Expression, perception and recognition of intense emotions in healthy and depressed individuals

Dissertation
zur Erlangung des Doktorgrades
der Naturwissenschaften

vorgelegt beim Fachbereich Psychologie und Sportwissenschaften
der Johann Wolfgang Goethe - Universität
in Frankfurt am Main

von
Sofia Maria Wenzler
aus Konstanz

Frankfurt am Main 2017

D30

Vom Fachbereich Psychologie und Sportwissenschaften der Johann Wolfgang Goethe – Universität als Dissertation angenommen.

Dekan: Prof. Dr. Dr. Banzer

Erstgutachter: Prof. Dr. Rolf van Dick

Zweitgutachterin: Prof. Dr. Sonja Rohrmann

DANKSAGUNG

An dieser Stelle möchte ich mich bei all denjenigen bedanken, die mich bei der Anfertigung meiner Dissertation unterstützt haben:

bei meinen Betreuern PD Dr. Viola Oertel-Knöchel und Prof. Dr. Rolf van Dick,
bei meinen Kollegen aus dem Labor für Neuroimaging,
bei Dr. Mika Tarvainen,
bei den Teilnehmern der Studien
und natürlich bei meinen Eltern und meiner Familie.

Besonderer Dank gilt zudem der Konrad-Adenauer-Stiftung für die ideelle und finanzielle Unterstützung meiner Promotion.

CONTENTS

ZUSAMMENFASSUNG

Die Emotionsverarbeitung, also das Wahrnehmen, Erkennen und Regulieren von Emotionen, spielen eine wichtige Rolle für das psychische Wohlbefinden des Menschen. Die Fähigkeit die Gefühle anderer zu erkennen und einzuordnen ermöglicht es soziale Situationen richtig einzuschätzen, soziale Beziehungen aufzubauen und diese zu erhalten. Durch eine dysfunktionale Emotionsverarbeitung kann also eine gute soziale Anpassung bedeutend erschwert werden. Gemäß etablierter Emotionstheorien können Emotionen entweder dimensional kategorisiert werden, basierend auf ihrer Valenz und dem Arousal (Erregungsniveau), das sie erzeugen (Russel, 1980), oder sie können in Emotionskategorien unterteilt werden wie beispielsweise von Ekman in sechs Basisemotionen (Ekman et al., 1987). Die Tatsache, dass diese Emotionskategorien international, sogar in von der westlichen Welt isolierten Populationen, weitestgehend gleich ausgedrückt werden, betont die grundlegende Bedeutung der Emotionsverarbeitung für den Menschen.

Da Emotionen in unserem Leben also eine wichtige Rolle spielen, kann eine Dysregulation der Emotionsverarbeitung auch zu elementaren Einschränkungen führen. So sind viele psychische Erkrankungen von einer gestörten Emotionsverarbeitung gekennzeichnet. Menschen, die unter depressiven Episoden leiden, durchleben beispielsweise regelmäßig Phasen intensiver und anhaltender Traurigkeit. Ihre Emotionsverarbeitung ist also beeinträchtigt. Jedoch ist noch nicht vollständig geklärt, wie es zu dieser verzerrten Emotionsverarbeitung kommt. Ein besseres Verständnis der zugrunde liegenden Prozesse bei depressiven und gesunden Menschen könnte also eine entscheidende Rolle für die Behandlung der Depression spielen.

Diese Dissertation untergliedert sich daher in drei Studien, die das Ziel hatten, einen spezifischen Bereich der Emotionsverarbeitung genauer zu beleuchten: den Ausdruck, die Wahrnehmung und das Erkennen extremer Emotionen. Als Grundlage wurde Russels dimensionale Sichtweise von Emotionen herangezogen (Russel, 1980). Ein besonderer Fokus lag dabei auf der Wahl der geeigneten Stimuli. In vergangenen Forschungsarbeiten kamen oft Stimuli zum Einsatz, die stereotype Darstellungen von Emotionsausdrücken enthielten. Meist wurden hierbei Schauspieler gebeten, Emotionen auszudrücken, die sie in dem Moment jedoch nicht unbedingt fühlten. Obwohl diese gestellten Emotionsausdrücke generell gut zu unterscheiden sind, gibt es vermehrt Hinweise darauf, dass sie sich von authentischen Emotionsausdrücken unterscheiden (Aviezer et al., 2015; Aviezer, Trope, & Todorov, 2012). Tatsächlich erscheinen echte Emotionsausdrücke oft ambivalent und schwieriger zu unterscheiden. In den hier vorgestellten Untersuchungen wurden deshalb grundsätzlich Stimuli gewählt, die spontane und authentische Emotionsausdrücke enthielten oder diese evozierten.

In Studie 1 wurden der Ausdruck und das Erkennen extremer Emotionen näher beleuchtet. Hierbei dienten aus dem Internet bezogene Videosequenzen von *N*=24 Kindern und *N*=36 Erwachsenen als Basis, in denen diese sich in Situationen befanden, die sie extrem negative (z.B. Zeuge eines Terroranschlags zu sein) oder extrem positive Emotionen (z.B. mit einem Ausflug nach Disneyland überrascht zu werden) durchleben ließen. Die Videosequenzen wurden in dem gewohnten Umfeld der Kinder und Erwachsenen aufgezeichnet, oft von vertrauten Personen wie Verwandten oder engen Freunden. So ermöglichte dieses Vorgehen einen einzigartigen Einblick in den spontanen und authentischen Ausdruck extremer Emotionen in verschiedenen Altersgruppen. Aus den Sequenzen wurde dann der Zeitpunkt gewählt, zu dem die Gesichtsausdrücke der Kinder und Erwachsenen die stärkste emotionale Erregung aufzeigten. Von diesem Zeitpunkt wurde ein einzelnes Bild extrahiert, das ausschließlich das Gesicht der jeweiligen Person zeigte, und in einem zweiten Schritt unabhängigen Ratern präsentiert, die den Kontext des Gesichtsausdruckes nicht kannten. Die Bilder der Kinder wurden von *N*=39 und die Bilder der Erwachsenen von *N*=28 Ratern beurteilt. Diese sollten die Valenz und das Arousal in den Emotionsausdrücken einschätzen.

Anhand der Einschätzungen der unabhängigen Rater konnte beobachtet werden, dass Emotionen hoher positiver und negativer Intensität schwer auseinander zu halten sind. Dabei machte es keinen Unterschied, ob es sich um Emotionsausdrücke von Kindern oder Erwachsenen handelte. In diesem Punkt widersprechen die Ergebnisse der Vorhersage etablierter Emotionstheorien (z.B. Ekman, 1993). Diese postulieren, dass Emotionen mit steigender Intensität leichter zu unterscheiden sein müssten. Die hier präsentierten Ergebnisse zeigen also die Ambiguität extremer Emotionsausdrücke auf - sowohl im Kindes- als auch im Erwachsenenalter. Zudem wird deutlich, dass der Gesichtsausdruck alleine oft nicht ausreicht, um eine Emotion verlässlich einordnen zu können. Obwohl in vielen Forschungsarbeiten das Gesicht als aussagekräftigster Ort des Emotionsausdrucks herangezogen wird, scheinen Kontextinformationen (wie z.B. die Körperhaltung) für das Erkennen intensiver Emotionen eine wichtige Rolle zu spielen.

Bei genauerem Betrachten der Ergebnisse wird zudem deutlich, dass positive Emotionsausdrücke von den Ratern häufig als negativ eingeschätzt wurden, während negative Emotionsausdrücke akkurat erkannt wurden. Eine mögliche Erklärung hierfür liefern Aragón und Kollegen (2015). Sie schätzen den Ausdruck negativer Emotionen in positiven Situationen als Emotionsregulationsstrategie ein, die dazu dient ein emotionales Equilibrium wieder herzustellen, das durch die überwältigenden positiven Emotionen aus dem Gleichgewicht gebracht wurde. Jedoch müsste es laut dieser Hypothese auch in als negativ erlebten Situationen zu einer solchen Gegenregulation kommen. Da jedoch die Emotionsausdrücke in den negativen Situationen fast durchgehend richtig eingeschätzt wurden, kann Aragóns Theorie nur einen Teil unserer Ergebnisse erklären.

Studie 1 zeigt somit auf, dass Emotionen – wenn sie eine gewisse Intensität erreichen – zu Reaktionen und Emotionsausdrücken führen können, die auf das soziale Umfeld paradox und verwirrend wirken. Manche Menschen erleben solche intensiven Emotionen jedoch häufiger als andere. Depressive Patienten berichten beispielsweise von anhaltenden und intensiven Phasen negativer Emotionen (z.B. Trauer), die oft von Interessen- und Antriebslosigkeit begleitet werden. Hier scheinen also nicht die positiven sondern die negativen Emotionen ein überwältigendes Level zu erreichen. Aus diesem Grund untersuchten wir in einem weiteren Schritt die Wahrnehmung negativer Emotionen bei depressiven Menschen im Vergleich zu gesunden Kontrollprobanden. Dabei betrachteten wir nicht nur die subjektiv gefühlten Komponenten der Emotionen sondern untersuchten auch Veränderungen physiologischer Prozesse während emotionaler Erregung mit besonderem Fokus auf das autonome Nervensystem (ANS).

Für einen generellen Überblick wurde zunächst im Rahmen von Studie 2 untersucht, ob sich verschiedene Parameter des ANS zwischen depressiven und gesunden Probanden unterscheiden und inwiefern sie mit Merkmalen der Depression (z.B. emotionale Kompetenzdefizite) zusammenhängen. Hierzu wurden 41 Patienten mit der Diagnose einer rezidivierenden depressiven Episode und 43 gesunde Kontrollpersonen untersucht. ANS-Parameter umfassten Hormone (Cortisol und Dehydroepiandrosteron [DHEA]), Hautleitfähigkeit, Hauttemperatur und Atemfrequenz. Zudem wurde die Herzratenvariabilität (HRV) untersucht. Die HRV bezeichnet die Fähigkeit des Herzens sich flexibel an wechselnde Anforderungen anzupassen. Die Herzrate verändert sich also in Reaktion auf beispielsweise körperliche Anstrengung, aber auch verursacht durch wechselnde interne Zustände. Eine eingeschränkte HRV konnte bei verschiedenen psychischen Erkrankungen (z.B. Schizophrenie oder bipolare Störung) nachgewiesen werden. Durch den Einbezug verschiedener physiologischer Parameter sollte ein umfassender Einblick in die Aktivität des ANS bei Depression ermöglicht werden. Um Merkmale der Depression zu erfassen, wurden Selbstbeurteilungsfragebögen zur emotionalen Kompetenz, zur depressiven Symptomatik sowie zur aktuellen Stimmung eingesetzt.

In Studie 2 konnten erhöhte DHEA-Werte, eine erhöhte Hauttemperatur und eine reduzierte Atemfrequenz in der Patientengruppe gefunden werden. Eine erhöhte Hauttemperatur korrelierte zudem mit der Ausprägung depressiver Symptome und der aktuellen Stimmung. Zudem konnte eine reduzierte HRV bei Patienten beobachtet werden. Weitere Analysen wiesen jedoch daraufhin, dass die veränderten HRV-Werte hauptsächlich auf antidepressive Medikation zurückzuführen waren.

