Emotion Regulation
in Somatic Symptom and Related Disorders:
A Dynamical and Interpersonal Approach

Inauguraldissertation
zur Erlangung des Akademischen Grades
eines Dr. phil.,

vorgelegt dem Fachbereich 02 Sozialwissenschaften, Medien und Sport
der Johannes Gutenberg-Universität
Mainz

von
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Mainz, 2022

Tag der Prüfungskolloquiums: 26 September 2022

Wanderer, the road is your
footsteps, nothing else;
wanderer, there is no path,
you lay down a path in walking.

In walking, you lay down a path
and when turning around
you see the road you'll
never step on again.
Wanderer, path there is none,
only tracks in the ocean foam.

Antonio Machado (translated by Francisco Valera)

Wanderer, deine Spuren sind
der Weg, und sonst nichts;
Wanderer, es gibt keinen Weg,
der Weg entsteht im Gehen.
im Gehen entsteht der Weg,
und wenn man den Blick zurückwirft,
sieht man den Pfad, den man
nie wieder betreten wird.
Wanderer, es gibt keinen Weg,
nur Kielwasser im Meer.

Für Elif, Ayşe und Yılmaz

Acknowledgments

First and foremost, I would like to express my gratefulness to the TESIS Network (“TESIS: Towards an Embodied Science of Intersubjectivity”, FP7-PEOPLE-2010-ITN, 264828), funded by the EU Marie-Curie Initial Training Network for letting me a part of this incredible researchers’ network. Our thought-provoking meetings and conversations were vital in inspiring me to think from multiple perspectives and in defining the path of my research. I would also like to extend my deepest gratitude to Avicenna-Studienwerk supported by the German Federal Ministry of Education and Research (BMBF) for making it possible to continue my studies, broaden my horizon and meet brilliant people towards whom I have felt respect and astonishment.

I would also like to convey my deepest appreciation to my TESIS node leader Peter for providing a holding environment and being a considerate host in Munich and for wonderfully managing a department. I thank him also for all the opportunities I was given to conduct my research and for his continuous support during my fellowship and afterward. I am equally grateful to Heribert who played multiple roles during this research; my first contact in Germany, a valued and enjoyable colleague, a trusted guide and supervisor, a helpful technical assistant, an engaged co-author, and a dear friend.

I am deeply indebted to my supervisor Michael for being an encouraging, responsive, kind, and reliable mentor. His rational and critical look pushed me to sharpen my ideas during my research. He provided me with the helpful advice that I needed to choose the right direction and complete my dissertation. I have been inspired by his ability to manage a department and a clinical center, to communicate with his team, and by our enjoyable conversations during our lunches together.

I am particularly thankful to Arcangelo and Daniela who helped me undertake this research and analyze the data. Their expertise and friendliness, and their hospitability during my research visit were an ideal combination to work and enjoy.

My very sincere thanks go to Peter and his team for kindly hosting me in KU Leuven. His insight and knowledge of the subject matter steered me through our collaboration. I also thank Yasemin for her warm company in Leuven and the enjoyable dinners at their home.

Special acknowledgments must be paid to the couples having participated in the study. Many thanks to Claas, Joram, and the clinical staff at the Technical University of Munich, Department of Psychosomatic Medicine for their collaborative effort during participant recruitment and data collection.

Many thanks to the committee members who provided insightful and constructive feedback and retained an appreciative stance toward the present work.

I also thank my colleagues at the Department of Psychology at the Johannes-Gutenberg-University of Mainz, for making the department a great place to be. I gratefully acknowledge the valuable support and assistance of Stefan, Severin, Anne, and Sylvan whenever I needed it.

Many thanks also go to Süleyman Wolf, Nadir Dede, Fahriye Yıldırım, Ayşe, Ibtissem, Paula, Michell, Reza, Aylin, Zana, Merve, Sibel, and Nariye, for their support and friendship.

Finally, I take this opportunity to express profound thanks from my deep heart to my family. My life is graced by your presence. You never wavered in your support, patience, and reassurance throughout this experience. My beloved mother, thank you for your nurturing love and your strong belief in me. To my mother-in-law, thank you for your relentless support whenever I needed it, especially after sleepless nights for helping me take care of my kids or with household chores. My dear sisters, Beyza, Esma, Merve, and Nursena, thank you for being a source of joy and togetherness. I am so fortunate to have you.

To my husband, Yilmaz; you are a blessing in my life. My heartfelt thanks for sharing my aspirations, your sincere attentiveness to my work, your constructive approach, and your support and encouragement. I am grateful to have met you just before the beginning of the experiments, despite all the long breaks you caused in my research afterward. My little joys, the light of my eyes, and my little teachers, dear Elif and Ayşe, I have learned a lot from you. You have been wonderful distractions to rest my mind outside of my research. Thank you for sharing your mom-time with my third baby, this thesis.

Thanks again to everyone who made this enriching journey and thesis possible.

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List of Abbreviations

ANOVA = Analysis of Variance

ANS = Autonomic Nervous System

CBT = Cognitive Behavioral Therapy

CNS = Central Nervous System

CI = Confidence Interval

DSM = Diagnostic and Statistical Manual of Mental Disorders

ER = Emotion Regulation

FPA = Focal Plane Array

fIRI = Functional Infrared Thermal Imaging

HPA = Hypothalamic-Pituitary-Adrenocortical

HR = Heart Rate

HRV = Heart Rate Variability

ICD = International Classification of Diseases

M = Mean

MD = Mean Difference

MUS = Medically Unexplained Symptoms

mK = milli-Kelvin

PL = Physiological Linkage

PRO = Patient Reported Outcome

SAM = Self-Assessment Manikin

SCL = Skin Conductance Levels

SD = Standard Deviation

SSD = Somatic Symptom and related Disorders

WCA = Wavelet Coherence Analysis

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Abstract

Somatic symptom and related disorders (SSD) are one of the most prevalent conditions in health care. Patients with SSD suffer significantly from one or multiple bodily symptoms and associated psychological problems, such as excessive thoughts, feelings, and behaviors related to the symptoms. SSD can lead to high disability in patients, seriously limit their quality of life and social functioning.

Several studies have documented emotional processes and regulation as crucial factors contributing to the development, maintenance, and worsening of somatic symptoms. However, before we can understand emotion regulation, we should first know what is it that is being regulated. Although contemporary emotion research has embraced a dynamic and embodied perspective stressing emotions' social nature (Butler, 2015; Kuppens & Verduyn, 2015; Lewis, 2005; Scherer, 2009), research on SSD has failed to integrate such developments into its field. This limitation poses a gap in understanding the biopsychosocial mechanisms of the relationship between emotions and SSD.

This dissertation aims to investigate emotional processing and regulation in SSD with a contemporary framework of emotions that understands emotions as a continuously changing process (i.e., a dynamic system) consisting of subsystems, such as subjective affect, body/physiology, and appraisals. Furthermore, this work addresses the social nature of emotions by examining socio-emotional mechanisms occurring in SSD patients' interpersonal interactions. In total three studies were conducted for this research.

The first study systematically reviewed earlier empirical research to investigate Emotion Regulation (ER) processes that characterize SSD. We organized findings based on the targets/components of the regulation (i.e., attention, body, knowledge). The review of the 64 articles largely supported the association between SSD and disturbances in ER, which are usually shared by different diagnoses of SSD. The overview of the findings indicates that patients show a reduced engagement with the cognitive content of emotions while their bodily ER processes seem to depict an over-reactive pattern. Similarly, patients tend to encounter difficulties flexibly disengaging their (spontaneous) attention from emotional material. The review also detected a scarcity of experimental and interpersonal studies in research on ER in SSD.

The second study attempted to develop a methodology to assess embodied and interpersonal emotional processes in couples with an SSD patient and healthy couples. This case study showed the utility of the experimental manipulation and method that successfully created variations in the couples' physiological processes and subjective affect.

Drawing on the methodology of the case study, the third study investigated whether interpersonal emotion dynamics between interacting partners, namely physiological coherence, differ between couples with an SSD patient partner and healthy couples across various emotional conditions. Results showed that emotional conditions and having a partner with an SSD significantly affected physiological coherence between partners. From baseline to anger condition, physiological coherence between patients with SSD and their partners significantly increased while it decreased between the healthy partners. Interdependence between partners' subjective affect, as measured by correlations across groups, followed a comparable pattern to the physiological coherence in healthy and SSD patient-couples. Inability to reduce emotional interdependence in the domains of sympathetic activity and subjective affect during a mutual conflict observed in SSD patient-couples appears to capture emotion co-dysregulation.

These data provide empirical evidence for a disturbance in ER processes in SSD at intra- and inter-personal levels. Investigating the dynamic interaction of several ER modalities concurrently at individual and social levels promises insights for better understanding the ER mechanisms in SSD. The research results represent a further step towards developing a holistic treatment approach for SSD that integrates emotional interventions, framing them as embodied and social.

Chapter I: General Introduction

Somatic Symptom and related Disorders (SSD) are disturbing states that make patients suffer significantly from bodily symptoms and related psychological dysfunctions. One or multiple physical symptoms accompanied by excessive thoughts, feelings, and behaviors concerning the symptoms and impaired life functioning characterize SSD (American Psychiatric Association, 2013). Most common symptoms include pain in different locations of the body (e.g., back, head, joints, muscles, abdomen), functional disturbances of the organ systems (e.g., dizziness, constipation, diarrhea, palpitations, limb weakness, fatigue, and exhaustion) (Henningsen, 2018a).

Several cognitive, behavioral, and emotional disturbances are seen SSD, which burdens the patients and their social system. It can lead to high disability in the patients, limit their daily activities, social functioning, and vitality and seriously lower their quality of life (Creed, Barsky, et al., 2011; Henningsen, Zipfel, et al., 2018). With a high prevalence rate ranging from 4% to 6% of the general population, SSD is costly because of the several visits of patients to different medical specialists, redundant and expensive physical investigations as an outcome of a lack of clear explanation of the symptoms, sick leaves at work, and early retirement (Barsky et al., 2005; Konnopka et al., 2013). The artificial separation of the complaints as physical and mental, or "medically unexplained" that have dominated the diagnosis and treatment of SDD complicates the situation even more: It leads to patients' negative attitudes towards health care providers, especially towards mental health care, stigmatization of the patients, and hinders communication between disciplines dealing with the disorder (Henningsen et al., 2011).

Evidence suggests that emotion regulation (ER) is one of the significant psychological factors contributing to the development, maintenance and exacerbation of the symptoms (Di Tella & Castelli, 2016; Koechlin et al., 2018; Waller & Scheidt, 2006). Therefore, several studies have examined the association between ER and SSD. This development goes in accordance with the exponential growth of research on emotions and regulation in several disciplines in the last three decades. However, as emphasized before (Gross & Thompson, 2007), "to understand emotion regulation, we first need to know what is being regulated" (p. 4). Contemporary emotion research has embraced a dynamical and embodied perspective stressing emotions' social nature (Butler, 2015; Kuppens & Verduyn, 2015; Lewis, 2005; Scherer, 2009a); however, research on SSD has failed to integrate such developments in emotion research into its field (Butler & Barnard, 2019; Smith, 2019; Uchino & Eisenberger, 2019). This limitation poses a serious gap in understanding the biopsychosocial mechanisms of the relationship between emotions and SSD.

The present dissertation aimed at investigating emotional processing and regulation in SSD through a contemporary framework of emotions, which capture emotions as a continuously changing process (i.e., a dynamic system) that consists of its subsystems, such as subjective affect, body/physiology, and appraisals (Camras & Witherington, 2005; Granic, 2000; Gross, 2015; Kuppens & Verduyn, 2015; Lewis, 2005; Scherer, 2009a). Furthermore, this work aims to address the social nature of emotions (Butler, 2017; Mesquita & Boiger, 2014; Randall & Schoebi, 2018a; van Kleef, 2016) by examining socio-emotional mechanisms taking place in SSD patients' interpersonal interactions with significant others.

Overview of the dissertation

The present dissertation's overall structure takes the form of three chapters: a general introduction, an empirical part, and a general discussion.

Chapter I introduces the main topics of the dissertation and provides a theoretical background. The initial section presents SSD, including its classification, clinical presentation, epidemiology, and etiology. The second section provides an overview of emotion regulation (ER) research, which includes emotions as dynamical and interpersonal systems. The third section contextualizes the dissertation by outlining the relationship between emotional processes and regulation and SSD. It identifies some of the problems and gaps in the existing literature and raises the research questions of the present dissertation.

Chapter II investigates ER processes that characterize SSD through a systematic review of the available empirical studies. The goal of this review is to 1) tabularize ER processes in different diagnoses given to SSD, 2) delineate the relationship between ER and symptom presentation in SSD, 3) compare ER in SSD, healthy controls, and patients with other mental or physical disorders, 4) classify and organize the findings based on a dynamic systems perspective to emotions, which investigates the emergent patterns in each target of the regulation (i.e., emotion constituents: attention, body, and knowledge) (Koole, 2009; Lewis, 2005).

Chapter III presents our case study that aims to develop a methodology to assess embodied and interpersonal emotion regulation in couples with a patient with SSD and healthy couples.

Chapter IV delineates a larger experimental study with SSD patient-couples and healthy couples drawing on the methodology of our case study. This study aims to uncover the interpersonal dimension of emotional processes of patients with SSD during their emotional interactions with significant others, focusing on physiological and subjective -affective constituents of emotion. It inquires whether interpersonal emotion dynamics (Randall & Schoebi, 2018a), such as physiological linkage (coherence) between interacting partners, varies as a function of having an SSD-patient partner and emotional context. Secondly, the study explores interpersonal subjective affective processes across dyads in SSD patient-couples and healthy couples.

Chapter V brings together the dissertation's principal findings and discusses the treatment suggestions derived from its' empirical results. The dissertation ends with the implications of the results and considers open questions for future research.

1. Somatic symptom and related disorders (SSD)

1.1 A holistic view of mind and body

SSD can be described as the disorders of the mind and body if such a separation between the two would even be possible. Bodily symptoms, accompanying cognitive, behavioral, and emotional disturbances, and co-occurring psychological disorders, such as anxiety or depression, and the patients' daily social life difficulties (Henningsen et al., 2007; Witthöft & Hiller, 2010), situate SSD at the interface of overlapping biological, psychological and social dynamics. Therefore, SSD is recognized as neither a mere psychological disturbance nor an organically rooted one. On the contrary, the symptom presentation demands refuting a mind-body dualism (Robinson, 2020) for accurately understanding the origins of the disorder and planning effective interventions. A message of the mind-body dichotomy delivered to the patients leaves them to accept the symptoms as mutually exclusive, either organic or psychological. It forms a barrier to taking a holistic view of symptoms and improving care for patients (Henningsen et al., 2011). Therefore, empirical findings to determine the factors that play a more substantial role in different stages of SSD (i.e., disposition, mechanisms, onset, and maintenance) are of higher importance than an artificial separation of the psychological and physical (Henningsen, 2003).

This holistic framework for physical complaints dates to pre-modern times. We see, for example, how in the 9th century, one of the earliest pioneers of psychosomatic medicine, Abu Zayd al-Balkhi (al-Balkhī, 2013), criticizes physicians who limited their treatment of illnesses to physical remedies and did not take psychological treatment into account. He writes:

> This discussion (on the sustenance of the soul) is not generally mentioned by physicians nor documented in their written books on medicine, the sustenance of the body and treatment of its physical ailments. This is because it is a subject not within their professional interest and because the treatment of psychological symptoms does not match the remedies they give (to patients) such as bloodletting, medicine, and other similar treatments… Man's stamina is a combination of both his body and soul, and one cannot imagine that he can exist without this dual combination, *which causes him to act* as a human being. *Their combination gives man his ability to respond to threatening issues and painful symptoms.* (p. 29, italics added)

Such an account of the mind as an embodied system and the view that response and action are only possible through this unity is currently underscored by the theory of embodied mind (Gallagher, 2013; Varela et al., 1991; Wilson, 2002). This view proposes that emotions, intentions, consciousness, and their conditions emerge from and are embodied in the self-organizing dynamics of the nested loops of the body systems (Thompson, 2008). The mind is embedded in its real world and inherently comprises perception, sensory processing, motor control, and action (Wilson, 2002).

In the context of SSD, modern views broadly adopt a bio-psycho-social perspective (Engel, 1977) to understand the etiology and course of SSD, which is based on the fact that psychosocial and cognitive processes materialize through the functions of the nervous system, hormonal, and immune systems. Several models of SSD agree that biological as well as developmental, psychological, and social mechanisms contribute to the development and maintenance of SSD (Deary et al., 2007; Fritzsche et al., 2020; Henningsen et al., 2007; Rief & Broadbent, 2007; Van den Bergh et al., 2017; Witthöft & Hiller, 2010). This approach was mirrored in the latest definition of SSD described below (American Psychiatric Association, 2013), which abandoned the previous statement that symptoms cannot be fully explained by a known general medical condition.

1.2 Symptomology, classification, and diagnosis

SSD has taken several labels depending on the specialty and the overriding symptoms. These labels include "medically unexplained symptoms", "somatoform disorders", "somatization disorder", "undifferentiated somatoform disorder", "abridged somatization disorder", "multisomatoform disorder", or many forms of "functional somatic syndromes" (Creed, Barsky, et al., 2011).

American Psychiatric Association updated the term "somatoform disorders" in DSM V (2013), which had a connotation of mind-body dichotomy. The current diagnostic criteria for SSD (300.82/F45.1) is described as follows:

Table 1

DSM-5 diagnostic criteria for somatic symptom disorder

Diagnostic criteria
A. One or more somatic symptoms that are distressing and/or result in significant disruption of daily life.
B. Excessive thoughts, feelings, or behaviors related to the somatic symptoms or associated health concerns as manifested by at least one of the following: a. Disproportionate and persistent thoughts about the seriousness of one's symptoms. b. Persistently high level of anxiety about health or symptoms. c. Excessive time and energy devoted to these symptoms or health concerns.
C. Although any one symptom may not be continuously present, the state of being symptomatic is persistent (typically more than 6 months).
Specify if: **With predominant pain** (previously pain disorder). This specifier is for individuals whose somatic symptoms predominantly involve pain.
Specify if: **Persistent:** A persistent course is characterized by severe symptoms, marked impairment, and long duration (more than 6 months).
Specify current severity*:* **Mild:** Only one of the symptoms specified in Criterion B is fulfilled. **Moderate:** Two or more of the symptoms specified in Criterion B are fulfilled. **Severe:** Two or more of the symptoms specified in Criterion B are fulfilled, plus there are multiple somatic complaints (or one very severe somatic symptom).

1.3 Prevalence

SSD is prevalent in the population, although several diagnostic labels given to the patients hinder a precise prevalence estimate. It is estimated that about 4% to 6% of the general population and 17% of primary care patients are affected by somatic symptom and related disorders (Creed, Barsky, et al., 2011; Levenson, 2020; Wittchen et al., 2011). In one-fifth of the patients, the symptoms persist over time and are regarded as difficult to treat by clinicians (Jackson & Kroenke, 2008). In the case of SSD with predominant pain, when other diagnostic terms used for chronic persistent pain are involved, such as chronic musculoskeletal pain, fibromyalgia, or chronic pain, a high prevalence rate is reported. For example, 37% to 41% of 12-months prevalence of chronic pain was found in the general population in developing and developed countries (Tsang et al., 2008). In Germany, about 17% of the population suffers from chronic pain (Wolff et al., 2011).

1.4 Etiology

Much of the evidence on the etiology of SSD is based on cross-sectional studies; hence, the studies can only provide the correlates of SSD. A lack of prospective research is observed in the literature, despite its promises in understanding the origins of the disorder (Creed, Barsky, et al., 2011).

Demographic correlates of SSD are documented as female sex, low socioeconomic status, and fewer years of education (Creed et al., 2011). Genetic predisposition was found to explain 33% of the variance separate from depression or phobic anxiety in a twin study (Gillespie et al., 2000), and similarly 25% in another one (Chang et al., 2018) with a genetic overlap of about 85% with psychological distress.

Developmental factors are also associated with SSD. Previous studies and reviews detected childhood adversity of physical and emotional abuse or neglect, parental chronic illness, trauma, and non-secure attachment related to SSD (Fiddler et al., 2004; Katon, 2001; Landa et al., 2012). Parental factors, such as parental neuroticism and poor health, neglect, maternal childhood adversity (Craig, Cox & Klein, 2002), parental affective (dys)responsiveness (Craig, Hodson & Cox, 2004), somatization (Gilleland et al., 2009), were reported to predict children's somatic symptoms. For example, a mother-child study observed mothers' joint attention and bids during play with a usual and medical theme. The somatizing mothers were less emotionally expressive and less involved in play than mothers of children with an organic disease or healthy children. On the other hand, they were more responsive to their child's bids during play with a medical theme (Craig, Hodson & Cox, 2004). Apart from parental factors, children's own psychosocial traits were shown to predict the symptoms, such as children's poor emotion regulation and negative affect (Gilleland et al., 2009). High symptoms in childhood tend to persist into adulthood (Steinhausen & Winkler, 2007).

Psychiatric or physical illnesses and stressful life events are linked to the onset and course of SSD (Creed, Barsky, et al., 2011). From those, especially anxiety and depression are common in SSD. Henningsen and colleagues (2011) have stressed this co-occurrence as “the rule rather than an exception” and suggest avoiding the term "comorbidity" (p. 64). The authors address such a co-occurrence as a support for the notion of SSD as a dysfunction of the Central Nervous System (CNS) processes in a context where SSD is conceived as "syndromes of abnormal stress reactions with emotional content" in which CNS plays a significant role (p. 63). A meta-analysis helps clarify the co-occurrence of depression and physical disturbances by concluding that clinically depressed individuals have altered immune assay outcomes compared to healthy controls (Herbert & Cohen, 1993).

Social and emotional factors affect bodily functioning and physical health, such as the functioning of the immune or Autonomic Nervous System (ANS). Cohen and Herbert (1996) reviewed studies that examined aspects of interpersonal relationships, such as loneliness, separation and divorce, perceived social support, and disclosure of traumatic events on human immunologic data. They concluded that interpersonal relationship affects immune outcomes, although more research is needed on the role of support-induced changes and intervention models. Additionally, emotional traits were underlined. Individuals who tended to deny or minimize distress and negative thoughts, in other words, repress them, showed suppressed cellular immune function and somatic disease (Cohen & Herbert, 1996; Mund & Mitte, 2012). Similarly, a repressive coping style was associated with higher physiological arousal (Myers, 2010). Psychosocial factors were also proposed to influence poor lifestyle choices, such as smoking, alcohol, drugs, lack of exercise, nutrition that eventually affect the functioning of the ANS and physical functioning (Thayer & Brosschot, 2005).

1.5 Models of SSD

Nearly all the models that have attempted to explain SSD underlined the multidirectional and recursive interaction of cognitive, emotional, behavioral, social, biological, and genetic processes, although they differ in their focus (Deary et al., 2007; Rief & Broadbent, 2007; Witthöft & Hiller, 2010). A useful overarching framework to explain how such an interaction of elements is associated with symptoms was put forward by Deary (2007). Borrowing the term “autopoiesis” from biology and dynamic systems theory (Maturana & Varela, 1972), he proposed that perpetuating factors including cognitive, behavioral, and biological processes produce a self-autonomous system, which organizes and maintains itself continuously based on its embedded environment, and generate symptoms suited to its environment and therefore should be unique for each individual. Why individuals with SSD depict different symptomatology is explained within this framework. Below some of the models attempting to explain the mechanisms of SSD are summarized.

1.5.1 Psychodynamic models

While early psychoanalytic and psychodynamic models of SSD conceived it as a defense of unresolved unconscious conflicts, later accounts have underscored deficits in the representation of emotions in SSD. Franz Alexander (1950) posited that if physiological activations associated with emotional arousal are not transformed into action and repressed in time, they lead to disturbing bodily symptoms. Others also emphasized such distinction between emotion response systems. For example, Bucci (1997), in her multiple code theory of somatization, distinguishes between symbolic (i.e., language, imagery, higher-order cognitive processes) and sub-symbolic (non-verbal, motoric, sensory, and somatic) representation of emotions. She proposes that SSD patients might have difficulty integrating these modalities of emotions, which leads patients to experience the emotions as bodily states. Alexithymia and mentalization theories (Luyten et al., 2012; Sifneos, 1973) similarly emphasize patients' difficulty in understanding and reflecting on emotions and point out the disequilibrium among stress regulation networks. In this respect, psychodynamic approaches show some commonalities with psychobiological approaches to SSD, which will be described below.

1.5.2 Cognitive-behavioral models

Cognitive-behavioral models emphasize attentional, perceptual, and learning processes (reviewed in Deary et al., 2007; Van den Bergh et al., 2017; Witthöft & Hiller, 2010) in symptom formation and maintenance. These models distinguish between predisposing, precipitating, and perpetuating factors and particularly stress the role of perpetuating factors for a vicious cycle in symptom development, maintenance, and amplification.

As predisposing factors genetics, early experiences (parental illnesses, overprotective parenting, early adversity, such as trauma or abuse), personality traits, such as neuroticism and aberrant biological conditions (e.g., hormonal) have been reported (Deary et al., 2007; Rief & Broadbent, 2007; Witthöft & Hiller, 2010).

From the perpetuating factors, the role of perceptual, attentional, and belief mechanisms, as well as illness behavior and quality of relationships in symptom formation and maintenance, have been underlined. These factors are suggested to influence each other in a multidirectional manner and include: 1) Increased responsivity to symptoms because of prior experience (sensitization) and possibly associated Hypothalamic-Pituitary-Adrenocortical (HPA) axis sensitivity, such as lower (Tak et al., 2011) or higher cortisol levels than usual, 2) non-conscious attentional filter-systems for the symptoms and origins of symptoms and a resulting bio-psycho-behavioral feedback loop that amplifies the symptoms, 3) rigid and consistent beliefs and attributions regarding the organic cause of the complaints, a lack of an illness narrative, 4) low quality of relationship with health caregivers, and 5) illness behaviours, such as the length of convalescence after illness, return to activity or coping behaviors with illnesses (reviewed in Deary et al., 2007 and Witthöft & Hiller, 2010).

Precipitating factors - the triggers of the vicious cycle of SSD - are usually studied in the context of significant life events. Deary (2007), in his review, concludes that major life events precipitate SSD, such as an internal pressure on patients for having to choose between undesired alternatives or prolonged activation of physiological stress responses through stressful life events that might have consequences at the neurological, hormonal, immunological and cardiovascular functioning.

1.5.3 Psychobiological approaches

Psychobiological approaches usually consider SSD as disorders of the stress systems: autonomic, endocrine, and immune (Chrousos, 2009; Lane et al., 2009; Rief & Barsky, 2005). These stress systems, or "transfer systems", link brain and body, as well as end organs and consequently health and disease (Lane et al., 2009). The structural and functional organization and integration of multiple brain regions associated with somatosensory, stress, and emotion processing support this perspective. Several neuroimaging studies have shown that noxious stimuli, such as pain, activates brain regions associated with sensory processing (e.g., primary and secondary sensory cortex), cognition and behavior organization (e.g., prefrontal cortex), and emotion processing (e.g., anterior cingulate and midcingulate cortex) (reviewed in Lane et al., 2009). Beginning from the spinal cord, brain stem, hypothalamus, amygdala, hippocampus, prefrontal, and cingulate cortex, thalamus, somatosensory cortex, and insula, especially, dorsal posterior insula (Orenius et al., 2017; Rief & Barsky, 2005; Segerdahl et al., 2015), brain regions that are linked to stress responding are also involved in both symptom perception and emotional processing. Such an entangled interaction between brain regions during symptom experience indicates that bodily symptom experience is a multidimensional phenomenon, including sensory, affective, and cognitive components.

