic?*

- GSR is a physiological phenomenon that has long been used in psychology research. It is an automatic response of the electro conductance level of the skin. Although it can be measured a number of different ways, most researchers tend to use the same method.
- Research has shown that GSR can change when individuals are presented with an emotional stimulus thus showing a close link between the emotional state and physiological reactions. Mood Disorder patients are characterized by a disturbance in mood and emotional state.

*What this paper adds?*

- This paper has helped consolidate the connection between emotional and physiological responses.
- It also has helped identify the specific ways in which Mood Disorder patients differ from other populations.

The Galvanic Skin Response (GSR) is a physiological response of Electro-Dermal Activity (EDA), and is a commonly measured manifestation of Autonomic Nervous System (ANS) activation, particularly the sympathetic partition (Fontanella, Ippoliti, & Arcangelo, 2012). EDA, and thus GSR, is simply the electrical properties of the skin as determined by sweat gland activity. There are two methodologies for measuring GSR, the exosomatic and the endosomatic methods. The exosomatic method can either use a direct current (DC) or alternating current (AC) through a circuit consisting of a galvanometer, electric battery and human body to measure changes in EDA; however DC currents are used more often than AC currents (Christie, 1981). In contrast the

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second method, the endosomatic method, uses a human body and galvanometer circuit to measure changes in resting electromotive force, or voltage of the skin (Christie, 1981). Of all the methods -(1) endosomatic and (2) exosomatic with either DC or AC- it is exosomatic DC that is most commonly used (Boucsein, 2012). Using the two methods, two processes of EDA can be measured; phasic and tonic. Phasic processes, referred to as responses or electrodermal responses (EDR), are more event related and have shorter time courses (Fontanella, Ippoliti, & Arcangelo, 2012). These responses are usually the result of eliciting stimuli, but can also be non-specific with unidentified origins and are reported in terms of amplitude (magnitude of response) and frequency (number of responses). Tonic processes, referred to as levels or electrodermal levels (EDL), consist of longer time courses and are slower to change and are usually described in terms of amplitude. Exosomatic DC, the most frequently used method, has two types of measurement and terms in which GSR can be reported -Skin Conductance (SC) and Skin Resistance (SR). It is important to note that an increase in conductance equals a decrease in resistance and visa versa. For each there are both phasic and tonic processes hence Skin Conductance Response (SCR) and Skin Conductance Level (SCL) as well as Skin Resistance Response (SRR) and Skin Resistance Level (SRL) (Christie, 1981) are all measures of GSR. The endosomatic method conversely has only one measurement -Skin Potential (SP), and again can be reported as a phasic (Skin Potential Response, SPR) or a tonic process (Skin Potential Level, SPL). GSR continues to be one of the most frequently used methods in psychophysiology and is considered the gold-standard (Fontanella *et al.*, 2012). Advantages of GSR, as the simplest measure of sympathetic responses (Fontanella *et al.*, 2012), include its relatively unobtrusive nature due to fairly simple methodology allowing for an ease of measurement and greater re-test reliability. It is also robust in terms of measuring EDA in various psychological states (Rachman, 1960; Roy, Boucsein, Fowles, & Gruzelier, 1993; Diamond & Otter-Henderson, 2007).

Methodology in GSR measurement has been mostly inconsistent. The psychophysiological research community has tried to address this by developing consistent guidelines (Fowles, Christie, Edelberg, Grings, Lykken, & Venables, 1981). Taking new technology developments into account, the Society for Psychophysiological Research has released a new set of recommendations for EDA measurements (Society for Psychophysiological Research, 2012). These recommendations summarise specific methodologies for each method (endosomatic, exosomatic with AC and exosomatic with DC). They also provide detailed information regarding different types of electrodes, electrode placement sites, as well as recording and analysis techniques. The Society for Physiological Research does not favour any one methodology as superior, but highlights the need for detailed information in study publications for replication purposes.

Examining GSR is the first major focus for this review. The second major focus, which allows for the incorporation of physiology and psychology, is on mood disorders. The present review includes literature that specifically measures GSR in mood disorder patients with the aim of establishing the presence of a GSR profile specific to mood disorder patients.

The Diagnostic and Statistical Manual of Mental Disorders (Fourth Edition, Text Revision) (DSM-IV-TR) (American Psychiatric Association, 2000) and The ICD-10

Classification of Mental and Behavioural Disorders: Clinical Descriptions and Diagnostic Guidelines (Tenth Edition) (ICD-10) (World Health Organisation, 1992) are commonly used diagnostic classification manuals in mental health settings. The DSM-IV-TR outlines a variety of mood disorders, such as Major Depressive Disorder (MDD), Bipolar (BPD), Bipolar I (BPDI) and Bipolar II (BPDII) Disorders. It should be noted that diagnostic criteria for most mood disorders require the presence or absence of a mood episode. The ICD-10 has developed a severity scale from mild to severe and discerns the following disorders; Bipolar Affective Disorder, Depressive Episode, Recurrent Depressive Disorder, Persistent Mood [Affective] Disorders, Other Mood [Affective] Disorders and Unspecified Mood [Affective] Disorders. Previous editions of the DSM-IV-TR and ICD-10 include disorders, such as Endogenous Depression, Retarded Depression or Agitated Depression, that are no longer in use.

Mood disorder prevalence has been extensively researched (Mathers, Vos, Stevenson, & Begg, 2000; Zutshi, Eckert, Hawthorne, Taylor, & Goldney, 2011). Mathers, Vos, Stevenson, & Begg, (2000) reported mental disorders as the third leading cause of disease burden in Australia, (accounting for 14% of the total), primarily composed of affective, substance use and anxiety disorders. These statistics indicate a high prevalence of mental disorders in Australia, with an over-representation of disorders involving mood dysfunction, namely affective, mood and anxiety disorders. Major features of mood disorders include depressed mood, loss of interest or pleasure in nearly all activities, manic episodes or hypomanic episodes. The symptoms associated with mood disorders severely affect a person's quality of life and present a serious risk of suicide and self-harm (American Psychiatric Association, 2000), ultimately affecting the individual, their significant others, as well as the wider community, due to costs associated with the burden of disease (Vincent, 2011).

The present review examined the relationship between mood disorders and GSR. Using emotional stimuli and GSR simultaneously is a popular methodology in psychological research (Banks, Bellerose, Douglas, & Jones-Gotman, 2012). So much so, research has advanced to include clinical practice, with the use of clinical populations such as Autism (Kylliainen & Hietanen, 2006) and Anxiety Disorders (Chattopadhyay, Bond, & Lader, 1975; Bradley, Brown, Chu, & Lea, 2009), as well as mood disorders. Past GSR research in mood disorders include comparisons with healthy controls (HC) (Ward, Doerr, & Storrie, 1983; Thorell, Kjellman, & D'Elia, 1987; Tsai, Pole, Levenson, & Muñoz, 2003); comparisons between other psychopathologies and physical health disorders (Sigmon, Whitcomb-Smith, Boulard, *et al.*, 2007; Nandrino, Berna, Hot, Dodin, Latree, Decharles, & Sequeira, 2012); investigations into links between mood disorders and suicide (Wolfersdorf, Straub, Barg, Keller, & Kaschka, 1999); as well as investigating mood disorder predispositions (Craddock & Forty, 2006; Lau & Eley, 2010; Fontanella *et al.*, 2012). Comorbidity is another aspect of research, due to the high rate of mood disorder comorbidity with other psychological and physical disorders (Bonnet & Naveteur, 2004; Hofmann, Schulz, Heering, Muench, & Bufka, 2010).

The present review aimed to identify if individuals with a mood disorder diagnoses have a distinctive pattern or profile of GSR. In line with mood disorder presentations of depressed mood or flat affect (World Health Organisation, 1992; American Psychiatric

Association, 2000) it was expected that mood disorder patients would have a flat or depressed profile with greatest responses to negative emotional stimuli. In keeping with the nature of Bipolar I and II it was expected that GSR profiles of Bipolar patients would be flat in depressed state and elevated in manic state. Initially studies were divided into two categories dependent on nature of stimuli used: 1. Emotional Stimuli and 2. Non-Emotional Stimuli. Both categories were subcategorized into five areas of specific focus based on the sample used.

1. *No Comparison Groups.* This review examined GSR profiles exclusively in mood disorder patients with no comparisons with other populations. This aids in identifying GSR profiles for mood disorder patients. It was expected that mood disorder patients would have a flat GSR profile reflected in small, if any, GSR responses to stimuli as well as low EDA during baseline.
2. *Mood Disorders and Healthy Controls.* This review compared studies examining GSR profiles of mood disorder patients and Healthy Controls (HC). This helps confirm if a GSR profile exists for mood disorder patients and if it is significantly different to HC. GSR was expected to be lower for mood disorder patients in comparison to HC.
3. *Mood Disorders and other diagnoses.* This review examined studies reporting GSR of mood disorder patients as compared to other psychological and physical disorders. It was expected that mood disorder patient GSR would be significantly lower than GSR from other psychological and physical disorders.
4. *Within Mood Disorders category.* The current review examined studies reporting GSR within the mood disorders category; whereby GSR from different types of mood disorders (Seasonal Affective Disorder [SAD]; Unipolar Depression; Recurrent Depression; Bipolar I and II; Major Depressive Episode) even those no longer in use (Endogenous Depression; Retarded Depression; Agitated Depression; Neurotic Depression; Psychotic Depression) were compared, highlighting differences and similarities in underlying mechanisms or response patterns between these various mood disorders.
5. *Mood Disorders and associated variables.* The present review examined GSR in mood disorders as related to comorbidity, suicidality and, genetic predisposition. It was expected that GSR would be impacted when there was a comorbid disorder; that there would be a link between mood disorder patients' GSR and suicidality and lastly, that GSR would be significantly different for undiagnosed individuals with a genetic predisposition for mood disorders.

## METHOD

### *Procedure*

A systematic search for publications focusing on the Galvanic Skin Response (GSR) within mood disorders was conducted using PsychINFO, CINAHL and MEDLINE databases, recommended by Library One Search as the most appropriate and relevant electronic databases.

The Medical Subject Headings website was used to clarify key search terms. Key words used for the search were separated into two groups and joined by "AND"

operators. The first group of key search terms addressed GSR and consisted of “electrodermal activity” OR “galvanic skin response” OR “skin conductance response” OR “psychogalvanic reflex” OR “skin conductance level”. The second group of key search terms addressed mood disorders and consisted of “Affective Disorders” OR “Mood disorders” OR “Bipolar disorder” OR “depress” OR “manic depress” OR “Bipolar affective disorders” OR “Bipolar disorder” OR “major depressive disorder” OR “seasonal affective disorder”.