Um im Anschluss zu überprüfen, inwiefern sich die genannten Parameter im Zustand emotionaler Erregung verändern, wurde eine weitere Untersuchung durchgeführt. In Studie 3 wurde die Reaktion depressiver und gesunder Probanden auf emotionsevozierende Stimuli aus dem International Affective Picture System (IAPS) untersucht. Es wurden 41 Patienten mit rezidivierenden depressiven Episoden und 42 gesunde Kontrollprobanden in die Studie mit eingeschlossen. Das IAPS enthält eine große Auswahl an Bildern von Szenarien, die in den Betrachtern Emotionen hervorrufen. Durchschnittswerte für die Valenz und das Arousal der Bilder wurden anhand einer großen Stichprobe erhoben und validiert. In Studie 3 wurden 90 Stimuli aus dem IAPS ausgewählt und verschiedenen Valenzkategorien (neutral, leicht negativ, hoch negativ) zugeordnet. Die Stimuli wurden dann in zwei Blöcke von je 45 Bildern unterteilt. In Block 1 sollten die Probanden die Bilder betrachten während die physiologischen Parameter (HRV, Respiration etc.) erhoben wurden. So sollte die Aktivität des ANS als Reaktion auf emotionale Erregung gemessen werden. In Block 2 wurden die Probanden dann gebeten, eine subjektive Einschätzung der Valenz und des Arousals der Stimuli abzugeben. Zuletzt wurden mit Hilfe von Selbstbeurteilungsfragebögen die soziale und emotionale Kompetenz sowie depressive Symptomatik und Stimmung erfasst.

Die Befunde bezüglich Hauttemperatur und HRV-Werten aus Studie 2 konnten in Studie 3 repliziert werden. Zudem zeigte sich eine akzentuierte Respirationsrate (d.h., die Atemfrequenz beschleunigte sich bei den Patienten in Reaktion auf die emotionsevozierenden Bilder). Auch die Valenz- und Arousalratings fielen in der Patientengruppe höher aus als bei den gesunden Kontrollprobanden. In den Selbstauskünften gaben die Patienten an, soziale Signale gut erkennen und interpretieren zu können. Jedoch schätzten sie sich in ihrer Fähigkeit, adäquate soziale Signale versenden und ihre Emotionen in sozialen Situationen kontrollieren zu können, im Vergleich mit den Kontrollprobanden schlechter ein. Diese sozialen und emotionalen Kompetenzdefizite waren korrelativ mit erhöhten Arousal- und Valenzratings assoziiert.

Die Ergebnisse aus Studie 2 und 3 weisen auf ein generell erhöhtes physiologisches Arousal bei depressiven Patienten hin, das sich in einer erhöhten Temperatur manifestiert.

Zudem konnte gezeigt werden, dass sich die Atmung in Reaktion auf emotionale Erregung beschleunigt. Diese physiologische Erregung spiegelt sich in den subjektiven Einschätzungen der Bilder wieder. Es ist also davon auszugehen, dass depressive Menschen negative Emotionen stärker wahrnehmen. Dies könnte zu intensiven und anhaltenden Phasen gedrückter Stimmung beitragen, wie sie im Störungsbild der Depression beschrieben sind. Ausgehend von solch intensiven negativen Emotionen kann angenommen werden, dass es sich für depressive Menschen schwieriger gestaltet, diese Gefühlszustände in sozialen Situationen zu kontrollieren und gleichzeitig adäquat auf soziale Signale anderer zu reagieren, was zu Einschränkungen in der sozialen Kommunikation führen könnte. Diese Annahme wird durch den korrelativen Zusammenhang zwischen einem intensiveren Emotionserleben und einer reduzierten sozialen Kompetenz bestärkt.

Diese Dissertation sollte Aufschluss über den Ausdruck, die Wahrnehmung und das Erkennen extremer Emotionen bei depressiven und gesunden Probanden geben. Es konnte gezeigt werden, dass intensive Emotionszustände oft zu ambivalenten Gesichtsausdrücken führen, die von Außenstehenden als zweideutig wahrgenommen werden, wenn keine ausreichenden Kontexthinweise vorhanden sind. Um ein genaueres Verständnis der Emotionswahrnehmung bei depressiven Menschen zu erlangen, konnten mehrere Parameter des ANS identifiziert werden, deren Aktivität sich zwischen depressiven und gesunden Probanden unterscheidet. Zudem wurde untersucht, inwiefern sich Aktivitätsmuster in Reaktion auf emotionale Erregung verändern. Einige der hier untersuchten Parameter des ANS wurden in einer depressiven Stichprobe bislang noch nicht untersucht. Hierbei wurden zusätzlich Zusammenhänge zu weiteren Aspekten der Depression, wie Defiziten in sozialen Kompetenzen, aufgezeigt. Damit gibt diese Dissertation Aufschlüsse über Emotionsverarbeitungsprozesse bei gesunden und depressiven Menschen und wirft gleichzeitig neue Fragen für die weitere Forschung auf.

GENERAL INTRODUCTION

"Let's not forget that the little emotions are the great captains of our lives and we obey them without realizing it."
—Vincent van Gogh

Humans are social beings whose every behavior, thoughts and needs are caused by and directed towards others (Batson, 1990). This predisposition is required through evolution due to the need of constantly evaluating the motivation of others (Brothers, 1989). But how do we evaluate another's motivation? One elementary tool of communication lies in our emotions. The ability to recognize emotions in others is crucial to successfully function in social contexts and to build and sustain relationships (Bourke, Douglas, & Porter, 2010). Emotions, thus, play an important role in our everyday lives. They are irreversibly tied to one's ability to adjust to a social environment. The fact that most populations around the world, even isolated tribes, express and recognize the same facial expressions of emotion aggravates their existential relevance (Ekman et al., 1987).

Every emotion has its evolutionary objective. While fear or disgust make a person avoid objects that could potentially cause harm, joy is a great motivator and makes one appear more likable and attractive to others. Thus, as in the quote by Vincent van Gogh, emotions do direct our lives to a certain degree and oftentimes subconsciously, as is discussed later. Regarding the great importance of emotions it becomes clear, however, that dysfunctions in emotion processing can lead to serious impairments in a person, respectively. In fact, many psychological illnesses are associated with deficits in emotional competence. Schizophrenia, for example, has been frequently linked to impaired emotion processing such as poor emotion recognition skills (Phillips, Drevets, Rauch, & Lane, 2003b). Increased levels of fear are associated with anxiety disorders while prolonged phases of sadness are often diagnosed as depressive episodes. Hence, an understanding of how we perceive, express and recognize emotions is crucial in order to gain insight into various psychological illnesses but also in order to understand the basic mechanisms of human behavior and cognition.

The two most influential models used to categorize an emotion are the *discrete category* view and the *dimensional model of affect*. According to the *discrete category* view proposed by Paul Ekman (1992), emotions can be assigned to discrete emotion categories. Ekman and Friesen proposed six universal emotions that are also known as *basic emotions*: sadness, fear, surprise, anger, happiness and disgust (Ekman & Friesen, 1971). According to this notion, positive (e.g., happiness) and negative (e.g., anger) emotions originate from distinct affect programs that are equipped with specific hardwired neurological systems and distinct universally recognized facial movements (Ekman & Friesen, 1978; Tracy & Matsumoto, 2008). Another approach to understanding the structure of emotions is offered by the *dimensional* or *circumplex model of affect* (Russell, 1980). As stated in this model, there are no discrete emotion categories. Rather, a small number of bipolar dimensions suffice to classify each emotional experience (Russell, 1997). Specifically, two dimensions - the valence (ranging from unpleasant to pleasant) and arousal - define an affective expression.

Emotions and their underlying biological correlates affect the whole human organism. According to the approach of cognitive-behavioral therapy (CBT) emotions, cognition and behavior are interdependent and influence each other, respectively (Kendall, 2006). Depression, for example, is oftentimes described as a downward spiral in CBT: when a person feels down or sad, he is likely to have negative thoughts that influence his behavior (e.g., social withdrawal) which in turn leads to a loss of (social) reinforcement and results in more negative emotions and so on (Abel & Hautzinger, 2013). The whole theory of CBT, hence, relies on these elementary associations. According to the theory of CBT, emotions are considered as the one component in this triad of behavior, cognition and affect that is the hardest to deliberately manipulate. In fact, neuroimaging studies confirm this notion as they demonstrated that emotions are to a certain degree based on subcortical neuronal processes and oftentimes perceived subconsciously, just as Van Gogh stated in the quote mentioned earlier (Ohman, Carlsson, Lundqvist, & Ingvar, 2007; Tamietto & de Gelder, 2010).

Hence, it appears essential to understand the biological correlates of emotion in order to gain a deeper comprehension of how emotions affect our lives. Theories regarding the neuronal correlates of emotion propose that emotion perception depends upon the functioning of two distinct neuronal systems: the ventral system (including, e.g. the amygdala, insula, ventral striatum, and other regions), which is involved in the identification of emotional signals and the production of affective states, and the dorsal system (including the hippocampus and dorsal regions of the anterior cingulate gyrus and prefrontal cortex), which is important for executive functioning and effortful regulation of affective states (Phillips, Drevets, Rauch, & Lane, 2003a). Another relevant physical correlate of emotion is autonomic nervous system (ANS) activity. Parameters of peripheral physiological responding such as respiration, heart rate or galvanic skin response (GSR) seem to play an important role in emotion processing (Kreibig, 2010). Furthermore, there is evidence that ANS activity is considerably specific regarding subtypes of distinct emotions (Ekman, 1992). Emotions, thus, are connected to the human organism as a whole - in thought, action and its physical aspects - and play an important role in psychological health or illness. Indeed, dysregulations of emotion are a main aspect of psychological illnesses and many times included in the very definition and classification of a disorder (American Psychiatric Association, 1994).

The better understanding of emotions and their impact on humans has, hence, been of great interest in research. Countless studies in healthy as well as psychologically ill subjects have led to remarkable breakthroughs that gave insight into the processes of emotion functioning. The works of Paul Ekman, for example, have become renowned around the world. Yet, a great number of questions remain unanswered. There is still a debate about which stimuli to use in order to assess emotion recognition and perception (McLellan, Johnston, Dalrymple-Alford, & Porter, 2010); it is not completely clear, yet, which cues a person uses in order to identify another's emotions (Aviezer, Trope, & Todorov, 2012); the biological correlates of emotion dysregulations in many psychological disorders need to be better understood (Phillips et al., 2003b). Those issues are just a few open questions in the vast field of emotion research.

To contribute to a better understanding of emotion processing and answer one of these open questions, this dissertation's goal was to examine the expression, perception and recognition of intense positive and negative emotions in healthy and depressed subjects. Following Russell's (1980) approach of a dimensional model of affect, the goal was to further investigate emotions that are to be found at the two ends of the valence continuum. Furthermore, we focused on only using stimuli that allowed a close transfer of our results to real-life emotional experiences.

In a first paper, we explored how intense emotions are expressed focusing on facial expressions of healthy children and adults when experiencing extreme (positive or negative) emotional situations. We investigated how observers perceive them and whether facial expressions are diagnostic of the experienced valence of the emotion. In a second and third paper, we focused on the role of intense emotions in a clinical sample. We examined whether depressed subjects perceive negative emotions as more intense and whether this intensified emotion perception is associated with an increased physiological arousal and depressive symptoms such as deficits in social skills and emotional competence. To explore this hypothesis, we conducted two consecutive experiments that are described in two papers presented here.