In a long-term disturbance of homeostasis and high allostatic load associated with stress, particular conditions are observed: a) HPA axis abnormalities, such as hyper- or hypo-cortisol levels, b) enduring heightened physiological arousal, and c) immune system dysfunction. Physical complaints can then develop directly or ultimately due to altered perception and cognitive processing of such sensory stimuli (Rief & Barsky, 2005). In the hormonal domain, it is known that the HPA axis and sympathetic-adrenomedullary system are activated in response to stress. This change elicits an increase in corticotropin-releasing hormone, cortisol, norepinephrine, and adrenaline, and eventually influences emotional and physical well-being in the long term (Patron et al., 2020). In addition, monoamine acids and neurotransmitters, such as serotonin or branched-chain amino acids, which play a role in psychological functioning, are related to SSD symptoms, such as a feeling of weakness, exhaustion, pain perception thresholds (Rief & Barsky, 2005).

In their signal-filtering model of somatoform symptoms, Rief and Barksy (2005) complemented the biological approaches by including the cognitive processes associated with stress responding. They proposed that stress-related bodily signals that are amplified through physiological processes (e.g., persistent heightened autonomic arousal, HPA dysfunction, sensitization) typically go through a neural filtering process. When such neural filtering is inhibited by individuals' psychological mechanisms (e.g., selective attention, depressed mood), they eventually lead to the person's heightened cortical perception of symptoms.

The neurovisceral integration model (Smith et al., 2017; Thayer & Brosschot, 2005) emphasizes the role of the ANS and a lack of inhibitory control in response to stress in health and somatic illnesses. This model assumes that to maintain adaptability and health, sympathetic and parasympathetic branches of ANS should retain a flexible and dynamic balance without dominating the other for prolonged periods. The Sympathetic Nervous System (SNS) is known to mobilize and Parasympathetic Nervous System (PNS) to restore and conserve metabolic energy depending on internal and external demands. The prefrontal cortex plays a considerable role in providing tonic inhibitory control to maintain unnecessary energy mobilization.

According to the neurovisceral integration model, a prefrontal hypoactivity, suggesting a weak inhibitory control reflected by attention bias, poor attention regulation, poor emotion processing and regulation, and prolonged autonomic imbalance might underline psychosomatic issues (Thayer & Brosschot, 2005). The model suggests autonomic imbalance as a common pathway linking somatic symptoms and emotional difficulties. It also claims that stress-related autonomic dysregulation might contribute to poor cognitive and attention performance. The neurovisceral integration model was recently updated with a predictive coding framework (Smith et al., 2017). In this revised version, the nervous system structures are gathered around eight hierarchical levels, from cardiac control to goal representation and higher-order cognitive functions, which are linked to vagal control. By doing so, the authors specified their model in a predictive coding account, whereby the connection between the neurovisceral hierarchical structures realizes through computing and integrating active predictions, outcomes, and prediction errors (Smith et al., 2017)

In case of prolonged energy mobilization by SNS and top-down disinhibition of sympathoexcitatory circuits by the prefrontal cortex, the autonomic imbalance might lead to wear and tear on the emotional and physical system, known as allostatic load. (Thayer & Brosschot, 2005). Although short-term stress responses are adaptive and evolutionarily valuable, persistent and extreme stimulation of stress response systems can have adverse effects on organ functions, as well as physical and psychological health (Patron et al., 2020). From a systems perspective, when negative feedback loops that inhibit the ongoing behavior and conserve energy are dominated by the excitatory positive feedback loops, the system is prone to hypervigilance, perseveration, and continued system activation, that limits the use of metabolic resources for other demands (Thayer & Brosschot, 2005).

Longitudinal studies lend some support for the involvement of ANS in symptom development. In a recent study, Heart Rate Variability (HRV) predicted overall burnout symptoms twelve months later, after controlling for age, sex, body mass index, adverse health behaviors, and depressive symptoms (Wekenborg et al., 2019). Of note here is that only the emotional exhaustion dimension of burnout, not the total burnout score, predicted the decrease of HRV one year later in this study. Another longitudinal study with children has shown that the effect of early stressful events on children's emotional and physical well-being was buffered by a positive cardiac vagal tone development (Patron et al., 2020). In fact, cardiac vagal tone was proposed to be a marker of the amount of self-regulatory resources to deal with stress (ibid).

Studies from psychoneuroimmunology also provide some insight into the development of somatic disturbances and SSD. In their review, Cohen and Herbert (1996) addressed how psychological variables can affect immunity and susceptibility to immune-system mediated disease through: a) direct innervation of the CNS and immune systems, b) hormonal pathways, or c) behavioral changes (e.g., smoking, or poor sleeping habits to cope with stress). They reviewed a series of studies showing that positive and negative life events or long-term stress can alter the immune system response at cellular and humoral levels. The authors also presented evidence that one of the primary pathways acute stress affects the immune system responses is through SNS functions, such as blood pressure, heart rate, temperature, SNS hormones, such as epinephrine and norepinephrine (Cohen & Herbert, 1996).

Although the biological approaches highlight the substantial role of bodily processes in symptom formation and maintenance, the roles of the factors on individuals might be highly variable (Kelly et al., 2020), non-specific, and multidirectional (Rief & Barsky, 2005). Some other approaches do not accept peripheral physiology as the primary physiological cause of the

SSD (Henningsen et al., 2011) and underline aberrant CNS functioning in the patients, associated with perceptual regulation of symptoms and altered homeostasis (Henningsen et al., 2011; Van den Bergh et al., 2017). The role of aberrant physiology is instead seen as secondary to disturbed homeostasis due to cognitive, neurobiological, or emotional perturbations (Craig, 2002; Henningsen et al., 2011).

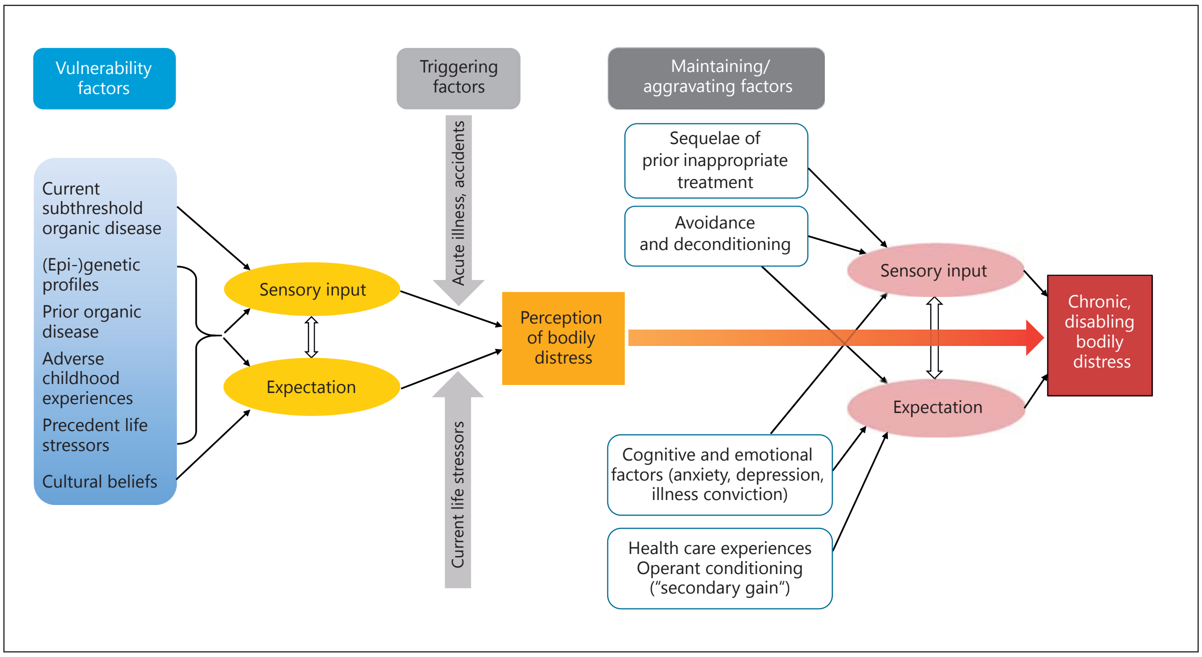
1.5.4 A unifying framework: Symptoms as perceptual dysregulation

The predictive processing account provides a computational neuroscience framework and specificity regarding the mechanisms concerning how somatic inputs, inferences, and relevant previous experiences can lead to symptom experience, an account that is supported in cognitive behavioral (Van den Bergh et al., 2017) as well as embodied cognition models (Smith et al., 2019). This critical approach to the classical cognitive-behavioral view has asserted a symptom perception model with a top-down approach, i.e., how prior knowledge forms predictions and inferences about interoceptive signals and leads to bodily symptoms (Henningsen, Zipfel, et al., 2018; Van den Bergh et al., 2017). This model does not necessarily assume a physiological dysfunction in symptom formation nor interoceptive hypervigilance and lowered perceptual threshold, or an attributional bias. Instead, the model proposes that our brain continuously predicts and updates hypotheses about the nature and causes of sensory information. According to this model, this hierarchical hypothesis-generating system relies on the interaction of preciseness of predictions (priors) about sensory input that is based on prior knowledge, actual sensory input (evidence or observation), and eventual symptom experience (posteriors), which in turn influence symptom perception. As the priors become more precise, their effect on the posteriors would be stronger. The experienced symptoms (posteriors) try to minimize errors and best fit the predictions and the prediction errors (discrepancy between predictions and sensory input).

The strength of this model is that it can explain both perceptions of medically “explained” and “unexplained” symptoms with a unifying framework. Moreover, the view of physical symptoms as perceptual dysregulation provides the potential to integrate the cognitive, developmental, biological, interpersonal, and psychodynamic approaches to symptom understanding in a unifying framework (Henningsen, Gündel, et al., 2018; Henningsen, Zipfel, et al., 2018). For example, chronic stress and associated nervous system functioning, dysregulated affect and early attachment failures, and emotion socialization experiences might lead to imprecise somatic inputs accompanied by precise predictive priors about the bodily states (Henningsen, Gündel, et al., 2018). As such, emotional and interpersonal processes might influence how the body is represented as interoceptive and exteroceptive information in the brain. When the vulnerability factors, such as childhood experiences, emotion regulation processes, or cultural beliefs influence the sensory input and expectations, perceptions of bodily distress become highly dependent upon the individual experiencing it. The triggering and maintaining factors contribute to the chronic bodily distress through top-down perceptual and expectation processes as well as the bottom-up sensory input (Henningsen, Zipfel, et al., 2018). Figure 1 depicts a schematic model of the etiology of bodily distres

Figure 1

A model of bodily distress (From "Management of functional syndromes and bodily distress" by Henningsen, Zipfel, Sattel & Creed, 2018, Psychotherapy and Psychosomatics, 87, p. 16. Copyright 2018 S. Karger AG, Basel).



1.6 Treatment

A stepped-care approach, describing an evidence-based, staged approach that differentiates between complicated and uncomplicated forms of SSD, where a hierarchy of interventions are tailored to the patients' needs is recommended (Creed, Kroenke, et al., 2011; Henningsen, 2018b; Henningsen, Zipfel, et al., 2018). A comprehensive review on the management of functional somatic syndromes concluded that interventions that activate patients' agency and involvement, such as exercise or psychotherapy, offer higher improvement potential than passive medical measures, such as injections (Henningsen, Zipfel, et al., 2018). In addition, in the case of medical interventions, the authors recommended pharmacological agents for CNS functioning than drugs for peripheral physiological functioning. The doctor-patient relationship should be observed closely to prevent iatrogenic harm to the patients due to unnecessary physical interventions or pharmacological treatments. The authors concluded that equilibrium should be maintained between biomedical, organ-oriented, and cognitive-interpersonal approaches for "this truly psychosomatic interface".

Psychological therapies, primarily cognitive and interpersonal therapies, were shown to be effective in treatment of SSD (Creed, Kroenke, et al., 2011). A recent meta-analysis of 15 randomized controlled trials employing Cognitive-Behavioral Therapies (CBT) with 1671 patients with SSD reported that CBT could improve the somatic symptoms, anxiety symptoms, depressive symptoms with a large effect size and improve physical functioning, which could be sustained in follow up measures. However, CBT did not seem to enhance social functioning, although it was most helpful when it applied group-based, affective and interpersonal strategies in the treatment (Liu et al., 2019).

Witthöft and Hiller (2010) and others (Creed, Kroenke, et al., 2011; Henningsen et al., 2007) have emphasized that a constructive and positive working alliance between the patient and the therapist/doctor is essential for the course of treatment. Recognizing patients' symptoms as distressing and real, taking an empathic and supportive stance, as well as delivering the patient a clear and optimistic message for the diagnosis and intervention plan are potentially helpful ingredients for treatment (Creed, Kroenke, et al., 2011; Witthöft & Hiller, 2010). Together with the patient, establishing when and how the symptoms occur and depicting patients' unique personal information are essential in case formulation (Witthöft & Hiller, 2010).

Cognitive behavioral therapies provide the patient agency and an active role during treatment rather than a hierarchical relationship between the psychotherapist and the patient. As such, the therapist and the patient should ally to identify the triggering situations, emotions, cognitions, and behaviors that play a role in the generation, maintenance, and amplification of symptoms. Especially psychosocial interpersonal problems are emphasized as typical elicitors and amplifiers of such symptoms (Witthöft & Hiller, 2010). In addition, psychoeducation on the unity of body and mind is offered, which underlines how stress and its associated thoughts and feelings can elicit physiological, immune, and hormonal reactions. For strengthening the patients' understanding of biopsychosocial models of the symptoms, biofeedback therapy is also recommended. When a biopsychosocial model of the symptoms is established, and the patient can internalize how the symptoms develop and remain, the following steps aim to reduce patients' suffering resulting from the symptoms that contain interventions at cognitive, affective, and behavioral levels: Changing selective attention to symptoms, cognitive restructuring in interpreting and catastrophizing the symptoms, relaxation exercises, reducing safety-seeking strategies and excessive-body scans, increasing social contact and physical activity (Witthöft & Hiller, 2010).

2. Emotion and regulation

2.1 Defining emotions

Emotions are a complex and ubiquitous part of the human experience. They are considered as humans' one of the essential tools for flexibility, adaptation, and survival in response to changing internal and external demands (Izard, 1993). Due to their complexity, emotions are difficult to define, and there is no gold standard for their definition (Izard, 2010). As a working definition, they can be described as feeling states, which may be either positive or negative, evoked by mental or physical events and experiences in a person's world that carry meaning and significance (Campos et al., 2004; Cole et al., 2004; Izard, 1993).

Based on her interviews with thirty-five renowned emotion scientists who conducted significant research on emotions, Izard (2010) summarized the agreed conceptualization of emotion as follows:

Emotions are feeling states that consist of dedicated neural circuits and response systems that motivate and organize cognition and action. They give meaning and significance to an event and provide information to the experiencer. They can be social or relational in nature. Cognitive appraisals and core affects can be antecedents or consequences of emotion. Further cognitive appraisals, expressions, approach or avoidance behaviors, and regulation of emotions can constitute emotions. In addition, a rapid, automatic and unconscious connection between emotion, cognition, and action is an essential interactional process.

In the study, a multi-component or multi-aspect nature of emotions was accepted by almost all the interviewed emotion scientists. These components include: 1) neural circuits and neurobiological processes, 2) phenomenal experience/feelings, and 3) cognitive-perceptual processes. There is also an agreement that these aspects interact with each other continuously in time, rendering emotions a dynamical process (Izard, 2010).

Gross (2015), in his integrative and influential review, also concluded that a) emotions entail loosely couples changes in subjective experience (feeling tone), behavior (action tendency, expressions, striking, withdrawing), and physiology (autonomic, neuroendocrine, and somatic), b) they unfold over time in a circular feedback mode, and c) they can be helpful (e.g., elicit action to avoid a dangerous situation) or harmful (e.g., anger leading to physical damage to a loved one) depending on the context.

With the recent advancement in data science, deep learning, and machine learning, new algorithms were developed in affective computing, and discrete emotions can be classified by the machines based on physiological signals (Jang et al., 2015; Shu et al., 2018), supporting the view that emotions exist as discrete feeling states. Yet, this issue on emotions as being constructed experiences (Barrett et al., 2007) versus discrete and innate states (Cowen & Keltner, 2021, Ekman, 1972) continues to be under debate.

2.2 Biological underpinnings of emotions

Among the physiology of emotions and regulation, the autonomic nervous system (ANS) has taken considerable attention. ANS is responsible for regulating homeostatic function and consists of Sympathetic (SNS) and Parasympathetic Nervous Systems (PNS) (Porges et al., 1994). Originating in the brain stem, these two systems play a role in regulating a variety of organs (from eyes, lacrimal, sweat glands, blood vessels, heart to adrenal glands, kidneys, intestines, and external genitalia). While SNS mobilizes the physical resources for a rapid muscular action needed for defense, PNS restores and conserves bodily energy and involves in resting the fundamental organs (ibid). Especially in response to demanding contexts, the vagal tone representing PNS, usually assessed by Respiratory Sinus Arrhythmia (RSA), withdraws, and the SNS is reciprocally excited. RSA has been proposed to represent the vagal circuit of emotion regulation that provides communication between cortex, amygdala, nucleus ambiguous (a large group of motor neurons), solitary tract (primary sensory fibers and descending fibers of the vagus, facial nerves, and ninth cranial nerve that carries afferent and efferent motor information), heart and larynx (voice box) (Porges et al., 1994). Such a connection was proposed to represent the integration of central and autonomic nervous systems and emotional processes (Porges et al., 1994).

There are several ways to measure the activity of ANS, such as cardiovascular, respiratory, electrodermal, and thermal measures (Ioannou et al., 2014; Kreibig, 2010). One of the most established ones is measuring vagal tone for PNS and heart rate for SNS activity (Porges et al., 1994; Thayer & Lane, 2000). Electrodermal activity, which measures the activity of the sweat glands, especially in the hands and soles of the feet, is another widely used method (Mendes, 2009). Imaging the infrared radiation emitted from the skin at a distance (temperature variations), usually on the face assessed also a recently used contact-free and non-invasive method (Clay-Warner & Robinson, 2015; Ioannou et al., 2014).

Hypothalamic-Pituitary-Adrenocortical (HPA) is another physiological system that is involved in emotion and regulation. The CNS regulates this neuroendocrine system. The hormonal product of this system, cortisol, and its antecedent hormones is mainly regulated by the hypothalamus, and the perceptual and cognitive inputs from the higher brain systems (reviewed in Stansbury & Gunnar, 1994). Three pathways are known to affect the HPA axis activity. 1) Direct stimulation of the pituitary and hypothalamus through the general circulation of biochemicals. 2) Direct visceral or sensory stimulation, including pain or blood pressure to the hypothalamus through brain-stem pathways 3) Psychological stimuli from the cerebral cortex to the hypothalamus through limbic tracks. In dealing with stress, the HPA axis is known to perform essential functions, such as a) mobilization of energy resources required for action, b) maintaining homeostasis in regulating other stress-related systems, such as central and peripheral catecholamine systems, endogenous opiate system, and the immune system, and c) affect memory, learning, and emotions (ibid). These functions and pathways of the HPA axis demonstrate its significance for emotion regulation and somatic functioning.

2.3 Dynamic and interpersonal approaches to emotions

There have been diverging views on emotions as discrete and innate states (Cowen & Keltner, 2021; Ekman, 1972) versus constructed experiences (Barrett et al., 2007) or as functional action tendencies (Frijda, 1986). Despite the diverging views, contemporary models of emotions converge on a dynamical framework, particularly on the idea that emotions are inherently regulatory "loosely coupled changes" (Gross, 2015) in the emotion components of subjective affect, physiology, and behavior unfolding over time (Butler, 2011; Butner et al., 2018; Camras & Witherington, 2005; Gendron & Barrett, 2018; Gross, 2015; Kappas, 2011; Kuppens & Verduyn, 2015; Lewis, 2005; Mauss et al., 2005; Scherer, 2009a). In this dynamic systems model of emotions, a continuous recursive interaction between the emotion components through feedback loops constitutes the core of the emotional process. This view postulates that, in response to an emotional perturbation, the components of emotion, such as appraisals, action tendencies, or arousal, are continuously updated and regulated based on internal (e.g., proprioceptive) and external (e.g., cultural norms) feedback sources (Kappas, 2013; Scherer, 2009a).

The proposition that emotions are continuous and multi-componential processes rather than static entities demands dynamic measurement of emotion components - how they fluctuate over time, their trajectories, patterns, and regularities (Kuppens & Verduyn, 2015). The variability, recurrence (functioning as "attractors"), and inertia of certain emotional episodes, duration, shape, and intensity of emotional trajectories, for example, are some examples of dynamic properties of emotional processes (Kuppens & Verduyn, 2015). The dynamic fluctuation of an emotion component (e.g., subjective affect, physiology) as well as the interaction of two or more emotion components, and how they cohere/concord over time are telling and have been a central topic in emotion research (Brown et al., 2019; Hollenstein & Lanteigne, 2014; Mauss et al., 2005; Sze et al., 2010). The coherence between subjective experience and physiology unfolding over time was associated with well-being (Brown et al., 2019). It was also stronger during emotionally intense conditions, when emotions are less suppressed, or in experienced vipassana meditators (Sze et al., 2010). Such investigations on how the emotion components interact over time have a significant value in understanding the mechanisms of emotional processes in individuals with healthy or dysfunctional emotion regulation styles.

2.4 Interpersonal emotion dynamics

Emotions do not occur in a vacuum; *persons* live through them, mostly during social encounters. During an emotional interaction, participants share and coordinate their emotional processes through several channels. They communicate, mimic or respond through verbal and non-verbal behavior (Hatfield et al., 1993), co-construct meaning (De Jaegher & Di Paolo, 2007), and even share autonomic physiology, such as heart rate (Feldman et al., 2011; Palumbo et al., 2016) or temperature (Ebisch et al., 2012). Beginning from infancy, a physiological co-regulation and synchrony between the baby and the caregiver through heart rate, thermoregulation, and endocrine functioning arise (Feldman et al., 2011; Saxbe et al., 2018). Throughout adulthood, this connection between interactants continues; short emotional encounters, as well as long-term relationships, influence the interactants' endocrine and autonomic nervous system activity (Saxbe et al., 2018; Wilson et al., 2018).

The sharing and coordination of emotional responses in social proximity have several psychobiological advantages: Individuals understand and empathize with each other (Nummenmaa et al., 2012; Wheatley et al., 2012), co-regulate their emotions, maintain allostatic balance (Butler & Randall, 2013; Feldman et al., 2011; Lunkenheimer et al., 2018; Thayer & Sternberg, 2006), and conserve their metabolic energy by sharing their emotional load that is otherwise metabolically costly (Beckes & Coan, 2011). According to social baseline theory (Beckes & Coan, 2011), human brains are evolved to assume a baseline condition of social proximity. Such proximity facilitates energy saving through social agents' sharing of load, for example, neural circuits related with emotion-regulation being less activated when there is social support. It was argued that social proximity as a default mode might have the function to reduce self-regulation and a return to a baseline state of relative-calm, where the saving of neural and peripheral resources is possible. In fact, in a series of experiments, Baumeister and colleagues (1998) found that effortful control and self-regulation are costly and turn individuals less efficient in their tasks. Effortful emotion regulation processing in the PFC can only be sustainable during a limited period, as it requires a high expenditure of metabolic resources.

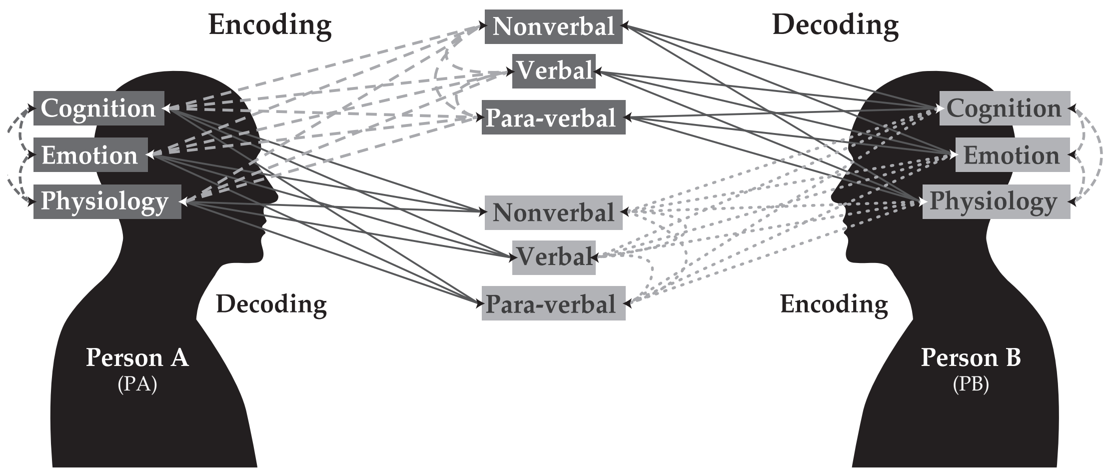
On the other hand, the effortless and automated nature of interdependence in interactants' physiology facilitates the brain's efficient use of energy and resources required for social understanding (Wheatley et al., 2012). During emotional encounters, even the activity in the somatosensory cortex, limbic system, visual attention, and mental simulation networks across individuals automatically synchronize, facilitating emotional understanding and empathy (Nummenmaa et al., 2012).

The last two decades have witnessed a growing interest in the connection of body, mind, and sociality (Di Paolo & De Jaegher, 2012; Dominey et al., 2016; Schilbach et al., 2013). A paradigm shift from an individualistic cognition model to a socially embedded one is one of the developments that have contributed to this increasing number of studies (Di Paolo & De Jaegher, 2012; Dominey et al., 2016; Schilbach et al., 2013). Besides, technological advancements enabled innovative methodological paradigms and analyses and thus behaved as catalyzers for this growth of research (Gates & Liu, 2016; Hamaker et al., 2015; Palumbo et al., 2016). Researchers could have empirically studied how emotions interdependently change between two or more people at the experiential, behavioral, and physiological levels with a high time resolution and sophisticated methods (Gates & Liu, 2016; Hamaker et al., 2015; Palumbo et al., 2016).