The search was refined using the following selection criteria: (i) publications from peer reviewed journals (ii) publications in English (iii) included participants with a formal diagnosis (iii) included a measurement of GSR (iv) included emotion evoking stimuli. If studies did not meet the last selection criterion (iv) (include an emotion evoking stimuli), only studies reporting GSR measurements recorded separately from stimuli presentation, such as during rest or baseline measures, were included. Some studies (Liberzon, Taylore, Fig, Decher, Koepp, & Minoshima, 2000; Malhi, Lagopoulos, Sachdev, Ivanovski, & Shnier, 2005; Eippert, Veit, Weiskopf, Erb, Birbaumer, & Anders, 2007) used GSR to measure emotion incorporating neuroimaging measures such as Magnetic Resonance Imaging (MRIs) and Functional Magnetic Resonance Imaging (fMRIs). However, the neurological implications of emotion are included in a different field. Thus only articles measuring and reporting GSR separately from neurological measurements were included. Consequently, to contain the scope of the current review, only empirical studies using a physiological measurements approach to investigate emotional reactivity in mood disorder populations were included. One study (Garralda, Connel, & Taylor, 1990) used child participants diagnosed with emotional disorder, as pathology is markedly different in children and adults and as this was the only study, without investigating genetic predispositions, focusing on children it was decided to exclude this from the review. Two studies were excluded as they were review papers, one of which is already mentioned in the introduction (Christie, 1981) and the other (Howland & Thase, 1991) reviews articles included in this review.

## RESULTS

Forty-one articles met inclusion criteria (see Table 1 for an overview) and were divided into two categories, based on nature of stimuli used, with five sub-categories, based on nature of sample population.

The Emotional stimuli category included twenty-one studies divided into five subcategories. The first subcategory used mood disorder patients exclusively and had only one study. Nine studies and sections from five studies were included in the second subcategory which compared healthy controls (HC) with mood disorder patients. Patients with different psychopathologies were compared with mood disorder patients in the third subcategory of four studies. The fourth subcategory, with two studies, examined comparisons between groups of patients with various mood disorders. The last subcategory examined mood disorders as they relate to comorbidity, suicidality and genetic predispositions.

Three studies focused on comorbidity while two focused on genetic predispositions. The Non-Emotional stimuli category included twenty studies divided into five similar subcategories. The first subcategory had only one study. Six studies and relevant sections from seven other studies were in the second subcategory. In the third subcategory there was one study and relevant sections from two other studies. Eight studies and sections from two other studies were in the fourth subcategory. In the last subcategory one study focused on comorbidity and three studies, together with a relevant section from an additional study, examined suicidality. This review will use the same terminology as the publishing authors in terms of GSR results and sample populations even though some terms, such as endogenous depression or retarded depression, are no longer used.

*Studies where Emotional Stimuli were Used.* This section included articles where an emotional stimulus was used to measure GSR in patients with mood disorders. The various measures of GSR, such as frequency or magnitude, are reported and discussed in the terms used by the article authors.

*Studies examining GSR in Mood Disorders.* In this section only one study used emotional stimuli to elicit GSR from mood disorder patients. Weidenfeller and Zimny (1962) studied groups of schizophrenia and mood disorder patients allowing for GSR to be examined exclusively in mood disorder patients. Two musical pieces were used; one exciting and one calming, to elicit emotional responses and GSRs. Results confirm the author's hypotheses of decreasing skin electrical resistance in mood disorder patients when presented with exciting music and an increase for calming music (Weidenfeller & Zimny, 1962). They also found mood disorder patients responded faster and with greater magnitude to exciting music however, responses to calming music were more consistent. These results highlight the link between GSR and emotional processes as well as indicate mood disorder patients' GSR changes depending on the stimulus. Examining GSR exclusively in mood disorder patients with the hope of identifying a GSR profile has shown a flat profile for calming stimuli and an elevated profile for exciting music.

*Studies comparing GSR in Mood Disorders with Healthy Control participants.* Fourteen studies compared GSR between mood disorder patient groups with healthy controls (HC) (Greenwald, 1936; Myslobodsky & Horesh, 1978; Rabavilas, Stefanis, Liappas, Perissaki, & Rinieris, 1982; Iacono, Peloquin, Lykken, Haroian, Valentine, & Tuason, 1984; Albus, Muller-Spahn, Ackenheil, & Engel, 1987; Tsai *et al.*, 2003; Malhi, Lagopoulos, Sachdev, Ivanovski, & Shnier, 2005; Sigmon *et al.*, 2007; Brankovic, 2008; McTeague, Lang, Laplante, Cuthbert, Strauss, & Bradley, 2009; Nissen, Holz, Blechert, Feige, Riemann, Voderholzer, & Normann (2010). Learning as a Model for Neural Plasticity in Major Depression. *Biological Psychiatry*, 6, 2010; Lagopoulos & Malhi, 2011; Lindsey, Rohan, Roecklein, & Mahon, 2011; Falkenberg, Kohn, Schoepker, & Habel, 2012). Neuroimaging was incorporated in two studies while another two studies used both emotional and non-emotional stimuli (Iacono *et al.*, 1984; Malhi *et al.*, 2005; Nissen *et al.*, 2010; Lagopoulos & Malhi, 2011).

Five studies included HC comparisons, despite this being only part of a wider study comparing mood disorders and other psychopathologies (Albus, Muller-Spahn, Ackenheil, & Engel, 1987; Greenwald, 1936); comparisons between different types of mood disorder (Myslobodsky & Horesh, 1978; Sigmon *et al.*, 2007); or comorbidity

Table 1. Study demographic information, diagnosis criteria, form of GSR used and results

Reference	Category	Sub-Category	Subjects	Diagnosis Criteria	Type of GSR Measured	Results
Widenfeller & Zmijewski (1962)	Emotional Stimuli Used	Mood Disorders	8 patients (4 female) diagnosed with Involitional, neurotic, Manic-depressive, and Reactive types of depressive illness. Mean age 32.	Patient population*	Tonic changes	Exciting music= Decrease in electrical resistance. Calming music= Increase in electrical resistance. Overall= Magnitude of change was greater for exciting music than for calming music. Responses to calming music were more consistent than responses to exciting music.
Falkenberg <i>et al.</i> (2012)	Emotional Stimuli Used	HC Comparison	16 MDD (8 female) age 37 (15) 16 matched HC (8 female) age 35(14) 23 MDD	SCID (German Version)	Phasic changes	MDD= Greater SCR in all conditions however, only cartoon condition contributed significantly in discrimination between groups.
Nissen <i>et al.</i> (2010)	Emotional Stimuli Used	HC Comparison	35 matched HC	ICD-10	Phasic changes	MDD= Enhanced conditioning when compared with HC
Lagopoulos & Malhi (2011)	Emotional Stimuli Used	HC Comparison	11 female BPD1 age 33.33 (9.23) 11 matched HC age 33.56 (6.73)	SCID-P	Phasic changes	No significant differences in number of GSRs evoked between groups.
Malhi <i>et al.</i> (2005)	Emotional Stimuli Used	HC Comparison	12 female remission BPD1 age 34.9 (9.1) 12 female matched HC age 33.7 (6.5)	SCID-P	Tonic and Phasic changes	BP1= A greater percentage increase in mean number of GSR due to a lower baseline. Mean number of GSR responses to affective words was identical for BP1 and HC.
Brankovic (2008)	Emotional Stimuli Used	HC Comparison	57 MDD (32 female) age 43.1 (10.9) currently in depressive episode. 52 HC (31 female) age 39.8 (8.1)	DSM-IV	Phasic changes	Significant SCR differences between groups based on the four parameters: Parameter A= higher in HC; Feedback Enhancement= higher in MDD; Feedback Inhibition= higher in MDD; Damping ratio= no sig difference; Period <sub>on</sub> = is longer in MDD
Tsai <i>et al.</i> (2003)	Emotional Stimuli Used	HC Comparison	12 depressed female Spanish-speaking Latinas 10 non-depressed female Spanish-speaking Latinas	PRIME-MD (DSM-IV)	Tonic changes	Neutral Film= Clip= No significant difference between groups. Emotional Film Clips= Across all film clips depressed subjects had lower SCL than nondepressed.
Rakavayas <i>et al.</i> (1982)	Emotional Stimuli Used	HC Comparison	12 involuntal depression patients (5 female) age 51.4 (8.6) 12 HC age 50.5 (8.2)	Patient population*	Tonic changes	Only patients higher basal GSR allow for differentiation between groups
Lindzey <i>et al.</i> (2011)	Emotional Stimuli Used	HC Comparison	24 S AD 24 HC Aged 18 or older	SCID	Tonic and Phasic changes	SAD= Greater SCR magnitude during overcast stimuli and lower SCR magnitude during sunny stimuli than HC. No significant interactions or main effects were found for SCL. SAD= Unique negative responses to overcast stimuli and a unique positive responses to sunny stimuli. Light intensity was a more salient cue than season in determining emotional reactions.
Iacono <i>et al.</i> (1984)	Emotional Stimuli Used	HC Comparison	22 UPD outpatients in remission 22 BPD outpatients in remission 26 HC.	RDC	Tonic changes	Unipolar and BP= Greater increase in conductance during balloon task
Greenwald (1936)	Emotional Stimuli Used	Between Disorder Comparison with Normal Data	50 psychiatric patients were used (SCH, manic-depressive psychosis, paranoia, organic disorder and psycho-neurosis)	Patient population*	Tonic changes	Manic depressive group= Ranges tended to cluster above or below mean depending on stage. (Depressed or agitated state) in response to reel I and not reel II. Reel I had greater range of responses than reel II. Response patterns did not allow for group differentiation based on critical diagnosis.
Albus <i>et al.</i> (1987)	Emotional Stimuli Used	Between Disorder Comparison. HC Comparison	12 acute SCH age 34 (8.5) 12 endogenous depressive age 48 (10.4) 9 anxiety neurosis patients age 37 (8.5) 69 HC age 37 (8.5)	ICD	Tonic and Phasic changes	SCR was significantly lower for anxiety and depressed patients than for schizophrenic and HCs.
Baegun, Baegun & Thorell (1998)	Emotional Stimuli Used	Between Disorder Comparison.	21 (7 female) in/out patients. Affective disorder= 7 (4 bipolar), Anxiety disorder=4. SCH= 10 Age 26 (5.6)	DSM-IV	Phasic changes	EDA did not significantly differ between diagnostic groups.

Table 1. Study demographic information, diagnosis criteria, form of GSR used and results (Cont.).