STUDY 1: BEYOND PLEASURE AND PAIN: FACIAL EXPRESSION AMBUGUITY IN ADULTS AND CHILDREN DURING INTENSE SITUATIONS

Theoretical background

As aforementioned, recognizing emotions in others is an important means of communication in humans. Most researchers agree that facial expressions are the best diagnostic cues to derive emotions from because of the face's dynamic and visible nature (Ekman & Rosenberg, 2005; McLellan et al., 2010). In fact, Ekman created a whole system in which movements of individual facial muscles are encoded as so called action units (AUs) and used to systematically categorize the physical expression of emotions, the Facial Action Coding System (FACS; Ekman & Friesen, 1978). By classifying the intensity, laterality and timing of activation of each AU, even complex emotional expressions such as, e.g., false and felt smiles can be distinguished (Ekman & Friesen, 1982). The face, thus, does serve as a highly diagnostic tool in order to read another person's emotions. However, recent research challenges whether humans do indeed rely mostly on facial expressions. Aviezer and colleagues (2008, 2012) showed that oftentimes the face loses its diagnostic specificity when separated from the body. In his experiment he asked participants to judge the valence of faces. Results showed that without including body language as an additional clue people were unable to judge a person's emotional state.

Another important issue lies in the selection of the stimuli used to assess emotion recognition. A large portion of previous work in the field relied on stereotypical facial expressions posed mostly by actors in the lab (Ekman & Friesen, 1976; Gur et al., 1992; LaRusso, 1978). Although those stimuli tend to portray emotions as highly distinguishable they may not reflect real-life emotional experiences. Recent research demonstrates that real-life portrayals of emotion tend to be more ambiguous in their character and harder to distinguish (Aviezer et al., 2015, 2012; Bartlett, Littlewort, Frank, & Lee, 2014). One could argue that real-life emotions might be subtler in their nature than the quite extreme portrayals that were staged in the lab. Yet, specifically intense emotions seem to reveal a certain degree of ambiguity when observed in real life. For example, recent work by Aviezer and colleagues (2012) demonstrated that intense facial expressions of winners and losers during a professional tennis match seem to be very hard to distinguish when separated from body cues. In fact, when rating the valence of the isolated faces, winners and losers were both judged as conveying highly similar levels of negative valence.

Real-life emotions, thus, tend to be harder to read than the stereotypical portrayals of emotion usually used to assess emotional competence, especially when looking at isolated faces. Interestingly, while stimuli that were produced in the lab become more distinguishable the more intense they get (Montagne, Kessels, Haan, & Perrett, 2007; Young, Perrett, Calder, Sprengelmeyer, & Ekman, 2002), the opposite might be true for real-life emotions. This is of particular interest since both, the discrete category view (Ekman, 1992) as well as dimensional emotion model (Russell, 1980, 1997) agree that positive and negative emotions are conveyed very differently and, thus, should be even easier to distinguish as they become more intense.

The seemingly counter-intuitive results by Aviezer (2012), hence, contradict existing emotion research. However, several issues remain to be addressed. Firstly, facial expressions in this study were obtained from professional tennis players. It can, hence, be criticized that the athletes were aware of the fact that their every move and facial expression were being watched by a life audience as well as by thousands on television. Maybe they were intentionally displaying certain expressions for the crowd (Fridlund et al., 1990; Hess, Banse, & Kappas, 1995). Secondly, one can assume that the tennis players were experiencing strong physical arousal due to the ongoing game. The intense physical exertion could possibly have led to the high ambiguity in the facial expressions. Thirdly, specific social rules may have led the players to conceal a winning smile due to cultural rules. Finally, the sample was not representative, since professional athletes have many similarities (e.g., age).

To address these issues, we conducted two experiments. In the first experiment, we observed facial expressions during real-life intense positive or negative situations. We specifically chose situations that were not staged or televised, did not include intense physical activity and were experienced by normal people in a familiar environment. In the second experiment, we wanted to see how young children react to intense positive or negative situations and whether their facial expressions differed from those of adults. To find those facial expressions we conducted an elaborate search on YouTube and other websites looking for video footage. Our actual participants, thus, were the people whose reactions were documented by the cameras. Participants tested in the lab were merely raters of the authentic facial expressions. The goal of the two experiments was to examine whether highly intense positive and negative situations evoke distinct or ambiguous facial expressions.

Experiment 1 – Methods and results

In the first experiment, we chose reactions to home coming U.S. soldiers as intense positive situations. Those typically include a son, brother or spouse surprising their loved ones and family members upon their return, which usually takes place in their homes or other familiar surroundings filmed by an inside accomplice. We can assume that soldier reunions evoke highly intense and spontaneous reactions among the surprised loved ones. As highly intense negative situations we selected the reactions of bystanders to terror attacks such as the Boston marathon bombing or the Utoya Norway attack. Although those facial expressions did not occur under controlled conditions and we have no self-reports to corroborate feelings, we did choose them for their intensity, spontaneity, and authenticity that cannot be easily reproduced in the lab.

The sample consisted out of 18 individuals (two males, 16 females) reacting to a highly positive situation and 18 (three males, 15 females) expressing emotions in response to a negative situation. The facial expressions were then rated by 28 undergraduate students (19 females, nine males, mean age = 24) from the Hebrew University in Jerusalem.

Stimuli were selected after conducting an Internet search on websites such as YouTube and others. A clear image of the most intense moment in the video footage was then selected and cropped from the image using photo shop (see Figure 1b).

Independent participants evaluated the valence and arousal on a scale from 1 to 9 with 5 serving as a neutral midpoint. The mean perceived valence and intensity were calculated for each picture across raters. Analyses showed that images depicting reactions to negative situations were judged as negative (valence rating < 5) in 94.4% of the cases. Interestingly, 77.7% of the images of positive situations were also rated as negative. In those cases the valence preceived from the facial expression, thus, did not reflect the valence of the situation. As can be seen in Figure 1a, the mean valence of expressions was found to be negative in both positive and negative situations. The mean intensity did not

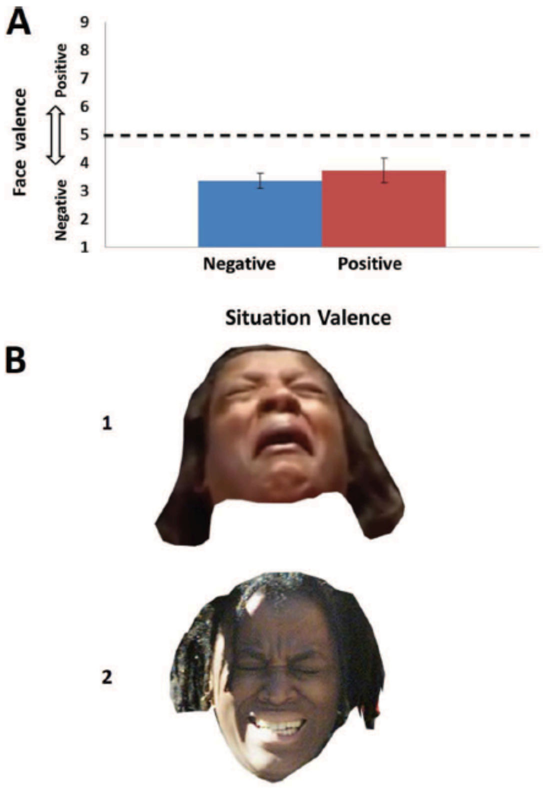

Figure 1 A. Mean facial valence ratings in negative and positive situations (Experiment 1). Values that fall below the broken line represent negative valence. B. Examples of face reactions to highly intense negative/ positive situations (1 = positive; 2 = negative). These extreme faces do not represent the full broad range of expressions seen in our sample. Image 1-B1 reproduced with permission of 6ABC, ABC Inc., WPVI-TV Philadelphia. Image 1-B2 reproduced with permission of Reuters A|S|A|P CREATIVE, Israel. See the online article for the color version of this figure.

significantly differ in the positive (*M*=6.08, *SE*=.25) versus negative situations (*M*=5.5, *SE*=.39), $t(34)=1.1$, $p>.20$.

Experiment 2 – Methods and Results

Theories on emotional development agree that the basic distinction between positive and negative emotion expressions should be evident from an early age (Izard, 1997; Sroufe, 1997). In addition to that, children tend to exert less regulation on emotions and analyze them less (Markovits, 2013). In order to observe spontaneous and authentic reactions of children to negative events we analyzed video sequences submitted to ABC's late-night show host Jimmy Kimmel. Jimmy traditionally challenges parents to prank their children and record their reaction. In his probably most popular comic prank, parents are supposed to tell their children that they ate all their candy after a night of trick-or-treating on Halloween. In a second scenario, children are filmed unwrapping Christmas presents to find that their gift is, in fact, a disappointing everyday item (e.g., a banana). Positive events included children being presented with tickets to a concert of an idolized pop star (e.g., Justin Bieber) or a surprise trip to Disneyland. Maybe because of the nature of the positive situations, the search yielded mostly girls. In order to avoid distortions of our data due to gender and age differences in emotion expression (Chaplin & Aldao, 2013) and regulation (Saarni, 1984), we selected only girls at the age of five to nine years. We analyzed 12 positive (Mean age = 7.1 years) and 12 negative situations (Mean age 6.5 years). Four judges blind to the study that watched the video clips in mute determined the apex of emotional intensity. Emotion expressions were rated by 39 students (29 females, 10 males; Mean age = 25.1). As in Experiment 1, the valence and

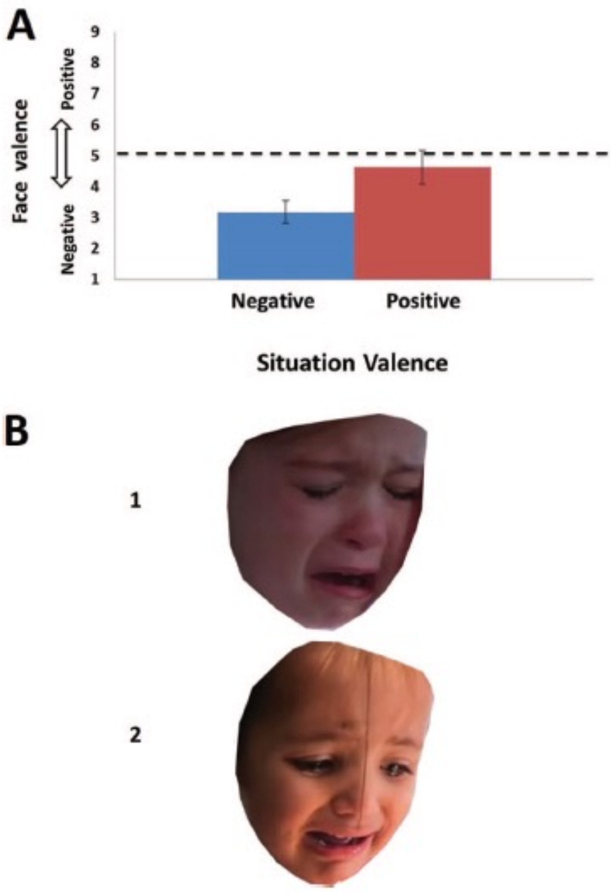

Figure 2 A. Mean age-matched facial valence ratings in positive and negative situations (Experiment 2). Values that fall below the broken line represent negative valence. B. Examples of face reactions to highly intense positive/ negative situations (1 _ positive; 2 _ negative). These extreme faces are brought for illustrative purposes, demonstrating the striking dissociation that can occur between facial appearance and emotional situation. They do not represent the full broad range of expressions seen in our sample. Image 2-B1 reproduced with permission of the YouTube Channel KaftC. Image 2-B2 reproduced with permission of the YouTube channels Table of 6 and RainingHotCoupons.com.

arousal of the facial expression in each image was evaluated on a scale from 1 to 9. An item analysis revealed that 11 of 12 negative situations were rated as negative in valence (91.6%) while 66.6% (eight out of 12) of the positive situations were rated as negative (valence < 5). Hence, negative-valence faces were again common in intense emotional situations. However, although the mean valence was negative in both positive (M=4.6, SE=.55) as well as negative situations (M=3.1, SE=.37), valence ratings were significantly higher in the positive situations. Mean intensity did not differ between the two situation types ($t(34)$=1.1; p=.20).