The social and dynamical systems framework holds that people mutually co-construct their emotions in a continuously changing trajectory that helps them to adapt to internal and external demands (Butler, 2011; Granic, 2000; Kuppens, 2015; Mesquita & Boiger, 2014; Randall & Schoebi, 2018b; Scherer, 2009b; Schilbach et al., 2013). The emotional system seeks stabilization and homeostasis through persistently fluctuating feedback loops between physiological (autonomic, somatic, and endocrine), behavioral, and cognitive response systems within and between persons. (Butler, 2011; Granic, 2000; Kuppens, 2015; Mesquita & Boiger, 2014; Randall & Schoebi, 2018b; Schilbach et al., 2013). This view argues that despite each participants' role in constituting an emotional interaction, the emotional system as a whole behaves in autonomous and self-organizing manner, which is not reducible to individual emotional processes (Butler, 2011; De Jaegher & Di Paolo, 2007; Granic, 2000). This autonomous self-organization concept (autopoiesis), explained in more detail in the previous section, is a fundamental principle in biology and constitutes the ground of dynamical systems theory (Maturana & Varela, 1972). For instance, even if an individual feels stable in emotional intensity in a given situation and context and does not intend to yell, s/he might find himself or herself in an escalation of anger and rage and shout at his/her partner during an emotional interaction. The new emerging system takes over the influence of individual parameters. A momentary examination of this individual's emotion regulation state by emotion regulation measures that carry no personal significance would not truly help to understand why and how this person behaves in such a way. Instead, interpersonal emotion dynamics, describing the interdependent emotional change between individuals (Randall & Schoebi, 2018b), offer insight into the origins and mechanisms of this person's emotion regulation processes that usually occur beyond individuals' conscious supervision. Such a framework analyses either the affective exchange between individuals (e.g., emotional influencing, encoding, and decoding processes) or the dyad's emotional change by treating the dyad as one unit of a temporal interpersonal emotion system (Butler, 2011). Figure 1 illustrates a dynamic interpersonal emotional process.

Figure 2

A depiction of a dynamic interpersonal emotional process (From "Conceptual approaches to studying interpersonal emotion dynamics" by Randall & Schoebi, 2018, Interpersonal Emotion Dynamics in Close Relationships, p. 20, Copyright 2018 Cambridge University Press).



Note. The interaction between emotion concomitants (here cognition, emotion, physiology) emerges at intra- and inter-personal levels. The encoded emotion through verbal, non-verbal, and para-verbal channels are decoded by the interaction partner. This cycle occurs multiple times during the interaction: a) A between-partners analysis for examining each partners' influence on the partner and the dyad's overall affect in a given time or b) a systems approach treating the dyad as one unit is possible.

The literature on the interpersonal dynamics of emotion is already dense among various disciplines spanning philosophy, cognitive science, psychopathology, and developmental psychology. Several properties were examined, especially within the last decade. Some of these dynamics are: *Covariation* between partners' emotion response systems (i.e., *coherence* or *synchrony*) (Baimel et al., 2018; Field et al., 1989; Fujiwara et al., 2019; Galbusera et al., 2019; Lunkenheimer et al., 2018; Palumbo et al., 2016; Rennung & Göritz, 2016; Schmidt et al., 2012; Timmons et al., 2015; Wheatley et al., 2012; Wilson et al., 2018), *fluctuations* or *variability* in the emotion responding (Sels et al., 2018), repeatedly visited emotional states (i.e., *attractors*) and *flexibility* (Hollenstein, 2015), or carryover of the emotional states in time (i.e., *inertia*) and *emotional influencing/transmission* (Sels et al., 2018). The interested reader can examine the works of Sels and colleagues (2018) and Butler (2011), who classified such dynamics based on time scales, change patterns, pragmatic descriptors, and analysis approaches. These dynamic properties are usually assessed on intensive longitudinal data obtained from at least two interaction partners. The data is generally gathered by electronic diaries, measurement of physiological changes during emotional tasks or in daily life during smart watches, and self-reports following emotional tasks based on continuous rating methods, such as dial rating.

2.5 Emotion regulation

Despite having inherently intra- and inter-personal regulating functions for humans, emotions themselves also need to be regulated. The underlying mechanisms of how these regulatory constructs turn out to be dysfunctional patterns and lead to psychopathology are still to be elucidated. However, it is known that difficulties in regulating emotions play a significant role in maladaptive behavior and various symptom presentations, such as depression, generalized anxiety disorder, complex post-traumatic stress disorder, or borderline personality disorder (Aldao et al., 2010; Austin et al., 2007; Bailer et al., 2017; Gratz & Roemer, 2003; Kring & Werner, 2004).

Emotion Regulation (ER) describes alteration of the natural flow of emotions that influences which emotions to have, when to have them, and how to experience and express them (Gross, 1998). It helps to accomplish individual and social goals by automatic or controlled ways of regulation, such as initiating, inhibiting, avoiding, or sustaining the emotion itself; modifying its form, intensity, duration, quality, as well as its cognitive, physiological, and behavioral concomitants (Campos et al., 2004; Cole et al., 2004; Eisenberg & Spinrad, 2004). Emotion regulation promotes a capacity for change and flexibility for an individual so that s/he can function adaptively in their environment and gain emotional competence (Diamond & Aspinwall, 2003; Eisenberg & Spinrad, 2004). Some scholars view ER not as a response to emotion but as a dynamic and systemic process unseparated from the emotion generation itself that is continuously intertwined with positive and negative feedback loops of the emotional process (Kappas, 2011; Stansbury & Gunnar, 1994).

A rapid and automatic connection between emotion and cognition is generally assumed during ER (Izard, 2010), and these are even posed as intertwined, inseparable systems by some views (Lewis, 2005). Izard (2010) listed the following conclusions of the emotion scientists regarding how emotions are most effectively regulated: Regulation through a) spontaneous neural/neuropsychological processes (i.e., hormonal changes, neurotransmitters), b) other emotions either within or between individuals (e.g., emotion contagion), c) cognitive processes, such as monitoring, effortful control, learning/training, reappraisal, cognitive restructuring, d) adaptive utilization of metabolic resources (e.g., energy and motivation) originating from the neurobiological concomitants of emotion, e) a personality/character employing effective emotion-response patterns as a result of learning and developmental processes, f) social processes, such as social feedback, seeking social support, etc. g) behavioral processes, such as controlling/avoiding expressions, situations, and h) different regulatory processes depending on the discrete emotion itself.

A very widely recognized model in the literature is Gross' (2015) modal model/process model of emotion that focuses on the temporal process of emotion. The model includes the elements of situation, attention, appraisal, and response, respectively. According to this model, an individual can regulate emotion by selecting an emotion eliciting situation before it happens, can modify the situation, deploy their attention in several ways (e.g., distraction), perform cognitive change (e.g., reappraisal), or modulate their responses (e.g., expressive suppression). Gross (2015) also distinguishes between intrinsic (regulating own emotion) and extrinsic (regulating other's emotion) emotion regulation, where a person can up (increase) and down (decrease) regulate positive or negative emotions, which end up with a 2×2 matrix. These two models, especially the first modal model of ER, have been utilized in previous studies (i.e., Koechlin et al., 2018) and show heuristic utility. However, in real life, it is undiscernible "where an emotion ends, and regulation begins" (Davidson, 1998, p. 308), and some ER processes are not easy to temporally detect, especially the ones that take place automatically, such as attention deployment. The categorical model can also classify effortful emotion regulation strategies, such as trying to calm oneself down when one is angry but falls short of capturing dynamic and automatic emotion regulation processes, which is usually the case in daily interactions.

Koole (2009) provided another descriptive and helpful framework of ER based on targets and functions of ER, a 3×3 matrix. As described in previous sections, emotions consist of emotion response systems or components, which themselves are the targets of regulation, such as regulation of ANS through breathing or reappraisal through regulation of cognitive processes. In Koole's model, targets of regulation are classified as: a) attention, b) body, and c) knowledge, as overarching categories of three emotion constituents. Functions of regulation include satisfying hedonic needs (i.e., thinking pleasant thoughts, attentional avoidance, self-defense, or stress-induced eating), pursuing specific goals (i.e., effortful distraction, cognitive reappraisal, or expressive suppression), and facilitating and maintaining the integrity of overall personality system (i.e., attentional counter-regulation, expressive writing, controlled breathing). The advantage of this taxonomy is that it assumes no temporal distinction, can be applied to dynamic models of emotions and informs what is being regulated during an ER and what functions it serves.

Emotion regulation and difficulties in ER have been assessed by implicit or explicit questionnaires, experimental paradigms which involve showing participants pictures or movie clips, punishment tasks, interviews, such as autobiographical recall, reliving past experiences, or dyadic interaction paradigms. Physiological measures include reflexive startle blink, cardiac measures, such as heart rate or heart rate variability, electrodermal measures, functional infrared imaging and endocrinological measures in short- and long-time frames (Kreibig, 2010; Porges et al., 1994; Thayer & Brosschot, 2005). Examination of brain activity and connectivity in brain regions is also commonly employed to assess neuropsychological underpinnings of emotion regulation (Craig, 2009; Lewis, 2005; Thayer & Lane, 2000)

3. Emotional processes and regulation in SSD

Research spanning the last two decades depicted a surge of interest in emotion and regulation, yielding accumulating lies of inquiry into the association between ER and SSD. Several studies have documented disturbances in emotion regulation processes in patients with SSD, such as alexithymia (i.e., difficulty in identifying and describing emotions) (De Gucht & Heiser, 2003; Di Tella & Castelli, 2016), lower levels of emotional awareness (Subic-Wrana et al., 2010), lack of mood clarity or emotional granularity (Zautra et al., 2001), emotion suppression (Gul & Ahmad, 2014; Rimes et al., 2016), rumination (Hadjistavropoulos & Craig, 1994), decreased ability to up-regulate positive emotions (Zautra et al., 2001), imbalance in autonomic activity (Koenig et al., 2016; Pollatos, Dietel, et al., 2011), and diminished ability in emotion recognition (Pollatos, Herbert, et al., 2011) and emotional awareness (Subic-Wrana et al., 2010). The following section briefly reviews the models and mechanisms on the relationship between emotional processes and SSD.

3.1 Models and mechanisms of the relationship between ER and SSD

Several models have been proposed that attempt to explain how emotional factors, such as stress-related arousal, negative affect, and interpersonal emotional processes, might contribute to SSD (Brown, 2004; Van den Bergh et al., 2017; Waller & Scheidt, 2006). While some models recognize disturbance in emotional processing and regulation as a predisposing factor (Lane et al., 2015; Waller & Scheidt, 2006), some others posit it as having a perpetuating and secondary role in the occurrence of the somatic symptoms, which is initially precipitated by perceptual and attentional errors and inflexible loops of convictions (Brown, 2004; Van den

Bergh et al., 2017; Witthöft & Hiller, 2010; Zautra et al., 2001).

3.1.1 Stress and emotion response systems as direct pathways to somatic experiences

Psychodynamic models based on attachment and affect regulation theories (Alexander, 1950; Bucci, 1997; Landa et al., 2012; Lane et al., 2009; Luyten et al., 2012; Waller & Scheidt, 2006), as well as psycho-neuro-biological models (Cohen & Herbert, 1996; Engert et al., 2019; Lane et al., 2009, 2015; Levenson, 2019; Slavich, 2020; Thayer & Brosschot, 2005) pay particular attention to ER processes for explaining SSD. These models mainly accentuate the role of stress-related bodily response systems and emotion dysregulation in symptom formation and postulate that some individuals are especially vulnerable to developing SSD as an outcome of early socio-emotional issues, insecure attachment, and/or parental emotion socialization. Such a developmental course has been asserted to play a role in dysfunctions in stress-related central and autonomic nervous systems and was associated with a wide range of health issues, ranging from cardiovascular diseases to auto-immune disorders, inflammation, or schizophrenia, an account which retains a transdiagnostic perspective (Cohen & Herbert, 1996; Engert et al., 2019; Slavich, 2020; Thayer & Brosschot, 2005).

The shared neurobiological systems between emotion and symptom processing are put forward as one of the main accounts of ER disturbances in SSD (Landa et al., 2012). It is known that emotional and somatosensory neural networks are functionally and anatomically closely connected, and they even overlap (Thayer & Brosschot, 2005). Thayer and Brosschot (2005) proposed a vagal imbalance model in SSD, which noted a diminished inhibitory control of stress and augmented stress reactivity in patients. With the hypoactivity of the prefrontal cortex in response to emotions, the activity of which was presumed to be inversely correlated to the subcortical structures (e.g., amygdala), patients with SSD might show reduced cognitive engagement with emotions, as in alexithymia, as well as reduced HRV. HRV has taken a considerable attention as an indicator of neurovascular integration and was associated with a functional and flexible prefrontal cortex activity. Especially the cortical and subcortical regions taking part in emotion and regulation processes were argued to play a role in cardiovascular regulation, visceral pain in functional gastrointestinal disorders, acute and somatic pain, and placebo (Lane et al., 2009).

In the case of SSD with predominant pain, the connection of emotional processing and the symptoms becomes much closer, as pain per se is considered both a sensory and affective experience (Di Tella & Castelli, 2016; Dima et al., 2013). The complex relationship between pain and emotion regulation has been supported by twin-, neurobiological, experimental, longitudinal, and self-report studies (see the reviews of Di Tella & Castelli, 2016; Dima et al., 2013; Koechlin et al., 2018). A study with 3266 monozygotic and dizygotic twins showed that chronic widespread pain and depression share a common genetic basis with emotional instability and emotional intelligence (Burri et al., 2015). This reciprocal connection of emotion processing and pain was also shown at the neuronal level, especially in an overlapping activation in the insula and secondary somatosensory cortex during pain and emotion processing (Orenius et al., 2017). The anterior insular cortex and anterior cingulate cortex were also implicated in pain processing, interoceptive awareness, and emotional awareness (Craig, 2009). It is noted that the connection of emotional and somatosensory networks allows for modulation of pain by cognitive and emotional resources and helps adaptation and survival (Price, 2000). Although there is considerable evidence for the relationship between emotion and pain, the mechanisms that explain the relationship are highly variable. This fact is well summarized by Dima and colleagues (2013) in their review, who concluded that no one-size-fits-all explanation seems to be proper; instead, personal and contextual factors explain the highly variable relationship between pain and emotion.

Interpersonal approaches underline that physical symptoms do not occur in a vacuum and that emotional interactions explain a considerable variance in development, course, and management of the symptoms (Haase et al., 2016; Henningsen et al., 2007; Karos, 2018; Pillai Riddell & Craig, 2018; Smith & Weihs, 2019). A shared neural system and other shared biological factors, such as genes, neurotransmitter systems, immunologic indicators, and physiological processes involved in interpersonal emotions (e.g., rejection and abandonment), and pain was proposed to account for this relationship (Karos, 2018; Landa et al., 2012). According to the developmental theory of somatoform pain, the development and maturation of these emotion and pain processes are shaped by early interactions with caregivers through several means, such as differentiation of emotion-somatic distress and regulation (Landa et al., 2012).

Studies with interpersonal focus provide some support to the interpersonal approaches. In a neuroimaging study with a modified cyberball paradigm, the role of interpersonal rejection and abandonment on pain experience was delineated (Landa et al., 2020). The activity of neural pain systems changed as a function of rejecting vs. accepting interactions with previously rejecting persons. This neuronal activity was also correlated with the quality of early interpersonal experiences with the caregivers. Moreover, reported pain severity and insular activity was positively correlated with subjective feelings of rejection. The study also showed that in response to pain induction, socio-emotional exposure modulated healthy subjects' reported pain severity as well as the activation of pain-related neural networks in the brain, especially the insula (Landa et al., 2020). Interestingly, social (i.e., feeling excluded) vs. non-specific (i.e., feeling good) aspects of emotions correlated with different regions of the pain circuits, insula vs. frontal gyrus. In fact, the insula is known as a region where pain and social emotion processing overlap (Orenius et al., 2017). Supporting this finding, another study reported that observed emotional behaviors of couples during conflict conversation task predicted the development of physical symptoms over 20 years of long-term marriages; anger behavior predicted increases in cardiovascular symptoms, and stonewalling (*i.e.,* resisting to communicate) predicted increases in musculoskeletal symptoms, especially in husbands (Haase et al., 2016). How the pain is communicated to others (partners, healthcare providers, employers, etc.) and the observer's feedback, such as validation or stigmatization, also dynamically influence the course of SSD (de la Vega et al., 2018).

3.1.2 Emotional processes as altering mechanisms of sensory perceptions

Another line of research has integrated emotional processes into the predictive processing framework of SSD. With the recent advances in computational neuroscience, predictive processing theory has specified in more detail how emotions and interpersonal history as prior knowledge and somatic input might interact and influence somatic perceptions and inferences (Henningsen, Gündel, et al., 2018; Henningsen, Zipfel, et al., 2018; Smith et al., 2017; Van den Bergh et al., 2017b). The integrative cognitive model (Brown & Reuber, 2016) and the predictive coding model (Van den Bergh et al., 2017) assume an active perceptual system that "continually generates, tests and refines hypotheses about the causes of sensory inputs, and which is vulnerable to mistaken inferences and false percepts under certain conditions" (Van den Bergh et al., 2017, p. 190). It is very plausible that such an actively constructing system is vulnerable to emotional processes and emotion regulation, which are, on the one hand, closely intertwined with the perceptual system and, on the other hand, can alter the precision of the priors. The accumulating evidence for dysregulated emotions in patients with SSD (see Chapter 3) and the substantial heterogeneity between individuals' symptom perception also supports the view that the symptom perception system is especially vulnerable to personal meaning-making and emotional processes. As such negative affect and dysregulated emotions might lead to less precise observations, leading to more prediction errors related to symptom reporting, as also proposed by Henningsen and colleagues (2018): "Enhanced affective-motivational responding to somatic experiences may go at the expense of detailed sensory-perceptual processing, resulting in augmented but imprecise prediction errors that largely overlap with prediction errors representing an emotional state" (p. 428).

Embodied and enactivist accounts of emotions similarly put emphasis on how subjects actively engage in and perceive their inner and outer world intentionally. In his seminal work on embodied and enactive cognition Thompson (2008) notes that the nervous system

> "actively generates and maintains its own coherent and meaningful patterns of activity, according to its operation as a circular and re-entrant network of interacting neurons. The nervous system does not process information in the computationalist sense but creates meaning… cognition is the exercise of skilful know-how in situated and embodied action. Cognitive structures and processes emerge from recurrent sensorimotor patterns of perception and action." (p. 13)

Based on this account, social-emotional processes might function as potential *"shapeshifters"* (McGraw, 2015) of perception and action, which emerge "in and with the body" (Kirmayer & Gómez-Carrillo, 2019, p. 172). In the latest works of Kirmayer and Gómez-Carrillo (2019), who complemented the socio-cultural framework of somatic diseases with the contemporary embodied, embedded, enactive and extended model of cognition (i.e., 4E model of cognition), the phenomenological facet of symptoms and the sense of agency was underlined. *Agency,* describing a person's sense of ownership, causality, control, and responsibility for their actions in the context of their goals, plans, and intentions, was posited to be *emerging from loops of action and perception* (Kirmayer & Gómez-Carrillo, 2019). In this regard, in addition to one's top-down multiple cognitive processes, other potential factors can change the experience of agency, which is ontogenically a sensory-motor process: Affective dispositions, emotions, contextual affordances, other social agents' responses, cultural affordances, as well as broader social, economic, and political processes. In sum, in embodied and enactive cognition models, emotional processes are recognized as moderators of how an embodied mind intentionally perceives the inside and outside world.

3.1.3 Effects of context on the components of emotion regulation in SSD

In order to examine the link between emotional processes and symptoms, the value of assessing actual emotional responding of patients is especially underlined, such as investigating emotion components in vivo during different emotional contexts (Levenson, 2019). A notable example highlighting the effect of context can be observed in the relationship between ANS and SSD. In an ambulatory assessment in SSD with chronic pain, aberrant autonomic activity, such as shorter inter-beat intervals and diminished HRV, was shown (Hallman & Lyskov, 2012). However, assuming a higher ANS activity in all the patients might be too simplifying. In a study with children with somatic gastrointestinal symptoms, who expected lower success from themselves, children's HRV was assessed. When the children succeeded in a task, they showed both higher sympathetic and parasympathetic activation than healthy children. However, when they failed, they did not show any difference in autonomic activity, although their somatic symptoms had increased (Puzonavova et al., 2009). This finding suggests that autonomic regulation is highly dependent on the context and adaptability to the system in which it is embedded. From a dynamic systems perspective, autonomic regulation, in fact, reflects the adaptation of the person's mind-body system to its environment, and any perturbation (here, the unexpected success) might increase the coactivation of sympathetic and parasympathetic nodes. On the other hand, an expected and already normalized failure might not act as a perturbation to the system's regularities and therefore might not have elicited autonomic arousal but only increased the symptoms as a way of the children's habitual coping.

In addition, as emotional experiences are highly dependent on perceptions and subjectivity, it is equally essential to examine emotional processes in terms of the subjective experience of discrete emotions as well as emotion dimensions. A dimensional approach to emotions that distinguish the valence and arousal changes can be particularly of heuristic value. Such an approach has been frequently used in research on ANS and emotions (Friedman, 2010; Kreibig, 2010). Other authors have asserted an emotional specificity view in explaining the link between specific health outcomes (e.g., cardiovascular diseases and musculoskeletal diseases) and particular emotions (e.g., anger, sadness, embarrassment) and recommended investigating specific emotional contexts as such (Levenson, 2019).

4. Summary: Dynamic interaction of emotion components in SSD in a social framework

The dualistic separation of mind and body in conceptualizing, diagnosing, and treating bodily distress leads to severe problems, such as stigmatizing the patients, insufficient treatment options, lack of communication between disciplines dealing with the disorders, patients' several visits to different specialists, expensive physical examinations, patients' feelings of not being understood, helplessness and frustration. In the latest definition and models of SSD, the unity of mind and body is significantly underlined, although their emphasis on the biological, cognitive, social, and emotional factors are highly variable.

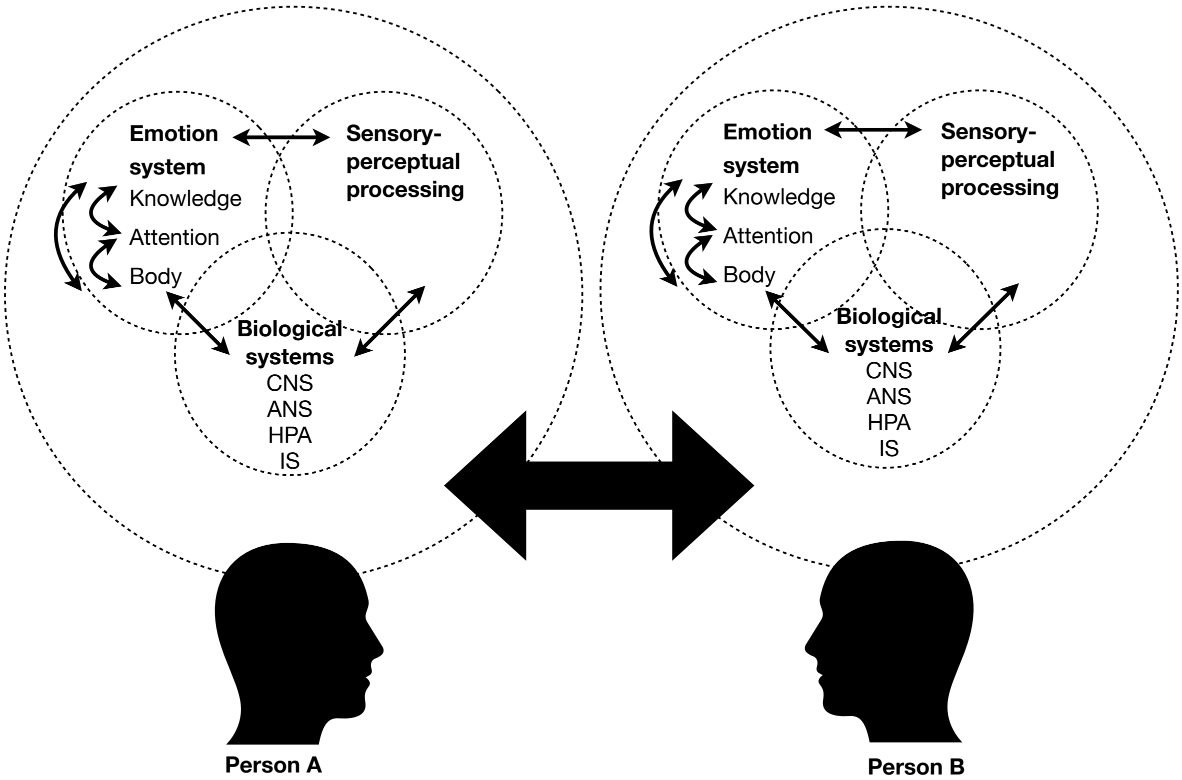
Despite the variability in the models of SSD, almost all views have paid substantial attention to emotional processes and regulation in understanding the mechanisms of SSD. Contemporary models of emotion conceive it as a dynamic and social process that consists of its components, such as attention, cognition, behavior, physiology, subjective experience. These components continuously feed back or forward each other recursively and in an intertwined course. Therefore, several views accept the entangled relationship between emotional and cognitive processes. What is more, as emotions entail regulating biological, social, and cognitive processes per se, it is not usually clear "where an emotion ends and regulation begins" (Davidson, 1998, p. 308). The regulatory constituents of emotion are simultaneously the targets of emotion regulation, which has several functions, such as satisfying hedonic needs, pursuing specific goals, and facilitating the integrity of one's personality (Koole, 2009). This view of emotions is compatible with and, as such, can be integrated into several models of SSD, including the developmental, biological, or predictive processing framework.

Some contemporary models also recognize humans not as passive perceivers of the outer reality but active and intentional sense makers, who co-construct sensory, perceptual, and action processes in and with the body embedded in its social milieu. Enactivist approaches (De Jaegher & Di Paolo, 2007; Kirmayer & Gómez-Carrillo, 2019; Thompson, 2008; Varela et al., 1991), social-constructivist views (Barrett et al., 2007; Gendron & Barrett, 2018), as well as predictive processing models (Smith et al., 2019; Van den Bergh et al., 2017) agree on this view. In such a context, emotions and feelings, which are a ubiquitous part of any human experience that gives meaning and significance to an event, continuously interact with how we think and experience our body, sensory experiences, and relationships. As dealing with emotions in a particular way alters not only HPA, immune, cardiovascular, metabolic, and neurological functioning but also the way how we think, it can thereby increase our prediction errors and alter preciseness of our perceptions of symptoms, our attributions, and beliefs about the symptoms.

Drawing on the dynamical and social models of emotion (Butler, 2011, 2017; Butler & Gross, 2009; Lewis, 2005; Scherer, 2009), and the cognitive-neurobiological accounts of SSD (Henningsen, Gündel, et al., 2018; Smith et al., 2017; Thayer & Brosschot, 2005; Van den Bergh et al., 2017), we posit that emotions exert three pathways of recursive influence on the symptoms: a) altering biological functions, such as the effect of stress on immune, hormonal, cardiovascular or musculoskeletal systems, thus directly influencing symptoms b) altering cognitive processes related to symptoms, such as increased sensitivity and selective attention to the symptoms and prediction errors related to sensory information, c) how they are processed and regulated through their constituents (i.e., cognitive, behavioural and physiological) at intra-personal and inter-personal levels, such as a person's disengaging attention away from emotions and immersing in symptomatic experiences, suppressing anger, stonewalling in relationships regarding emotional content, lower levels of emotional awareness and reflection, doctor-hopping when being anxious about the symptoms or failing to self-regulate in conflictual emotional situations. Based on the reviewed literature, we sketch a working summary of the mechanisms of how dynamic and embodied emotional processes are related to SSD by including the overlapping and interactional processes between the systems of emotion, symptom perception, and biological functions (Figure 3).