Reference	Category	Sub-Category	Subjects	Diagnosis Criteria	Type of GSR Measured	Results
Prunetti <i>et al.</i> (2010)	Emotional Stimuli Used	Between Disorder Comparison	60 patients (31 female) age 38.4 (9.7); GAD=24 (16 female); MDE=14 (9 female); PAD=12 (3 female); OCD=10 (3 female)	DSM-IV-TR	Tonic changes	All groups= Significant difference between "rest" and "stress". MDE= significant difference between "rest" and "recovery". GAD, PAD and OCD= Significant within group differences between various phases. GAD and PAD differed from MDE and OCD in all phases. GAD and PAD= More activation, greater response magnitude and higher extinction response. GSR recovery. GAD= Restoration of autonomic baseline.
Myslobodsky & Horesh (1978)	Emotional Stimuli Used	Mood Disorder Comparison HC Comparison Bilateral Comparison	19 depressed patients: 10 endogenous (7 female) 9 reactive (8 female) 14 HC (8 female).	Patient population*	Phasic changes	HC= more EDA on right hand in verbal task. Endogenous depression= more left hand EDA in verbal emotional task Reactive depression= no results in visual, verbal or tone conditions were significant.
Simmon <i>et al.</i> (2007)	Emotional Stimuli Used	Mood Disorder Comparison HC Comparison	45 participants: 15 MDD-SAD(2 female); 15 MDD(10 female); 15 HC(12 female) Age 38.93(13.20)	SCID-CV	Tonic and Phasic changes	Basal SCL=No significant differences MDD-SAD= higher SCR frequency and greater SCR amplitude for winter scenes than MDD and HC. MDD and HC no significant difference in SCR frequency or SCR amplitude for to winter scenes. No significant difference between groups for SCR frequency or SCR amplitude for summer scenes.
Hofmann <i>et al.</i> (2010)	Emotional Stimuli Used	Comorbidity	• 39 GAD patients age 28 (9.92); 14 of which met a comorbid MDD diagnosis	ADIS-IV-L	Tonic changes	SCL had a linear trend with increasing levels from base-line through relaxation and worrying to recovery. No significant difference between group base-line measures or during experimental procedure.
Campbell-Sills <i>et al.</i> (2006)	Emotional Stimuli Used	Comorbidity	60 patients (30 female) age 35.33 (11.74) diagnosed with a current anxiety or mood disorder; SOP=34; MDD=20; GAD=9; PAD=17; Specific phobia=10; OCD=10; DD=8	ADIS-IV-L	Tonic and Phasic changes	SCL generally increased from the anticipation phase to the exposure phase and remained at the same level through the recovery phase. Interaction effects for time x condition were not significant. Between-subjects effect of condition differences were not significant.
McTeague <i>et al.</i> (2009)	Emotional Stimuli Used	Comorbidity HC Comparison	75 SOP patients (25 circumscribed); 27 comorbid mood disorder (major depression, DD, or depressive disorder NOS) 75 HC	ADIS-IV	Tonic changes	Baseline SCL produced no reliable differences between patients and HC. Patients had greater skin conductance reactivity than HC There was little difference in skin conductance between patients with or without comorbid depression.
Zahn, Nurnberger & Bertetti (1989)	Emotional Stimuli Used	Genetic Predispositions Bilateral Comparison	22 high risk subjects (12 female) at least one parent with BPD Age 21.4 (2.5) 27 low risk subjects (10 female) first and second degree relatives were free of major psychiatric diagnosis. Age 19.7 (3.0)	RDC; SADS-L	Tonic and Phasic changes	No differences for SCL. No differences in spontaneous fluctuations during rest. High risk= more marked increase and higher levels in SCR's during mental arithmetic task (MAT). Lateralization= high risk showed a significant left-hand advantage in amplitude of SCR during MAT. This left-hand advantage was also seen in SCR frequency which increased during the MAT compared to pretask rest in high risk subjects which was significantly different from the decrease seen in low risk.
Zahn <i>et al.</i> (1991)	Emotional Stimuli Used	Genetic Predispositions Bilateral Comparison	22 high-risk subjects (12 female) at least one parent with BPD Age 21.4 (2.5) 62 HC (28 female) 1 <sup>st</sup> and 2 <sup>nd</sup> degree relatives free of major psychiatric diagnosis. Age 21.2 (3.2)	RDC; SADS-L	Tonic and Phasic changes	Only SCR frequency during the mental arithmetic task was higher in the high-risk group.
Hemsey & Philips (1975)	Non-Emotional Stimuli Used	Mood Disorder Longitudinal Case Study	1 male (age 27) manic-depressive psychosis-circular type diagnosis	Patient population*	Tonic and Phasic changes	Psychiatric rating and EDA correlation. EDA more affected by manic than depression



Table 1. Study demographic information, diagnosis criteria, form of GSR used and results (Cont.).

Reference	Category	Sub-Category	Subjects	Diagnosis Criteria	Type of GSR Measured	Results
Byrne <i>et al.</i> (2010)	Non-Emotional Stimuli Used	HC Comparison	127 adolescents (44 boys, age 14-18) formed two matched groups: 1. Depressed=54 (current UPD) 2. HC=73	DSM-IV	Tonic changes	EDA did not allow for differentiation between groups.
Biswas (1990)	Non-Emotional Stimuli Used	HC Comparison	84 patients (42 female) reported to be suffering from depression. Mean age 36.00 84 HC (42 male) mean age 36.20	Psychiatrist assessment*	Tonic and Phasic changes	Patients= non-significant lower SCL and significantly more SFs SCL was positively correlated with SFs for patients and HC's. Only resting measures included. In terms of resting spontaneous fluctuations the patient group was significantly different from the control group but there was no significant difference in skin conductance level.
Dawson <i>et al.</i> (1985)	Non-Emotional Stimuli Used	HC Comparison	• 20 MDD patients (16 female) age 63.8 (7.8) • 20 HC. Age 62.2 (7.6)	DSM-III and RDC	Tonic and Phasic changes	Depressed= lower SCL than HC The depressed patients, compared to the nondepressed normal controls, exhibit lower SCL.
Ward, Doerr & Shore (1983)	Non-Emotional Stimuli Used	HC Comparison <i>Mood Disorder Bilateral Comparison</i>	Inpatients (12 female) primary complaint of depression. Age 42.58, range 22-57 HC (33 female) aged 35.59, range 21-59	RDC and DSM-III	Tonic changes	No significant difference between right and left handed measurements for all subjects. HC mean SCL exceeded experimental group mean SCL. Experimental group had significant positive correlation between age and SCL, this was not found in HC. Women in both groups had significantly lower SCLs than men. Recurrent depression patients had significantly lower SCL than first episode depression patients. No significant differences between medicated and unmedicated patients.
Pazdacka-Robinson, Morrison & Flor-Henry (2004)	Non-Emotional Stimuli Used	HC Comparison <i>Between Disorder Comparison</i>	43 CFS patients, age 46.3 (9.6) 25 Depressed Patients, age 35.3 (10.5) 44 female HC, age 27.8 (9.3)	DSM-IV	Tonic and Phasic changes	CFS group was significantly different from average of HC and depressed groups. There was no distinction between the depressed and HC groups.
Ward & Doerr (1986)	Non-Emotional Stimuli Used	HC Comparison <i>Mood Disorder Comparison</i>	50 UPD patients (new experimental group 15 male and 22 female age 35.3; 26 inpatients and 11 outpatients). Control group 1=71 HC (33 female) age 35.5 Control group 2=34 "stressed" normal controls (163 male, 171 female) age 28.7.	RDC; DSM-III	Tonic changes	Depressed group= significantly lower mean SCL than both control groups Control groups= mean SCL did not significantly differ from each other. Depressed women= lower mean SCLs than depressed men. Stressed control group= no difference between men and women
Tome, Cooke & Lader (1981)	Non-Emotional Stimuli Used	Between Disorder Comparison <i>HC Comparison Bilateral Comparison</i>	22 SCH patients (14 female) age 35.8 11 depressed patients (8 female) age 40.6, all unipolar 4 manic patients (2 female) age 38.7 12 anxiety patients (6 female) age 30.1. 32 HC (18 female).	Diagnoses by consultant psychiatrist* PSE	Tonic and Phasic changes	Mean SCL at rest was found to be correlated with age in the depressive and schizophrenic patient groups.
Mitkin & Coppen (1980)	Non-Emotional Stimuli Used	Mood Disorder Comparison <i>HC Comparison</i>	18 depressive patients (13 female) classed as either endogenous or non-endogenous, age 58.6 (1.9) 15 HC (9 female) age 54.2 (1.7)	Patient population*	Tonic and Phasic changes	Patients did not differ significantly from controls. Non-endogenous= significantly lower pre-stimulus levels than controls and non-endogenous patients.
Perez Reyes & Cochrane (1967)	Non-Emotional Stimuli Used	Mood Disorder Comparison <i>HC Comparison</i>	190 patients: 108 Neurotic depressed 82 psychotic depressed 69 HC	Patient population*	Tonic and Phasic changes	No significant differences between groups for initial skin conductance or GSR frequency levels.

Table 7. Study demographic information, diagnosis criteria, form of GSR used and results (Cont.)