Discussion

The findings add further support to the idea that facial expressions in highly intense positive and negative situations often convey similar levels of valence. Previous findings of winning and losing tennis players (Aviezer et al., 2012) could, thus, be replicated in an untelevised, private setting. Furthermore, it was demonstrated that findings are not limited to adults. Since emotion regulation is less developed in young children, it can be assumed that a child's expression of emotion is highly authentic and deliberate to a degree that their reactions to positive emotions often confused even their parents. Comments such as "Why are you crying?" and "If you aren't happy, I'll take it back!" were not uncommon.

One possible explanation for the counter-intuitive reactions in adults and children has been previously described by Aragón and colleagues (2015). They revealed that cute pictures of babies (as an elicitor of emotion) evoked dimorphous displays of affect, care and aggression. They propose that humans might express negative emotions during positive situations as an adaptive means of emotional regulation. According to this view, the emotions in the positive situations are intense to a degree that they literally overwhelm a person. Positive emotions, thus, have to be countered by negative expressions in order to reestablish an emotional equilibrium. This theory would, in fact, also provide additional explanation for the slight difference in results for children and adults. In the sample consisting out of young children, negative emotion expressions in positive situations were less negative in valence (M=4.60) than in the adult sample (M=3.73). One could, thus, argue that emotion regulation skills that manifest themselves in the form of negative emotion expressions in highly positive situations are developed to a lesser extent in young children than in adults.

This notion is further supported by currently unpublished data in which we analyzed reactions to receiving pop concert tickets across different age groups. Since we cannot know whether the emotions elicited by a soldier returning from war are comparable to a child receiving a highly desired gift, comparing the results of experiment 1 and 2 might lead to false assumptions. Our aim in this additional experiment, thus, was to compare reactions to positive emotional situations to one specific situation across age groups. An Internet search yielded that the scenario of receiving surprise pop concert tickets encompassed the biggest age span. To create a sufficient age difference between two samples we included one group of 17 children aged six to ten (M=8.71) and another group of 18 teenagers aged 13.5 to 18 years (M=15.76). Due to the characteristics of the scenario, the younger sample in this experiment was slightly older than the sample in study 1 (M=7.10 years) where we also included surprise Disneyland trips as positive situations. As in study 1, only girls were included into the analyses. Isolated facial expressions were cropped from the original video clips and then rated on a scale from 1 to 9 for valence and arousal.

Group comparisons revealed similar arousal ratings ($t(33)=1.15$, $p=.26$) across groups. Valence ratings were higher in the younger sample (M=5.67, SD=1.59) than in the teenage group (M=4.69, SD=1.72). Although group differences did only reach borderline significance ($t(33)=1.73$, $p=.09$) these results reveal a trend of slightly more negative reactions towards extreme positive situations in teenagers than in younger children. Thus, they are adding further support to the hypothesis that the expression of negative emotions in moments of intense joy might be an emotion regulation strategy that gets more pronounced with increasing age.

Yet, Aragón's notion is only in some parts in line with the results in study 1. According to his proposal - unless one was to assume that only positive emotions reach a point of total overpowering - one would expect the expression of positive emotions in negative situations as well. There is little evidence in our data for such behavior. This asymmetry is also true for the expressions of winning and losing professional tennis players (Aviezer et al., 2012; Aviezer et al., 2015).

Regardless of Aragón's theory, study 1 suggests that intense emotions - be they positive or negative - do seem to be reaching an overwhelming level at times so much that our affective response or attempts to cope with those emotions might occasionally seem out of context or puzzling to others. Many individuals suffering from psychological disorders, however, experience intense emotions more frequently and to a greater extent than others. People who suffer from anxiety, for example, frequently experience intense levels of fear that make it hard for them to face certain situations such as speaking in front of a group or riding a bus. Sometimes they start avoiding those situations altogether, which potentially limits them in their everyday life (American Psychiatric Association, 1994). People suffering from depression, on the other side, typically report prolonged and intensified episodes of sadness, which are frequently accompanied by additional depressive symptoms such as loss of interest and enjoyment, and increased fatigability. In this case, it is not positive but negative emotions that seem to reach an overwhelming level.

STUDIES 2 AND 3: EMOTION PERCEPTION IN DEPRESSED SUBJECTS, ITS PHYSIOLOGICAL CORRELATES AND IMPACT ON DEPRESSIVE SYMPTOMS

Theoretical background

The fact that at least one prolonged episode of sadness is one of the core criteria for diagnosing a depressive episode (American Psychiatric Association, 1994; World Health Organization, 1992) implies that emotion processing in depressed subjects differs from healthy individuals. However, it is not clear, yet, which aspects of emotion processing lead to these prolonged and intense depressive episodes. According to Phillips and colleagues (2003b), three main processes define an emotional reaction: 1) the identification and recognition of the emotional significance of a stimulus; 2) the production of a specific affective state in response to the stimulus, including autonomic, neuroendocrine, and somatomotor responses; 3) the regulation of the affective state and behavior. To avoid confusion, process one will be referred to as *emotion recognition*, process two as *emotion perception* and process three as *emotion regulation* in the following passages.

The topic of emotion recognition has received quite a bit of attention in psychiatric research up to now. Stimuli depicting facial expressions of emotion are most frequently used in order to assess emotion recognition skills (Dapretto et al., 2006; Derntl et al., 2009). Deficits were reported in various psychological disorders such as Schizophrenia (Derntl et al., 2009; Edwards, Jackson, & Pattison, 2002; Gaebel & Wölwer, 1992) or bipolar disorder (Rocca, Heuvel, Caetano, & Lafer, 2009). In major depressive disorder (MDD), findings can seem quite heterogeneous, at first. Some studies have reported that depressed subjects have difficulties recognizing specific emotions such as sad, happy (Mikhailova, Vladimirova, Iznak, Tsusulkovskaya, & Sushko, 1996), neutral and disgusted (Douglas & Porter, 2010) facial expressions. Some researchers propose a global deficit (Asthana, Mandal, Khurana, & Haque-Nizamie, 1998; Persad & Polivy, 1993) while others do not observe any emotion recognition deficits at all (Gaebel & Wölwer, 1992; Kan, Mimura, Kamijima, & Kawamura, 2004). These differences in results might be due to methodological differences (e.g., different stimuli) in the various studies (Bourke et al., 2010). Reviews by Bourke and colleagues (2010) and Leppänen (2006), however, suggest that regardless of methodological differences there is reasonable evidence of a response bias towards negative and away from positive emotional cues in individuals suffering from MDD as compared with healthy control subjects. However, it is not completely understood why depressed individuals exhibit this negativity bias. One explanation might be, that negative information (such as sad face) leads to an intensified perception of negative emotion in MDD patients, which causes them to focus on this kind information. Moreover, the majority of these studies used pictures of isolated stereotypic facial expressions to examine emotion recognition (Kan et al., 2004). As described before, such pictures might not be representative of real-life emotional experiences. Moreover, emotion-eliciting situations are not limited to perceiving and interpreting facial expressions. A general bias towards negative emotional information, thus, has to be found in different types of scenarios.

As stated before, depressive symptoms might be caused by an intensified perception of emotion in patients suffering from MDD. This intensified emotion perception might lead to a focus towards negative and away from positive information. However, episodes of prolonged and intensified sadness might also be due to deficits in emotion regulation. Emotion regulation can be conceptualized as the "processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions" (Rottenberg & Gross, 2003). Through emotion regulation, individuals consciously or unconsciously (Mehrabi, Mohammadkhani, Dolatshahi, Pourshahbaz, & Mohammadi, 2014) respond to environmental demands by modifying the intensity or type of their emotional experience (Aldao, Nolen-Hoeksema, & Schweizer, 2010). There are different types of emotion regulation strategies. According to (Gross, 2002), antecedent-focused emotion regulation strategies include things one does before the emotion response tendencies have become fully activated (e.g., *situation selection* or *situation*). Response-focused emotion regulation strategies, on the other hand, are considered things one does once an emotion is already underway (e.g., suppression of emotion expression). Since antecedent-focused strategies aim towards avoiding a fully exacerbated emotional response, the focus here is put on response-focused emotion regulation strategies.

There is evidence that depressed people exhibit deficits in response-focused emotion regulation (Mehrabi et al., 2014). They tend to respond to negative affect using ineffective emotion regulation strategies (e.g., rumination and suppression) and less effective ones such as reappraisal or distraction (Joormann & Stanton, 2016). Yet, one essential issue remains: was there an intensified reaction to negative information in the first place? There are two possible explanations why subjects suffering from MDD struggle to cope with negative emotional situations: because they fail to apply response-focused emotion regulation strategies or because they experience an amplified emotional reaction that is disproportional to that of healthy individuals and thereby makes it harder to apply effective emotion regulation strategies as suggested by Joormann and Stanton (2016). If the latter were true, one could assume that depressed subjects experience states of being emotionally overwhelmed on a regular basis, which would clearly limit them in their ability to master day to day tasks and function on a social level. Thus, regarding the three processes of emotion functioning proposed by Phillips and colleagues (2003b), an intensified emotion perception might cause emotion recognition processes to be biased towards negative information. It might further impair emotion regulation, consequently causing depressive symptoms such as prolonged episodes of sadness.

However, if the emotional experience of a depressed person would differ from that of a healthy subject, one would expect that the biological processes associated with emotion functioning such as neuronal factors or aspects of the ANS would be affected, as well (Phillips et al., 2003a; Quintana, Guastella, Outhred, Hickie, & Kemp, 2012; Schneider et al., 2012). Indeed, neuroimaging studies revealed that subjects with MDD display an amplified neuronal reaction (e.g., increased activation in the amygdala and ventral striatum) when confronted with negative stimuli such as sad facial expressions (Leppänen, 2006; Surguladze et al., 2005; Suslow et al., 2010) or negative affective pictures (Anand et al., 2005).

Yet, an intensified response to negative emotional information might also occur in other aspects of the physical stress reaction such as those related to the ANS. The ANS is responsible for the body's response to stress. Through its sympathetic and parasympathetic arms it can induce activation and relaxation in order to restore and maintain balance (Ulrich-Lai & Herman, 2009). Studies looking into associations between depression and ANS activity found, for instance, a reduced heart rate variability (Brunoni et al., 2013; Kemp et al., 2010) which is associated with other mood disorders, as well (Bassett, 2015; Henry, Minassian, Paulus, Geyer, & Perry, 2010; Moon, Lee, Kim, & Hwang, 2013). Other measures of ANS activity include, for instance, GSR, skin temperature (TEMP) or respiratory frequency (RSP).