Figure 3

A graphical summary depicting the mechanisms of the relationship between emotional processes and somatic symptoms



Note. Emotional processes, perceptual processes related to body and symptoms, and biological systems are semi-open systems that operate in recursive interaction with each other. Emotions can directly alter biological and perceptual processes and vice versa. Also, how emotions are processed and regulated at intra-, and inter-personal levels contribute to this relationship. The intersections between the systems represent the directly overlapping processes, such as the direct influence of HPA alterations on emotions or perception. The double-headed arrows illustrate the two-way interaction between systems and components.

CNS: Central Nervous System; ANS: Autonomic Nervous System; HPA: Hypothalamic Pituitary Adrenal Axis; IS: Immune System

5. Aims and hypotheses of the present dissertation

Negative affect, aberrant emotional processing, and emotion regulation have been associated with somatic symptoms in a growing number of empirical studies and the models of SSD. Although contemporary emotion research adopts a dynamic and social framework in understanding and measuring emotional processes, emotion research on SSD has lagged behind these developments (Smith & Weihs, 2019). Emotion regulation processes are vaguely defined and measured, and there is no clear understanding of which constituent(s) of emotions is actually (dys)regulated during actual emotional processes. This elusiveness poses a limitation not only in understanding the mechanisms of the association between ER and SSD, but also in the scientific language crucial for interdisciplinary communication. Secondly, what we know about ER in SSD has been derived mainly from self-report studies or experimental designs with personally non-significant emotional stimuli, such as affective pictures. The paradigms have also relied on individual-based and static paradigms that have usually ignored the interpersonal and continuously changing nature of emotions. Although emotions typically occur in social interactions or involve social connotations in the absence of immediate social interactions, the interpersonal emotion dynamics in patients with SSD have been poorly examined. We know little how and why disturbances in emotional processes occur in patients' interactions with significant others.

The present dissertation aims to investigate emotion processes and regulation in SSD from a dynamical and interpersonal perspective (Butler, 2017; Koole, 2009; Kuppens & Verduyn, 2015; Lewis, 2005; Mesquita & Boiger, 2014; Randall & Schoebi, 2018a). It addresses how emotion components are regulated at intra and inter-personal levels. The dissertation consists of three studies. The aims and hypotheses for each study are described below.

5.1 Aims of the first study

The first study aims to systematically review the empirical literature on ER processes in patients with SSD, including several different diagnostic labels given to the patients. The recent two decades of research have paid substantial attention to emotion and ER. Research on SSD has gone through a similar course, and there has been a rapid increase in studies and clinical reports highlighting the association between emotion regulation and SSD. This accumulation has aroused the need to compile and systematize the findings together to understand how patients with SSD regulate their emotions, i.e., what ER patterns exist that characterize and distinguish SDD. Specifically, we aim to answer the following descriptive (Question 1), exploratory (Question 2 and 3), and inductive questions (Question 4):

Which ER processes have been examined in SSD, including several other descriptive/diagnostic labels given to the patients?

1. Do the findings support a relationship between ER processes and somatic and psychological symptoms in SSD?
2. Do the findings show differences in ER processes between patients with SSD, healthy controls, and patients with other mental or physical disorders?
3. What are the characteristic ER processes in patients with SSD? With the terminology of dynamical view to emotions, how does ER work in emotion constituents in patients with SSD?

The fourth question fulfils the primary goal of the systematic review. To realize this, we re-organized the findings in an interdisciplinary language that is compatible with the existing theories of ER in SSD. Based on contemporary approaches to ER and SSD, the results were classified according to components of ER (attention, body and knowledge) (Koole, 2009). Such an approach sheds light on how emotion modalities might interact and generate particular regulation patterns in patients with SSD.

5.2 Aims and hypotheses of the second study

This methodological case study aims to test the applicability of an interpersonal paradigm to examine intra- and inter-personal emotional processes of patients with SSD. Two case couples, one with a partner with SSD and one with two healthy partners, were presented for analysis. First, we expected to elicit significant subjective and physiological variations in the SSD patient-couples and healthy couples in response to our experimental conditions. Secondly, we predicted that the SSD-patient couple would show considerable ER difficulties accompanied by hypervigilant autonomic activity at the intra-personal level and lower physiological interdependence (i.e., coherence) between partners at the inter-personal level.

5.3 Aims and hypotheses of the third study

The third study implemented the experimental paradigm that was tested in the second study and revised its' hypotheses based on the most recent findings on physiological coherence in dyads in different emotional contexts. This literature suggests that physiological coherence (or physiological linkage) between persons during emotional interactions can be either functional or dysfunctional for well-being depending on context. In this study, our goal was to investigate whether and how interpersonal emotion dynamics differ between couples with a patient with SSD (SSD patient-couples) and health control couples. Specifically, we examined couples' real-time physiological (i.e., cutaneous facial temperature) and subjective emotional interdependence during their emotional interactions, which consist of neutral, conflictual, and relaxing conditions.

We postulated the following hypotheses:

There is compelling evidence for disturbances in emotional processing and regulation in SSD (Koechlin et al., 2018; Levenson, 2019; Okur Güney et al., 2019; Waller & Scheidt, 2006). Accordingly, during a conflict, we expected a higher physiological coherence in SSD patient-couples than baseline, which is linked with stress reactivity or escalation in a mutual conflict (Butler, 2015; Timmons et al., 2015; Wilson et al., 2018) and diminished self-regulation (Galbusera et al., 2019). On the other hand, based on previous evidence for the functionality of physiological coherence in facilitating empathy and attunement in positive or neutral contexts, we expected healthy couples to show higher physiological coherence at baseline but to attenuate it during anger as an adaptive means to disengage from the conflict.

As a secondary goal, we explored how the relationship between partners' subjective affect changed in experimental conditions. We investigated the group-level relationships between the partners' a) actual affect (emotional similarity), b) self-affect and perceived partner-affect (assumed similarity), and c) perceived partner-affect and the partners' actual affect (empathic sensitivity). Based on the previous studies, which suggested that physiological coherence reflects psychological interdependence (Ebisch et al., 2012; Helm et al., 2014; Lougheed et al., 2016; Manini et al., 2013; Ruef, 2001; Saxbe et al., 2018), we expected that SSD patient-couples would show a greater between-dyad emotional interdependence (i.e., relationship) at anger than the baseline condition, while healthy couples would show the opposite pattern of a weaker emotional interdependence during anger compared to the baseline condition.

6. References (Chapter I)

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Chapter II: Emotion regulation in patients with somatic symptom and related disorders: A systematic review[1]

Abstract

Background: Somatic symptoms and related disorders (SSD) are prevalent phenomena in the health-care system. Disturbances in emotion regulation (ER) are commonly observed in patients suffering from SSD.

Objectives: This review aimed to examine ER processes that characterize SSD by a systematic analysis of the available empirical studies.

Data Sources: PsycINFO and PubMed databases for the articles published between January 1985 and June 2018.

Search Terms: "emotion/al regulation" or "affect regulation" and various forms of SSD. **Study Eligibility Criteria:** Empirical studies that a) assigned adolescent or adult patients suffering from SSD based on a clinical diagnosis, and b) examined the relationship between ER and SSD, were included.

Study Synthesis Methods: A tabular summary of the articles was generated according to study characteristics, study quality, variables, and findings. The findings were organized based on ER variables used in the articles and diagnoses of SSD, which were then re-organized under the main constituents of ER (attention, body, and knowledge).

Results: The findings of the 64 articles largely supported the association between SSD and disturbances in ER, which are usually shared by different diagnoses of SSD. The results indicate that patients show a reduced engagement with cognitive content of emotions. On the other hand, bodily constituents of ER seem to depict an over-reactive pattern. Similarly, the patients tend to encounter difficulties in flexibly disengaging their (spontaneous) attention from emotional material.

Limitations: There is a scarcity of longitudinal designs, randomized controlled trials, experiments, and diary studies suited to investigate the short- and long-term causal relationship

[1] This chapter was published as: Okur Güney, Z.E, Sattel, H., Witthöft, M., Henningsen, P. (2019) Emotion regulation in patients with somatic symptom and related disorders: A systematic review. PLoS ONE 14(6): e0217277. https://doi.org/10.1371/journal. pone.0217277. The paper was written by Zeynep Emine Okur Güney and co-authored by Heribert Sattel, Michael Witthöft, and Peter Henningsen.

between ER and SSD. Symptoms of SSD and measures to assess emotion regulation are heterogeneous.

Conclusions and Implications: Assessment of ER processes is potentially useful to understand SSD and for treatment planning. Furthermore, a concurrent investigation of the dynamic interaction of the ER modalities promises insights for better understanding of the role of ER in development, course, and maintenance of SSD.

Keywords*:* Emotion regulation, emotion components, emotion constituents, attention, body, emotional appraisals, affect, somatoform disorders, somatic symptom disorders, functional somatic syndromes, medically unexplained symptoms.

1. Introduction

1.1 Somatic symptom and related disorders

Somatic symptom and related disorders are characterized by one or more bodily symptoms that are accompanied by excessive thoughts, feelings and behaviors [1]. The most common symptoms include pain in different parts of the body (back, joint, head, chest, etc.), disturbances in the organ functions (gastrointestinal, respiratory, etc.), fatigue, and exhaustion [2–4]. These symptoms cannot be adequately attributed to conventional organic diseases, structural changes in the body, or biochemical abnormalities [2,4–6]. The patients usually suffer from multiple physical symptoms, as well as comorbid mental and psychosocial disturbances, which precipitate and maintain the symptoms [2,7,8]. In case of a chronic course, the symptoms become difficult to treat and cause impairments in patients' lives, resulting in high direct and indirect costs (increased health-care demands, working disability, and early retirement) [9].

As a consequence of the complex clinical presentation of SSD, the patients are diagnosed and treated by different health-care specialties, depending on their overriding complaints and the referral source. In general medicine, the symptoms are captured as "functional somatic syndromes," such as "irritable bowel syndrome" for abdominal pain and altered bowel problems, "fibromyalgia" for musculoskeletal pain, joint pain, and fatigue (see Brown, (2007) [10], for the diagnostic labels for common symptoms by specialties). In conventional mental health, the symptoms are classified as somatoform disorders or recently, "somatic symptom disorders" [1,11]. "Medically unexplained symptoms" is another widely used term, although its use is contentious, as it is inadequate to represent the biopsychosocial nature of the complaints, it splits mind and body, and it constitutes premature labeling [2,10,12].

The classification of SSD is quite complex because of the extensive commonality between different syndromes of SSD. The diagnostic criteria for different syndromes typically overlap: Patients with a specific diagnosis usually also meet the criteria for another [8,13]. Also, different diagnostic groups share certain non-symptom characteristics, such that a majority of the patients are women, suffer from comorbid emotional disorders such as anxiety or depression, and report a childhood history of trauma [7,8]. The etiology, pathology, and neurophysiology of different diagnoses also show similarities [13]. What is also notable is that patients benefit from similar forms of treatment without regard to the specific symptom profile

[14–16]. Such commonalities impede a clear-cut diagnosis and are complicated by the fact that criteria are not well established to differentiate symptom presentations and diagnoses [2,8,10,17].

Related to the difficulties in classification of SSD, there has been a debate between so-called "splitting" and "lumping" views. The splitting perspective holds that separate diagnoses for different symptom pictures should be given, because commonalities between diagnoses do not describe all patient groups, and lumping the disorders would not adequately explain the diversity and heterogeneity in patients' symptom presentations. The lumping perspective, on the other hand, draws attention to the mentioned similarities among separate diagnoses and claims that commonalities are greater than differences between them. "Lumpers" note that a single syndrome receives different labels depending on the medical specialty and propose lumping the syndromes along a continuum [2,5,8,13,18]. Their concern is that clinicians and researchers focusing on one specific diagnostic entity tend to classify the symptoms as isolated from other biopsychosocial factors. Recent evidence seems to support both views, by showing both commonality and heterogeneity within and between diagnostic groups [17].

In order to avoid the terminology complications mentioned above and ensure comprehensive and integrative inclusion criteria, in this paper we examined the whole range of somatic symptom and related disorders that includes different functional somatic syndromes and medically unexplained symptoms (SSD) [5,19]

1.2 Emotion regulation in patients with somatic symptom and related disorders

Theories about SSD acknowledge disturbances in emotion regulation (ER) processes as one of the psychological aspects contributing to the development, progression, and treatment of the symptoms [7,20–23] (see [24] for a review of the theoretical models). Empirical and clinical reports also quite consistently confirm the association between disturbances in ER processes and SSD [25–27]). However, the underlying mechanism of this association is not clearly established. An overview of the theoretical accounts of SSD suggests that ER in SSD is characterized by an incoherent functioning of emotional response systems (cognition and body) during the regulation of emotions [20–24,28,29].

Biopsychosocial accounts of SSD include a developmental course of disturbed early interpersonal interactions, insecure attachment styles or trauma history as risk factors for the development of emotion regulation disturbances in patients with SSD. This socio-emotional trajectory has been found to be associated with alterations in the endocrine, immune, and pain-regulating systems [2,23,24,30]. Accordingly, psychotherapies for SSD incorporate interpersonal aspects and emotion regulation training into the therapy planning (e.g., [15,31–33]).

A relationship between ER processes and SSD is also supported by neurobiological studies highlighting the substantial neuronal connectivity and overlap of the emotional, somatosensory, and motoric subsystems [34–38]. These networks communicate closely with the autonomic and immune system and hypothalamic–pituitary–adrenal (HPA) axis, which also play key roles in awareness of internal body sensations and homeostatic regulation in response to emotional changes [36,39,40].

1.3 Constituents of emotion regulation

How emotional processes are conceptualized certainly guides the pathway of ER research. Contemporary approaches to emotional processes draw attention to its systemic and dynamic nature, which consists of components interacting with each other at multiple levels, mainly physiological, cognitive, and behavioral (expressive). This perspective highlights the importance of research focusing specifically on these components and how they interact during ER [41–45].

According to this view, an emotional process is an inherently regulatory system that consists of its components operating through dynamic systems principles, such as continuous feedback mechanisms and circular causality (i.e. multi-directional and recursive relationship between elements of a system) [41,45–47]. This view postulate that, in response to an emotional perturbation, the components of emotion, such as appraisals, action tendencies or arousal, are continuously updated and regulated based on internal (e.g. proprioceptive) and external (e.g. cultural norms, socialization) feedback sources [45,48]. As a function of the continuity in feedback mechanisms, in the emotion process, the temporal distinction between emotion generation and regulation cannot be clearly distinguished [46,49]). Hence, emotion regulation goes beyond deliberate and effortful regulation strategies that are assumed to take place after the emotion is generated [50,51]. Instead, emotion regulation can be held as a suite of effortless and effortful processes, with or without a conscious supervision that changes the “spontaneous flow of emotions” [52]. When ER is not adaptively and flexibly employed, disturbances occur in emotional functioning [53]. As previously stated, no ER “strategy” in its broad sense, is healthy or unhealthy per se, without considering its context [53]. However, a dimensional approach that examines over- and rigid use of certain ER “strategies”/processes, such as suppression, disconnection from emotional experiences, or hypo- or hyper-reactivity in the components of ER [54] or even reappraisal [53] can define disturbances in ER.

In order to better understand ER, as previously remarked, "…we first need to know what is being regulated" [55]. During the regulation of emotions, what are indeed being regulated are the constituents of emotion. For example, expressive suppression of anger primarily requires the regulation of bodily behavior [56]. Or rumination basically involves a perseveration of attention on negative thoughts and feelings [55]. Catastrophizing mainly comprises a dysregulation of appraisals and thus overreliance on negative thoughts and feelings; techniques for breathing and muscle relaxation primarily regulate the body [52]. Certainly, ER being a dynamic process, multiple constituents of emotional process are simultaneously engaged; however, particular components are predominantly active depending on the form of ER process.

Given that ER occurs through the regulation of its constituents, identifying how each of them operates and interacts in an emotional context would help us to elucidate the ER process more precisely. Such an approach to ER, which looks closer at its constituents or targets, was implemented in previous studies and demonstrated its empirical and clinical utility [27,44,52,57,58]. For example, Koole (2009) [52], classified ER processes in terms of targets/constituents of ER (e.g. attention, body and knowledge), as well as its functions. He has gathered ER constituents such as action tendency, arousal, reflection, evaluation, beliefs, etc. around 3 overarching categories, "attention, body and knowledge", thus refined the complex components into a practicable taxonomy. This approach offers high heuristic and experimental potentials to understand the mechanisms of ER. Moreover, in the context of SSD, classifying ER based on its targets is compatible with theoretical accounts and empirical evidence, which indicate a disintegrated interaction between cognitive and bodily components of ER in SSD [20,21,23,24]. In fact, with the recent progress in neuropsychobiology, it has been highlighted that concordant functioning of ER modalities is vital for healthy bodily functioning [36,37,59,60].

1.4 The present study

The growing interest in ER and the body-mind connection in the past decades has yielded an accelerating number of studies that examined the association between ER and SSD. As these empirical findings accumulate, the need has grown for a systematic investigation of the literature that can explain and specify the relationship between ER processes and SSD. Our research was mainly guided by the central question: "How do patients with SSD regulate their emotions?" In order to pursue this goal, we specifically posed the following descriptive (Question 1), exploratory (Questions 2 and 3) and inductive (Question 4) questions: 1) Which ER processes were examined in different diagnoses of SSD? 2) Did the articles show a relationship between ER processes, and somatic and psychological symptoms in SSD? 3) Do these ER processes show differences between patients with SSD, healthy controls and patients with other mental or physical disorders? 4) What are characteristic ER processes in patients with SSD? In other words, how does ER operate in attentional, bodily, and knowledge domains in SSD? The fourth question is aimed to clarify the foremost question of the present review and will be elaborated in the discussion through the inferences drawn from the existing study findings.

The primary object of interest of this review is emotion regulation processes. When conceptually needed, we use the term "disturbances in ER" or similar terms. "ER constructs" denominate specific latent domains examined in the included studies (such as emotional awareness, expressive suppression, etc.) and "ER variables" the observed variables of each study.

2. Method

2.1 Literature search and inclusion of the articles

We conducted this review following the PRISMA guidelines for systematic reviews [61] (See Appendix A). We carried out a systematic search in PsycINFO and PubMed for articles published between January 1985 and June 2018. Due to the paucity of empirical research on emotion regulation before mid-eighties [62] we chose 1985 as a starting point for our search. We did not pre-register or make a formal protocol of the review publicly available.

The search terms included the keywords "emotion regulation" or "emotional regulation" or "affect regulation" and various forms of SSD. The keywords for SSD were established based on a previous meta-analysis [63] and a recently updated national guideline for SSD [5] (see Appendix B for a list of the search terms for SSD). Additional records identified through other sources and studies that examined emotion regulation despite their primary focus on alexithymia were also included.

The screening and selection of the studies was conducted by two authors of this review (ZEOG and HS). In the initial screening of the articles, the two authors checked the titles and abstracts and eliminated papers that clearly did not satisfy the inclusion criteria. The same authors then independently read the full text papers to determine the eligibility. Any disagreements or uncertainty were settled by a discussion and were resolved with a third author (PH) if necessary. Studies that assigned adolescent or adult patients (minimum age of 13) suffering from SSD based on a clinical diagnosis were selected for the review. We included a study if it either: (a) reported a relationship between ER and SSD, or (b) compared ER processes in patients with SSD with those of patients with other mental or medical disorders, or healthy subjects. All study designs (cross-sectional, case control, longitudinal, and experimental) except case studies were included. Dissertations and non-empirical papers, such as reviews, commentaries, expert opinions, and book chapters, and non-English papers were excluded. Brain-imaging and psychotherapy studies, which are beyond the scope of our review, were not included. As previous reviews on the relationship between alexithymia and somatization already exist, we excluded studies having examined only alexithymia as an ER variable (e.g., [26,28])

Following the initial screening, full-text articles were further examined for their eligibility. At this stage, relevance, sample details and measures of the studies were re-examined in the full text. Studies that assigned only a healthy sample or patients without an SSD diagnosis were excluded. In addition, the measurement methods, experimental procedures, and single items of the scales used were examined, in order to check their eligibility related to content validity (e.g., whether the instructions or the content of the experiment or scale items really measure ER vs. a more general regulation-construct, such as coping). If the scales were not provided in the article, they were examined in the original source of the scale. Articles presenting only a global score of an emotion regulation-related construct that did not allow identification of specific ER Subscale scores were excluded (e.g., those providing only the findings on coping style, but not on the reappraisal subscale). If a study examined merely regulation of somatoform symptoms without any emotional reference, it was excluded (e.g., pain regulation, avoidance of painful activities, catastrophizing the symptoms, or rumination about the symptoms). Studies that assessed only feeling tone/affective experience but not ER were excluded. Finally, studies that did not report a relationship between ER variables and SSD were excluded.

2.2 Organization of the articles

The articles were organized based on (a) ER variables referred to in the article, and (b) diagnoses of SSD. They were then relocated under the overarching categories of attention, body, and knowledge [52], through investigation of the measures and the findings. When locating the ER processes, we implemented a combination of bottom-up (empirical) and top-down (theoretical) methods, which renders it a robust classification approach [58]. In other words, besides the guidance of previous studies [52,57] and models [41,45,50] in defining the constituents and classification of the ER processes (top-down), the examined ER variables and their measurement method in each study contributed to the classification (bottom-up). We examined the operational definition of each ER term assessed in the article, the corresponding measurement method, and the experiment instructions/procedures or single items of the administered psychometric scales implemented for the assessment of ER. The original sources of the measures were also consulted and listed in a separate reference section (see Appendix C). The first and the second author built the organization system. In cases of indecision about locating the ER variables, they discussed the cases and settled on a consensus. The outcome of this organization, including emotion regulation variables and their assessment methods, are presented for the attention, body, and knowledge domains in Table 1.

Table 1

Emotion regulation variables and measurement methods in the reviewed articles

ER component	ER variable	Measurement
Attention	Acting with awareness	Five Facet Mindfulness Questionnaire, Actaware Subscale (e.g., ‘‘I find myself doing things without paying attention’’) (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006).
	Attention switching, flexibility, fixedness and attentional hyper-vigilance	Emotional Stroop Task, Task Switching Paradigm (attentional bias to emotional material).
	Attending to emotions	Difficulties in Emotion Regulation Scale, Awareness Subscale (e.g., “I pay attention to how I feel”) (Gratz & Roemer, 2004). Emotion Regulation Skills Questionnaire, Awareness Subscale (e.g., “I paid attention to my feelings”) (Berking & Znöj, 2008).
	Difficulties engaging in goal directed behavior	Difficulties in Emotion Regulation Scale, Goals Subscale (e.g., “When I’m upset, I have difficulty focusing on other things”) (Gratz & Roemer, 2004).
	Mindful attention	Mindful Attention Awareness Scale (e.g., “I could be experiencing some emotion and not be conscious of it until sometime later”) (Brown & Ryan, 2003).
	Observing, noticing, and attending to sensations, thoughts, and feelings	Five Facet Mindfulness Questionnaire, Observe Subscale (e.g., “I pay attention to how my emotions affect my thoughts and behavior”) (Baer et al., 2006).
	Suppression of thoughts and feelings	Experimental paradigm (subjects were instructed to suppress what they were thinking and feeling about the task, through an “ironic effect,” greater attention deployment). (Burns et al., 2011).
Body	Action readiness to confront distressing situations	Emotion Regulation Skills Questionnaire, Readiness to Confront Subscale (e.g., “I did what I had planned, even if it made me feel uncomfortable or anxious” (Berking & Znöj, 2008).
	Affect-modulated startle in the muscles	Electromyogram
	Anger expression and suppression	Diary sampling Self-Expression and Control Scale (Elderen, Maes, Komproe, & Kamp, 1997) State-Trait Anger Expression Inventory (Spielberger, 1988)

	Autonomic nervous system activity	Blood pressure, heart rate, heart rate variability, skin conductance response, respiration rate, Electromyogram, cortisol levels, respiratory sinus arrhythmia
	Behavioral expression of validation and invalidation	Specific Affect Coding System (Gottman, McCoy, Coan, & Collier, 1995).
	Control of emotional reactions	Courtauld Emotional Control Scale (e.g., "I let others see how I feel") (Watson & Greer, 1983).
	Distinguishing bodily sensations during emotions	Emotion Regulation Skills Questionnaire, Sensations Subscale (e.g., "My physical sensations were a good indication of how I was feeling") (Berking & Znöj, 2008).
	Emotional behavior	
	Emotional decision making	IOWA Gambling Task (requires awareness of internal bodily signals during affective arousal) (Bechara, Damasio, Tranel, & Damasio, 2005).
	Expressive suppression	Emotion Regulation Questionnaire, Suppression Subscale (e.g., "I control my emotions by not expressing them") (Gross & John, 2003).
	Facial emotional expression	Emotional Facial Action Coding System (Friesen & Ekman, 1983).
	Impulse control difficulties	Difficulties in Emotion Regulation Scale (Impulse Subscale; e.g., "When I'm upset, I lose control over my behaviors") (Gratz & Roemer, 2004).
	Nonverbal expression of emotions	Affect Consciousness Interview (Monsen, Eilertsen, Melgård, & Ødegård, 1996).
	Progressive muscle relaxation	Experimental instruction
Knowledge	Access to emotion regulation strategies	The Difficulties in Emotion Regulation Scale, Strategies Subscale (e.g., "When I'm upset, I believe that I'll end up feeling very depressed" (Gratz & Roemer, 2004).
	Acceptance of emotions	Acceptance and Action Questionnaire (e.g., "I'm afraid of my feelings; emotions cause problems in my life") (Hayes et al., 2004).
		Emotion Regulation Skills Questionnaire, Acceptance Subscale (e.g., "I accepted my emotions") (Berking & Znöj, 2008).
		Cognitive Emotion Regulation Questionnaire ("e.g., I think that I have to accept that this has happened") (Garnefski & Kraaij, 2006).

Adjusting emotional experiences	Affective Style Questionnaire, Adjust Subscale (e.g., “I can get into a better mood quite easily”) (Hofmann & Kashdan, 2010).
Affective memory	Experimental Affective Memory Performance Test
Automatic negative thoughts	Automatic Thoughts Questionnaire (Hollon & Kendall, 1980).
Beliefs about emotions	Beliefs about Emotions Scale (Rimes & Chalder, 2010), Beliefs About Emotions Questionnaire (Manser, Cooper, & Trefusis, 2011).
Describing emotional experience	Five Facet Mindfulness Questionnaire, Describe Subscale (e.g., “I’m good at finding words to describe my feelings”) (Baer et al., 2006).
Efficacy in emotional regulation	Assessing Emotions Scale (e.g., “I am aware of the non-verbal messages I send others”) (Schutte, Malouff, & Bhullar, 2009)
Emotional clarity	The Difficulties in Emotion Regulation Scale, Clarity Subscale (e.g., “I have difficulty making sense out of my feelings”) (Gratz & Roemer, 2004), Trait Meta-Mood Scale (Salovey et al.,1995).
	Emotion Regulation Skills Questionnaire, Clarity Subscale (e.g., “I was clear about what emotions I was experiencing”) (Berking & Znöj, 2008).
Emotional awareness for self & other	The Levels of Emotional Awareness Scale (Lane, Quinlan, Schwartz, Walker, & Zeitlin, 1990). The Affect Consciousness Interview (Monsen et al., 1996), Assessing Emotions Scale, Appraisal Subscale (Schutte et al., 2009)
Emotion recognition	Karolinska Directed Emotional Faces Battery (Lundqvist, Flykt, & Öhman, 1998), Tübinger Affekt Batterie (Breitenstein, Daum, Ackermann, Lutgehetmann, & Muller, 1996), Facially Expressed Emotion Labeling (Kessler, Bayerl, Deighton, & Traue, 2002), Animated Morphing Paradigm (Schönenberg et al., 2014), Comprehensive Affect Testing System (Froming, Levy, Ekman, 2004).
Emotional theory of mind	Emotional content in Frith-Happé-Animations Task (White et al., 2011), Reading the Mind in the Eyes Test (Baron-Cohen et al., 2001)
Empathy capacity	Empathy Quotient (Baron-Cohen & Wheelwright, 2004).
Modification of emotional experience	Emotion Regulation Skills Questionnaire, Modification Subscale (e.g., “I was able to influence my negative feelings”) (Berking & Znöj, 2008).