Reference	Category	Sub-Category	Subjects	Diagnosis Criteria	Types of GSR Measured	Results
Lapierre & Butter (1980)	Non-Emotional Stimuli Used	Mood Disorder Comparison IC Comparison	20 Retarded depressives (14 female) age 38.2; 20 Agitated depressives (15 female) age 237.8; 20 HC (15 female) age 24.1	DSM III	Tonic changes	Retarded depressive patients manifested a significantly higher basal skin resistance than controls. After experimental manipulations the agitated depressive's basal skin resistance was significantly lower than controls.
Thoroff & d'Elia (1988)	Non-Emotional Stimuli Used	Mood Disorder Comparison Active/Remission Comparison IC Comparison Suicidality	28 patients when depressive and when in remission matched for age, sex, and education 59 unmedicated HC	DSM-III	Tonic and Phasic changes	EDA was significantly higher at follow-up for patient group with no statistical difference from HC.
Bob, Jasova & Raboehi (2011)	Non-Emotional Stimuli Used	Mood Disorder Comparison IC Comparison Bilateral Comparison	44 outpatients: 26 depressive episode; 18 recurrent depression (11 patients in remission, 25 partial remission, 8 relapse) Age: 37.06 (8.72) 35 HC (20 female) age: 35.12 (8.10)	DSM-IV	Tonic changes	No significant differences in EDA were found to distinguish between groups.
Lapierre & Butter (1978)	Non-Emotional Stimuli Used	Mood Disorder Comparison Drug Comparison	40 depressed patients; 20 agitated depressives (15 female) age 37.8; 20 retarded depressives (14 female) age 38.2	Clinical history and clinical psychiatric examination*	Tonic and Phasic changes	FSR significantly lower in agitated depressives than that of HC. Spontaneous fluctuations not significantly different between each drug group. No marked differences between patient groups.
Berg, Wolfensdorf & Kuppe (1996)	Non-Emotional Stimuli Used	Mood Disorder Comparison Drug Comparison	48 MDE patients divided into three groups of 16 (8 female): 1) without meds age 36.1 (1.9); 2) with serotonergic antidepressant age 45.8 (10.2); 3) with nonadrenergic antidepressant age 45.4 (9.9)	DSM III-R	Tonic and Phasic changes	Lower SCL in nonadrenergic group than the serotonergic group and the group without antidepressants.
Syz (1926)	Non-Emotional Stimuli Used	Mood Disorder Comparison IC Comparison Bilateral Comparison	64 medical students 43 HC 20 paranoid SCH patients 7 catatonic stupor patients 15 depressed patients	Patient population*	Tonic and Phasic changes	Catonic stupor= average resistance twice as high as HC. Unusually large difference in resistance between left and right hands. Paranoid Schizophrenic= average resistance similar to HC.
Argyle (1991)	Non-Emotional Stimuli Used	Comorbidity IC Comparison	63 BAD subjects, 21 of which had MDE. 10 HC	DSM-III, SCID-UP	Tonic changes	Depressed patients= average resistance was not as high as catatonic stupor group but still higher than HC. MDE patients= significantly more attacks of MDE than the SCID-UP group.
Keller et al. (1991)	Non-Emotional Stimuli Used	Suicidality	24 attempted suicide patients, Divided into violent and nonviolent method groups. 18 patients with suicidal thoughts; 18 nonsuicidal patients	ICD-9	Tonic and Phasic changes	No significant difference between the three groups for any EDA variables.
Jandi, Sleyer & Katselkat (2010)	Non-Emotional Stimuli Used	Suicidality	50 MDD patients three groups: 1) 16 (9 female) 'Hard attempted suicide', age 47.3 (11.9); 2) 16 (11 female) 'Soft attempted suicide', age 49.8 (8.0); 3) 18 (12 female) no attempted suicide, age 47.9 (11.6)	DSM-IV	Phasic changes	No significant difference in SCL between violent and nonviolent attempted suicide patients.
Wolfensdorf, Straub & Barg (1996)	Non-Emotional Stimuli Used	Suicidality Between Disorder Comparison	11 female PD suicide history patients (PD) nonsuicidal depression patients (DNA) suicidal depression patients (DSA) Female suicidal and nonsuicidal SCH patients	ICD-10	Tonic and Phasic changes	No significant difference between the three patient groups. SCL= PD significantly different from DNA and DSA. SFL= PD significantly different from DNA and not significantly different from DSA. PD SCL and SFL comparison with schizophrenic suicidal and nonsuicidal was only significantly different for suicidal schizophrenic SCL. EDA variables especially when the DNA and DSA comparisons are made.

\*Notes: \*Formal diagnosis assumed due to patient status psychiatric assessment. Major Depressive Disorder (MDD), Minor Depressive Episode (MDE), Generalized Anxiety Disorder (GAD), Obsessive Compulsive Disorder (OCD), Bipolar Disorder (BPD), Bipolar Disorder I (BPD-I), Unipolar Disorder (UPD), Seasonal Affective Disorder (SAD), Dysthymic Disorder (DD), Social Phobia (PAD), Social Phobia (SOP), Personality Disorder (PD), Chronic Fatigue Syndrome (CFS), Schizophrenia (SCH) Diagnostic and Statistical Manual of Mental Disorders (DSM-III; DSM-III-R; DSM-IV; DSM-IV-TR), Structured Clinical Interview for DSM (SCID; SCID-P; SCID-CV; SCID-UP), Primary Care Evaluation of Mental Disorders (PRIME-MD), Research Diagnostic Criteria (RDC), International Classification of Disease (ICD; ICD-9; ICD-10), Anxiety Disorders Interview Schedule (ADIS-IV; ADIS-IV-L), Schedule for Affective Disorders and Schizophrenia (SADS-L), Present State Examination (PSE).

comparisons (McTeague *et al.*, 2009). Only sections pertaining to HC comparisons were reported in this section.

Using “neutral expression” and “disgust expression” facial images, Lagopoulos and Malhi (2011) compared female Bipolar I Disorder (BPDI) patients to matched HC. No significant differences were found between the two groups in terms of total GSRs or GSRs in response to disgust stimuli (Lagopoulos & Malhi, 2011). Malhi *et al.* (2005) also compared female remitted Bipolar patients with HC using an eStroop task. The eStroop task is based on the conventional Stroop task, but uses emotional, positive and negative, as well as neutral words. Both HC and patient groups had an increase in GSR for affective words, however the percentile increase was greater for bipolar patients due to lower baseline measures (Malhi *et al.*, 2005). Although all participants had more GSRs for emotional words, there was no significant difference between groups based on word valence.

Iacono *et al.* (1984) and Nissen *et al.* (2010), used a combination of emotional and non-emotional stimuli. Groups of bipolar patients, unipolar patients and HC were presented with different tones and sounds in addition to a stress inducing task; blowing up a balloon until it burst (Iacono *et al.*, 1984). Skin conductance increased for all participants (excepting one bipolar patient) during the balloon task. However, this increase was significantly larger for HC than either patient group. In Nissen *et al.*'s study (2010), a fear conditioning paradigm was the emotional condition. Comparing Major Depressive Disorder (MDD) patients with HC, results indicated MDD patients had significantly stronger Skin Conductance Responses (SCRs) to conditioned stimuli than non-conditioned stimuli compared to HC (Nissen *et al.*, 2010).

Facial expression images (happy and neutral) as well as funny and neutral cartoons were used by Falkenberg *et al.* (2012) to compare MDD patients with HC. Due to the intermixed presentation of cartoon and neutral images, analysis of reactivity between the two types of stimuli was not conducted, thus results are reported in terms of cartoon condition as well as the happy and neutral conditions. Results indicate, for all participants, the cartoon condition elicited positive SCRs where both the happy and neutral conditions elicited significantly different negative SCRs. The happy and neutral conditions were not significantly different (Falkenberg *et al.*, 2012). MDD patients had higher SCRs in the cartoon condition than HC thus allowing for group discrimination (Falkenberg *et al.*, 2012). Rabavilas *et al.* (1982) used basal GSR measures to discriminate between patient population, [in their case involuntional depression patients, a diagnosis that has been absorbed into the MDD diagnosis (Hirshbein, 2009)] and HC. Stimuli used included individually determined neutral and stressful stimuli such as, “a recent event related to loss” or “an event related to adverse feelings (‘hostility’)” predetermined during prior interviews. GSR in response to stimuli however, did not allow for group discrimination. Participants were first asked to concentrate on predetermined stimulus and secondly to complete a “mental task”, -while subsequent GSR was measured and recorded (Rabavilas *et al.*, 1982). The basal GSR was significantly higher for patients than HC. GSR responses to stimuli indicated patients’ significantly higher responses to “loss” and “mental task” stimuli whilst HC greatest response was during “mental task”. For both groups neutral stimuli produced the lowest GSR.

Brankovic (2008) used GSR to develop five characterizing parameters of Electrodermal Activity (EDA) when comparing depression patients with HC utilizing eleven evocative short stories. The first parameter is the initial GSR response, and was larger in HC than depression patients. The second parameter, labelled as “Enhancement (E)”, is a positive feedback loop, proportional to emotional arousal rates of change. This means that after the initial GSR response, feedback into the GSR response is positive and has an enhancing effect. Depression patients had greater feedback Enhancement (E) than HC. Depression patients also responded higher on the third parameter “Inhibition (I)”, also a feedback loop however, a negative one and proportional to actual levels of emotional arousal. “Period50%”, the length of time needed for the magnitude of GSR responses to decrease to half of the original response magnitude, also produced statistical differences between groups. Period 50% was longer in depression patients than HC. The last parameter, “Damping ratio”, produced no significant differences between the two groups. Comparisons between male and females, for both groups, were conducted for all parameters, with no significant findings (Brankovic, 2008).

Spanish-speaking Latinas (females with Latino descent), with and without depression, were compared by Tsai *et al.* (2003) using sad, amusing and neutral film clips. No differences were found between groups for skin conductance level (SCL) during the neutral film clip. Expectations were that participants with depression would have increased SCL (representing more negative emotion) for sad film clips and decreased (representing less positive emotion) for amusing clips; however participants with depression showed an overall decrease in SCL over all emotional clips while participants without depression showed an increase (Tsai *et al.*, 2003). Less positive emotion equals less physiological activation.

Seasonal Affective Disorder (SAD) patients participated in two studies (Sigmon *et al.*, 2007; Lindsey *et al.*, 2011) both of which used scenic images as stimuli. Lindsey *et al.*'s (2011) scene images varied in light intensity and season. Participants were asked to imagine thoughts and feelings should they find themselves in the scene. Results showed SAD patients had more frequent and greater magnitude skin conductance responses (SCRs) for overcast scenes than HC. SAD patients had lower magnitude SCRs during sunny scenes than HC. No significant differences were found between the groups when SCL was compared. Along with SAD patients and HC, Sigmon *et al.* (2007) include a non-SAD depression group and used summer and winter scene images. Similarly, no significant differences between HC and depression groups were found for baseline SCL however, SAD patients' number and magnitude of SCRs to winter scenes were significantly greater than HC. Non-SAD depression participants and HC did not differ in number or magnitude of SCRs to winter scenes. HC were not significantly different in number or magnitude of SCRs, to summer scenes when compared with SAD and non-SAD depression participants.

A number of studies, including Sigmon *et al.* (2007), contain healthy controls (HC) comparisons within wider study scopes (Greenwald, 1936; Myslobodsky & Horesh, 1978; Albus *et al.*, 1987; McTeague *et al.*, 2009). Myslobodsky and Horesh's (1978) study used multiple stimuli in which verbal and visual tasks were emotionally salient. Bilateral EDA analysis showed more EDA asymmetry in the verbal task, for

all participants (Endogenous depression patients, Reactive depression patients and HC). HC bilateral EDA was task dependent with more right-hand EDA during the verbal task and more left-hand EDA during the visual task. Conversely, Endogenous depression patients had no change in hand dominance across tasks but, indicated a left-hand bias for all tasks. The verbal task produced significant bilateral differences between groups; HC having more right-hand EDA and Endogenous depression patients more left-hand EDA. Interestingly, Reactive depression patients did not significantly differ from HC for any of the tasks (Myslobodsky & Horesh, 1978). With social phobia and mood disorder comorbidity as a primary focus, McTeague *et al.* (2009) include HC when narrative imagery scripts; such as social or survival threats as stimuli were used with co-morbid social phobia patients. Results indicate no significant difference for baseline Skin Conductance Level (SCL) between patients and HC. However, patients appeared to have greater skin conductance responses (SCRs) particularly for social threat and personal fear stimuli. Otherwise response patterns were similar for patients and HC. These results should be considered with caution as comorbid and non-comorbid patients were not distinguished when compared to HC (McTeague *et al.*, 2009). Rest and a mental arithmetic task were two experimental conditions in Albus *et al.*'s (1987) study comparing schizophrenia, endogenous depression and anxiety patients with HC. During rest and the mental arithmetic task, depression and anxiety patient groups had significantly lower SCR than HC (Albus *et al.*, 1987). Although HC were not used in Greenwald's (1936) study, normative data was used for comparison with a number of diagnostic patient groups including schizophrenia, manic-depressive psychosis, paranoia, organic disorder and psychoneurosis. Findings showed during depression stages mean electrodermal levels (EDLs) clustered around the HC mean, often falling below it (Greenwald, 1936).