The aim of studies 2 and 3 was to further examine those ANS parameters and to investigate whether patients suffering from MDD experience emotions as more intense - on the physiological as well as the subjective level. Therefore, we first analyzed whether MDD patients exhibit an increased physiological arousal at rest. In a second step, we investigated how depressed subjects react to negative emotional stimuli physiologically and according to their own perception. We predicted that depressed patients exhibit an intensified reaction towards negative emotional material that is accompanied by an increased physiological arousal. Additionally, we wanted to examine whether the physiological reactions to emotional stress are associated with depressive symptoms such as emotional competence and social skills.

Participants

MDD is a highly prevalent illness that affects almost 20% of the population in Europe and the US at some point in their lives (Andrade et al., 2003; Kessler & Wang, 2009; Kessler et al., 2005; Wittchen & Jacobi, 2005). Murray and Lopez predicted in (1997) that MDD would be one of the most disabling medical conditions by 2020. In addition, depression often takes a chronic course in about one-half to two-thirds of people who have experienced a depressive episode once in their lives. The majority of those suffer from recurrent episodes of depression (Kessler & Wang, 2009). In study 2 and 3 we chose to only include subjects suffering from recurrent depressive episodes that were currently experiencing an acute depressive episode into our sample since recurrent episodes of depression are a clear sign of a predisposition for depression while a single mild episode might be due to situational factors as well. The patient group was then compared to a group of psychologically healthy control subjects who did not differ from the patient sample in age or gender.

Parameters of the ANS

HRV - is an aspect of the ANS that reflects the ability of the heart to adjust flexibly to different challenges. Two common methods of measuring HRV include analyzing the length and variability of intervals between successive normal complexes (Malik et al., 1996) or breaking the heart rate signal into its spectral components (frequencies) and measuring which frequencies occur in which quantities (frequency domain measures; Malik et al., 1996; Xhyheri, Manfrini, Mazzolini, Pizzi, & Bugiardini, 2012). A reduced HRV, which indicates a reduced ability of the heart to adjust to stress, was discovered in depression by many research groups (Bassett, 2015). Although results show some heterogeneity, results of a meta-analysis conducted by Kemp and colleagues (2010) examining HRV in 673 patients suffering from MDD and 407 healthy control subjects revealed a reduced HRV in time domain measures and a lower high frequency power in subjects suffering from MDD. A literature review conducted two years later came to a similar conclusion (Stapelberg, Hamilton-Craig, Neumann, Shum, & McConnell, 2012).

Antidepressant medication, however, is to be considered when testing depressed patients since it has been shown to reduce HRV. Although the exact influences of antidepressant medication are not completely understood, yet, it does seem like tricyclic substances do influence HRV the most while SSRIs appear to have a smaller impact (Bassett, 2015; Kemp et al., 2010). Thus, antidepressant medication remains a topic of controversy in the measurement of HRV. One could, of course, choose to test unmedicated subjects to avoid effects of medication (Kemp & Quintana, 2013). However, this would also mean taking into account that unmedicated patients might suffer from milder depressive episodes and are more likely to have suffered through fewer episodes in their life. Antidepressant medication is recommended in mild to moderate depression and highly recommended in severe depression, especially when episodes are recurrent (American Psychiatric Association, 2010; Anderson, Nutt, & Deakin, 2000; Reimherr et al., 1998; Young, 2001). Thus, choosing a representative sample of depressed subjects appears to be intricate when assessing HRV. In study 2 and 3 we chose a group of patients suffering from recurrent depressive episodes since recurrent episodes of depression are a clear sign of a predisposition for depression. Yet, we chose to assess medication very thoroughly and included medication equivalents in our analyses to compensate for possible biases.

Lead II electrocardiogram (ECG) was measured at 2048 Hz in order to assess HRV. Time intervals between successive heart beats needed for HRV analyses were extracted from the ECG using the QRS detector of Kubios HRV software (Tarvainen, Niskanen, Lipponen, Ranta-aho, & Karjalainen, 2014). Both time domain and frequency domain measures were computed. For further explanations regarding measures of HRV, please see Table 1.

Table 1: Overview of the most important measures of HRV. Poincaré plots are scatter plots where each NN-interval is plotted against the next NN-interval. *Abbreviations*: ms = millisecond, HF = high frequency, LF = low frequency, VLF = very low frequency.

	Time Domain Measures	
Estimate	Description	Unit
SDNN	Standard deviation of all NN intervals	ms
RMSSD	Square root of the mean squared differences of consecutive NN intervals	ms
pNN50	Percentage of NN50 relative to all NN intervals	%
SD 1	Standard deviation perpendicular to line-of-identity in poincaré plots	ms
SD 2	Standard deviation along the line-of-identity in poincaré plots	ms
	Frequency Domain Measures	
LF	Power in LF range	ms^2
HF	Power in HF range	ms^2
LF/HF-ratio	LF (in ms^2) divided by LF (in ms^2)	

GSR – is defined as shifts in the skin conductance level. Since they reflect on the autonomic innervation of the sweat glands in the skin they are considered as an indicator of the human stress response. GSR appears to be elevated in MDD (Branković, 2008; Toone, Cooke, & Lader, 1981). However, there is also evidence of lower levels (Storrie, Doerr, & Johnson, 1981; Straub, Hole, & Wolfersdorf, 1992; Ward, Doerr, & Storrie, 1983). The role of GSR in depression, thus, needs to be further investigated. In study 2 and 3 GSR was measured using two Ag-AgCl electrodes that were secured to each participant's left hand on the intermediate phalanges of digits II and IV.

RSP – was assessed using a belt fastened tightly around the subject's chest above the navel. While respiratory sinus arrhythmia (RSA) - a measure of the variation in interbeat intervals of the heart at the frequency of breathing that reflects parasympathetic nervous system functioning (Gentzler, Santucci, Kovacs, & Fox, 2009) - has repeatedly been associated with the course of depression, symptom improvement and emotion regulation (Kovacs et al., 2016; Panaite et al., 2016) breathing frequency (i.e., breaths per minute) has, to our knowledge, not been topic of much research.

TEMP – represents another measure of ANS activity that has been studied very little in connection to depression so far. In study 2 and 3, TEMP was measured using a sensor specifically designed for monitoring very small temperature changes in the peripheral extremities. The so-called thermistor was attached to the palmar surface of the distal phalange of digit III on the left hand.

Hormones - indicating ANS activity included cortisol and dehydroepiandrosterone (DHEA). Cortisol is considered as a parameter reflecting possible dysregulations in the hypothalamic-pituitary-adrenal axis (HPA), a common finding in depression (Holsboer, 2000; Ising et al., 2007; Knorr, Vinberg, Kessing, & Wetterslev, 2010). Indeed, reports on cortisol in subjects suffering from MDD describe slightly elevated cortisol levels in depressed patients as compared to control subjects (Knorr et al., 2010). However, cortisol is influenced by many different factors such as age, life events and psychological traits (Herbert, 2013), which may bias findings. DHEA has been frequently connected to the pathogenesis of depression (Wong et al., 2011) and might also be able to decrease depressive symptoms when given as a treatment (Hu et al., 2015).

Both, cortisol and DHEA, were measured from salivary samples. In order to avoid distortion of the data due to differences in the circadian rhythm of the subjects, salivary samples were taken from all participants at 8 am in the morning. All subjects were asked not to drink, eat, smoke or engage in physical activities such as sports from 10 pm on the previous evening until the point of measurement in order to ensure better comparability.

Study 2: The Impact of ANS and Hormonal Parameters on Symptoms of Depression

Methods and Results

The general aim of study 2 was to investigate parameters of the ANS at rest and analyze associations with depressive symptoms such as mood and emotional competence. We included 41 patients (25 females, 16 males; M_{age}=43.46) diagnosed with recurrent depressive disorder according to DSM-IV criteria (APA, 1994) and 43 healthy control participants (32 females, 11 males; M_{age}=36.88 years). Patients had suffered from on average 5.28 depressive episodes (*SD*=4.72) and were all taking antidepressant medication (mean amitriptyline equivalent score=200.76) except for one. Control subjects were matched in gender and cognitive abilities as indicated by the 'Mehrfachwahl-Wortschatz-Test', the German equivalent to the 'Spot-the-Word test' (MWT-B; Lehrl, 2005), a measure of crystallized intelligence. However, the control group was slightly younger than patients. Therefore, age was included as a control variable in further analyses. Body mass index (BMI; kg/m^2) and the average number of cigarettes per day, two variables that have been found to influence HRV (Xhyheri et al., 2012), were assessed as additional covariates.

The Beck Depression Inventory II (BDI II; Hautzinger, Keller, & Kühner, 2009) was applied to measure acute depressive symptoms. As a measure of current mood, the Positive and Negative Affect Schedule (PANAS; Krohne, Egloff, Kohlmann, & Tausch, 1996) was assessed. Finally, the German version of the Emotional Competence Questionnaire (ECQ; Rindermann, 2009) was used as a measure of emotional processing. ECQ scores can be expressed as a global score and divided into four subscales: *Recognition and understanding of one's own emotions (RE)*, *recognition of others' emotions (RO)*, *emotion regulation (ER)* and *emotional expressivity (EX)*.

Hormonal parameters of the ANS included cortisol and DHEA. Other physiological measures included GSR, TEMP, RSP and HRV that were recorded in two measurements to ensure robust results. Both measurements were assessed in the morning of the same day. Between the measurements, participants were involved in very simple cognitive (e.g., counting shapes on a computer screen) and affective tasks (e.g., judging the emotional quality of facial expressions) in order to imitate regular day-to-day tasks. We calculated the mean standard deviation (SD) and arithmetic mean (AM) for each measure. Furthermore, we analyzed time domain as well as frequency domain measures of HRV. Before calculating repeated measure ANCOVAs for all ANS parameters, we tested if either age, cigarettes per day, BMI or medication dosage influenced our results. If significant correlations between these variables and the physiological variables were observed, we included them as covariates.

As to be expected, patients reported significantly more depressive symptoms in the BDI II than healthy controls ($t(43.7) = -11.68$, $p<.001$). Patients rated their own mood as less positive ($t(74.1)=8.41$, $p<.001$) and more negative ($t(67.3)=-8.55$, $p<.001$). In addition, patients reported less emotional competence than control subjects (all $p\leq.01$).

Regarding parameters of the ANS, we observed higher DHEA levels in the depressed sample ($F(1)=4.29$, $p=.05$) while cortisol levels were comparable across groups ($F(1)=.41$, $p=0.53$). GSR did not differ significantly between the two groups ($F(1,81)=.56$; $p=.46$) but increased from measurement 1 to 2 in both groups, respectively ($F(1,81)=74.53$; $p<.001$). We found significant group differences in TEMP ($F(1,81)=4.65$; $p=.03$). Furthermore, RSP was elevated in control subjects ($F(1,81)=5.25$; $p=.03$).

ANCOVAs including age and amitriptyline as covariates did not reveal significant group differences for either of the assessed measures (Mean NN, SDNN, RMSSD, NN50) in both measurements. Further analyses revealed that patients did display lower levels in all time domain measures when only considering the mean HRV levels. However, since the ANCOVAs including age and amitriptyline equivalents did not reveal any significant group effects, one can assume that these differences were mostly caused by the influence of the covariates. Regarding frequency domain measures, we observed a similar pattern as initially significant group differences turned out to be largely due to medication effects.

To see whether differences in physiological arousal were associated with symptoms of depression, we computed correlational analyses including ANS parameters that had shown to differ between patients and control subjects (i.e., TEMP, RSP and DHEA). DHEA and RSP did not correlate with symptoms of depression. We discovered significant correlations between TEMP and current mood. Positive affect was negatively associated ($r\leq.01$) while negative affect was positively correlated with TEMP in both measurements ($r=.02$-$.03$). Depressive symptoms assessed using the BDI II revealed a significant positive association with high TEMP scores in measurement 1 ($r=24$, $p=0.03$).