Non-acceptance of emotional responses	The Difficulties in Emotion Regulation Scale, Non-acceptance Subscale (e.g., “When I’m upset, I feel guilty for feeling that way”) (Gratz & Roemer, 2004)
Non-judging of emotions & thoughts	Five Facet Mindfulness Questionnaire, Non-judge Subscale (e.g., “I criticize myself for having irrational or inappropriate emotions”) (Baer et al., 2006).
Other-blame	Cognitive Emotion Regulation Questionnaire (e.g., “I feel that others are to blame for it”) (Garnefski & Kraaij, 2006).
Reappraisal	Emotion Regulation Questionnaire (Gross & John, 2003) Cognitive Emotion Regulation Questionnaire (e.g., “I think I can learn something from the situation”) (Garnefski &Kraaij, 2006).
Rumination	Cognitive Emotion Regulation Questionnaire (e.g., “I often think about how I feel about what I have experienced”) (Garnefski &Kraaij, 2006).
Self-support in emotional challenges	Emotion Regulation Skills Questionnaire, Self-support Subscale (e.g., “I supported myself in emotionally distressing situations”) (Berking & Znöj, 2008).
Tolerance and resilience to emotional confrontations	Emotion Regulation Skills Questionnaire, Tolerance Subscale (e.g., “I felt I could tolerate my negative feelings”) (Berking & Znöj, 2008).
	Affective Style Questionnaire, Adjust Subscale (e.g., “I can tolerate being upset”) (Hofmann & Kashdan, 2010).
Understanding emotions	Emotion Regulation Skills Questionnaire, Understanding Subscale (e.g., “I was aware of why I felt the way I felt”) (Berking & Znöj, 2008).
Utilization of emotions	Assessing Emotions Scale (e.g., “When my mood changes, I see new possibilities”) (Schutte et al., 2009).

2.2.1 Attention

Attentional regulation is phylogenetically and ontogenetically one of the earliest mechanisms for dealing with affects [38,60]. Infants' gaze aversion, parents' visual orienting or rocking of infants to reduce distress and alert behavior, are examples of early forms of attentional regulation of affect [38,64]. In response to affective perturbations, attentional, affective, and autonomic systems operate in a highly interconnected functional and structural network, whereby the organism allocates its resources for organization and selection of responses, and for psychophysiological modulation [64–67]. Attentional regulation of emotions can be automatic or deliberate, which involves alerting, directing one's attention towards or away from the emotional material, or modifying the attention process [52,56,64,68]. Previous studies suggested the following attention-oriented emotion regulation processes: attention deployment, flexibility or hypervigilance in attention, thought suppression, attentional avoidance, rumination, distraction, focusing on the positive, meditation, and mindfulness [52,57,58].

2.2.2 Body

The vital role of bodily processes in the experience and regulation of emotions has been consistently confirmed. Research across different disciplines continues to converge on the bidirectional role of afferent and efferent feedback in the experience and regulation of emotions [39,69,70]. Bodily constituents of emotion involve indicators of arousal, action tendency, and embodied means of emotional behavior such as facial and bodily expressions of emotion [41,45]. The following regulation processes are considered in this domain: sympathetic and parasympathetic autonomic activity; startle responses; involuntary muscle movements; vocal, facial, and postural behavior; bodily relaxation; stress-induced eating [45,52,71].

2.2.3 Knowledge

Knowledge-oriented emotion regulation is the most widely studied form of emotion regulation. It involves conscious or unconscious appraisals and attribution of emotionally significant events, such as the relevance, implications, significance, and meaning of the event [45,72,73]. Emotion regulation styles, such as catastrophizing, reappraisal, acceptance, emotional awareness, emotional clarity, and ability to reflect and distinguish emotions are considered in this domain [52,57,58]

2.3 Data analysis

Because of the large heterogeneity of the studied patient groups, ER variables, and methods, no statistical comparison by a meta-analysis was possible. It is expected that our qualitative findings can pave the way for future studies with specific research questions suitable for a quantitative review.

For the narrative analysis, a preliminary synthesis was first developed using tabulation of the data according to the study characteristics, study quality, variables, and findings. Emotion regulation variables and their measurement methods were specified at this stage. The findings were organized based on ER variables and diagnoses of SSD (for research questions 1 to 3). At the second stage, the articles were relocated under the categories of attention, body, and knowledge for interpretation of the findings (main goal of the study, for the research question 4). Finally, the findings of the articles were summarized and discussed in a theoretical framework.

2.3.1 Quality appraisal

The quality appraisal followed a systematic procedure, which is a modified version of the one conducted by Brown and Reuber [74]. Because an established quality rating system in this field did not exist at that time, the authors developed and validated a modified catalogue, which we modified slightly in order to cover the specific needs of the review presented here. We followed a procedure similar to that of Brown and Reuber [74] for assessing the criteria related to: (1) design, (2) sample size adequacy (based on considerations of effect size and the power criteria of Cohen [75]- i.e., how large an effect size had to be detected: very small < 15 participants, small < 26 participants, moderate 26–63 participants, and large ≥ 64 participants, in each group), (3) consecutive sampling (yes/no or not stated clearly), (4) use of standardized measures (yes/no), (5) type of comparison groups, if available, and (6) demographic matching of the comparison group (yes/no or post-hoc analysis). [75]

We added four other criteria that we considered relevant to assess the included articles, which had assigned heterogeneous diagnoses. The quality appraisal was amended accordingly by the following criteria: (7) specificity of the diagnostic labels (specific, e.g., psychogenic non-epileptic seizures vs. broad, e.g., medically unexplained symptoms), (8) the presence of sufficiently reported inclusion and exclusion criteria (yes/no), (9) the use of established diagnostic criteria (yes/no/not available), and (10) the application of more powerful inferential statistics, as opposed to more explorative and descriptive statistics (yes/no). Well-reported in-

/exclusion criteria and the use of established diagnostic criteria should make it possible to recruit other samples from the population in question with a high probability of substantial concordance, and to generalize conclusions from the respective study to the larger populations for those patients. Finally, we introduced a distinction between the use of explorative statistics (when only means, standard deviations, or simple correlations were provided) vs. inferential statistics (controlling for potential confounders, application of higher order/interaction analyses). While the former allow-in a strict sense- conclusions related to the observed sample only, the latter provide conclusions and tests of hypotheses related to properties of a population, by assuming that the observed data stem from a larger population [76].

As the original rating system developed by Brown and Reuber [74] had already demonstrated high interrater reliability, we determined the reliability of the added criteria applying a similar approach. 12 articles were independently rated by ZEOG and HS resulting in a substantial overall interrater-reliability for those three items (Cohens Kappa $\kappa = 0.78$). The remaining empirical papers were then evaluated by HS, and any uncertain ratings of the remaining articles were discussed and agreed with ZEOG subsequently.

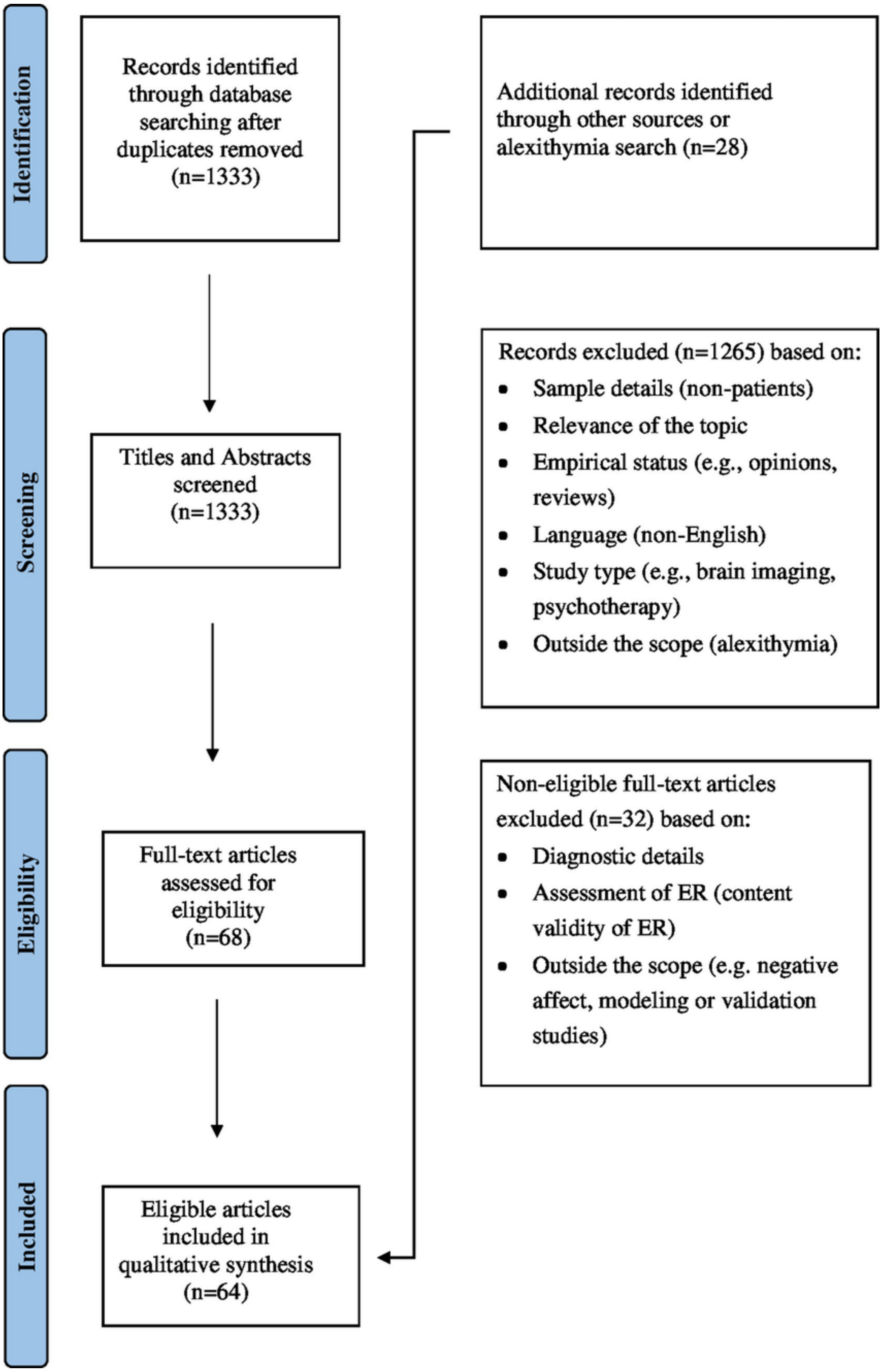
We finally calculated a total quality score defined as the proportion of criteria items rated as “yes” (items 3, 4, 6, 8, 9, 10). This score refers to a total of 4 to 6 items (depending on whether established diagnostic criteria exist and/or a comparison group was examined, which could be matched demographically). Quality of the studies was rated with +, ++, or +++ when 25–49%, 50–79%, or 80% or more of the criteria were rated with “yes.”, following the suggestion of Brown & Reuber [74]

3. Results

The flow diagram for the 64 included articles is shown in Figure 1.

Figure 1

Information flow on study selection.



3.1 Quality appraisal

The characteristics of the included studies displayed a large variability. The majority of the studies (42; 68.9%) included patients with specific diagnostic labels, e.g. functional syndromes, and most of those studies (32 out of 43; 74.4%) used established diagnostic criteria for those. For broadly defined diagnostic labels well defined criteria were not available or not applied more often (10 out of 19; 52.6%). Nearly two-thirds of the studies reported inclusion criteria sufficiently to allow a replication (38; 62.3%). More than a half of the investigations reported multilevel outcomes, whilst the remainder provided patient reported outcomes only, using consistently validated instruments (with the exception of a qualitative study applying grounded-theory methodology). 46 studies compared the diagnostic label under question with one or more other samples, most often with healthy controls (43; 70.5%), and in a few cases with other medical conditions (7; 11.5%) or both. 20 out of those 46 studies (43.5%) matched the examined samples according to sociodemographic data. 15 studies (24.6%) reported a consecutive recruitment mode. For statistical analyses inferential approaches were used in 32 (52.5%) of the studies. Sample sizes varied from very small to large and were in 41 studies at least moderate (67.2%). Small sample sizes were more common in studies applying experimental approaches. The total quality score, defined as the proportion of preferable criteria items rated as “yes”, indicated that the majority of studies fulfilled 50% or more of those criteria (50, 82.0%). Two studies did reach less than 25%, indicating a low methodological or empirical quality of the study (Table 2)

Table 2

Quality ratings of the studies included in the review

Authors	**Specificity of examined diagnoses**	**Design**	**Inclusion exclusion criteria**	**Established (research) diagnostic criteria (RDC)**	**Comparison groups**	**Comparison groups matched?**	**Sample type / recruitment mode**	**Sample size**	**Use of validated instruments**	**Quality of statistics**	**Total quality score**
	Diagnostic category broad / unspecific vs. narrow	*Patient reported outcomes (PRO) or multilevel*	*Provided information sufficient? (yes/no)*	*Not available n.a.; no criteria stated; criteria applied*	*None; healthy controls (HC); other medical condition (OMC)*	*Demographic match (yes/no)*	*Consecutive sampling? (yes/no)*	*Based on effect size consideration (Brown & Reuber, 2016)*	*For primary and secondary outcomes (yes/no)*	*Inferential (yes/no)* [a]	*+ 25-49%, ++ 50-79%, +++ 80% or more*
Agar-Wilson & Jackson (2012)	broad	PRO	no	- (n.a.)	none	-	no	large	yes	yes	++ (2 of 4)
Baslet (2017)	specific	PRO	no	- (n.a.)	none	-	no	large	yes	no	+ (1 of 4)
Beck et al., (2013)	specific	multilevel	no	yes (ICD)	HC	no	no	moderate	yes	no	+ (2 of 6)
Brooks et al., (2017)	specific	PRO	no	yes (Oxford or CDC)	HC	yes	no	large	yes	no	++ (3 of 6)
Brown et al. (2013)	specific	PRO	yes	- (n.a.)	OMC	no	yes	small	yes	yes	+++ (4 of 5)
Bruehl et al., 2007	broad	multilevel	yes	- (n.a.)	HC	no [b]	no	very small	yes	yes	++ (3 of 5)
Bruehl et al., (2012)	broad	multilevel	yes	- (n.a.)	HC	no	yes (sample was part of a larger study)	moderate	yes	yes	+++ (4 of 5)
Burger et al., (2016)	broad	PRO	yes	- (n.a.)	none	-	yes	large	yes	no	++ (3 of 4)
Burns et al., (2015)*	broad	multilevel	yes	- (n.a.)	HC/OMC	no	no	large	yes	yes	++ (3 of 5)
Burns et al., (2008)	broad	multilevel	yes	- (n.a.)	none	-	no	large	yes	yes	++ (3 of 4)

Burns et al., (2011)	broad	PRO	yes	- (n.a.)	none	-	no	moderate	yes	yes	++ (3 of 4)
Castelli et al. (2013)	specific	PRO	yes	yes (American Academy of Orofacial Pain)	HC	no [b]	yes	moderate	yes	no	++ (4 of 6)
Chavooshi et al. (2016)	broad	PRO	yes	- (n.a.)	none	-	no	large	yes	no	++ (2 of 4)
Constantinou et al., (2014)	specific	multilevel	no	yes (Rome III)	HC	no [b]	no	moderate	yes	yes	++ (3 of 6)
De Greck et al., (2011)	specific	multilevel	no	yes (DSM IV)	HC	yes	no	small	yes	no	++ (3 of 6)
Del Rio-Casanova et al. (2018)	specific	PRO	yes	yes (DSM-V)	HC	no	yes	moderate	yes	yes	+++ (5 of 6)
Demartini et al., (2014)	specific	PRO	yes	- (n.a.)	OMC; HC	yes	no	moderate	yes	no	++ (3 of 5)
Di Tella et al., (2015)	specific	multilevel	yes	no	HC	yes	yes	moderate	yes	no	++ (4 of 6)
Elsenbruch et al (2010)	specific	multilevel	yes	yes (Rome III)	HC	no	no	very small	yes	yes	++ (4 of 6)
Erkic et al., (2017)	broad	multilevel	yes	Yes (DSM IV or V)	HC	yes	no	moderate	yes	yes	+++ (5 of 6)
Fournier et al. (2018)	specific	multilevel	yes	yes (Rome II)	HC	no	no	small	yes	no	++ (3 of 6)
Geenen et al., (2012)	specific	PRO	no	yes (ACR)	none	-	no	large	yes	yes	++ (3 of 5)
Gul & Ahmad (2014)	specific	multilevel	yes	yes (DSM IV)	HC	yes	no	large	yes	yes	+++ (5 of 6)
Haas et al. (2013)	specific	multilevel	yes	yes (RDC TMD)	HC	yes	yes	small	yes	no	+++ (5 of 6)
Kienle et al. (2018)	broad	multilevel	yes	yes (ICD)	HC	no[b]	no	small	yes	yes	++ (4 of 6)
Kilkens et al., (2004)	specific	multilevel	yes	yes (Rome)	HC	yes	no	very small	yes	yes	+++ (5 of 6)
Kleiman et al., (2016)	broad	multilevel	yes	yes (ICD)	None	-	no	moderate	yes	yes	+++ (4 of 5)

Koenig et al., (2015)	specific	multilevel	no	yes (WAD I-III)	HC	no	no	moderate	yes	no	+ (2 of 6)
Leong et al., (2011)	broad	multilevel	yes	- (n.a.)	HC	no	no	large	yes	yes	++ (3 of 5)
Mazaheri (2015)	specific	PRO	no	yes (Rome III)	none	-	yes [c]	large	yes	yes	+++ (4 of 5)
Mazaheri et al. (2016)	specific	PRO	no	yes (Rome III)	HC	yes	no	moderate	yes	no	++ (3 of 6)
Merten & Brunnhuber (2004)	broad	multilevel	no	yes (DSM-IV)	HC	no	no	very small	yes	no	+ (2 of 6)
Ozturk et al., (2016)	specific	multilevel	yes	yes (DSM V)	HC	yes	yes	moderate	yes	yes	+++ (6 of 6)
Pedrosa Gil et al., (2008)	specific	multilevel	yes	yes (ICD)	HC	yes	no	small	yes	no	++ (4 of 6)
Pollatos, Dietel et al. (2011)[**]	specific	multilevel	yes	yes (Kroenke)	HC	yes	no	small	yes	yes	+++ (5 of 6)
Rasting et al., (2005)	broad	multilevel	no	no	none	-	no	very small	yes	no	+ (1 of 4)
Rimes & Chalder (2010)	specific	PRO	no	yes (Oxford)	HC	no	no	large	yes	no	+ (2 of 6)
Rimes et al., (2016)	Specific	multilevel	no	Yes (CDC)	HC	no	no	large	yes	yes	++ (3 of 6)
Roberts et al. (2012)	specific	multilevel	yes	- (n.a.)	HC	no [b]	no	small	yes	no	+ (2 of 5)
Sayar et al., (2004)	specific	PRO	yes	yes (ACR)	OMC; HC	no	yes	small	yes	yes	+++ (5 of 6)
Schoenenberg et al., (2015)	specific	multilevel	no	- (n.a.)	HC	yes	yes	very small	yes	no	++ (3 of 5)
Schwarz et al., (2017)	specific	PRO	yes	yes (DSM-V)	HC; OMCs	no	no	large	yes	yes	++ (4 of 6)
Seignourel et al., (2007)	specific	multilevel	yes	- (n.a.)	HC	yes	no	very small	yes	yes	+++ (4 of 5)
Sibelli et al., (2017)	specific	PRO	no	yes	n.a.	n.a.	no	moderate	no[e]	n.a.	n.a.

Steffen et al. (2015)	broad	PRO	yes	yes (ICD)	HC	no [b]	no	moderate [d]	yes	yes	++ (4 of 6)
Stonnington, et al., (2013)***	specific	multilevel	yes	yes (DSM IV)	OMC	yes	yes	moderate	yes	yes	+++ (6 of 6)
Subic-Wrana et al., (2010)	broad	multilevel	no	yes (ICD)	HC	yes	yes	moderate	yes	no	++ (4 of 6)
Twiss et al. (2009)	specific	multilevel	yes	yes (Rome II)	HC	no	no	very small	yes	yes	++ (4 of 6)
Uliaszek et al., (2012)	specific	multilevel	no	- (n.a.)	none	-	yes	moderate	yes	no	++ (2 of 4)
Urbanek et al. (2014)	specific	PRO	yes	- (n.a.)	HC	no	no	moderate [d]	yes	yes	++ (3 of 5)
van Middendorp, et al., (2008)	specific	PRO	no	yes (ACR)	HC	no	no	large	yes	yes	++ (3 of 6)
van Middendorp et al., (2010)	specific	PRO	yes	yes (ACR)	none	-	no	large	yes	yes	+++ (4 of 5)
Veehof et al., (2011)	specific	PRO	no	no	none		no	large	yes	no	+ (1 of 4)
von Piekartz, et al., (2015)	broad	multilevel	yes	yes (RDC TMD)	HC	yes	no	small	yes	yes	+++ (5 of 6)
Waller & Scheidt (2004)	specific	multilevel	yes	yes (ICD)	HC	yes	no	small	yes	yes	+++ (5 of 6)
Walteros et al. (2011)	specific	multilevel	no	no	HC	no	no	very small	yes	no	- (1 of 6)
Wingenfeld (2011)	broad	multilevel	yes	yes (DSM IV)	HC	no [b]	no	moderate	yes	no	++ (3 of 6)
Wong & Fielding (2013)	broad	PRO	yes	- (n.a.)	none	-	no	large	yes	yes	++ (3 of 4)
Yucel et al. (2002)	specific	PRO	yes	yes (IHSC)	HC	yes	yes	large	yes	no	+++ (5 of 6)
Zautra et al., (2001)	specific	PRO	no	yes (ACR)	OMC	No	no	large	yes	no	+ (2 of 6)
Zoccali et al., (2006)	specific	PRO	no	yes (Rome II)	HC	yes	no	moderate	yes	no	++ (3 of 6)

*identical sample with that of Burns et al., (2016).

**identical sample with that of Pollatos, Herbert et al., (2011).

***identical sample with that of Lane et al., (2015).

a inferential (models controlling for potential confounders; information for probability distribution provided), as opposed to descriptive/ explorative (simple group comparisons, correlations)

b authors report a balanced recruitment mode or provide post-hoc sensitivity analyses

c census method applied

d (power analysis provided)

e data driven based on grounded research principles, qualitative study

3.2 Diagnostic groups

The review covered various patient groups disturbed by: general somatic symptoms, chronic pain symptoms in the whole or some regions of the body and musculoskeletal system, fibromyalgia, fatigue, gastrointestinal, neurological, or motor/movement symptoms. Pain-related disorders have taken considerable attention compared to others; however, diagnoses were diverse, and their symptom presentations usually overlapped. Different ER variables were examined heterogeneously in various diagnostic groups and there was no systematic focus on a certain ER facet exclusive to a certain diagnosis. (Table 3)

Table 3

Diagnostic groups examined for each emotion regulation variable

Classification	ER Variable (Study[ER Measure])	ER Measure
Chronic pain	• Expressive suppression (Chavooshi, et al., 2016[1]) • Emotional expression (Leong, Cano & Johansen, 2011[2]; Merten & Brunnhuber, 2004[3]) • Reappraisal (Chavooshi, et al., 2016[1]; Wong & Fielding, 2013[2]) • Efficacy in emotion regulation, awareness, and utilization of emotions (Agar-Wilson & Jackson, 2012[4])	1. Emotion Regulation Questionnaire 2. The Specific Affect Coding System 3. Emotional Facial Action Coding System 4. Assessing Emotions Scale (Efficacy, Appraisal and Utilization Subscales)
Chronic low back pain	• Anger expression style (Bruehl, et al., 2007[1], 2012[1]; Burns, et al., 2008[1], 2011[1]) • Real time anger expression vs. inhibition (Burns, et al., 2008[2]) • Emotional thought suppression (Burns, et al., 2011[3]) • Momentary daily anger expression and inhibition (Bruehl, et al., 2012[4]; Burns, Gerhart, et al., 2015[4] & 2016[4])	1. Anger Expression Inventory 2. Experimental manipulation of anger expression 3. Experimental manipulation through thought suppression 4. Electronic diary assessment
Chronic musculoskeletal pain	• Emotional awareness & emotional theory of mind (Burger et al., 20161)	1. Level of Emotional Awareness Scale
Medically unexplained pain	• Mindful attention (Chavooshi, et al., 2016[1])	1. Mindful Attention Awareness Scale
Persistent somatoform pain disorder	• Autonomic nervous system activity (Kleiman. et al., 2016[1,2,3])	1. Heart rate 2. Skin conductance response 3. Electromyogram
Fibromyalgia	• Attending to emotions (Veehof, et al., 2011[4]) • Anger expression style (Sayar, et al., 2004[1]; van Middendorp, et al., 2008[2], 2010[2]) • General emotional expression (Geenen, et al., 2012[10]; van Middendorp, et al., 2008[11]) • Emotional decision making (Walteros, et al., 2011[8]) • Acceptance & non-judgement of emotions (Veehof, et al, 2011[3]) • Emotion recognition, empathy and emotional theory of mind (Di Tella, 2015[5,6,7])	1. State Trait Anger Expression Inventory 2. Self-Expression and Control Scale 3. Five Facet Mindfulness Questionnaire (Non-judge & describe subscales) 4. Five Facet Mindfulness Questionnaire (Observe subscale) 5. Reading the Mind in the Eyes Test 6. Empathy Quotient 7. Ekman 60 8. Iowa Gambling Task 9. Trait Meta-Mood Scale