Studies in this section allow us to determine if the GSR profile present for mood disorder patients is significantly different from HC. In summary, results from the fourteen studies with HC comparisons using emotional stimuli indicate Mood disorder patients have significantly different GSR patterns when compared to HC. Bilateral analysis indicated HC to have greater right-hand EDA and mood disorder patients to have greater left-hand EDA. The last study did not clearly state a statistical analysis with normative data thus their findings must be considered with circumspection.

*Studies comparing GSR in Mood Disorders with other Psychopathologies.* Four studies (Greenwald, 1936; Albus *et al.*, 1987; Bogren, Bogren, & Thorell, 1998; Pruneti, Lento, Fante, Carrozzo, & Fontana, 2010) used emotional stimuli to compare GSR between mood disorders and other psychological disorder groups. Albus *et al.* (1987) compared schizophrenia, endogenous depression and anxiety patients in terms of SCL and SCR using a number of different stimuli including a mental arithmetic task. They found depression and anxiety patients had significantly lower SCR than schizophrenia patients however, no other comparisons resulted in significant findings (Albus *et al.*, 1987). Also comparing schizophrenia, mood disorder and anxiety patients, Bogren *et al.* (1998) used a defence mechanism test involving two pictures with a younger character identifiable as a hero and another older person identifiable as a threat against the hero. EDA results did not show any significant differences between diagnostic groups (Bogren *et al.*, 1998).

Using two film clips, Greenwald (1936) compared schizophrenia, manic-depressive psychosis, paranoia, organic disorder and psychoneurosis diagnostic groups. Although distinguishing groups from response patterns was unsuccessful, Greenwald (1936) noticed patients in the depressive stage of manic-depression presented “flat” GSR profiles clustered around zero or the baseline. Conversely those in the manic stage had greater ranges of responses with averages above zero. Clustering of manic-depression patients dependent on disorder phase was more apparent for first film clip (suggestive or erotic) than for the second (danger scenes). It should also be noted that although the two film clips were described as having love-scenes; danger/conflict scenes; pagan feasting/worship scenes; and scenes involving the destruction of a city, GSR responses for all participants had a greater range to the first film clip than the second - the latter being more focused on scenes of danger (Greenwald, 1936).

A wider range of psychological diagnostic groups: Generalized Anxiety (GAD), Major Depression Episode (MDE), Panic Disorder (PAD) and Obsessive-Compulsive Disorder (OCD), were compared by Pruneti *et al.*, (2010). A mental arithmetic task used to create a stress condition, comprised of three phases; baseline, stress and recovery. Multiple significant differences were seen in GSR between different phases for all groups (Pruneti *et al.*, 2010). In comparing the different diagnostic groups with each other, GAD and PAD had generally greater autonomic activation in terms of magnitude and extinction of response than MDE and OCD. Again groups appeared to be divided with GAD and PAD on one side and MDE and OCD on the other in terms of baseline, response and recovery patterns. Only GAD and PAD subjects had a GSR recovery (reduction in GSR in recovery phase) and only the GSR’s participants with GAD returned to baseline measures (Pruneti *et al.*, 2010).

The studies in this section allow us to determine if the GSR profile for mood disorder patients is significantly different from GSR from patients with other pathologies. In summary, four studies compared GSR from mood disorder patients with that from other psychological disorder patients when an emotional stimulus was used. Two studies found no significant differences in GSR between mood disorder patients and other psychological disorder patients (Greenwald, 1936; Bogren *et al.*, 1998). Another two studies found mood disorder patients had similar responses to anxiety (Albus *et al.*, 1987) and OCD (Pruneti *et al.*, 2010) patients however these responses were significantly different from Schizophrenia (Albus *et al.*, 1987), PAD and GAD (Pruneti *et al.*, 2010). This highlights the inconsistency of findings in relation to anxiety disorders. Lastly one study indicated changes in GSR depending on mood state, with less activation during depressive states and more activation during manic states.

*Studies comparing GSR between various Mood Disorders.* Only two studies used emotional stimuli to compare GSR between different types of mood disorders (Myslobodsky & Horesh, 1978; Sigmon *et al.*, 2007). As mentioned before, in Sigmon *et al.*'s (2007) study GSR responses are compared between HC, SAD and non-SAD depression patients. Findings show SAD patients having greater number and magnitude SCRs to winter scenes than non-SAD depression patients. Conversely, there was no significant difference between SAD and non-SAD depression patient groups for baseline SCL as well as number and magnitude of SCRs to summer scenes. Myslobodsky and Horesh

(1987) also mentioned before, compared groups of endogenous depression patients with reactive depression patients as well as with HC. Bilateral analysis between depression groups showed endogenous depression patients had left-hand bias (more EDA on the left-hand) for verbal and visual tasks whereas there were no significant differences for reactive depression patients (Myslobodsky & Horesh, 1978).

The studies in this section help establish if mood disorder GSR profiles vary depending on the specific mood disorder present. In summary results indicate specific GSR differences between different types of mood disorder become apparent when emotional stimuli are used. Baseline measures from the two studies (Myslobodsky & Horesh, 1978; Sigmon *et al.*, 2007;) showed no differences between types of mood disorder. SAD patients had distinguishing GSR from non-SAD depression patients only when winter scenes were used and only when bilateral GSR was compared were endogenous and reactive depression patients significantly different.

*Studies examining GSR in Mood Disorders as it relates to Comorbidity, Suicidality and Genetic Predispositions.* Three studies used emotional stimuli whilst examining GSR in mood disorders comorbid with other psychological disorders (Campbell-Sills, Barlow, Brown, & Hofmann, 2006; McTeague *et al.*, 2009; Hofmann *et al.*, 2010). Hofmann *et al.* (2010) compared GAD patients with and without a comorbid MDD (Major Depressive Disorder) using worry and relaxation experimental conditions. After baseline measures, participants were given either worry or relaxation instructions, such as asked to worry about “their most worrisome topic” for five minutes, these topics having been identified in a prior interview. For both groups a significant linear trend was seen for SCL -increasing through baseline, relaxation, worrying and recovery phases. No significant differences in SCL for each experimental condition between the two groups were found (Hofmann *et al.*, 2010).

Participant criteria for Campbell-Sills *et al.*'s (2006) study included a current mood or anxiety diagnosis, the most frequent being social phobia, MDD, GAD, PAD and dysthymic disorder (DD). Most participants met more than one current diagnosis, some even as many as five. A specifically selected film clip eliciting negative affect was presented to participants, who were randomly assigned to either the suppression group (encouraged to control emotional reactions) or the acceptance group (encouraged to experience emotional reaction). For all participants SCL was linear, with increases from anticipation to exposure, reaching a plateau through the recovery phase. There were no significant differences between the suppression and acceptance groups (Campbell-Sills *et al.*, 2006). McTeague *et al.* (2009) compared social phobia patients with and without comorbid depression. Results showed little difference in terms of skin conductance between patients with comorbid depression and those without.

An emotional stimulus was used to elicit GSR from patient populations with various comorbidity issues in three studies (Campbell-Sills *et al.*, 2006; McTeague *et al.*, 2009; Hofmann *et al.*, 2010). Results from these studies indicate that patients with comorbid mood disorders show no significantly different patterns in GSR from patients without comorbid mood disorders. Two studies did however show significant linear trends in GSR through baseline, experimental condition and recovery for both comorbid and non-comorbid patients.

Two studies used emotional stimuli to examine GSR in terms of mood disorder genetic predisposition compared with HC (Zahn, Nurnberger, & Berrettini, 1989; Zahn, Nurnberger, Berrettini, & Robinson, 1991). Zahn *et al.* (1989) and Zahn *et al.* (1991) both compared high-risk, children of at least one parent with bipolar affective disorder, and low-risk children (HC) with first and second degree relatives free of psychiatric diagnosis. Bilateral EDA measurements were taken in both studies and although both studies utilize various tasks, only the mental arithmetic task, used to elicit stress, had emotional valence. Zahn *et al.* (1989) found no significant difference in SCL between groups however the high-risk group had a greater increase and magnitude of spontaneous fluctuations in SCRs than HC. Bilaterally the high-risk group had left-hand bias in SCR magnitude during the mental arithmetic task, which HC did not. Groups differed significantly with the high-risk group left-hand bias increasing during the task, compared to the before task rest period, however, for HC there was a decrease. In terms of frequency of SCRs, the high-risk group, during the mental arithmetic task, had significantly increased SCRs (Zahn *et al.*, 1989). The findings for Zahn *et al.* (1991) are similar in that only SCR frequency produced significant differences between the two groups; the high-risk group have more frequent SCRs.

Comparing individuals considered to be at high-risk for developing mood disorders and those as low-risk indicated that those at high-risk have significantly different SCRs; either greater magnitudes (Zahn *et al.*, 1989) or more frequency (Zahn *et al.*, 1991). It also appears that those at high-risk have a left hand bias.

Studies in this section help determine if GSR profiles are affected by comorbidity as these are common phenomena in mood disorder patients and thus may confound the interpretation of GSR. There is also the possibility that GSR may be used as an indicative tool for individuals at greater risk of developing a mood disorder.

*Studies where Non-Emotional Stimuli was used.* This section included articles that used non-emotional stimuli to measure GSR in mood disorder patients. As per inclusion criteria all studies have conducted and reported GSR measurements unconnected to non-emotional stimuli presentation. This section was included as it provides valuable information as regards GSR in mood disorders specifically through baseline measurement and analysis.

*Studies examining GSR in Mood Disorders.* Only one study used non-emotional stimuli, a reaction time test, to measure GSR on a patient with a mood disorder. A longitudinal single case study of a 27-year-old man diagnosed with manic-depressive psychosis, over a period of five months was conducted by Hemsley and Philips (1975). Only basal SCL measurements are relevant to this review and comparisons from beginning and end of rest periods showed no significant results thus, no EDA adaptation occurred. Developing a discriminatory index for depressive and manic phases Hemsley and Philips (1975) indicate EDA is more affected by manic phases than depressive phases. Lastly Hemsley and Philips (1975) were able to use drug and drug free data; finding drug-free data significantly increased spontaneous EDA fluctuations during the last period of rest, however significance was lost when using drug data. These results indicate the impact of drugs or medication on GSR. This section aims to identify a GSR profile for mood disorder patients when emotional stimuli are absent.