Although the reported correlations represent patterns of significant associations across measurements and different parameters (AM, SD) we did correct for multiple comparisons. After Bonferroni correction, only associations between TEMP and positive mood remained significant. Interestingly, when looking at correlations for the patient and control group, separately, we discovered that positive mood and TEMP were only correlated in the patient ($r=.01$-$.04$) but not in the control group.

Discussion

In study 2, we gained some first understanding of physiological arousal in depression. We discovered group differences in DHEA, TEMP and RSP between patients and control subjects. Regarding effects of measurement time point, we observed that GSR increased significantly from measurement 1 to 2. However, GSR increased for both groups, respectively. Furthermore, our results clearly replicate previous findings showing that variations in HRV can, to a large extent, be explained by the influence of medication.

Depressed patients showed significantly elevated DHEA levels in comparison with controls. Changes in DHEA levels have been associated with a hyperfunction of the HPA-axis as well as depression, Our results, thus, confirm the hypothesis that changes in DHEA might point towards higher levels of stress which in turn influence the pathophysiology of depression (Kurita et al., 2013). However, many factors can contort DHEA concentrations in the body. Specifically, age and gender might play an important role (Hu et al., 2015; Kurita et al., 2013). Furthermore, there are many studies that analyze either DHEA or its sulfate (DHEAS). However, there is evidence that DHEA and DHEAS levels are not always comparable. Kurita and colleagues, e.g., demonstrated elevated DHEA levels while DHEAS levels were reduced in male depressed participants. Thus, further research assessing DHEA and DHEAS considering age and gender as confounds is needed to analyze the association of those hormones.

Results concerning group differences in TEMP and RSP appear contradictory since elevated TEMP levels indicate arousal while a reduced RSP points towards relaxation in the patient group. Considering prior research, there is one other study that analyzed both TEMP and RSP in association to depression. Lin and colleagues (2011) assessed GSR, TEMP, RSP and heart rate and reported an association of TEMP with symptoms of depression. However, they merely measured depressive symptoms in a student sample using the BDI II. Because a diagnosis of depression was not required and since the sample was significantly younger (age 18-24 years), Lin's results cannot be directly compared to our study. Hence, further research is needed to find out whether these results can be replicated and how they can be interpreted.

Another finding of this study regarded associations between parameters of the ANS and depressive symptoms. Group differences in mood and emotional competence were associated mainly with TEMP scores: elevated skin temperature was linked with more negative and less positive affect as well as higher scores in the BDI II.

Several limitations have to be noted in study 2. We assessed salivary samples in order to measure cortisol and DHEA levels at 8 am in the morning. However, while control subjects usually arrived from home, patients were mostly inpatients of the clinic in which the experiment was conducted. Thus, we can assume that control subjects got up earlier on average than patients and had already engaged in more physical activation. Although we specifically instructed control subjects and outpatients to arrive by public transportation or car to avoid physical activity, we can assume that even a walk of five minutes from the bus station might make a difference. Furthermore, we instructed all participants to refrain from smoking, drinking, eating and sports starting at 10 pm prior to testing. However, we cannot be entirely sure that all participants followed those instructions.

We assessed baseline physiological arousal in this study. Yet, it is of specific interest how depressed subjects handle emotionally stressful situations in order to understand how they experience emotional situations in their daily life. Thus, it appears necessary to assess physiological parameters not only at rest but also while simulating real-life emotional situations.

Finally, people suffering from depression are impaired in their daily lives not only by deficits in emotional competence. They are limited in their ability to master social situations, as well (Cole, Lazarick, & Howard, 1987; Cole & Milstead, 1989; Youngren & Lewinsohn, 1980). Consequently, they exhibit symptoms such as social withdrawal (American Psychiatric Association, 1994) and interpersonal problems, which restrict them in their social relationships and further exacerbate the illness severity. According to the *polyvagal theory* (Porges, 2007), reduced HRV can be regarded as a reflection of poor ANS regulation that might contribute to depressive symptoms such as reduced social skills. Indeed, there is evidence that HRV correlates positively with emotion recognition in healthy subjects suggesting that HRV and abilities related to empathetic interactions with others are related (Quintana et al., 2012). Thus, deficits in social skills should be included in further analyses since they can be considered an important aspect of depression.

In order to address these limitations and to gain further insight into associations between physiological arousal in depressed subjects, we conducted a second experiment that is documented in study 3.

Study 3: Intensified emotion perception is associated with deficits in social skills and increased physiological arousal in depressed subjects

Methods and Results

In study 3, parameters of the ANS were assessed in depressed patients as compared to healthy control subjects at rest and while viewing emotionally arousing picture material. Additionally, we examined whether physiological and subjective reactions to emotional stress are linked to emotional competence and social skills. Thereby, we wanted to further understand associations between parameters of the ANS and symptoms of depression in order to discover underlying mechanisms causing symptoms of depression.

We included 41 patients diagnosed with recurrent depressive disorder (25 females, 16 males; M_{age}=43.85 years) and 42 healthy control participants (29 females, 13 males; M_{age}=40.67 years) matched in gender and age. Patients had suffered from depressive episodes for a duration of up to 43 years (M=12.75; SD=31.11). As in study 2, depressive symptom severity was assessed using the BDI II (M=22.66; range=3-47). Amitriptyline equivalents ranged from 0 up to a dose of 375 (M=103.7). BMI and cigarette consumption were assessed as covariates.

The Social Skills Inventory (Riggio & Carney, 2003) was assessed as a self-report of social skills. We used the subscales *social expressiveness (SE)*, *sensitivity (SS)* and *control (SC)* in our analyses. In addition, the PANAS and ECQ were applied as in study 2.

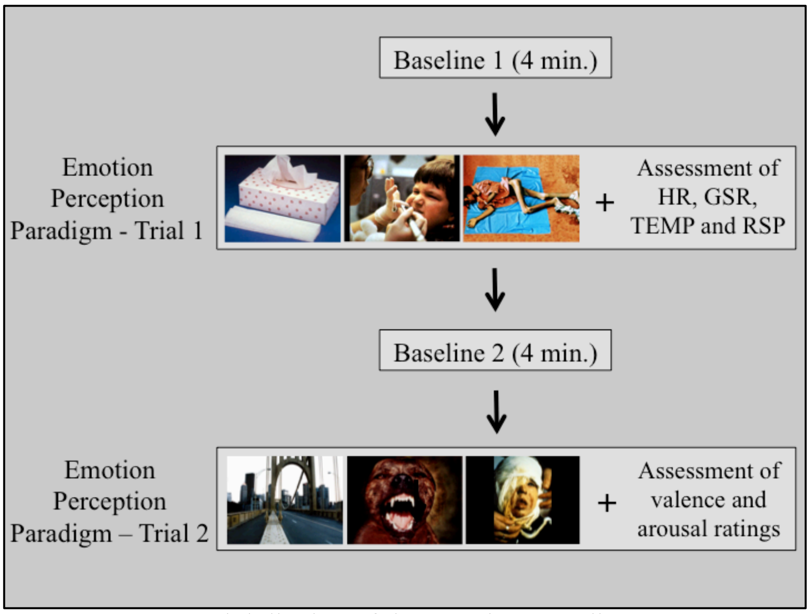

Figure 3: Sequential display of the emotion paradigm.

In the emotion perception paradigm developed to evoke and analyze a reaction to emotionally stressful material we presented a selection of pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) to all participants. The IAPS is a “large set of standardized, emotionally- evocative, internationally accessible, color photographs that include contents across a wide range of semantic categories” (Lang, Bradley, & Cuthbert, 1997). Here, we used a subset of 90 pictures from the IAPS battery, which was then equally split into three categories of each 30 stimuli: *Neutral* pictures (valence: M=5.09, SD=.23 / arousal: M=2.99, SD=.63) depicted mainly day-to-day objects like telephone. *Unpleasant* pictures (valence: M=3.63, SD=.13 / arousal: M=5.18, SD=0.86) showed scenarios like an attacking shark or a child crying at the dentist. Lastly, pictures of, for instance, mutilated faces or an old man sitting at the side of his dying wife's bed were classified as *very unpleasant* pictures (valence: M=1.93, SD=.17 / arousal: M=5.87, SD=.65, see also Figure 3). The stimuli were presented in two blocks of each 45 pictures. The first trial was conducted after the first baseline measurement of ANS parameters while the participants were still connected to the biofeedback device in order to assess their physiological reactions to the pictures. Hence, there were five conditions in which ANS parameters were assessed: a first baseline, neutral, unpleasant and very unpleasant pictures and a second baseline (see also Figure 3). During the second trial participants were instructed to issue valence and arousal ratings while viewing the pictures. We calculated the mean standard deviation (SD) and arithmetic mean (M) for each physiological measure (GSR, TEMP, RSP) for each of the five conditions (baseline 1, baseline 2, neutral, unpleasant and very unpleasant pictures). As in study 2, covariates (e.g., BMI) were included in the analyses if they correlated with the measures assessed. Results regarding the questionnaires assessed are illustrated in Figure 4.

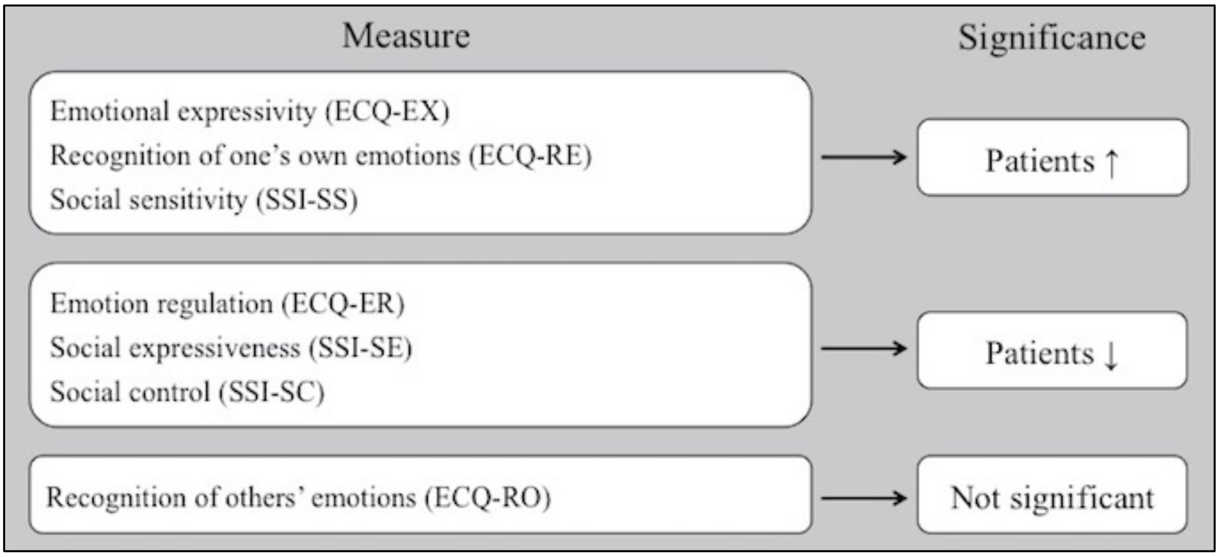

Figure 4: Overview of group comparisons of emotional competence (ECQ) and social skills (SSI).