	• Emotional clarity (Zautra, et al., 2001[9]) • Reapparaisal (Geenen, et al., 2012[11]; van Middendorp, et al., 2008[11])	10. Emotional Approach Coding Scale 11. Emotion Regulation Questionnaire
Myofascial pain	• Anger expression style (Castelli, et al., 2013[1])	1. State Trait Anger Expression Inventory
Chronic whiplash-associated disorders	• Autonomic nervous system activity (Koenig, et al., 2015[1])	1. Heart rate variability
Temporomandibular disorders	• Emotion recognition (Haas, et al., 2013[1])	1. Facially Expressed Emotion Labeling
Chronic facial pain	• Emotion recognition (Piekarzt, et al., 2015[1])	1. Facially Expressed Emotion Labeling
Tension-type headache	• Automatic negative thoughts (Yucel, et al., 2002[1])	1. Automatic Thoughts Scale
Chronic fatigue syndrome	• Belifes about acceptability of emotions (Rimes & Chalder, 2010[1])	1. Beliefs about Emotions Scale
Functional abdominal pain	• Autonomic nervous system activity (Walker, et al., 2017[1, 2])	1. Heart rate 2. Heart rate variability
Functional gastrointestinal disorders	• Acceptance and clarity of emotions • Attending to emotions • Mindful attention • Engaging in goal directed behaviour • Impulse control difficulties (Mazaheri, 2015)	1. Difficulties in Emotion Regulation Scale (DERS) (Clarity, Strategies and Accept) 2. DERS-Awareness 3. Mindful Attention Awareness Scale 4. DERS-Goals 5. DERS-Impulse
Functional dyspepsia	• Emotional acceptance (Mazaheri, et al., 2016[1]) • Positive reappraisal, blaming & rumination (Mazaheri, et al., 2016[2])	1. Emotion Regulation Skills Questionnaire 2. Cognitive Emotion Regulation Questionnaire
Interstitial cystitis/painful bladder syndrome	• Affect-modulated startle (Twiss, et al., 2009[1])	1. Affect modulated startle in the eye-blink

Irritable bowel syndrome	• Anger expression style (Zoccali, et al., 2006[1]) • Muscle relaxation (Elsenbruch, et al., 2010[2]) • Emotional Expression (Fournier, et al., 2018[5]) • Autonomic nervous system (Fournier, et al., 2018[7,8,9]) • Emotional exposure and emotion labelling (Constantinou, et al., 2014[3]) • Affective memory (Kilkens, et al., 2004[4]).	1. State-Trait Anger Expression Inventory 2. Manipulation of muscle relaxation 3. Modified Affect Labeling Task 4. Affective Memory Performance Test 5. Emotional Facial Action Coding System 6. Heart rate 7. Heart rate variability, 8. Cortisol level
Medically unexplained symptoms	• Emotional understanding • Modification & self-support during emotional challenges • Attending to emotions • Action readiness to confront emotions • Distinguishing bodily sensations (Schwarz, et al., 2017[1])	1. Emotion Regulation Skills Questionnaire
Somatoform disorders/ Somatic symptom disorders/ Multisomatoform disorders/	• Autonomic nervous system activity (Pollatos Dietel, et al., 2011[1,2,3,4]; Pollatos. Herbert, et al., 2011[1,2,3]) • Non-verbal expression of emotions (Waller & Scheidt, 2004[7]) • Emotional awareness & emotional theory of mind (Subic-Wrana, et al., 2010[5,6]; Waller & Scheidt, 2004[5,7]) • Emotion recognition (Beck, et al., 2013[8], De Greck, et al., 2011[9], Ozturk, et al., 2016[10]; Pedrosa Gil, et al., 2008[11], Pollatos, Herbert et al., 2011[12])	1. Heart rate variability 2. Heart rate 3. Skin conductance response 4. Respiration rate 5. Level of Emotional Awareness Scale 6. Emotional Content in Frith-Happe-Animations Task 7. Affect Consciousness Interview 8. Comprehensive Affect Testing System 9. Tübinger Affekt Batterie 10. Ekman & Friesen faces 11. Facially Expressed Emotion Labeling 12. Karolinska Directed Emotional Faces battery
Psychosomatic disorders	• Attention switching (Wingenfeld, et al., 2011[1]) • Facial emotional expression (Rasting, Brosig, & Beutel, 2005[2])	1. Emotional Stroop Test 2. Emotional Facial Action Coding System
Functional neurological symptoms	• Expressive suppression (Steffen, et al., 2015[1]) • Reappraisal (Kienle, et al., 2018[1])	1. Emotion Regulation Questionnaire

Psychogenic non-epileptic seizures	• Attention switching (Gul & Ahmad, 2014[1]) • Attending to emotions (Brown, 2011[2]; Uliaszek, Prensky & Baslet, 2012[2]) • Engaging in goal directed behaviour (Brown, 2011[3]; Uliaszek, et al., 2012[3]) • Control of emotional reactions (Urbanek, et al., 2014[4]) • Expressive suppression (Gul & Ahmad, 2014[5]) • Impulse control difficulties (Brown, et al., 2013[6]; Uliaszek, et al., 2012[6]) • Positive & negative emotional behavior (Roberts, et al., 2012[12]) • Autonomic nervous system activity (Roberts, et al., 2012[13,14]) • Emotion recognition (Schoenenberg, et al., 2015[7]) • Acceptance and clarity of emotions (Brown, 2011[8]; Uliaszek, et al., 2012[8], Urbanek, et al., 2014[8]) • Reappraisal (Gul & Ahmad, 2014[9]) • Toleration and acceptance of emotions (Baslet, et al., 2017[10,11])	1. Task switching paradigm 2. Difficulties in Emotion Regulation Scale (DERS)-Awareness 3. DERS-Goals 4. Cortauld Emotional Control Scale 5. Emotion Regulation Questionnaire-Suppression 6. DERS-Impulse 7. Animated morphing paradigm 8. DERS- Clarity, Strategies and Accept 9. Emotion Regulation Questionnaire-Reappraisal 10. Acceptance and Action Questionnaire 11. Affective Style Questionnaire 12. Observation coding 13. Heart rate 14. Respiratory sinus arithymia
Psychogenic movement disorders	• Affect modulated startle (Seignourel, et al., 2007[1])	1. Affect modulated startle in the eye-blink (EMG)
Conversion disorders &/vs. functional somatic syndromes	• Emotional awareness & emotional theory of mind (Lane, et al., 2015[1],2, Stonington, et al., 2013[1,2,6]) • Acceptance and clarity of emotions (Del Rio-Casanova, et al., 2018[4]) • Engaging in goal directed behaviour (Del Rio-Casanova, et al., 2018[5]) • Control of emotional impulses (Del Rio-Casanova, et al., 2018[7]) • Attending to emotions (Del Rio-Casanova, et al., 2018[6])	1. Level of Emotional Awareness Scale 2. Reading the Mind in the Eyes Test 3. Emotional Content in Frith Happe Animations Task 4. DERS- Clarity and Accept 5. DERS-Goals 6. DERS-Awareness 7. DERS-Lack of Emotional Control Scale
Functional motor disorders	• Emotional theory of mind (Demartini, et al., 2014[1])	1. Reading the Mind in the Eyes Test

3.3 Emotion regulation variables examined in the articles based on regulation targets

A wide range of ER variables were examined in patients with SSD: Attention switching, anger expression and suppression, autonomic nervous system activity, emotional expressiveness, emotional awareness, emotional theory of mind, emotion recognition, and emotional appraisals were among the most investigated ones. These variables were heterogeneously investigated in diverse diagnostic groups. (See Table 4)

Table 4

Emotion regulation variables examined in each diagnostic group

ER Variable	Measure	Diagnostic group (Reference[measure])
Attention		
Attention switching •	1. Experimental manipulation through thought suppression 2. Task switching paradigm 3. Emotional Stroop Test	• Chronic low-back pain (Burns, et al., 2011[1]) • Psychogenic non-epileptic seizures (Gul & Ahmad, 2014[2]) • Psychosomatic disorders (Wingenfeld, et al., 2014[3])
Attending to emotions	1. Five Facet Mindfulness Questionnaire, Observe subscale 2. Mindful Attention Awareness Scale 3. Difficulties in Emotion Regulation Scale- Awareness Subscale 4. Emotion Regulation Skills Questionnaire, Awareness Subscale	• Conversion disorders (Del Rio-Casanova, et al., 2018[3]) • Fibromyalgia (Veehof, et al., 2011[1]) • Functional gastrointestinal disorders (Mazaheri, 2015[2]) • Medically unexplained pain (Chavooshi, et al., 2016[1]) • Medically unexplained symptoms with and without depression (Schwarz, et al., 2017) • Psychogenic non-epileptic seizures (Brown, et al., 2013[3]; Uliaszek et al., 2012[3])
Goal directedness when emotionally distressed	1. Difficulties in Emotion Regulation Questionnaires- Goals subscale	• Conversion disorders (Del Rio-Casanova, et al., 2018[1]) • Functional gastrointestinal disorders (Mazaheri, 2015[1]) • Psychogenic non-epileptic seizures (Brown, et al., 2013[1]; Uliaszek, Prensky & Baslet, 2012[1])
Anger expression and anger suppression	1. Anger Expression Inventory 2. Electronic diary 3. State-Trait Anger Expression Inventory 4. Self-Expression and Control Scale 5. Experimental manipulation of anger expression	• Chronic low back pain (Bruehl, et al., 2007[1]; 2012[1]; Burns, et al., 2008[1,5]; 2011[1], Burns & Gerhart, et al., 2015[2]; 2016[2] • Fibromyalgia (Sayar, et al., 2004[3]; van Middendorp, 2008[4]; 2010[4]) • Irritable bowel syndrome (Zoccali, et al., 2006[3]) • Myofascial pain (Castelli, et al., 2013[3])
Autonomic nervous system activity	1. Heart rate variability 2. Heart rate 3. Skin conductance response 4. Respiration rate 5. Affect modulated startle in the eye-blink 6. Manipulation of muscle relaxation 7. Electromyogram	• Chronic whiplash associated disorders (Koenig, et al., 2015[1]) • Functional abdominal pain (Walker, et al., 2017) • Interstitial cystitis/painful bladder syndrome (Twiss, et al., 2009[5]) • Irritable bowel syndrome (Elsenbruch, et al., 2010[6], Fournier, et al., 2018[1,2,9])

	8. Respirators sinus arrhythmia 9. Cortisol levels	• Multisomatoform disorders (Pollatos, Dietel, et al., 2011[1,2,3,4]; Pollatos, Herbert at al., 2011[1,2,3]) • Persistent somatoform pain disorders (Kleiman, et al., 2016[7,2,3]) • Psychogenic movement disorder (Seignourel, et al., 2007[5]) • Psychogenic non-epileptic seizures (Roberts, et al., 2012[2,8])
Expressive suppression & emotional expression	1. Emotion Regulation Questionnaire 2. The Specific Affect Coding System 3. Emotional Facial Action Coding System 4. Emotional Approach Coding Scale 5. Cortauld Emotional Control Scale 6. The Affect Consciousness Interview 7. Observational coding	• Chronic pain (Chavooshi, et al., 2016[1]; Leong, et al., 2011[2]; Merten & Brunnhuber, 2004[3]; Wong & Fielding, 2013[1]) • Fibromyalgia (Geenen, et al., 2012[4]; van Middendorp, 2008[1,4]) • Functional neurological symptoms (Steffen, et al., 2015[1]) • Psychogenic non-epileptic seizures (Gul & Ahmad, 2014[1]; Urbanek, et al., 2014[5], Roberts, et al., 2012[7]) • Somatoform Disorders (Waller & Scheidt, 2004[6]) • Psychosomatic Disorders (Rasting et al., 2005[3]) • Irritable bowel syndrome (Fournier at al., 2018[3])
Impulse control difficulties	1. Difficulties in Emotion Regulation Questionnaire, Impulse Subscale	• Conversion disorders (Rio-Casanova, et al., 2018[1]) • Functional gastrointestinal disorders (Mazaheri, 2015[1]) • Psychogenic non-epileptic seizures (Brown, et al., 2013[1]; Uliaszek et al., 2012[1])
Emotional decision making based on bodily signals/ perception of bodily signals	1. Iowa Gambling Task 2. Emotion Regulation Skills Questionnaire, Sensations Subscale	• Fibromyalgia (Walteros, et al., 2011[1]) • Medically unexplained symptoms (Schwarz, et al., 2017[2])
Emotional awareness, emotional theory of mind, emotion recognition •	1. Facially Expressed Emotion Labeling 2. Level of Emotional Awareness Scale 3. Reading the Mind in the Eyes Test 4. Empathy Quatient 5. Ekman 60 6. Emotional Content in Frith Happe Animations Task 7. Karolinska Directed Emotional Faces battery	• Chronic facial pain (Piekarzt, et al., 2015[1]) • Chronic muskuloskeletal pain (Burger, et al., 20162) • Conversion disorder (Lane, et al., 2013[2,3]; Stonington, et al., 20132,3,[6]) • Fibromyalgia (Di Tella, et al., 2015[3,4,5]) • Functional motor disorders (Demartini, et al., 2014[3]) • Functional somatic syndrome (Lane, et al., 2013[2,3;] Stonington, et al., 2013[2,3,6]) • Irritable bowel syndrome (Constantinou, et al., 2014[13])

	8. Comprehensive Affect Testing System 9. Tübinger Affekt Batterie 10. Affect Consciousness Interview 11. Ekman & Friesen faces 12. Animated Morphing paradigm 13. Modified Affect Labeling Task 14. Emotion Regulation Skills Questionnaire, Understanding Subscale	• Medically unexplained symptoms (Schwarz, et al., 2017[14]) • Multisomatoform disorders (Pollatos, Herbert, et al., 2011[7]) • Somatoform disorders (Beck, et al., 2013[8]; De-Greck, et al., 20119; Pedrosa Gil, et al., 2008[1]; Subic-Wrana, et al., 2010[2,6]; Waller & Scheidt, 2004[2,10]) • Somatic symptom disorders (Ozturk, et al., 2016[11]) • Psychogenic non-epileptic seizures (Schonenberg, et al., 2015[12]) • Temporamandibular disorders (Hass, et al., 2013[1])
Beliefs about and attitude to emotions	1. Beliefs about Emotions Scale 2. Difficulties in Emotion Regulation Scale (Clarity, Strategies and Accept Subscales) 3. Five Facet Mindfulness Questionnaire (Non-judge & describe subscales) 4. Trait Meta-Mood Scale 5. Acceptance and Action Questionnaire-II 6. Emotion Regulation Skills Questionnaire, (Clarity, Acceptance, Tolerance Subscales) 7. Cognitive Emotion Regulation Questionnaire, Acceptance subscale 8. Affective Style Questionnaire (adjust, tolerate, conceal subscales)	• Chronic fatigue syndrome (Rimes & Chalder, 2010[1]) • Conversion disorders (Del Rio-Casanova, 2018[2]) • Fibromyalgia (Veehof, et al., 2011[3]; Zautra, et al., 2001[4]) • Functional dyspepsia, (Mazaheri, et al., 2016[7]) • Functional gastrointestinal disorders (Mazaheri, 2015[2]) • Medically unexplained symptoms (Schwarz, et al., 2017[6]) • Psychogenic non- epileptic seizures (Brown, et al., 2013[2]; Uliaszek, Prensky, & Baslet, 2012[2]; Urbanek, et al., 2014[1], Baslet, et al., 2017[5,8])

Reappraisal, automatic thoughts, efficacy in emotion regulation	1. Assessing Emotions Scale (Efficacy, Appraisal and Utilization Subscales) 2. Emotion Regulation Questionnaire 3. Automatic Thoughts Scale 4. Affective Memory Performance Test 5. Emotion Regulation Skills Questionnaire, (Modification and Self-support Subscales) 6. Cognitive Emotion Regulation Questionnaire	• Chronic pain (Agar-Wilson & Jackson, 2012[1]; Wong & Fielding, 2013[2]) • Fibromyalgia (Geenen et al., 2012[2]; van Middendorp, et al., 2008[2]) • Functional dyspepsia (Mazaheri, et al., 2016[6]) • Functional neurological symptoms (Kienle, et al., 2018[2]) • Irritable bowel syndrome (Kilkens, et al., 2004[4]) • Medically unexplained pain (Chavooshi, et al., 2016[2]) • Medically unexplained symptoms (Schwarz, et al., 2017[5]) • Psychogenic non-epileptic seizures (Gul & Ahmad; 2014[2]) • Tension-type headache (Yucel, et al., 2002[3])

3.3.1 Attention

Directedness and flexibility of attention to emotional stimuli, suppression of emotional thoughts, and facets of mindfulness (non-judgmental attention to and awareness of one's current experience) [77] were among the researched topics of attention-oriented ER. Four articles have examined attention-focused ER with behavioral paradigms, whereas 11 articles examined it by self-report measures (Table 5).

3.3.1.1 Attention switching.

Experimental paradigms for assessing patients' attentional regulation of emotional stimuli pointed out patients' attentional inflexibility and difficulty in disengaging from emotional material. In a study including patients with psychogenic non-epileptic seizures, patients took a longer time to switch their attention from the emotional dimension of pictures than from the age dimension, indicating more cognitive costs for emotional features of pictures. Healthy controls, on the other hand, showed equal switching performance for both age and emotion dimensions [78]. In patients diagnosed with psychosomatic disorders, it was likewise found that difficulty in switching attention from the emotional material was predicted by somatic symptoms, depression, childhood trauma, and dissociation [79]. These two studies also demonstrated a positive association between emotion suppression and attentional fixedness in both patient groups [78,79]. This relationship among emotion suppression, attentional fixedness, and somatic symptoms could be also supported by a study with chronic back-pain patients [80] and another one with chronic fatigue syndrome [81]. The first study reported that suppression of anger-related thoughts, which through an *ironic effect* deploys attention, influenced pain behaviors of the patients depending on patients' trait anger regulation style [80]. In the second study, suppression condition also increased the level of anxiety in both patient and healthy groups but it did not affect self-fatigue of the participants [81].

3.3.1.2 Goal directedness when emotionally distressed

Based on a commonly used questionnaire for examining difficulties of emotion regulation (Difficulties of Emotion Regulation Scale, DERS) [82] patients with psychogenic non-epileptic seizures or conversion disorders reported greater difficulties in focusing on their tasks when they are distressed, compared to medical patients or a normative sample [25,83,84]. This difficulty also predicted gastrointestinal symptoms in patients with functional gastrointestinal disorders [85].

3.3.1.3 Attending to emotions

More effortful and conscious ways of attending to emotions were also focused by several studies. They found evidence of a negative relationship with certain aspects of SSD and consciously attending to emotions. For example, in patients with fibromyalgia, depression, anxiety, and neuroticism were negatively correlated with acting with awareness, such as doing things by paying attention [86]. Similarly, in patients with functional gastrointestinal symptoms, mindful attention negatively predicted depression, anxiety, and stress, and also negatively correlated with all facets of emotion regulation disturbances [85]. Mindful attention capacity was also shown to improve following psychotherapy, accompanied by improvement in SSD in patients with medically unexplained symptoms [87].

Nevertheless, two studies including patients with non-epileptic seizures and epilepsy, having used another questionnaire DERS [82] did not support these results. Patients' evaluations of their capacity to attend to emotions and acknowledge them did not differ from those of patients with epilepsy or a normative sample [25,83]. The authors discussed a possible reliability or validity problem with this subscale [25]. However, another study, which used the same measure to compare patients suffering from conversion disorders with healthy adults, confirmed the capacity of attending to and acknowledging emotions to be reduced in the patient group with conversion [84].

When patients with medically unexplained symptoms (MUS) were compared with patients with MUS and comorbid major depressive disorders (MDD), with only MDD, or with healthy adults, the results seemed different. In this study, the only difference in the capacity of attending to emotions was reported between the MUS with comorbid MDD patients and healthy controls. The authors suggested that depression play a mediator role between difficulties in consciously attending to emotions and MUS [116].

Table 5

Study characteristics and summaries of articles that examined emotion regulation involving mainly attentional processes

Diagnostic details & control condition (number of participants)	Authors	Emotion regulation measures	Psychosomatic symptom variables (Measure)	Design	Quality assessment[1]	Results
Attention switching						
Psychogenic non-epileptic seizures (72) & healthy controls (72)	Gul & Ahmad (2014)[78]	Task-switching paradigm	Psychological distress (DASS)	E	+++	Patients showed more difficulty in switching their attention from the emotional dimension of pictures than from the age dimension, indicating more cognitive costs for emotional features of pictures. Controls, on the other hand, showed equal switching performance for the emotion and age dimensions of the pictures. This attentional bias towards emotional dimensions was related to higher emotion suppression and lower cognitive reappraisal.
Psychosomatic disorders (82) & healthy controls (39)	Wingenfeld, et al. (2011)[79]	Emotional Stroop test	Adverse childhood experiences (CTQ), anxiety and depression (HADS), bodily symptoms (FBL), dissociative experiences (DES)	E	++	Emotion suppression, somatic symptoms, depression, childhood trauma, and dissociation were the significant predictors of mean reaction times in disengaging attention from the affective content of the words.

Chronic low back pain (58)	Burns et al. (2011)[80]	Manipulation of thought suppression during anger induction	Current pain behavior (structured pain behavior task)	E	++	Through an ironic effect of attention, anger report was higher in the suppression group compared to the no-suppression group. Suppression of emotional thoughts was positively related to pain behaviors in patients with higher trait anger-out and negatively related to pain behaviors in patients with higher trait anger-in.
Chronic fatigue syndrome (80) and healthy controls (80)	Rimes, Ashcroft, Bryan, & Chalder, (2016)[81]	Manipulation of thought suppression during a distressing film.	State affect and fatigue (VAS)	E	++	Through an ironic effect of attention, in the suppression condition, regardless of the group, anxiety levels increased from pre to post film-watching. Suppression condition did not affect self-reported fatigue of the patients.
Goal directedness when emotionally distressed						
Functional gastrointestinal disorders (167)	Mazaheri (2015)[85]	Difficulties in Emotion Regulation Scale, GOALS Subscale	Depression, anxiety and stress (DASS), gastrointestinal symptoms (GSRS)	CS	+++	Difficulties in engaging attention to one's current task when emotionally distressed predicted gastrointestinal symptoms in the patients.
Conversion disorders (43) & healthy controls (42)	Del Rio-Casanova et al. (2018) [84]	Difficulties in Emotion Regulation Scale, GOALS Subscale	Depression, anxiety (HADS), somatoform dissociation (SDQ-20), psychoform dissociation (DES-II)	CC	+++	The patient groups reported greater difficulties in focusing on their tasks when they are distressed, compared to healthy controls. After stepwise elimination of DERS factors, this factor remained a significant predictor of patient status.
Psychogenic non-epileptic seizures (PNES) (43) & epilepsy (24)	Brown et al. (2013)[25]	Difficulties in Emotion Regulation Scale, GOALS Subscale	Anxiety (GAD-7), depression (PHQ-9), somatization (SDQ-20), attachment styles (RSQ)	CC	+++	Patients with PNES reported greater difficulties in focusing on their tasks when they are distressed. This difference was more pronounced between the emotionally dysregulated PNES group and the epilepsy patients.

Psychogenic non-epileptic seizures (70)	Uliaszek et al. (2012) [83]	Difficulties in Emotion Regulation Scale, GOALS Subscale	Depression (BDI-II), dissociative experiences (DES), psychological distress (DASS), functioning and physical distress (PHQ-15, DFI)	CS	++	Patients with PNES reported greater difficulties in focusing on their tasks when they are distressed compared to normative data, which was more obvious in the emotionally dysregulated patient group.
Attending to emotions						
Fibromyalgia (141)	Veehof et al. (2011) [86]	Five Facet Mindfulness Questionnaire, Observe Subscale	Neuroticism and openness to new experiences (NEO-FFI), anxiety and depression (HADS), mental and physical health (SF-12)	CS	+	The capacity to observe, notice, and attend to subjective experience was negatively related to alexithymia and positively related to openness to experience. Acting with awareness, such as doing things by paying attention, was positively correlated with acceptance of experiences and negatively correlated with alexithymia, neuroticism, depression, and anxiety.
Functional gastrointestinal disorders (167)	Mazaheri (2015) [85]	1. Mindful Attention Awareness Scale. 2. Difficulties in Emotion Regulation Scale, AWARENESS Subscale	Depression, anxiety and stress (DASS), gastrointestinal symptoms (GSRS)	CS	+++	Mindful attention negatively predicted depression, anxiety, and stress. Mindful attention was also negatively correlated to all facets of emotion dysregulation.
Medically unexplained pain (100)	Chavooshi et al. (2016) [87]	Mindful Attention Awareness Scale	Pain intensity (NPRS), depression & anxiety (DASS-21), quality of life (QOLI)	I	++	Patients treated with intensive, short-term dynamic psychotherapy had improved mindful attention following the psychotherapy, compared to patients who received treatment as usual. Other psychosomatic variables were also much improved compared to the control group.

Medically unexplained symptoms (MUS) (138), MUS comorbid with major depressive disorder (MDD) (114), MDD (106), healthy controls (100)	Schwarz et al. (2017) [116]	Emotion Regulation Skills Question-naire, Awareness Subscale	Physical complaints (SOMS-7T), depression (BDI-II), symptom checklist (SCL-90)	CC	++	No difference was found in the capacity for attending to emotions between MUS patients and healthy controls, or between MUS and MDD patients or MUS and MUS+MDD patients. Only between MUS+MDD and healthy controls was the awareness score different, being higher in the control group.
Conversion disorders (43) & healthy controls (42)	Del Rio-Casanova, et al. (2018) [84]	Difficulties in Emotion Regulation Scale, AWARENESS Subscale	Depression, anxiety (HADS), somatoform dissociation (SDQ-20), psychoform dissociation (DES-II)	CC	+++	The capacity of attending to and acknowledging emotions was decreased in the patient group, compared to controls.
Psychogenic non-epileptic seizures (PNES) (43) & epilepsy (24)	Brown et al. (2013) [25]	Difficulties in Emotion Regulation Scale, AWARENESS Subscale	Anxiety (GAD-7), depression (PHQ-9), somatization (SDQ-20), attachment styles (RSQ)	CC	+++	Capacity to attend to emotions and acknowledge them did not differ between the two patient groups, or between clusters based on emotion dysregulation level. Authors propose a possible reliability or validity problem with the AWARENESS Subscale.
Psychogenic non-epileptic seizure (70)	Uliaszek et al. (2012) [83]	Difficulties in Emotion Regulation Scale, AWARENESS Subscale	Depression (BDI-II), dissociative experiences (DES), psychological distress (DASS), functioning and physical distress (PHQ-15, DFI)	CS	++	The capacity for attending to and acknowledging emotions was not different from the normative sample and slightly higher in the emotionally dysregulated patient group, compared to the patient group with elevated emotion regulation.

[1]Quality of the studies was rated with +, ++, or +++ when 25–49%, 50–79%, or 80% or more of the criteria were rated with "yes".

Abbreviations of the study designs

CS: Cross Sectional, **CC:** Case Control, **E:** Experimental, **L:** Longitudinal, **I:** Intervention/psychotherapy study

Abbreviations of the symptom measures & paradigms

BDI: Beck Depression Inventory, **CTQ:** Childhood Trauma Questionnaire, **DASS:** Depression, Anxiety and Stress Symptoms , **DES:** Dissociative Experiences Scale, **DFI:** Disruption of Functioning Index, **FBL:** Freiburger Beschwerdeliste-Revised, **GSRS:** Gastrointestinal Symptom Rating Scale, **GAD:** Generalized Anxiety Disorder

Questionnaire, **HADS:** Hospital Anxiety and Depression Scale, **NEO-FFI:** NEO Five-Factor Personality Inventory, **NPRS:** Numerical Pain Rating Scale, **PHQ:** The Patient Health Questionnaire, **RSQ:** Responses to Stress Questionnaire, **QOLI:** Quality of Life Inventory, **SCL-90:** Symptom Checklist-90, **SDQ:** Somatoform Dissociation Questionnaire, **SF:** Short form Health Survey, **SOMS:** Screening for Somatoform Disorders

3.3.2 Body

Bodily-oriented ER processes were a relatively salient topic of the reviewed studies after knowledge-oriented ER processes (Table 6). The frequently researched themes were the overt facial and bodily expressions of emotions, especially anger expression; autonomic nervous system activity; affect-modulated startle in the muscles; and impulse control difficulties when emotionally distressed. While 26 articles examined body-focused ER by self-report measures, 16 articles implemented behavioral measures.