*Studies comparing GSR in Mood Disorders with Healthy Control participants.* Thirteen studies used non-emotional stimuli to elicit GSR from mood disorder patients and healthy control (HC) participants (Syz, 1926; Pérez Reyes & Cochrane, 1967; Lapierre & Butter, 1980; Mirkin & Coppen, 1980; Ward *et al.*, 1983; Dawson, Schell, Braaten & Catania, 1985; Ward & Doerr, 1986; Thorell & d'Elia, 1988; Biswas, 1990; Argyle, 1991; Pazderka-Robinson, Morrison, & Flor-Henry, 2004; Byrne *et al.*, 2010; Bob, Jasova, & Raboch, 2011;). In Byrne *et al.*'s (2010) study adolescents diagnosed with unipolar depression and HC were compared with no significant differences found in baseline SCL. Although depressed patients had lower baseline SCL, Biswas' (1990) found the difference was nonsignificant. Spontaneous fluctuations however were significantly greater in the patient population compared to HC (Biswas, 1990). Dawson *et al.*, (1985) found depressed patients had significantly lower SCL compared to HC. Bilateral and gender comparisons were conducted by Ward *et al.* (1983) with bilateral analysis showing no significant results. Mean SCL however, was lower for the depression group than for HC (Ward *et al.*, 1983). Women in both groups had significantly lower SCL than men. Ward *et al.* (1983) also conducted a correlational analysis and found a positive correlation for the depression group between SCL and age, this correlation was not found in HC.

Six of the thirteen studies include HC comparisons while conducting a comparison between different types of mood disorder (Pérez Reyes & Cochrane, 1967; Lapierre & Butter, 1980; Mirkin & Coppen, 1980; Ward & Doerr, 1986; Thorell & d'Elia, 1988; Bob *et al.*, 2011) however Bob *et al.* (2011) conducted no statistical comparison between unipolar depression patients and HC. Thorell and d'Elia (1988) studied EDA variables in depression patients when in the depressive state and when in remission, which they compare to HC. No significant differences in any EDA variables between patients at follow up and HC were found. However, patient's EDA levels at follow up were closer to HC levels than when in depression (Thorell & d'Elia, 1988). Comparing SCL, Mirkin and Coppen (1980) found endogenous depression patients had significantly lower SCL than HC but, when included in a combined depression patient group, there were no differences from HC. Neurotic depressed patients, psychotic depression patients and HC were compared by Pérez Reyes and Cochrane (1967). Results indicated no significant difference between HC and either patient group, in terms of average SCL or number of GSRs during rest (Pérez Reyes & Cochrane, 1967). SCLs in unipolar depression patients, HC and "stressed" HC were compared by Ward and Doerr (1986). "Stressed" HC were first time parents of newborns. The depression group had significantly lower mean SCL compared to the two HC groups, which did not differ (Ward & Doerr, 1986). Depressed women SCLs were significantly lower than depressed men though this difference was not seen in "stressed" HC. A correlation between SCL and age was established but varied depending on group. The depressed group SCL increased with age and in the "stress" HC it decreased however, there was no significant relationship between age and SCL in HC (Ward & Doerr, 1986). Lastly, using resistance measures Lapierre and Butter (1980) found patients categorized with retarded depression had significantly higher basal skin resistance than HC.

Two of the thirteen studies are primarily concerned with comparisons between mood disorders and other disorders both psychological (Syz, 1926) and physical (Pazderka-Robinson *et al.*, 2004) however also include HC comparisons. In comparing catatonic stupor patients with HC and depression patients, Syz (1926) found catatonic stupor patients had an average resistance twice as high as HC. Unlike the previous two studies, Pazderka-Robinson *et al.* (2004) included a physical disorder patient group (Chronic Fatigue Syndrome [CFS]) in their study with depression patients, and HC. Their findings indicated no significant differences between depression patients and HC in resting SCL.

The last study included HC comparisons while addressing comorbid MDE and social phobia as the primary focus of research (Argyle, 1991). Participants were tested in two environments; the first was a small sound attenuated room with no external windows; the second was a bigger office with no external windows but lit by a skylight. All participants were tested in the second environment but 10 panic patients (4 comorbid MDE) and 10 HC were tested in both environments. Both HC and patients had significantly higher SCL in the first environment however; comparing the groups resulted in no significant difference (Argyle, 1991).

The studies in this section compare mood disorder patients with HC with the aim of identifying if the GSR profile for mood disorder patients is significantly different from HC. The twelve studies that conducted statistical comparisons between mood disorder patients with HC had five with significant findings (Syz, 1926; Lapierre & Butter, 1980; Mirkin & Coppen, 1980; Dawson *et al.*, 1985; Ward & Doerr, 1986), five with nonsignificant findings (Pérez Reyes & Cochrane, 1967; Thorell & d'Elia, 1988; Argyle, 1991; Pazderka-Robinson *et al.*, 2004; Byrne *et al.*, 2010) and two had both significant and nonsignificant findings (Ward *et al.*, 1983; Biswas, 1990). Results highlight the impact of age and gender on GSR patterns, generally, however, results from the studies struggled to identify a GSR profile for mood disorder patients.

*Studies comparing GSR in Mood Disorders with other Psychopathologies.* Using non-emotional stimuli three studies compare GSR between mood disorder and other psychological (Toone, Cooke, & Lader, 1981; Wolfersdorf, Straub, & Barg, 1996) and physical disorders (Pazderka-Robinson *et al.*, 2004). Toone *et al.* (1981) compare schizophrenia, depression and anxiety patients as well as HC but are not included in the above section, as no statistical analysis was conducted between patient groups and HC for resting SCL. Only the depression and schizophrenia patients showed a significant negative correlation between age and mean SCL at rest. No other results specific to mean SCL at rest are reported. Although focused on suicidality, Wolfersdorf *et al.* (1996) compared personality disorder patients with past suicide attempts with non-suicidal depression patients. SCL and spontaneous fluctuations were measured during rest and showed non-suicidal depression patients had significantly lower mean SCL and spontaneous fluctuations (Wolfersdorf *et al.*, 1996). Comparing Chronic Fatigue Syndrome (CFS) and depression patients, Pazderka-Robinson *et al.* (2004) found CFS patients had significantly lower SCLs than depression patients.

Studies in this section allow for distinction between the GSR profile for patients with a mood disorder as compared to patients with other mental health and physical pathologies. Results from studies comparing mood disorder GSR with other psychological

and physical disorder GSR indicate that, although there are some similarities such as matching correlations (Toone *et al.*, 1981), there are also some distinct differences. Depression patients were found to be significantly different from personality disorder patients (Wolfersdorf *et al.*, 1996) and CFS patients (Pazderka-Robinson *et al.*, 2004).

*Studies comparing GSR between various Mood Disorders.* Ten studies compare GSR between different types of mood disorders using non-emotional stimuli (Syz, 1926; Perez-Reyes & Cochrane, 1967; Lapierre & Butter, 1978; Lapierre & Butter, 1980; Mirkin & Coppen, 1980; Ward *et al.*, 1983; Ward & Doerr, 1986; Thorell & d'Elia, 1988; Barg, Wolfersdorf, & Ruppe, 1996; Bob *et al.*, 2011). Two of these studies however, are primarily healthy control (HC) comparison studies (Ward *et al.*, 1983; Ward & Doerr, 1986). Incorporating complex partial seizure-like symptom inventory (CPSI) to assess epileptiform activity, Bob *et al.* (2011) conduct EDA measurements in unipolar depression patients, divided into depressive episode and recurrent depression groups. No association between condition, relapse and remission, and EDA changes was found (Bob *et al.*, 2011). Classifying a group of endogenous depression patients as either agitated or retarded, Lapierre and Butter (1978) found skin resistance was significantly lower in agitated depression patients.

Five studies comparing GSR in different types of mood disorder also contained HC comparisons and thus have been previously mentioned (Syz, 1926; Pérez Reyes & Cochrane, 1967; Lapierre & Butter, 1980; Mirkin & Coppen, 1980; Thorell & d'Elia, 1988). Barg *et al.* (1996) compare three groups of depression patients; unmedicated, serotonergic antidepressant (paroxetine) and noreadrenergic antidepressant (imipramine or reboxetine). SCL at rest showed noradrenergic group had significantly lower levels than the other two groups (Barg *et al.*, 1996). Mirkin and Coppen (1980) comparing endogenous and non-endogenous depression patients found endogenous depression patients had significantly lower SCL at rest than non-endogenous depression patients. Neurotic depression patients were compared to psychotic depression patients by Pérez Reyes and Cochrane (1967), with no significant differences for average SCL or number of GSRs. A correlation between SCL and mean number of GSRs per minute for each group was conducted, again with no significant findings (Perez-Reyes & Cochrane, 1967). Basal skin resistance was compared in retarded depression patients, agitated depression patients and HC by Lapierre and Butter (1980). Findings showed that retarded depression patients significantly differed from HC, with higher basal skin resistance, but agitated depression patients did not (Lapierre & Butter, 1980). However, after experimental manipulations, agitated depression patients' basal skin resistance was significantly lower (Lapierre & Butter, 1980). Bilateral comparisons by Syz (1926) showed catatonic stupor patients' difference in level of resistance between the two hands was unusually large. Other comparisons showed depression patient's average resistance was not as high as catatonic stupor patients (Syz, 1926). Unlike the previous studies, Thorell and d'Elia (1988) compared separate GSR measurements from the same group of depression patients; firstly while in remission and secondly in depression. Results at follow up showed that SCL was significantly higher than during depression and in patients experiencing recurrent depressive episodes a significant increase in SCL was seen, reaching the same levels as HC (Thorell & d'Elia, 1988).

Ward and Doerr (1986) compared recurrent depression and nonrecurrent depression patients using separate criteria for male and female SCL. Results showed SCLs in men with recurrent depression were lower than for men with nonrecurrent depression. Comparisons of depression subgroups resulted in women with endogenous depression having lower SCLs than those without. Ward and Doerr (1986) however, recommend that these results be considered cautiously as, under a Bonferoni procedure these results were no longer significant. In another study Ward *et al.* (1983) compared depression subgroups. No significant differences were found in SCL between medicated and unmedicated patients. Recurrent depression patients however, had lower SCLs than first episode depression patients and this was significant. Further analysis indicated this result to be confounded by unequal gender distribution. There were also no significant differences in the depression subgroup comparisons such as endogenous-nonendogenous, primary-secondary, situational-nonsituational and with anhedonia-without anhedonia (Ward *et al.*, 1983).