Concerning GSR, group differences did not reach a significant level ($F(1,65)=1.76$; $p=.19$). However, a significant increase from baseline 1 to baseline 2 ($F(1,62)=5.29$; $p<.01$) was discovered in both groups, respectively. We found significant group differences in TEMP ($F(1,78)=8.29$; $p<.01$). Regarding RSP, the groups did not differ significantly ($F(1,77)=.65$; $p=.42$). However, as illustrated in Figure 5, emotion condition did show a significant effect

(F(1,74)=3.814; p<.01). Post-hoc dependent t-tests revealed that RSP-levels increased from baseline 1 to neutral pictures (t(40)=-3.56, p<.01), from neutral to unpleasant pictures (t(40)=-3.00, p<.01) and from baseline 1 to very unpleasant pictures (t(40)=3.33, p= p<.01) in the patient sample. In the control sample, however, significant changes were only observed between neutral and unpleasant pictures (t(41)=-2.09, p=.04).

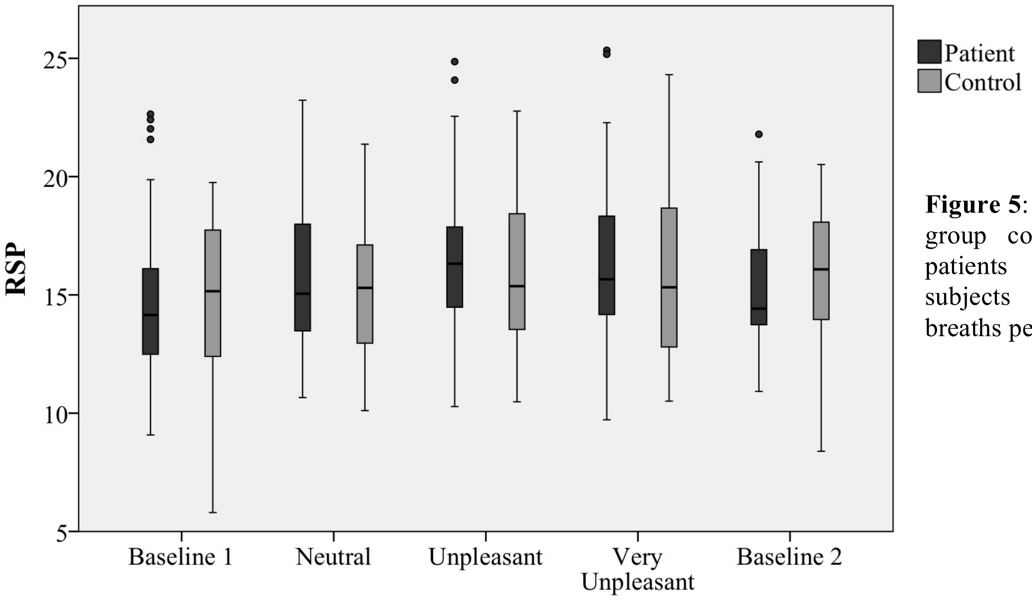

Figure 5: Graph of the group comparison of patients and control subjects in RSP (in breaths per minute).

Results for HRV revealed reduced scores in the patient group for most time domain measures (RMSSD, SDNN, SD 1, SD 2; p=.04-.01). Including amitriptyline equivalents and age as covariates into the analyses, however, revealed that those seemed to largely cause group differences (p-values after including covariates=.45-.99). Frequency domain measures did not differ significantly between groups with (p=.22-.59) or without including covariates (p=.17-.76).

Looking at the subjective valence and arousal ratings patients rated the pictures as more arousing (F(1,80)=6.76; p=.01) and more negative in valence (F(1,80)=6.66; p=.01). Furthermore, subjective ratings were associated with emotional competence (ECQ) and most strongly with depressive symptom severity (BDI II) and social skills (SSI) (see also Table 2).

Table 2: Correlations of valence and arousal ratings with the subscales of the questionnaires, Emotional Competence Questionnaire (ECQ) and Social Skills Inventory (SSI). *Abbreviations*: ER = emotion regulation; EX = emotional expressivity; RO = recognition of others' emotions; RE = recognition of own emotions; SS = social sensitivity; SE = social expressiveness; SC = social control; ** = p<.01; * = p < .05.

	Arousal *r* (*p*)			Valence *r* (*p*)		
	Neutral	**Unpleasant**	**Very unpleasant**	**Neutral**	**Unpleasant**	**Very unpleasant**
ECQ-ER	-.19 (.081)	-.11 (.344)	-.22* (.047)	-.22* (.050)	-.13 (.244)	-.24* (.028)

ECQ-EX	.17 (.134)	.22* (.044)	.12 (.294)	.12 (.281)	.11 (.318)	.04 (.724)
ECQ-RO	-.06 (.600)	.01 (.957)	-.03 (.808)	-.15 (.175)	-.07 (.560)	-.06 (.587)
ECQ-RE	.19 (.094)	.20 (.073)	.11 (.332)	.13 (.245)	.07 (.509)	.03 (.792)
SSI-SE	-.28* (.012)	-.16 (.139)	-.26* (.019)	-.31** (.004)	-.20 (.066)	-.24* (.030)
SSI-SS	.23 (.041)	.28* (.010)	.30** (.007)	.28* (.010)	.18 (.104)	.32** (.003)
SSI-SC	-.35** (.001)	-.33** (.002)	-.42** (.000)	-.39** (.000)	-.26* (.017)	-.36** (.001)
BDI II	.35** (.001)	.32** (.003)	.33** (.002)	.36** (.001)	.264* (.016)	.256* (.016)

Further correlational analyses revealed significant associations between TEMP and depressive symptomatology (BDI II; $r \leq .01$). Furthermore, elevated TEMP was positively correlated with negative mood (PANAS NA: $r \leq .01$) and negatively associated with positive mood (PANAS PA: $p = .02-.03$). After Bonferroni corrections, none of the other associations between other ANS parameters and self-reported symptoms (SSI, ECQ, DERS, BDI II, PANAS) reached a significant level.

Discussion

Several findings of study 2 could be replicated in study 3. Elevated TEMP levels in both samples appears as one consistent finding. Furthermore, increased TEMP levels were associated with measures of depressive symptoms (BDI II) and mood (PANAS) across studies. TEMP in association with depressive symptoms has – to our best knowledge – only been examined in one more study (Lin et al., 2011). Hence, our results give new insight into physiological correlates of depression. Concerning GSR existing research in depressed samples at rest found elevated (Branković, 2008; Toone et al., 1981) or reduced (Straub et al., 1992; Ward et al., 1983) levels while our results did not reveal group differences at all. In addition, we did not observe variations in GSR levels in reaction to the emotion perception paradigm between patients and controls. Our results are in line with Gehricke and Shapiro (2001) as well as Lin and colleagues (2011) who did not find differences in GSR in response to stress tasks in depressed subjects as compared to controls, either. Thus, we have to concur with Straub and colleagues (1992) in that GSR levels do not appear to reliably distinguish between depressed and non-depressed individuals. Furthermore, they do not seem to serve as an indicator of emotional arousal.

Reduced HRV scores were also discovered and consistently associated with effects of antidepressant medication across the two studies as reported in prior findings (Bassett, 2015; Davidson et al., 2005; Kemp et al., 2010, 2013). Our sample did not suffice to separate scores into subsamples in order to further examine effects of different substances (SSRI, tricyclic etc.) on HRV. However, differences in significance of group effects with or without accounting for medication equivalent scores showed that medication was largely associated with the observed group variations. Given these findings and the fact that antidepressants have been shown to alter neuronal patterns such as amygdala activation (Rosenblau et al., 2012), the effect of medication on ANS processes in depression must not be underestimated.

Regarding RSP the inclusion of emotion evoking stimuli in study 3 revealed interesting results. During the presentation of the IAPS pictures patients actually showed an accentuated breathing frequency, i.e., patients reacted to negative pictures more strongly than controls (see also Figure 5). These results demonstrate an increased response to negative emotional stimuli which is in line with prior findings regarding physiological (Lin et al., 2011; Schneider et al., 2012) and neuronal parameters (Mayberg et al., 1999; Rosenblau et al., 2012; Suslow et al., 2010; Thomas et al., 2001). To our knowledge, however, these are the first findings regarding respiratory frequency as a parameter of ANS activation in depression.

An intensified perception of emotional stimuli was also observed in the subjective ratings of valence and arousal that all participants issued. Patients clearly perceived the pictures as more negative and arousing in all three conditions. Furthermore, they reported deficits in emotional and social competence. However, they did not report shortcomings in emotion recognition or misinterpretations of social signals as reported in prior research (Bourke et al., 2010). Instead, they admitted problems, for instance, in emotion regulation and social control when in an emotional state. One possible explanation for these findings is that an intensified perception of emotional information aggravates depressive symptoms such as prolonged and intense phases of sadness that are hard to regulate and, hence, lead to an impairment of emotional and social competences in depression. Assuming that depressed patients are constantly trying to regulate intense negative emotions while interacting with others, it seems plausible that they are more likely to send out confusing social signals than healthy individuals, which then might affect their ability to socialize and handle social interactions in the same way as healthy subjects would (Prkachin, Craig, Papageorgis, & Reith, 1977). This notion is in line with our findings of valence and arousal ratings being correlated with deficits in emotional competence, social skills and general depressive symptoms.

However, some measures of physiological arousal did not reveal an effect caused by the negativity of the stimuli. TEMP, for instance, was elevated in the patient sample across measurements regardless of the level of negativity in the pictures. This raises the question whether the stimuli used in our study elicited enough stress to account for a pronounced physiological response. The subsamples selected from the IAPS battery in this study included neutral pictures as well as stimuli that were low or even very low in valence (1.8-3.9 on a scale from 1 to 9). Yet, the media (daily news, internet, movies etc.) provide us with pictures and video clips of negative material on a daily basis. And although one might be able to categorize them as negative or arousing (such as depressed patients did in our study) they might not elicit the same kind of physiological reaction since processes such as habituation might attenuate the actual arousal.

GENERAL DISCUSSION

This dissertation aimed at gaining an understanding of how intense positive emotions are expressed, perceived and recognized in healthy and depressed subjects. As a theoretical background of emotion classification we relied on Russell's (1980) approach of a dimensional model of affect. Hence, we determined the emotion's valence and arousal to characterize it. In study 1, we examined how intense emotions are expressed and recognized focusing on facial expressions in children and adults who experienced extreme emotional situations. In study 2 and 3, it was investigated how depressed subjects perceive negative emotions. We wanted to further elucidate their physiological and subjective response to negative information. Lastly, we expected that an intensified emotion perception was associated with depressive symptoms such as deficits in social skills and emotional competence.

Expression and recognition of intense emotions

One of the most important issues tackled in study 1 was the selection of stimuli to assess emotion recognition. Previous work has focused on using stereotypic pictures of facial expressions in order to determine emotion recognition skills (Bourke et al., 2010). Some researchers chose to expand their stimuli repertoire to morphed facial expressions, recordings of prosody or video clips depicting facial expression, voice prosody, and sentence content all at once (Schneider et al., 2012). Yet, the consensus still lies with adult actors demonstrating emotions in the lab. Due to this narrow set of stimuli deployed to reflect emotion expression, we can assume that in return results concerning emotion recognition skills or impairments only capture a very limited range of the actual construct. In order to address some of these limitations, we created two new sets of stimuli in study 1. We chose individuals that were not acting but actually experiencing real-life emotions while in a familiar, untelevised environment. Furthermore, subjects of two age groups (adults and children) were included.