3.3.2.1 Anger expression and anger suppression

Patients' anger expression style has drawn considerable attention. All of the anger expression studies except one [88] were conducted with pain and fibromyalgia patients, on the basis of possible shared neurophysiological pathways for anger expression and pain. The assessment of anger expression was based on self-report questionnaires, diaries, and experimental manipulations. All the studies except that with irritable bowel syndrome [88] found a positive association between excessive expressive anger suppression or uncontrolled anger expression and aspects of SSD. Habitual expression of anger in an uncontrollable manner (anger-out) was related to higher experimental acute pain intensity [89]. As an interesting biological observation, the study showed that beta-endorphin release, which was related to less pain being experienced, was negatively predicted by greater anger-out style in both patient and healthy groups. Daily anger expression, assessed by the diary method, was also elevated in patients relative to controls, which amplified their subsequent chronic pain intensity later in the day [90]. The diary method for examining anger expression was also employed for examining both patients' and their spouses' perceived criticism, hostility, and negative affect. This interpersonal study revealed that the gender of the patient is an important predictor of perceived criticism, hostility, and negative affect reported by both patient and spouse, such that for male patients, expressing anger elicits more negative reactions from the spouse [91]. Secondly, the study reported that, congruently with other studies, greater anger expression and inhibition are related to patient- and spouse-reported pain and pain interference of the patients [92].

In addition to higher trait anger-out, trait anger-suppression (anger-in) was greater in patients than healthy controls [93,94] and patients with "medically explained" pain [94]. Some positive association was also reported between anger-in and psychosomatic variables, such as end-of-day-pain [95], experimental acute pain intensity [89], state pain and pain interference

[92], depression, alexithymia [93], and mental distress [96]. One interpersonal study found that greater anger inhibition was related to decreased concurrent spouse criticism, which indicates that patients might inhibit their anger expression in order to avoid criticism from the partner, at the expense of greater pain [91].

A mismatch between habitual anger expression style and state anger expression was shown to be decisive in predicting pain-related complaints in four studies. A diary study reported the lowest pain in the patients with high trait anger expression who actually expressed their anger [95]. Supporting this interaction, trait anger-out patients in the suppression condition displayed more pain behavior and symptom-specific muscle reactivity followed by the slowest recovery compared to their counterparts in the no-suppression condition [80,97]. Pain experience could also influence subsequent state anger expression, moderated by the trait anger expression style [90], suggesting that persons with high trait anger-out and anger-in styles are at risk for dysregulated anger expression when they are in pain.

3.3.2.2 Expressive suppression and emotional expression

Expressive suppression of emotions, measured by self-reports of patients, was also quite frequently reported in patients with SSD. Three studies of patients with psychogenic non-epileptic seizures or functional neurological symptoms examined self-reports of the patients regarding expressive control. These studies reported elevated control reactions especially for sadness and anxiety, in addition to expressive suppression in patients [78,98,99]. Another study with a broad diagnosis of SSD also reported a trend towards more expressive suppression in the patients compared to controls [100]. These findings were supported by a reduced self-report-based emotional expressiveness in the fibromyalgia patients [96].

Higher expressive suppression was associated with other psychological factors, such as poorer cognitive flexibility [78] negative affect, and mental distress [96]. It was also related to pain catastrophizing and mediated the relationship between negative affect and pain catastrophizing [101]. One study reported an interaction between the experience and suppression of emotions and somatic symptoms, such that patients who experience emotions intensely but suppress emotional expressions suffer most from the impact of symptoms [102]. Expressive suppression of emotions was shown to decrease following psychotherapy, which was accompanied by improvements in symptom reports [87].

In an interview-based study, patients with somatoform disorders reported a lower capacity to nonverbally express their feelings than controls, which was also positively correlated with dimensions of alexithymia [103]. Another qualitative study also reported patients' tendency to bottle up emotions but not to express them, for reasons such as believing that expressing does not make a change, fear of rejection or not wanting to worry others [104].

Observable emotional behavior of patients with SSD was examined by three interpersonal paradigms. The characteristics of the non-verbal emotional expressions were shown to be quite negative according to two studies conducted with patients diagnosed with psychosomatic disorders, including somatoform disorders (however, the sample also included anxiety and depression patients) [105] and chronic pain disorders [106]. One of the studies reported that during therapist-patient interviews, patients displayed more facial contempt and negative emotions than controls, who displayed more genuine joy [106]. Moreover, these negative or aggressive expressions were associated with a low integrated personality structure [106] or lower alexithymic traits [105]. What is also notable is that, in response to patients' negative displays, therapists' facial expressions were also negative, especially that of contempt [105,106]. These findings illustrate that patients with SSD can facilitate certain types of negative interactional patterns in their social encounters. One study examined how the interaction partners' validation and invalidation is related to patients' pain complaints. It was found that patients' gender interacts with behavioral expressions of validation and invalidation in predicting pain complaints. Only in couples with a male patient was reciprocal invalidation related to worse pain, but interestingly, not in couples with a female patient [107].

Computerized tasks, such as picture viewing or film watching, for observing emotional behavior were implemented in three studies with psychogenic non-epileptic seizures [108],irritable bowel syndrome [109] and chronic fatigue syndrome [81]. Roberts and colleagues [108] compared patients with psychogenic non-epileptic seizures, with seizure-free individuals with high or low posttraumatic stress symptoms, given the high rates of trauma history in the patients. The study reported a difference between the patients and the trauma-low control group only in positive emotional expressiveness, not negative ones, during positive, negative, and neutral picture viewing. Another study with irritable bowel syndrome reported that patients displayed more sadness and tended to display more rage than healthy controls while watching frightening films [109]. A third study with patients with chronic fatigue syndrome examined patients' facial expressions also during watching stressful films for expression choice and suppression conditions. As opposed to the previous two studies, this study found lower number of expressed, as well as intensity of emotions in the patient group compared to controls, as rated by the observers. This effect remained significant after controlling for anxiety and depression [81].

In sum, although self-report studies point to a higher level of expressive suppression and limited expressivity, majority of the studies based on observed emotional behavior suggest that patients are not less expressive, except one study [81]. These studies reported that, patients with SSD tend to display more negative and fewer positive emotional expressions compared to healthy controls. Their interaction partner also tends to exhibit more negative emotions. Whether the diverse findings in observable emotional expression between studies stem from methodological or diagnostic differences should be further examined.

3.3.2.3 Autonomic nervous system activity

Research on the physiological parameters of emotion regulation has mostly shown aberrant autonomic functioning in patients with SSD. The findings indicate somatic vigilance and reduced capacity to down-regulate the autonomic reactivity to stress. In a recent study, even during a resting state, patients with chronic whiplash-associated disorders presented reduced heart rate variability (HRV). Remarkably, vagally mediated HRV was inversely correlated with pain catastrophizing, which was more elevated in the patient group than in the healthy controls [110]. Resting state aberrant parasympathetic functioning was highlighted in another study comparing psychogenic non-epileptic seizures with seizure-free individuals with low or high posttraumatic stress symptoms (PTS) [108]. Unexpectedly, patients did not differ from either group of seizure-free individuals when looking at emotional pictures. However, at baseline, patients displayed lower respiratory sinus arrhythmia than individuals with low PTS, but did not differ from those with high PTS. These two studies indicate a hypervigilant emotional system expecting a continuous threat and an inability to inhibit sympathetic activation.

Some other studies showed autonomic differences between baseline and emotion-inducing tasks. One study with somatoform disorders confirmed that during emotion-relevant tasks, patients displayed lower parasympathetic and increased sympathetic activation [71,111]. Similarly, patients with irritable bowel syndrome displayed a sympathetic withdrawal and increased heart rate from baseline to a fear-eliciting film session [109]. Such an increased sympathetic activation was also found in a study with patients with chronic fatigue syndrome. This study reported higher skin conductance during stressful film watching but not during baseline, which remained significant after controlling for anxiety and depression [81]. Moreover, increases in fatigue was positively related to skin conductance response during baseline and film watching only in the patient group Another study made a distinction between low vs. high levels of alexithymia and compared the autonomic functioning of the patients with persistent somatoform pain. This study reported lower skin conductance and greater negative affect in the high-alexithymic patient group. Nevertheless, the high- and low-alexithymic groups did not differ in terms of heart rate or muscle electrical activity across baseline, relaxation, or stress phases [112]. However, the study did not compare the findings with healthy controls.

Besides peripheral physiology parameters, affect-modulated startle in eye blink during emotional exposure was examined and studies showed congruent results with those that examined cardiac functions. Startle reflex is known to be mediated by the activities of the amygdala complex and is used as an indicator of emotional reactivity [113]. A study assessed eye blink reactivity in patients with psychogenic movement disorder and found higher and indiscriminate startle responses to both positive and negative pictures compared to neutral ones; however, controls displayed the highest startle responses to negative pictures followed by positive and neutral ones [114]. Another sample of patients with interstitial cystitis/painful bladder syndrome likewise showed a greater acoustic startle reflex than controls during non-imminent threat conditions (baseline, safe, and anticipation phases); however, patients and controls showed similar robust responses in imminent threat conditions [113]. This indiscriminate and rather vigilant bodily arousal in response to emotional stimuli was supported by another study of patients with irritable bowel syndrome, who reported greater pain for painful and non-painful rectal distensions in both stress and relaxation conditions, as compared to controls [115].

3.3.2.4 Impulse control difficulties

Impulse control difficulties indicate difficulties in controlling behavior when emotionally distressed. The studies that examined these difficulties (mostly by using self-report questionnaires) provide some insights about patients' difficulty in down-regulating physiological markers of arousal and action tendency. Patients with psychogenic non-epileptic seizures reported greater impulse control difficulties compared to epilepsy patients [25] and normative data [83]. This difficulty was especially pronounced in the emotionally dysregulated patient group [25,83]. The difficulty of impulse control could also independently predict the gastrointestinal symptoms and anxiety of patients with functional gastrointestinal disorders [85]. Also in patients with conversion disorders, impulse control difficulties were more pronounced than in healthy controls and remained a significant predictor of patient status, after statistically controlling for other emotion dysregulation factors [84]. As opposed to marked impulse control difficulties reported in the literature, which represent a non-adaptive emotion regulation strategy, an action readiness to confront emotions was reduced in patients with medically unexplained symptoms, but only those with a comorbid major depressive disorder [116].

3.3.2.5 Emotional decision making based on bodily signals

One study examined fibromyalgia patients' emotional decision-making ability in tasks requiring awareness of internal bodily signals associated with affective change (the Iowa Gambling Task). The study reported reduced performance in patients, characterized by more disadvantageous and random card selections than was the case for controls. However, patients' performance on other standardized cognitive tests was comparable with that of controls, ruling out a cognitive difficulty responsible for patients' reduced performance in the experiment [117]. When the capacity for perceiving the bodily sensations associated with emotions was examined, it was shown to be reduced compared to controls only in patients with medically unexplained symptoms (MUS) and a comorbid major depressive disorder (MDD), but not in those with only MDD or MUS [116].

Table 6

Study characteristics and summaries of articles that examined emotion regulation involving mainly bodily processes

Diagnostic details & control condition (number of participants)	Authors	Emotion regulation measures	Psychosomatic symptom variables (Measure)	Design	Quality assessment[1]	Results
Anger expression & anger suppression						
Chronic low back pain (13) & healthy controls (14)	Bruehl et al. (2007) [89]	Anger Expression Inventory	Ongoing and general pain (pain manipulation & MPQ-short), blood pressure, plasma beta-endorphin level, anxiety	E	++	Greater trait anger-out and anger-in were associated with greater acute pain in patients. Pain-induced beta-endorphin release was related to lower pain in both groups. Greater anger-out scores predicted smaller beta-endorphin release.
Chronic low back pain (84)	Burns et al. (2008) [97]	1. Anger Expression Inventory 2. Manipulation of expression vs. inhibition during experimental harassment paradigm	Symptom-specific muscle reactivity (EMG)	E	++	High trait anger-out patients in the anger inhibition condition showed the greatest lower paraspinal reactivity followed by the slowest recovery. High trait anger-out in anger expression condition showed the highest SBP followed by rapid recovery. Higher trait anger-out scores were related to higher heart rate reactivity during experimental harassment.
Chronic low back pain (58)	Burns et al. (2011) [80]	Anger Expression Inventory	(STAI), depression (BDI), current pain behavior (structured pain behavior task)	E	++	Trait anger expression style interacted with the experimental thought suppression on predicting pain behavior. Trait anger-out was related to more pain behavior during the suppression condition, but less pain behavior during the no-suppression condition.

Chronic low back pain (48) & healthy controls (36)	Bruehl et al. (2012) [90]	1. Anger Expression Inventory 2. Electronic Diary	Pain (electronic diary), depression (BDI), anxiety (STAI)	E	+++	Patients showed higher daily anger expression. Greater state anger expression affected subsequent time-lagged pain intensity. Trait anger expression moderated the relationship between state anger expression and chronic pain.
Chronic low back pain of patients (105) & their spouses (36)	Burns et al. (2015; 2016)[3][92,91]	Electronic diary from both patients and their spouses	1.Perceived criticism, hostility, and support by both patients and spouses 2. Electronic diary for state pain and pain interference	L (14 days)	++	As patients' anger arousal increased, perceived criticism, hostility, and negative affect of the spouse also increased, especially in couples with a male patient. Only in the male patients was anger expression associated with perceived criticism, hostility, and negative affect in the spouses. The predominant relationship between anger expression and response of the spouse was rather concurrent than lagged. Greater anger inhibition was related to decreased concurrent spouse criticism. Anger expression and inhibition were also related to patient- and spouse-reported pain and pain interference.
Myofascial pain (45) & healthy controls (45)	Castelli, et al. (2013) [93]	State Trait Anger Expression Inventory-II	Medical evaluation, psychological distress (BDI, STAI, Distress Thermometer)	E	++	Myofascial pain patents showed a greater tendency to suppress anger expression (anger-in). Anger-in was correlated with depression, anxiety, and alexithymia in patients.
Fibromyalgia (FA) (50), rheumatoid arthritis (20) & healthy controls (42)	Sayar et al. (2004) [94]	State Trait Anger Expression Inventory	Pain (VAS), fibromyalgia impact (FIQ), depression (BDI), anxiety (BAI)	CC	+++	Anger-in was greater in fibromyalgia patients than in rheumatoid arthritis patients and healthy controls. Behavioral expression of anger, together with anxiety, predicted the severity of the pain.

Fibromyalgia (403) & healthy controls (196)	van Middendorp et al. (2008) [96]	Self-Expression and Control Scale	Pain (MPI), fibromyalgia impact (FIQ), mental distress (MPI & FIQ)	CC	++	Internalization of anger was positively correlated with mental distress.
Fibromyalgia (333)	van Middendorp et al. (2010) [95]	1. Self-Expression and Control Scale 2. Diary	Pain (Diary)	CS	+++	Trait anger inhibition, but not state anger inhibition, was related to end-of-day-pain. The lowest pain was reported in patients with high trait anger expression who actually expressed their anger (state anger expression).
Irritable bowel syndrome (52) & healthy volunteers (100)	Zoccali et al. (2006) [88]	State Trait Anger Expression Inventory	Defense mechanisms (DMI)	CC	++	No statistical difference was found between groups in expression or suppression of anger.
Expressive suppression and emotional expression						
Chronic pain (224)	Wong & Fielding (2013) [101]	Emotion Regulation Questionnaire	Pain (CPQ), pain catastrophizing (PCS)		++	Expressive suppression was related to pain catastrophizing and mediated the relationship between negative affect and pain catastrophizing.
Chronic pain (100) (in the article cited as medically unexplained pain)	Chavooshi et al. (2016) [87]	Emotion Regulation Questionnaire	Pain intensity (NPRS), depression & anxiety (DASS-21), quality of life (QOLI)	I	++	Patients treated with intensive short-term dynamic psychotherapy reported significantly reduced suppression compared to patients who received treatment as usual, along with other decreasing psychosomatic complaints.
Somatic symptom disorders (35) & healthy controls (35)	Erkic, Bailer, Fenske, et al., (2017) [100]	Emotion Regulation Questionnaire	Number and intensity of symptoms (SOMS), symptom severity (PHQ-15), life disruption (PDI), depression (BDI)	E	+++	A trend was found towards more expressive suppression in the patients compared to controls.

Fibromyalgia (403)	Geenen et al. (2012) [102]	Emotional Approach Coping Scale	Fibromyalgia impact (FIQ)	CS	++	Patients who experience their emotions intensely but suppress their emotional expressions suffer more from the impact of fibromyalgia.
Fibromyalgia (403) & healthy controls (196)	van Middendorp et al. (2008) [96]	Emotional Approach Coping Scale, Emotion Regulation Questionnaire	Pain (MPI), fibromyalgia impact (FIQ), mental distress (MPI & FIQ)	CC	++	Patients' general emotional expression was lower than that of the controls, and was negatively correlated with negative affect and mental distress. Expressive suppression was positively correlated with negative affect and mental distress.
Functional neurological symptoms (45) & healthy controls (45)	Steffen et al. (2015) [98]	Emotion Regulation Questionnaire	Functional neurological symptoms (SDQ), early trauma (ETI), stressful life events (LEQ)	CC	++	Patients reported greater suppressive emotion regulation, which was positively associated with the severity of the symptoms.
Psychogenic non-epileptic seizures (72) & healthy controls (72)	Gul & Ahmad (2014) [78]	Emotion Regulation Questionnaire	Psychological distress (DASS)	E	+++	Patients scored higher on expressive suppression. Greater expressive suppression was related to poorer cognitive flexibility.
Psychogenic non-epileptic seizures (56) & healthy controls (88)	Urbanek et al. (2014) [99]	Courtauld Emotional Control Scale	Depression (HADS), seizure characteristics	CC	++	Patients reported greater control over their emotional reactions than controls, especially for anxiety and sadness behavior.
Psychogenic non-epileptic seizures (PNES) (18), seizure-free individuals with high (18) and low (18) posttraumatic stress symptoms (PTS)	Roberts et al. (2012) [108]	Emotional behavior in response to positive, negative, and neutral affective pictures	Trauma (PCL-S), psychiatric distress (SCL-90R),	E	+	Fewer PNES patients than PTS-high participants displayed positive emotional behavior. PNES and PTS-low patients did not differ. PNES patients did not differ from PTS-high or -low individuals in negative emotional behavior.

Somatoform disorders (40) & healthy controls (20)	Waller & Scheidt (2004) [103]	The Affect Consciousness Interview	Somatoform symptoms (SOMS), negative affect (HADS)	CC	+++	Patients reported lower capacity to nonverbally express their feelings than controls. Nonverbal expressiveness was negatively correlated with the dimensions of alexithymia.
Irritable bowel syndrome (52)	Sibelli, Chalder, Everitt, Workman, Bishop & Moss-Morris (2017) [104]	Semi-structrured interviews		CS, qualitative	n.a (qualitative)	When experiencing negative emotions, patients spoke about bottling up emotions but not expressing them, for reasons such as believing that expressing does not make a change, fear of rejection or not wanting to worry others.
Chronic fatigue syndrome (80) and healthy controls (80)	Rimes, Ashcroft, Bryan, & Chalder, (2016) [81]	Observer ratings of emotional expression in suppression and expression choice conditions (FACES), Self-ratings of emotional suppression and expression (VAS)	Anxiety and depression (HADS)	E	++	Patients expressed lower number and intensity of emotions than healthy controls in both expression and suppression conditions. This effect remained significant after controlling for anxiety and depression.
Chronic pain (21), healthy controls (11) & therapist	Merten & Brunnhuber (2004) [106]	Emotional Facial Action Coding System during interviews	Psychodynamic character of the patients (OPD)	E	+	The total negative expressions (anger, disgust, contempt) were higher in patients. Patients expressed more frequent contempt and controls expressed more genuine joy. Therapists' facial expressions involved more negative emotions when talking to patients. Negative expressions were negatively correlated to level of personality organization. The congruence between negative emotional experience and expression was found only in patients.

Psychosomatic disorders (12)	Rasting et al. (2005) [105]	Emotional Facial Action Coding System during interviews	-	E	+	Patients' expressivity of aggressive affect, especially contempt, was negatively related to their alexithymia level. Therapists' facial response was distinguished by expression of contempt.
Irritable bowel syndrome (25) & healthy controls (26)	Fournier et al. (2018) [109]	Emotional Facial Action Coding System while watching frightening film	Anxiety (STAI-Y), depression (CES-D)	E	++	Patients displayed more sadness and tended to display more rage than healthy controls.
Chronic pain (78) (patients and their spouses)	Leong et al. (2011) [107]	The Specific Affect Coding System during couple interviews	Pain (MPI), psychological distress (MASQ), dyadic adjustment (DAS)	E	++	Significant interaction was found between patient gender and sequences of invalidation and validation. Only male patient couples' reciprocal invalidation was related to worse pain. Spouses' indiscriminate validation was associated with poorer pain and relationship satisfaction in couples in which the patient was male.
Autonomic nervous system activity						
Chronic whiplash-associated disorders (30) & healthy controls (31)	Koenig et al. (2015) [110]	Vagally mediated heart rate variability	Pain catastrophizing (PCS)	CC	+	Patients presented lower vagally mediated HRV (high frequency-HRV), indicating a lower parasympathetic activation during resting state. They also reported higher pain catastrophizing, which was inversely correlated with vagally mediated HRV

Multisomatoform disorder (21) & healthy controls (21)	Pollatos, Dietel, et al. [2] (2011) [71]	Heart rate, heart rate variability, skin conductance response, & respiration rate	Pain threshold and pain tolerance (pain manipulation and pain imagination), depression (BDI)	E	+++	Patients showed lower parasympathetic and higher sympathetic activation during baseline, experimentally induced pain, and pain imagination. Patients had decreased pain tolerance. Controls showed greater vagal withdrawal during pain assessment, which correlated with increased pain tolerance.
Multisomatoform disorder (23) & healthy controls (23)	Pollatos, Herbert, et al. [2] (2011) [111]	Heart rate, heart rate variability, skin conductance response	Depression (BDI), somatosensory amplification (SAS), trait anxiety (STAI)	E	*	Patients showed lower parasympathetic reactivity during emotion recognition and emotion appraisal tasks, and increased sympathetic activation during baseline.
Persistent somatoform pain disorder (42)	Kleiman et al. (2016) [112]	Electromyogram, heart rate, skin conductance response		E	+++	During a stressful task (oral presentation), high alexithymic patients showed significantly lower skin conductance and reported greater negative affect than low alexithymic patients. Alexithymic patients did not have increased autonomic arousal at baseline, relaxation, or stress compared to non-alexithymic patients.
Chronic fatigue syndrome (80) and healthy controls (80)	Rimes, Ashcroft, Bryan, & Chalder, (2016) [81]	Skin conductance response	Fatigue (VAS)	E		Patients showed higher skin conductance during stressful film watching task, but not during baseline, compared to controls. This effect remained significant after controlling for anxiety and depression. Increases in fatigue was positively related to skin conductance response during baseline and film watching only in the patient group.

Psychogenic movement disorder (12) & healthy controls (12)	Seignourel et al. (2007) [114]	Affect-modulated startle in eye blink (EMG)	Depression (BDI), trait anxiety (STAI)	E	+++	Patients showed higher startle responses to both positive and negative pictures than neutral ones, as compared to control subjects. Controls showed highest startle responses to negative pictures, followed by positive and neutral ones.
Psychogenic non-epileptic seizures (18), seizure-free individuals with high (18) and low (18) posttraumatic stress symptoms	Roberts et al. (2012) [108]	Heart rate & respiratory sinus arrhythmia (RSA)	Trauma (PCL-S), psychiatric distress (SCL-90R),	E	+	PNES patients did not differ from seizure-free PTS-low or -high individuals in their average HR and RSA while looking at pictures. However, during a resting state, patients showed lower RSA than PTS-low, but did not differ from PTS-high.
Interstitial cystitis/painful bladder syndrome (13) & healthy controls (16)	Twiss et al. (2009) [113]	Affect-modulated startle in eye blink (EMG)	Pain (VAS during visceral threat), anxiety and depression (HADS)	E	++	Patients had greater acoustic startle reflex than controls in non-imminent threat conditions (baseline, safe, and anticipation phases). Patients and controls showed similar robust responses in imminent threat conditions.
Irritable bowel syndrome (25) & healthy controls (26)	Fournier et al. (2018) [109]	Heart rate, heart rate variability, cortisol levels	State anxiety (STAI-Y), depression (CES-D).	E	++	Patients showed a parasympathetic withdrawal from baseline to fear-eliciting film watching, whereas healthy controls did not. Patients also showed an increase in their heart rate from baseline to fearful task, while HC did not. There was no correlation between patients' expressiveness and their physiological responses.
Irritable bowel syndrome (IBS) (15) & healthy controls (12)	Elsenbruch, et al. (2010) [115]	Progressive muscle relaxation (experimental manipulation)	Pain (pain manipulation), anxiety and depression (HADS), anxiety (STAI)	E	++	In both stress and relaxation conditions, patients reported higher pain ratings for painful and non- painful rectal distensions than controls.

Impulse control difficulties, action tendency, action readiness						
Psychogenic non-epileptic seizure (70)	Uliaszek et al. (2012) [83]	Difficulties in Emotion Regulation Scale, Impulse Subscale	Depression (BDI-II), dissociative experiences (DES), psychological distress (DASS), functioning and physical distress (PHQ-15, DFI)	CS	++	From two empirically established clusters, one had significantly increased impulse control difficulties as compared to normative data. This cluster was also associated with higher rates of comorbid psychiatric symptoms and life impairment. The other cluster's impulsivity score did not differ from the normative data.
Psychogenic non-epileptic seizures (PNES) (43) & epilepsy (24)	Brown et al. (2013) [25]	Difficulties in Emotion Regulation Scale, Impulse Subscale	Anxiety (GAD-7), depression (PHQ-9), somatization (SDQ-20), attachment styles (RelSQ)	CC	+++	Patients with PNES reported greater impulse control difficulties compared to epilepsy patients. This difficulty was more pronounced in the emotionally dysregulated cluster of PNES patients, who also had higher alexithymia, somatization, and psychopathology scores.
Conversion disorders (43) & healthy controls (42)	Del Rio-Casanova et al. (2018) [84]	Difficulties in Emotion Regulation Scale (DERS), Lack of Emotional Control Subscale	Depression, anxiety (HADS), somatoform dissociation (SDQ-20), psychoform dissociation (DES-II)	CC	+++	Patients reported greater difficulties in emotional action control compared to controls. After stepwise elimination of DERS factors, this factor remained a significant predictor of patient status.
Functional gastrointestinal disorders (167)	Mazaheri (2015) [85]	Difficulties in Emotion Regulation Scale, Impulse Subscale	Depression, anxiety and stress (DASS), gastrointestinal symptoms (GSRS)	CS	+++	Patients' difficulty in controlling their behavior when they are emotionally distressed independently predicted their gastrointestinal symptoms and anxiety.