Studies in this section aim to establish if the GSR profile for mood disorder patients is significantly different depending on the specific mood disorder. Six of the ten studies had significant findings (Syz, 1926; Lapierre & Butter, 1978; Mirkin & Coppen, 1980; Ward & Doerr, 1986; Thorell & d'Elia, 1988; Barg *et al.*, 1996) and three had nonsignificant findings (Pérez Reyes & Cochrane, 1967; Ward *et al.*, 1983; Bob *et al.*, 2011). The last study had both significant and nonsignificant findings (Lapierre & Butter, 1980). Results highlight the impact of drugs and gender on GSR as well as bilateral differences however, distinct differences between mood disorders based on GSR was not clearly established.

*Studies examining GSR in Mood Disorders as it relates to Comorbidity, Suicidality and Genetic Predispositions.* Only one study used non-emotional stimuli in studying GSR in comorbid disorders (Argyle, 1991). Panic disorder patients with or without comorbid Major Depressive Episode (MDE) were tested in two environments by Argyle (1991). SCL scores were divided into upper and lower quartiles, the lower quartile had non-significantly more MDEs. The number of patients with MDE was too low for analysis, however the patients with SCL lower than the mean for the whole group, appeared to have a later onset of panic disorder than those above the mean (Argyle, 1991). These results indicate lower SCL for patients with comorbid MDE however, as the sample was small, results were not significant so should be considered with caution.

Four studies examined suicidality in mood disorders using GSR (Thorell & d'Elia, 1988; Keller, Wolfersdorf, Straub, & Hole, 1991; Wolfersdorf *et al.*, 1996; Jandl, Steyer, & Kaschka, 2010). Thorell and d'Elia (1988) compared depression patients, in depression and in remission, and HC but they also conducted analysis on participants who were suicidal. EDA for participants who attempted suicide was not significantly different at follow-up and, even then, it was not significant when compared to HC (Thorell & d'Elia, 1988).

MDD patients were divided by Jandl *et al.* (2010) into three groups based on past suicidal history; "hard" attempted suicide history (including hanging, shooting, drowning as examples); "soft" attempted suicide (this was still rated as severe and an example is self-poisoning); no history of any suicidal behaviour. Non-specific SCR frequency

measures conducted for 3min before the presentation of stimuli showed no significant differences between groups (Jandl *et al.*, 2010). In a similar study, depression patients were divided into three groups (Keller *et al.*, 1991); the first group was non-suicidal, the second was those with suicidal thoughts and the last was those with a suicide attempt in their history. The suicide attempt group was further divided into violent and non-violent methods. The difference in SCLs between the three groups was not significant. When Electro-Dermal Activity (EDA) was compared in terms of either violent or non-violent methods, there were no significant differences in SCLs (Keller *et al.*, 1991). Wolfersdorf *et al.* (1996) compared Personality disorder patients with past suicide attempts, depression patients with past suicide attempts and lastly non-suicidal depression patients. Many EDA variables were measured, but only spontaneous fluctuations SCL appear to be measured during rest. Differences between the personality disorder group and depression group with suicide attempts are only slight and not significant. When the two depression groups are compared, it appeared that past suicide attempts influence EDA measurements (increasing them) (Wolfersdorf *et al.*, 1996).

Studies in this section help determine if comorbidity and suicidality significantly affect GSR and thus may be a confounding factor when trying to determine a GSR profile for mood disorder patients. Three studies investigating the link between GSR and suicidality in mood disorder patients indicated that GSR in mood disorder patients is not affected by suicidality. Only one study indicated a link in which EDA increased with past suicide attempts.

## DISCUSSION

The literature pertaining to GSR in mood disorders has been inconsistent, with some research indicating GSR in mood disorder patients is significantly different when compared to other populations, while others report no significant differences. In the present section, articles from both categories (Emotional Stimuli and Non-Emotional Stimuli) are summarized and discussed in terms of the five sub-categories. Overall, more studies indicated the presence of a low or flat GSR profile characteristic of mood disorders. Limitations are also discussed in terms of the studies themselves as well as for the current review.

The sub-category *Studies examining GSR in Mood Disorders* examined studies that recruited only patients with mood disorders with the aim of identifying a GSR profile. It was hypothesised that mood disorder patients would have a flat GSR profile with small, if any, GSR responses to stimuli and low levels of electrodermal activity (EDA) during baseline. In conclusion, using results from both studies, mood disorder patients' GSR profile appeared to be characterized by increased EDA (decreased skin resistance) with increased emotional activity, including manic phases, and decreased EDA (increased skin resistance) with decreased emotional activity, including depressive phases. This pattern of EDA response to emotional activity appears similar to our understanding of and expectations from HC, therefore mood disorder patients respond similarly to HC in terms of type of emotional activity experienced. This finding is helpful to clinicians

when describing the nature of mood disorders to patients and can also help patients feel less stigmatized. The impact of drugs in reducing EDA is important for researchers' knowledge of significant confounding factors, but also to clinicians and patients as a potential method for measuring effectiveness of different drugs and also the way in which they work. However, with only two studies focused entirely on mood disorder GSR (Weidenfeller & Zimny, 1962; Hemsley & Philips, 1975) conclusions are less reliable than if more studies were conducted. Conducted before 1980, both studies appear more limited when compared to more recent studies, which would use newer technology and methodologies. Therefore it is important that more studies, using newer technology and methodologies, focused on GSR profiles in mood disorder patients are conducted and that conclusions, using only these two studies, are regarded with circumspection.

The sub-category *Studies comparing GSR in Mood Disorders with Healthy Control participants* included studies where GSR was compared between mood disorder patients and HC aiming to confirm a GSR profile for mood disorder patients and establishing if it is significantly different from HC. Fifteen studies and sections from twelve other studies were included. Results indicate that a number of studies found mood disorder patients' GSR to be no different from HC while an equal number found differences in GSR between mood disorder patients and HC. Four studies reported differences in GSR for mood disorder patients and HC in some instances but not in others (Myslobodsky & Horesh, 1978; Ward *et al.*, 1983; Biswas, 1990; Tsai *et al.*, 2003). Of all the studies, only twelve were conducted in the last ten years, thus the remaining studies are dated in terms of disorder diagnosis as well as GSR measurement technology. Some of the diagnoses used in this section included neurotic depression, psychotic depression, endogenous depression, bipolar disorder, major depressive episode, unipolar depression, SAD and reactive depression. Again, although not as severe, this highlights the need for more research to be conducted to incorporate newer diagnoses and GSR technology.

In conclusion several studies suggest that the emergent GSR profile for mood disorder patients is characterized by low magnitude and quantity of responses and levels and thus can be described as being "flat" in nature. This is consistent with expectations based on emotional presentation of mood disorders, however there are still a number of studies that have not replicated these findings. Surprisingly, mood disorder patients also appeared to have more unprovoked responses, thus their GSR profile appears more erratic than HC which may be indicative of the lack of stability in emotional processes for mood disorder patients. These findings may contribute to our understanding of the difficulties faced by mood disorder patients in their rapidly changeable emotional experiences. One study (Brankovic, 2008) established its own parameters to characterize GSR in mood disorder patients and findings suggest depression patients' GSR profile, despite being slower to start, has more radical changes and takes longer to stabilize and thus can be describes as "flat" as well as "erratic" in nature. Many of these studies used a stress inducing task to gain GSR from mood disorder patients however; it was interesting to note that in a fear acquisition experiment GSR indicated that Major Depressive Disorder (MDD) patients had greater levels of fear acquisition than HC. These findings suggest that GSR profiles may vary depending on the type of emotion that is targeted in the experiment and that perhaps if more emotions are examined a more detailed profile may

emerge. Not only does GSR appear to be emotion sensitive but also stimuli sensitive especially when different kinds of mood disorders are considered. Two studies (Sigmon *et al.*, 2007; Lindsey *et al.*, 2011) examined SAD patients and results suggest that in comparison to non-SAD and HC, GSR profiles for SAD patients are more affected by winter scenes than summer scenes and also affected to a greater degree. These findings are consistent with current understanding of SAD however further research using GSR may be able to establish what specifically about winter scenes is the affective component. Contrary to understanding it appears that despite remission patients' GSR profile being more similar to HC than depression patients' GSR, the finding was not significant, thus concluding that upon remission GSR does not change to emulate HC. However, remission patients participated in only one study in this subcategory and thus more research is needed to confirm or negate this conclusion.

Several themes emerged from research findings from studies within this subcategory. The first apparent theme is concerned with the impact of patient age on GSR. Study results suggest GSR measures increase with age, but interestingly this correlation is only found in depression patients and is either not found, or is a negative correlation for HC. These findings highlight age as a variable and reaffirm to researchers to be aware of this variable as it may be a significant confounding factor which affects accuracy and reliability of results. Gender of patient was identified as the second theme present in a couple of the studies. Results indicated that women tend to have a lower GSR profile than men. These findings not only alert researchers to the impact of this variable but also may help explain why some disorders have an over representation of one gender over the other. The last theme occurring in several studies is the asymmetry in bilateral GSR in patients with mood disorders. Although results indicate that HC have asymmetry dependent on task, it appears that mood disorder patients have a pervasive left-hand bias. A left-hand bias means that there is more electrodermal activity occurring and being measured from the left-hand as compared to the right-hand. These findings may be indicative of underlying hemispheric activity in mood disorder patients that is distinct from HC.

The last conclusion for this subcategory is concerned with the interpretation of GSR measurements as it relates to changes in emotional activity. Only one study appeared to interpret GSR and emotional activity differently. The dominant interpretation is characterised by increased GSR (decrease in skin resistance) which is reflective of increased emotional activity and decreased GSR (increase in skin resistance), which is reflective of decreased emotional activity. Tsai *et al.* (2003) interpreted GSR in terms of less physiological activation, reflecting decreased positive emotion arousal and increased physiological activation reflecting more negative emotion arousal, for amusing and sad clips respectively. Using this interpretation Tsai *et al.* (2003) concluded that depression only minimally affects GSR (Tsai *et al.*, 2003). This study establishes that there are different methods of interpretation and researchers should be aware of how they interpret their data as well as to fully explain it, so as not to mislead their readers.

The sub-category *Studies comparing GSR in Mood Disorders with other Psychopathologies* included studies in which GSR was compared between mood disorder patients and other psychological or physical disorders aiming to determine if mood

disorder patients' GSR was significantly different from other pathologies. Five studies and relevant sections from two other studies (Wolfersdorf *et al.*, 1996; Pazderka-Robinson *et al.*, 2004) were examined in this sub-category. The psychological disorders that were compared to mood disorder patients included schizophrenia, anxiety, manic-depressive psychosis, paranoia, organic disorder, psychoneurosis, OCD, GAD and PAD whereas only one study compared a physical disorder (CFS).