Regarding stimuli selection, another issue remained: the importance and diagnostic validity of body cues. Since facial expressions are considered as significant cues to deduce emotions from because of the face's dynamic and visible nature (Ekman & Rosenberg, 2005; McLellan et al., 2010), body cues have been rarely included in studies concerning emotion recognition so far (Aviezer et al., 2012). However, recent research demonstrated that facial expressions lose their diagnosticity when intense emotions are analyzed (Aviezer et al., 2015, 2012). In study 1, we confirmed this notion and demonstrated that those effects are not only stable but can also be observed in different age groups and different situations that are not televised.

We could show that emotion expressions in the face can often appear as ambiguous, specifically when looking at intense emotions. Thus, our results challenge established theories of affect by Ekman and Russel who proposed that emotions become easier to distinguish the more intense they get (Tracy, 2014). However, regarding the stereotypic character of stimuli used in emotion recognition research thus far, one might suspect that subtler expressions of emotions might be harder to read when observed in real life as well. Furthermore, the ambiguity appears to lie only in the eyes of the observer. While the raters struggled to distinguish between facial expressions that were high and low in valence, objective movements in the facial muscles according to Ekman's FACS do, in fact, bear several differences (Aviezer et al., 2015). Thus, in future research it would be interesting to further examine, which objective facial movements differentiate between negative expressions during negative situations and negative appearing expressions during positive situations.

Lastly, study 1 gives rise to another interesting issue. The reason why emotion expressions in response to highly positive or anticipated events frequently appear as negative to the outside observer is not answered, yet. Aragón and colleagues (2015) contributed an interesting thought, suggesting that this kind of reaction might be an emotion regulation strategy employed to reestablish an emotional equilibrium. While this thought is in line with our results regarding positive events and Aragón's work results one would expect the opposite reaction in negative events, as well. Since such responses were not observed in our experiments, further explanation concerning the origin of negative facial expressions to highly positive situations is needed.

Perception of negative emotions in depression

As depression is marked by intense and prolonged negative affective states such as sadness or anxiety it is important to understand how these negative emotions are coped with and which aspects of emotion processing are affected. In our research we showed that depressed patients display an intensified physiological and subjective response to negative information compared to healthy subjects.

In order to provoke an emotional reaction we specifically created an emotion perception paradigm (see also Figure 3). We chose a subset of pictures of the IAPS as emotion eliciting material. These stimuli are very well validated and include mean valence and arousal ratings for each picture. Moreover, while many other studies relied on a single facial expression as an emotion evoking stimulus (Leppänen, 2006) the IAPS battery depicts elaborate scenarios of different contents that vary in their valence.

The emotion perception paradigm did not only serve to assess subjective ratings of valence and arousal but also to assess parameters of ANS activation. Thus, connections could be drawn from behavioral to physiological measures. In both study 2 and 3 we included parameters frequently assessed in depression such as the hormones cortisol and DHEA, GSR or HRV but also aspects of the ANS that have received less attention so far. In fact, RSP and TEMP have – to our best knowledge - been examined only in one other study concerning depression (Lin et al., 2011). Hence, our research gives insight into a more comprehensive model of physiological functioning in depression revealing first results concerning TEMP and RSP and linking them to subjective evaluations of emotional stimuli.

Furthermore, we chose to address connections between emotion perception in physiological and subjective measures on the one hand and depressive symptoms, social skills and emotional competence on the other. Interestingly, associations with subjective emotion perception (valence and arousal ratings) were strongest for depressive symptom severity and social skills.

The concept of social skills (also known as interpersonal skills, interpersonal competence, social competence or communication competence) has at least as many definitions as synonyms (Segrin, 2000). According to (Segrin, 1992) it can be described as the ability to interact with others in an appropriate and effective manner. Appropriateness is understood as not breaking social norms or disappointing social expectations while effectiveness signifies the reaching of personal goals and execution of plans through interaction with others. Deficits in social skills, thus, complicate the building and sustaining of relationships with others (Segrin, 1992). This notion is supported by research showing that depressed individuals tend to make less eye contact with their conversation partners (Rutter & Stephenson, 1972) and need more time to react to others (Libet & Lewinsohn, 1973). Consequently, people suffering from depression receive less positive reactions in an interpersonal context (Youngren & Lewinsohn, 1980) and more social rejection than those who do not (Segrin & Abramson, 1994).

Our results support findings of reduced social skills in depression and further imply that these deficits might be connected to an intensified emotion perception. Our explanation for this association is that depressed individuals frequently experience intense negative emotions that impair them in their ability to engage in and control social interactions. This notion is in line with the (Coyne, 1976) *interactional model of depression*, which assumes that it is the depressive symptoms that lead to social skill deficits. However, another theoretical framework of depression that emerged in the 1970s contradicts this hypothesis. Lewinsohn (1974) proposed that depressive symptoms emerge due to a lack of positive social reinforcement caused by a lack of social skills. Although depressive symptoms, social skills and emotion perception were significantly associated in our studies, we cannot infer causality since we applied correlational analyses. Thus, we cannot state whether an intensified emotion perception lead to impairments in social skills or the other way around.

The question remains whether deficits in social skills are only associated with an intensified perception of emotion on the subjective level or whether there are also physiological correlates. According to Quintana and colleagues (2012) and the polyvagal theory (Porges, 2007) poor ANS regulation and reduced social skills in depression might be associated. Recent work by Häusser and colleagues (2012) suggests associations between social skills and physiological arousal in healthy subjects, as well. According to them, the concept of social identity plays an important role. Social identity is understood as the "part of an individual's self-concept, which derives from his knowledge of his or her membership of a social group" (Tajfel, 1978), p. 63) and influences our social perceptions and behavior (Frisch, Häusser, van Dick, & Mojzisch, 2014). In their work, Häusser and colleagues could show that the presence of others had a stress buffering effect that lowered physiological arousal when a shared social identity was salient. Further research confirmed this notion and showed that social support only buffers stress when the recipient and sender of the social support shared a social identity.

Depressed individuals who suffer from deficits in social skills receive less social support than others (Youngren & Lewinsohn, 1980) and tend to withdraw from social interactions. It would, thus, be interesting to see whether the results of Häusser and colleagues could be replicated in a depressed sample. In studies 2 and 3 we did not find associations between physiological arousal and self-reported social skills. This might be due to differences in the physiological parameters that were assessed. Since we found that results concerning HRV were strongly influenced by antidepressant medication, we calculated correlational analyses only with TEMP and RSP. Another explanation might be that social skills were only assessed using self-report questionnaires. A paradigm such as presented by Häusser and colleagues could give interesting insights into how depressed subjects actually react to stress in social situations.

Limitations

Specific limitations of the three studies were already discussed before. A general issue, however, of research into peripheral physiological measures is the lack of consistent guidelines determining how to deal with artifacts in the measurements. While there are guidelines for dealing with artifacts in HRV measurements (Task Force, 1996) few studies mentioned here report to adhered to those instructions. Furthermore, there are no guidelines on how to cope with artifacts in other measures of the ANS. Thus, a careful examination of the various methods for dealing with artifacts is essential to decrease the risk of bias in future scientific work. Other potential factors that vary between different studies such as age or comorbid somatic disorders may bias findings, as well.

However, we tried to deal with these issues by screening and correcting all physiological measurements for potential confounds to increase the validity of our results. We tried to keep the conditions, under which we measured physiological parameters as stable as possible. For instance, we instructed patients to not consume nicotine or caffeine 12 hours prior to measurement and used medication equivalent scores, average nicotine consumption, BMI etc. as covariates in our analyses. Thus, we reduced the potential impact of person-situation-environment interactions. Nevertheless, we cannot know with certainty whether participants actually followed our instructions. In addition, menstrual cycle in women should be assessed in future research.

Another limitation might lie in our selection of emotion eliciting stimuli. Here, we relied on the dimensional view of emotions and distinguished emotions based on their valence and arousal scores in all three studies. However, this view does not distinguish between different emotion categories. Since an increased vigilance and selective attention towards, e.g., sad facial expressions has been demonstrated before (Bourke et al., 2010; Leppänen, 2006) focusing specifically on sad emotional stimuli would have given more specific insight into the topic. In addition, regarding physiological arousal Ekman described distinct ANS patterns for different basic emotions (Ekman, 1992 & Kreibig, 2010).

Conclusion

This dissertation tried to give comprehensive insights into the processing of intense emotions. Results allow a better understanding of how they are expressed, recognized and perceived. We report that intense emotions when recorded in real-life scenarios lead to ambiguities in facial expressions across age groups and different situations. These results challenge well-established theories of emotion by Paul Ekman and others. Furthermore, possible connections to strategies of emotion regulation are drawn that require further research.

Our results clearly point towards a lack of variety and the stereotypical nature of stimuli used in research so far. These stimuli are likely to only capture limited aspects of emotion processing. Different options of how to measure emotions have been discussed and weighed in this dissertation. We attempted to follow the notion of relying on material that was as authentic and close to real-life as possible. The question remains, however, whether stimuli - as authentic as they might be - can, in fact evoke or reflect emotions as experienced in our day-to-day lives. In study 1, we succeeded to record real-life emotional expressions. Yet, we were limited by what the cameras revealed to us and implied emotional experience as distant observers.

Since emotional experiences are closely linked to our own autobiography and personality, one can never expect a stimulus to elicit the same emotional response in two different persons. To find stimuli that are authentic and reflect real-life but also evoke similar emotional reactions in different individuals, thus, should be a primary objective of further research. An alternative to this ambitious task would be to find a way of measuring emotional states in individuals following participants through their daily lives and routine. While subjective perceptions of emotion are frequently tracked in the form of emotion diaries for therapeutic purposes, the recording of physiological arousal could give new and comprehensive insights into emotion functioning in healthy and depressed individuals.

In study 2 and 3, we investigated whether an intensified reaction to negative emotional stimuli in depressed subjects was related to frequent symptoms of depression such as reduced social skills and emotional competence. Here, we did not limit our investigations to subjective ratings but also examined physiological underpinnings of emotion perception. Patients experienced the pictures as more arousing and negative in valence. Also, they showed an accentuated respiratory frequency in response to the stimuli. Therefore, we found evidence to support our hypothesis of an intensified perception of negative information in depressed subjects. In addition, the acute perception of emotion in depressed individuals was associated with deficits in social and emotional competence as well as severity of depressive symptoms, as predicted.

In summary, this dissertation provides insight into the way depressed individuals perceive their surroundings, specifically, negative information. Moreover, associations between aspects of the ANS and depressive symptoms are revealed that have – to our best knowledge – not been investigated before. Findings like these may help to understand how dysfunctional emotional processing leads to emotional and social impairments in depression. To further investigate the way depressed subjects respond to emotional stress on a subjective as well as physiological level may give insight into diagnostic questions. As a potential therapeutic avenue, it may help to identify specific stressors that affect the ANS and then influence those with specific training to reduce stress levels and improve clinical symptomatology. Ultimately, helping depressed people deal with emotional stress in a more functional and effective way might enhance their abilities to overcome social impairments and thereby improve their quality of life.

Finally, this dissertation underlines van Gogh's notion that emotions are indeed "the great captains of our lives". Emotions are a basic tool to communicate with others and are expressed similarly around the world. They influence the whole human organism in body, thought and action and guide us through our lives – oftentimes without us consciously realizing it – determining not only our current mood but also our social integration and psychological well-being.

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