In conclusion it appears that GSR for mood disorders is not consistently different from other psychological disorders but it does appear to have more similarities with some disorders compared to others. GSR for mood disorder patients was more similar to OCD patients and, at times, anxiety patients when compared to schizophrenia, PAD, paranoia, organic disorder and psychoneurosis patients. These findings are helpful in understanding the nature of mood and other disorders using another aspect of similarity or differentiation. In terms of research these findings can perhaps be used in the context of the most likely comorbid disorders and may even provide additional information as to how and why comorbidity occurs. Two themes from previous subcategories were also found in this section. Firstly, the impact of manic and depressive phases on EDA and secondly, a correlation, in this case it was negative, between age of patient and EDA.

There was only one study where GSR in mood disorder patients was compared with physical disorder patients, thus generalizability is questionable, requiring more studies of this nature to be conducted. Unexpectedly, CFS patients had less emotional excitation than depression patients which is of interest to CFS researchers as it may illuminate the nature of psychological processes in CFS patients. As mood disorders and CFS have a high comorbidity rate these findings need to be considered with circumspection however, they may also contribute to comorbidity research. Lastly, non-suicidal depression patients had significantly lower mean SCL and spontaneous fluctuations than personality disorder patients with suicidal history. This finding shows mood disorder patient GSR profile as different from personality disorder GSR profile however this may also be indicative of effect of suicidality on GSR. Therefore, there are not enough studies with consistent results to establish a GSR profile for mood disorder patients separate from other psychological and physical disorders.

The sub-category *Studies comparing GSR between various Mood Disorders* conducted GSR comparisons within the mood disorder category to determine if mood disorder GSR profiles vary within this diagnostic category. Ten studies and extracts from two other studies (Ward *et al.*, 1983; Ward & Doerr, 1986) were included in this sub-category. Most of the studies in this subcategory are severely dated as seen in the types of mood disorders they compare, some of which are no longer in use. Mood disorders that have been compared included endogenous depression, reactive depression, agitated depression, retarded depression, recurrent and non-recurrent depression, SAD and non-SAD as well as catatonic stupor patients. As diagnostic terms, definitions and criteria are continually changing, research within this area needs to stay current in order for it to be most useful. From other subcategories it is apparent that GSR is affected by manic and depressive phases which characterize a GSR profile for bipolar patients. Using the studies in this subcategory GSR profiles for the various, if dated, types of mood disorder were not as easily identified.



In conclusion it appears that a number of themes present in other subcategories are also present in this subcategory however; in terms of the subcategory's primary objective there appears no consistent findings to establish that different mood disorders have unique GSR profiles. The first theme is the left-hand bias in GSR experienced by mood disorder patients however, it is interesting to discover the left-hand bias is present for endogenous depression patients but not for reactive depression patients. These findings suggest that, despite diagnoses that are no longer used, there may be differences between mood disorders in terms of hand bias and thus research using more recent diagnoses should be conducted. This research would be helpful in defining different disorders as well as possibly contributing to understanding of potential underlying hemispheric processes.

Another recurrent theme is the effect of medication on GSR. Comparing GSR from depression patients on different medications indicate that noradrenergic antidepressants reduce GSR more than serotonergic antidepressants. These findings confirm the impact of medication on GSR but expand on previous findings by identifying that impact on GSR varies depending on the type of medication. This information may help in further establishing how various medications work which may later lead to more precisely matching medications for specific disorders however, more research is needed using a wider variety of available medications.

The last recurrent theme is the impact of patient gender on GSR patterns as one study reported an unevenly distributed sample and highlighted this as a confounding factor resulting in less accurate and reliable results. Understanding the impact of gender on GSR may help us explain or understand why there is over representation of one gender or another for the various disorders which again can increase understanding in the features of various disorders. For each of these themes there were studies with significant findings and studies with no significant findings and this should be noted when analysing these conclusions.

In terms of differentiating between disorders by establishing different GSR profiles, results are contradictory, thus making it difficult to establish reliable conclusions. Results indicated a number of distinctive features but these findings were not found across all studies. It appeared that endogenous depression patients had a particularly low SCL with a left-hand bias, agitated depression patients had lower skin resistance than retarded depression patients and recurrent depression patients' SCLs were lower than non-recurrent. Catatonic stupor patients had particularly high average resistance levels, followed by depression patients and lastly by HC. This last finding suggests that perhaps in terms of GSR in mood disorders there is a continuum scale with disorders appearing on the scale at different intervals with different average GSRs however, more research is needed to investigate this. It appeared patients in remission had higher SCLs than those in depressive states suggesting that GSR is changeable depending on state of mental health of the individual in question. This finding may be a helpful tool in accurately establishing remission but also in monitoring individual progressions. SAD patients' GSR was more affected by winter scenes than summer scenes which supports current understandings of the disorder.

The sub-category *Studies examining GSR in Mood Disorders as it relates to Comorbidity, Suicidality and Genetic Predispositions* included nine studies and a relevant section from one other study (Thorell & d'Elia, 1988) aimed at determining if there were any links between GSR and comorbidity, suicidality or genetic predispositions. Four studies examined GSR in terms of comorbidity with other psychological disorders including GAD, social phobia and panic disorder (Argyle, 1991; Campbell-Sills *et al.*, 2006; McTeague *et al.*, 2009; Hofmann *et al.*, 2010). Three studies (Keller *et al.*, 1991; Wolfersdorf *et al.*, 1996; Jandl *et al.*, 2010) and a relevant section from one study (Thorell & d'Elia, 1988) focused on GSR in mood disorders as it relates to suicide. Lastly two studies examined GSR in mood disorders as it relates to genetic predispositions (Zahn *et al.*, 1989; Zahn *et al.*, 1991).

In conclusion each area of focus in this subcategory has four or less studies making reliance on their conclusions, problematic, but also indicating that GSR has not been used very often to expand knowledge in mood disorder patients for each of these areas. In terms of comorbidity a lineal trend in GSR for comorbid patients and a pattern of lower GSR when a comorbid mood disorder is present is suggested. Otherwise there were no other apparent common themes or findings among the studies focused on comorbidity. When examining suicidality, one emergent theme indicated that GSR increased with an increase in past suicide attempts but this was not found across all studies. Another trend suggested GSR did not significantly change for suicidal depression patients in remission. There did not appear to be any other significant findings to indicate a specific GSR profile for mood disorder patients in relation to suicidality. As regards genetic predispositions in mood disorders it became apparent that individuals at greater risk had a left-hand bias, reported earlier as a characteristic of mood disorder patients. Also mentioned previously this bias may be indicative of varying hemispheric activity however, these findings may also be useful in quantifying the degree of risk for high-risk individuals. Within this subcategory it is clear that more research needs to be conducted to confirm the emergent patterns as at this point few of the findings are replicated.

Of the forty-one articles reviewed, there are limitations that need to be considered when interpreting the results. As mentioned at the beginning of the review, in early GSR studies there was much variation and little standardisation in methods and technology for measuring and interpreting GSR. As many of the review studies were conducted more than ten years ago there may be a wide variation between studies in terms of their GSR measurement and interpretation methods. In order to negate this limitation, researchers would need to utilize guidelines set by the Society of Psychophysiological Research. Due to the age of review studies, the diagnoses of many study samples are no longer in use. An ideal study would implement diagnoses definitions and criteria as outlined by one of the two foremost diagnostic manuals [DSM-IV-TR (APA, 2000); ICD-10 (WHO, 1992)]. As gender and age of patients have been identified as significant variables, this is an area where researchers would need to assure a balanced study sample in order to avoid confounding results.

In conducting the present review it is apparent that many of the studies included were conducted over ten years ago and this brings into question the applicability of their findings today. As noted previously, many of the patient diagnoses are no longer in use

and are not able to be identified using today's diagnoses. It also affects the methods and tools used to measure GSR as technology has changed considerably in recent times. The number of more recent studies indicates there is interest in this field of research although it has not been thoroughly explored.

More research needs to be conducted to expand and advance this field whereby newer diagnoses and technology are utilized. Identifying ways in which to utilize and incorporate GSR within therapeutic settings would exponentially expand the psychophysiological field of psychology.

The review findings indicate specific features of a GSR profile for mood disorder patients rather than a complete and distinct profile. Such features include GSR tending to be "flat" and "erratic" in nature as well as predominantly occurring on the left-hand. In comparing this profile with GSR from HC it appears that they are significantly different. Comparing results from different studies analysing GSR from bipolar and SAD patients indicate that, due to the difference in nature of the disorders, there are different patterns in GSR, however more research is needed to establish GSR differences between mood disorders. In terms of other psychological and physical disorders, results indicate that GSR was similar between some disorders but very different between others. This suggests that some disorders are more alike and potentially share some underlying features compared to others. Considering comorbidity, suicide and genetic predisposition results were fairly inconclusive however, it was indicated that individuals with a greater genetic predisposition tended to have a left-hand bias similarly found in mood disorder patients. Three major themes became apparent across the subcategories; the first being the impact of age on GSR; the second is the impact of patient gender on GSR and lastly the impact of medication on GSR. Each of these is highlighted as variables researchers should be continuously aware of.

Although the present review is focused on GSR in mood disorder patients there are a number of different fields of research that are connected and may benefit from the findings. Some examples of this include pharmacotherapy, as GSR can help to indicate the effectiveness as well as how different medications work and help to illuminate the emotional experiences of medicated patients. Another example is the emergence of bilateral asymmetry in patients with a mood disorder as this contributes to neuropsychology research, specifically hemispheric research.

The conclusions from the current review may have significant impact on clinicians and the way they practice. With the presence of a GSR profile for mood disorder patients' clinicians may utilize GSR as a diagnostic aid but also help to monitor their patient's emotional experiences. A GSR profile would also potentially aid in establishing the effectiveness of pharmacotherapy as well as help identify the most suitable medication for a patient with a specific mood disorder. In terms of comorbidity, a GSR profile helps understanding why certain disorders have a higher rate of comorbidity than others. GSR would also aid in the defining and categorization of various disorders. As benefits to patient populations a GSR profile may aid in establishing the level of genetic predisposition in family members as well as expanding their understanding of the disorders. In terms of researchers a GSR profile opens up a variety of further avenues for research. Exploration of underlying reasons for gender over representation in certain

disorders becomes possible due to the different GSR patterns of men and women. There is also the exploration of possible explanations for remission being feasible and attained by some patients and not others.

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Received, June 25, 2014

Final Acceptance, February 27, 2015