Medically unexplained symptoms (MUS) (138), MUS comorbid with major depressive disorder (MDD) (114), MDD (106), healthy controls (100)	Schwarz et al. (2017) [116]	Emotion Regulation Skills Questionnaire, (Readiness to confront)	Physical complaints (SOMS-7T), depression (BDI-II), symptom checklist (SCL-90)	CC	++	MUS patients were better than MUS+MDD patients in readiness to confront negative emotions. Only MDD+MUS patients scored lower than healthy controls in readiness to confront emotions, but not MUS or MDD patients.
Emotional decision making based on bodily signals, perception of bodily signals						
Fibromyalgia patients (15) & healthy controls (15)	Walteros et al. (2011) [117]	Iowa Gambling Task	Anxiety (STAI), depression (BDI), general cognitive functioning (WAIS), cognitive flexibility (Stroop test), conditional associative learning (CALT)	E	-	Patients selected more disadvantageous cards and showed more random behavior in the emotion-based decision task than did healthy controls. They also showed more perseveration errors in the CALT task. Groups did not differ in other standardized cognitive tests. The findings indicated a specific cognitive deficit regarding affective information rather than a general cognitive difficulty in the patients.
Medically unexplained symptoms (MUS) (138), MUS comorbid with major depressive disorder (MDD) (114), MDD (106), healthy controls (100)	Schwarz et al. (2017) [116]	Emotion Regulation Skills Questionnaire, Sensations Subscale	Physical complaints (SOMS-7T), depression (BDI-II), symptom checklist (SCL-90)	CC	++	MUS patients were better at distinguishing bodily sensations than MUS+MDD patients. Healthy controls differed only from MUS+MDD patients, that ability being higher in the healthy control group. No difference was found between the capacity for perceiving bodily signals of emotions between MUS patients and healthy controls, or between MUS and MDD patients.

[1]Quality of the studies was rated with +, ++, or +++ when 25–49%, 50–79%, or 80% or more of the criteria were rated with "yes."

[2] The two article findings are based on the same sample data.

[3] The two article findings are based on the same sample data.

Abbreviations of the study designs

CS: Cross Sectional, **CC:** Case Control, **E:** Experimental, **L:** Longitudinal, **I:** Intervention/psychotherapy study

Abbreviations of the symptom measures & paradigms

BDI: Beck Depression Inventory, **CALT:** Conditional Associative Learning Task, **CES-D:** Center for Epidemiology Articles-Depression Scale, **CPQ:** Chronic Pain Questionnaire, **DAS:** The Dyadic Adjustment Scale, **DASS:** Depression, Anxiety and Stress Symptoms , **DES:** Dissociative Experiences Scale, **DFI:** Disruption of Functioning Index, **DMI:** Defense Mechanism Inventory, **ETI:** Early Trauma Inventory, **FACES:** Facial Expression Coding System, **FIQ:** The Fibromyalgia Impact Questionnaire, **GSRS:** Gastrointestinal Symptom Rating Scale, **GAD:** Generalized Anxiety Disorder Questionnaire, **HADS:** Hospital Anxiety and Depression Scale, **LEQ:** Life Events Questionnaire, **MASQ:** The Mood and Anxiety Symptom Questionnaire, **MPI:** Multidimensional Pain Inventory, **MPQ:** McGill Pain Questionnaire, **NPRS:** Numerical Pain Rating Scale, **OPD:** Operationalized Psychodiagnostic Manual, **PDI:** Pain Distruption Index, **PHQ:** The Patient Health Questionnaire, **RelSQ:** Relationship Scales Questionnaire, **QOLI:** Quality of Life Inventory, **SAS:** Somatosensory Amplification Scale, **SCL-90:** Symptom Checklist-90, **SDQ:** Somatoform Dissociation Questionnaire, **SOMS:** Screening for Somatoform Disorders, **STAI:** State Trait Anxiety Inventory, **WAIS:** Wechsler Adult Intelligence Scale, **VAS:** Visual Analog Scale

3.3.3 Knowledge

Twenty-five articles reported knowledge-oriented ER in terms of self-report based results, 15 articles reported behavioral results and two articles reported the both (Table 7).

3.3.3.1 Emotional awareness and emotional theory of mind

Patients' awareness and capacity to understand their own and others' feelings was the most-studied subject of knowledge-oriented emotion regulation. These capacities were typically assessed by an interview or content analyses. Although there is some divergence in study results depending on the measurement used, studies typically confirmed patients' difficulty in emotional awareness and emotional theory of mind.

Several studies examined patients' emotional awareness by analyzing the words patients used in order to describe their own and others' emotions (Level of Emotional Awareness Scale). In one study based on this measure, patients with somatoform disorders showed reduced emotional awareness compared to healthy controls [118]. Another psychotherapy study with patients with musculoskeletal pain reported similar results. An improvement in patients' emotional awareness from pre- to post-psychotherapy was demonstrated, particularly regarding others' emotions. This was also accompanied by improvement in psychosomatic complaints [119]. In another study, emotional awareness in somatoform patients was found to be reduced; however, this was based only on an affect consciousness interview but not on the Level of Emotional Awareness Scale [103]. Awareness of anger, guilt, and mean negative affect was particularly diminished in the patient group in these interviews. Finally, one study examined patients' ability to understand and reflect on their own emotions by a self-report questionnaire and found that patients with only MUS scored worse than healthy controls, although they were better in that domain than patients with a comorbid MUS and MDD or with only MDD [116].

It was suggested that patients' reduced emotional awareness might be a function of reduced capacity to mentally represent feelings rather than a lack of emotional vocabulary [59]. The authors could support this empirically by showing that emotional awareness was correlated with emotional theory of mind in patients with conversion disorders, functional somatic syndrome, and somatoform disorders [59,118]. It was also shown that patients with fibromyalgia and somatoform disorders presented reduced emotional content and emotional theory of mind performance in their discourses compared to healthy controls [118,120]. A study investigated whether fibromyalgia patients' such difficulty in affective theory of mind is connected to a general neuropsychological deficit. No correlation was found between affective social cognition and neuropsychological variables, suggesting that patients' social cognition difficulties might rather be exclusively related to emotions [120]

Despite the results pointing to a reduced emotional theory of mind ability in these patients, the findings should be treated cautiously, given the diverging results between different measures of the construct. For example, one study administered an emotional theory of mind test which requires attribution of emotions based on pictures of emotional expression around the eyes and eyebrows (EYES test) [121]. This study found no difference between patients with functional motor disorders or organic movement disorders and healthy controls [122]. Similarly, when patients with conversion disorders or functional somatic syndromes and medical controls were compared, a study reported limited emotional theory of mind in SSD only in one theory of mind test, based on dynamic animations of emotions (FHAT) [123], but not in the EYES [121] test [124].

3.3.3.2 Emotion recognition

Patients' abilities to recognize emotions were typically examined by computerized emotion-recognition tests. The majority of the studies confirmed reduced emotion-recognition accuracy in patients with somatoform disorders [111,125–128], fibromyalgia [120], chronic facial pain [129] and temporomandibular disorders [130], compared to healthy controls. Reduced recognition performance was reported for the individual emotions of anger, joy, sadness, fear, disgust, and neutral emotions [111,120,126,127], even after controlling for alexithymia, depression and anxiety [111]. However, in contrast to those studies, one study reported a trend towards patients' better performance in recognition of emotions, especially of angry faces [100].

Lower emotion recognition performance was usually associated with alexithymic traits of the patients, and in some studies, the difference between patients and healthy controls diminished when alexithymia was statistically controlled. These studies suggested that emotion recognition difficulties are secondary to more basic problems, such as alexithymia or depression [127,128,130]. One interesting finding was that patients with chronic facial pain who were less accurate in recognizing emotions compared to controls were also less accurate in recognition of left/right facial movement. The authors suggested that reduced emotion recognition might not only be about emotion processing, but also about disorder-specific motor processing [129]. Only one study employed a measure involving dynamic animated emotional faces, as opposed to other static picture paradigms. This study reported no difference between patients with psychogenic non-epileptic seizures and healthy groups, indicating a possible effect of methodology on the emotion-recognition performance [131].

3.3.3.3 Beliefs about and attitude towards emotions

Beliefs about emotions were shown to be a predictor of SSD in five studies. For example, patients with psychogenic non-epileptic seizures reported more negative beliefs about emotions and evaluated them as more overwhelming, uncontrollable, shameful, irrational, contagious, useless, and damaging than did controls. A positive correlation was also reported between negative beliefs about emotions and seizure severity [99]. In another study, patients with chronic fatigue syndrome held significantly more beliefs about the unacceptability of experiencing and expressing emotions than controls [81,132]; especially prior to the onset of the syndrome [132]. These negative beliefs were also associated with depression, anxiety, fatigue, and self-sacrifice [133], as well as self-reported suppression [81]. It was also found that, not only patients, but also patients' close relatives rated the patients to have more negative beliefs about emotions [132]. In a qualitative study, especially female patients emphasized their beliefs about non-acceptability of expressing negative emotions. Moreover, beliefs related to high expectations of self and social desirability was connected with how emotions are experienced [104]. Patients' negative beliefs about emotions were shown to decrease following psychotherapy, along with other somatic and psychological improvements [133]. As opposed to negative beliefs about emotions, in one study, self-efficacy beliefs in emotion regulation were related to higher quality of life in the patients with chronic pain [134].

Other ER facets regarding attitudes towards emotions were non-acceptance of emotions, non-judging of emotions, tolerance to emotions, accessing ER strategies, and emotional clarity, which means the ability to discern how one feels. Two studies with patients with psychogenic non-epileptic seizures (PNES) examined non-acceptance of emotions and lack of emotional clarity by a commonly used self-report scale of ER difficulties. These two studies confirmed that lack of emotional clarity and not accepting emotions were significantly related to somatic complaints, emotion dysregulation, and quality of life [25,83]. One study distinguished also between PNES patients who do not respond to the external world during seizures (altered responsiveness group) and an intact responsiveness group. The study reported that the abilities to accept experienced emotions and to tolerate emotions were reduced in the altered responsiveness group compared to the intact responsiveness group, suggesting that even different semiology of the same diagnosis might show different associations with ER [135].

Another study with functional gastrointestinal disorders also showed a positive link between lack of emotional clarity and non-acceptance of emotions on the one hand, and depression on the other. These difficulties were also related to lower mindful attention [85]. Likewise, patients with functional dyspepsia reported less frequent use of acceptance compared to healthy controls [136]. Some mindfulness facets, such as non-judging of emotions and being able to describe them, were examined in patients with fibromyalgia. These variables were negatively related to alexithymia, neuroticism, and negative affect, although their association with physical health was not confirmed [86].

Differences in attitudes towards emotions among different groups of patients were also supported by a study which distinguished among patients with MUS, MUS and MDD, and only MDD and healthy controls. Patients with MUS received lower scores than healthy controls in the ability to clearly distinguish emotions, accept their emotions, and be tolerant and resilient towards emotional challenges, but higher scores than MDD or MDD and MUS patients [116].

Finally, difficulty in accessing strategies for dealing with emotions predicted anxiety and stress, as well as decreased mindful attention in functional gastrointestinal disorders [85]. This difficulty was found to be greater especially in the emotionally dysregulated patient group with psychogenic non-epileptic seizures, who had likewise more somatic symptoms, higher levels of alexithymia, and a lower quality of life [25,83].

3.3.3.4 Reappraisal and automatic thoughts

Three studies with patients with fibromyalgia [96,102] and chronic pain [101] failed to find a relationship between psychosomatic complaints and reappraisal (assessed with a self-report measure), especially when negative affect was statistically controlled.

On the other hand, two studies with functional neurological symptoms, one study with functional dyspepsia and another one with SSD found evidence for an association between reappraisal and SSD: Patients with functional dyspepsia reported less frequent use of positive reappraisal, but more use of rumination and other-blame compared to healthy controls [136]. One study in patients with functional neurological symptoms and another with SSD reported a lower tendency to use cognitive reappraisal compared to healthy controls [100,137]. Similarly, patients with PNES tend to utilize cognitive reappraisal to a lesser extent than controls, which was also associated with cognitive inflexibility [78]. This pattern of a less flexible cognitive style in the light of negative content was supported by another study, which found that patients with chronic tension-type headaches had more frequent automatic negative thoughts than did controls [138]. Moreover, psychotherapy with chronic pain patients increased the reappraisal capacity of these patients, accompanied by improved somatic symptom reports [87].

Table 7

Study characteristics and summaries of articles that examined emotion regulation involving higher order knowledge/appraisal processes

Diagnostic details &control condition (number of participants)	Authors	Measures	Psychosomatic symptom variables (Measure)	Design	Quality Assessment[1]	Results
Emotional awareness, emotional theory of mind & emotion recognition						
Somatoform disorders (40) & healthy controls (20)	Waller & Scheidt (2004)[103]	1. Level of Emotional Awareness Scale 2. Affect Consciousness Interview	Somatoform symptoms (SOMS), negative affectivity (HADS)	CC	+++	A reduced awareness of emotions was found in patients based on ACI but not LEAS. Particularly awareness of anger, guilt, and mean negative affect was diminished in the patient group. Alexithymia was greater among patients.
Somatoform disorders (20) & healthy controls (20)	Pedrosa Gil et al. (2008) [128]	Facially Expressed Emotion Labeling	Somatoform symptoms (SOMS), psychological distress (SCL-90-R), depression (HAMD)	E	++	Patients recognized fewer emotional expressions than controls, which became non-significant when alexithymia was controlled.
Somatoform disorders (30) and healthy controls (30)	Subic-Wrana et al. (2010) [118]	1. Level of Emotional Awareness Scale 2. Emotional Content in Frith-Happe-Animations Task	Theory of mind functioning/ mentalizing (FHAT), somatic and psychic symptoms (SCL-90- R)	E	++	Patients showed reduced emotional awareness in LEAS. Reduced emotional content and reduced emotional theory of mind functioning at FHAT was observed in patients. Theory of mind (FHAT) and emotional awareness (LEAS) together correctly classified 80% of the patients.
Somatoform disorders (20) & healthy controls (20)	De Greck et al. (2011) [126]	Tübinger Affekt Batterie	Somatoform symptoms (SOMS-2, BSI)	E	++	Somatoform patients showed more diminished mean emotion recognition and recognition of single emotions of anger, joy, sadness, and fear, but not of neutral emotions.
Somatoform disorders (35) & controls (73)	Beck et al. (2013) [125]	Comprehensive Affect Testing System	Somatoform symptoms (SOMS-2, BSI)	E	+	Patients demonstrated reduced abilities to recognize others' affects.

Somatic symptom disorders (54) & healthy controls (46)	Ozturk et al. (2016) [127]	Ekman & Friesen Faces	Depression (BDI), anxiety (BAI)	E	+++	Patients had lower scores in recognizing fear, disgust, and neutral faces. Mean alexithymia and its dimensions were also higher in patients than controls. After controlling for alexithymia, depression, and anxiety, the difference between patients and controls in emotion recognition diminished.
Somatic symptom disorders (35) & healthy controls (35)	Erkic, Bailer, Fenske, et al., (2017) [100]	NimStim set of facial expressions	Number and intensity of symptoms (SOMS), symptom severity (PHQ-15), life disruption (PDI), depression (BDI)	E	+++	A trend was found in patients' scores in recognition of more angry faces correctly.
Multisomatoform disorder (23) & matched healthy controls (23)	Pollatos, Herbert, et al. (2011) [111]	Karolinska Directed Emotional Faces battery	Depression (BDI), somatosensory amplification (SAS), trait anxiety (STAI)	E	+++	Patients showed decreased emotion recognition for faces showing sad and neutral emotions even after alexithymia, depression, and anxiety were controlled for.
Medically unexplained symptoms (MUS) (138), MUS comorbid with major depressive disorder (MDD) (114), MDD (106), healthy controls (100)	Schwarz et al. (2017) [116]	Emotion Regulation Skills Questionnaire, (Understanding Subscale)	Physical complaints (SOMS-7T), depression (BDI-II), symptom checklist (SCL-90)	CC	++	MUS patients were better than MDD and MUS+MDD patients in their ability to understand and reflect on their own emotional experiences, but worse than healthy controls.
Chronic musculoskeletal pain (72)	Burger et al. (2016) [119]	Level of Emotional Awareness Scale	Pain intensity and interference (BPI), depression (CES-D), sensory and affective pain (MPQ), psychological distress (BSI), psychological attribution for pain	I (pre, post, & follow-up)	++	Patients' emotional awareness, in particular for others' emotions, increased from pre- to post- treatment (psychological attribution, emotional awareness and expression therapy). Accordingly, the alexithymia level significantly decreased. Patients' psychological attribution for pain was also improved. Parallel with the findings, many of the pain and psychological symptom variables in the pre-treatment improved in the post-treatment and still increased slightly after 6-month follow-up.

Conversion disorder (29), functional somatic syndrome (FSS) (30) & explained medical disorder (30)	Stonnington et al. (2013)[2] [124]	Emotional Content in Frith Happe Animations Task 2. Reading the Mind in the Eyes Test 3. Level of Emotional Awareness Scale	Cognitive theory of mind (MSS), depression, anxiety, & physical symptoms (MADRS, HAM-A, SCL-90), quality of life (SF-36)	E	+++	Patients with conversion disorder and FSS scored lower than medical controls on the affective theory of mind task measured by FHAT-L, but not on EYES. They also reported greater anxiety and decreased positive affect. Patients with conversion disorder showed higher alexithymia than medical controls.
Conversion disorder (29), functional somatic syndrome (FSS) (30) & explained medical disorder (30)	Lane et al. (2015)[2] [59]	1. Level of Emotional Awareness Scale 2. Reading the Mind in the Eyes Test	Cognitive theory of mind (MSS), depression (MADR), quality of life (SF- 36), positive and negative affect (PANAS)	E	*	Emotional awareness measured with LEAS was positively related to affective and cognitive theory of mind after controlling for negative affect in the patients.
Functional motor disorders (55), organic movement disorders (33) & healthy controls (34)	Demartini et al. (2014) [122]	Reading the Mind in the Eyes Test	Depression (MADRS), personality disorders (SCID)	E	++	No difference was found between groups in the EYES test.
Psychogenic non- epileptic seizures (15) & healthy controls	Schönenberg et al. (2015) [131]	Animated morphing paradigm	Cognitive theory of mind (MASC), perceived stress (PSS), psychopathology (MINI)	E	++	Patients' performance in the dynamic emotion recognition test was not different from the healthy controls. Divergence reported in the literature might have stemmed from methodological differences.

Fibromyalgia (40) & healthy controls (41)	Di Tella et al. (2015) [120]	1. Reading the Mind in the Eyes Test 2. Empathy Quotient 3. Ekman 60	Pain intensity (FIQ- Pain), anxiety and depression (HADS) neuropsychological assessment (short- term memory, learning, attention, executive functioning)	E	++	Patients had greater difficulty in attributing others' affects compared to controls. Similarly, they showed reduced ability to recognize emotions, especially anger and disgust, and reported greater mean alexithymia, especially in identifying and describing feelings, compared to controls. In empathy, no difference was found between groups. The patients scored lower on many neuropsychological tests compared to controls; however, no significant correlation was found between neuropsychological variables and affective-social cognition variables. This suggests that affective-social cognition capacities are independent of the neuropsychological deficits.
Chronic facial pain	von Piekartz et al. (2015) [129]	Facially Expressed Emotion Labeling	Left/right facial movement judgment task, depression (BDI), pain intensity (CAS)	E	+++	Patients were less accurate in total emotion recognition than controls. Accuracy in emotion recognition was negatively related to pain intensity. Patients were also less accurate and had longer response time in the left/right facial movement judgment task than controls, which indicated a disruption of body-part motor processing. The facial motor processing and facial emotion recognition were also related to each other, suggesting the emotion recognition problems not exclusively about emotion processing.
Temporomandibular disorders (20) & healthy controls (20)	Haas et al. (2013) [152]	Facially Expressed Emotion Labeling	Somatoform symptoms (SOMS- 2a), depression (HAMD), pain (German Pain Questionnaire)	E	+++	Patients had more pronounced alexithymia and impaired total emotion recognition. Alexithymia together with somatization explained a higher proportion of variance of the emotion recognition scores, as compared to group membership.

Irritable bowel syndrome (29) & healthy controls (26)	Constantinou et al. (2014) [153]	Modified Affect Labeling Task	Physical symptoms (Symptom Checklist), habitual symptom reporting (CSDL), anxiety and depression (HADS)	E	++	Viewing negative pictures increased the arousal and gastrointestinal symptoms of both groups. Labeling the pictures did not reduce these effects, although a trend towards less arousal symptoms on the part of patients was observed. A possible confounding variable was reported: the mild affective stimulation used in the experiment.
Beliefs about and attitude to emotions						
Chronic fatigue syndrome (121) (21patients measured in pre-post-treatment) & healthy controls (73)	Rimes & Chalder (2010) [133]	Beliefs about Emotions Scale (BES)	Fatigue-related symptoms (CFS), anxiety and depression (HADS), self-sacrifice (YSQ), maladaptive attitudes (DAS-24), perfectionism (PSBS)	CC	+	Patients had significantly more beliefs about the unacceptability of experiencing and expressing emotions than did controls. The scores on the BES had significant positive correlations with measures of negative perfectionism, self-sacrifice, dysfunctional attitudes, depression, anxiety, and fatigue. After psychotherapy a significant reduction of unhelpful beliefs was achieved.

Chronic fatigue syndrome (67), close relatives of the patient (44), healthy controls (73)	Brooks, Chalder & Rimes (2017) [132]	Beliefs about Emotions Scale (BES)	Fatigue (CFQ), anxiety and depression (HADS), self-sacrifice (YSQ), perfectionism (PSBS), Goals (RGQ)	CC & retrospective	++	Patients' negative beliefs about emotions were more pronounced than those of healthy controls, especially prior to onset of the syndrome. They retrospectively reported more negative beliefs about emotions in 6 months pre-CFS onset than at the current time. Patients´ and their close relatives' perceptions of patients' negative beliefs about emotions were consistent with each other.
Chronic fatigue syndrome (80) and healthy controls (80)	Rimes, Ashcroft, Bryan, & Chalder, (2016) [81]	Beliefs about Emotions Scale (BES)	Anxiety and depression (HADS)	E	++	Increased negative beliefs about emotions was correlated with greater self-reported suppression.
Irritable bowel syndrome (52)	Sibelli, Chalder, Everitt, Workman, et al., (2017) [104]	Semi-structrured interviews		CS, qualitative	n.a. (qualitative)	How emotions are experienced was related to beliefs of high expectations of self and social desirability. Beliefs about non-acceptability of expressing negative emotions was highly emphasized, especially by female participants.
Medically unexplained symptoms (MUS) (138), MUS comorbid with major depressive disorder (MDD) (114), MDD (106), healthy controls (100)	Schwarz et al. (2017) [116]	Emotion Regulation Skills Questionnaire, (Clarity, Acceptance, Tolerance Subscales)	Physical complaints (SOMS-7T), depression (BDI-II), symptom checklist (SCL-90)	CC	++	MUS patients were better than MDD and MUS+MDD patients in: (a) being able to clearly distinguish their emotions, but worse than healthy controls (clarity), (b) accepting their emotions. MUS Patients scored higher in showing tolerance and resilience against strong negative emotions compared to MDD+MUS patients, and lower than healthy controls.
Functional dyspepsia (43) & healthy controls (43)	Mazaheri et al. (2016) [136]	Cognitive Emotion Regulation Questionnaire (Acceptance Subscale)	Rome III Interview	CC	++	Patients reported less frequent use of acceptance compared to healthy controls.

Functional gastrointestinal disorders (167)	Mazaheri (2015) [85]	Difficulties in Emotion Regulation Scale (Clarity, Strategies, and Accept Subscales)	Depression, anxiety and stress (DASS), gastrointestinal symptoms (GSRS)	CS	+++	Difficulty in access to strategies for dealing with emotions predicted anxiety and stress, while non-acceptance of emotions predicted depression. Lack of emotional clarity and limited access to strategies were correlated with depression, anxiety, and stress, and negatively predicted mindful attention. All the facets of emotion dysregulation were negatively related to mindful attention.
Conversion disorders (43) & healthy controls 42)	Del Rio-Casanova et al. (2018) [84]	Difficulties in Emotion Regulation Scale (Clarity and Accept Subscales)	Depression, anxiety (HADS), somatoform dissociation (SDQ-20), psychoform dissociation (DES-II)	CC	+++	The patient groups had higher scores in lack of emotional clarity and non-acceptance of emotions compared to healthy controls.
Psychogenic non- epileptic seizures (70)	Uliaszek et al. (2012) [83]	Difficulties in Emotion Regulation Scale (Clarity, Strategies, and Accept Subscales)	Depression (BDI-II), dissociative experiences (DES), psychological distress (DASS), functioning and physical distress (PHQ-15, DFI), quality of life (QOLIE-31)	CS	++	Two clusters of patients were identified, which differentiated low vs. severe emotion dysregulation. The highly emotion-dysregulated group reported greater difficulties in emotional clarity, acceptance of emotions, and access to emotion regulation strategies, compared to normative data and the low emotion-dysregulated cluster. This group was significantly associated with more psychopathology symptoms as well as higher rates of comorbid psychiatric diagnoses and impairment in quality of life.
Psychogenic non- epileptic seizures (43) & epilepsy patients (24)	Brown et al. (2013) [25]	Difficulties in Emotion Regulation Scale (Clarity, Strategies, and Accept Subscales)	Anxiety (GAD-7), depression (PHQ-9), somatization (SDQ- 20), attachment styles (RSQ)	CS	+++	Two clusters of patients were identified, one of which had more difficulties in emotional clarity, acceptance of emotional responses, access to emotion regulation strategies than the other cluster and the epilepsy patients. They also presented greater alexthymia, psychopathology, and somatization scores than epilepsy patients

Psychogenic non- epileptic seizures (56) & healthy controls (88)	Urbanek, et al. (2014) [99]	Beliefs About Emotions Questionnaire	Depression (HADS), seizure characteristics	CC	++	Patients evaluated emotions as more overwhelming and uncontrollable, shameful, irrational, contagious, useless, and damaging than did controls. Patients showed more negative beliefs about emotions. Positive correlation was found between negative beliefs about emotions and seizure severity.
Psychogenic non- epileptic seizures (71)	Baslet et al. (2017) [135]	1. Affective Style Questionnaire (adjust & tolerate Subscales) 2. Acceptance and Action Questionnaire	Depression (BDI-II), dissociative experiences (DES), somatic symptoms (PHQ-15)	CS	+	The ability to accept experienced emotions was reduced in the altered responsiveness group (those who do not respond during the seizure) compared to the intact responsiveness patient group. Capacity to tolerate intense emotions was also reduced in the former group.
Study 1: rheumatoid arthritis (RA) or osteoarthritis (175) Study 2: fibromyalgia (FA) (89)	Zautra, Smith, Affleck, & Tennen (2001) [154]	Trait Meta-Mood Scale	Daily pain (electronic diary)	CS	+	Mood clarity weakened the inverse relationship between positive and negative affect only in the arthritis group. Mood clarity was related to lower negative affect only in the fibromyalgia group.
Fibromyalgia (141)	Veehof et al. (2011) [86]	1. Five Facet Mindfulness Questionnaire (Non-judge & Describe Subscales) 2. Acceptance and Action Questionnaire-II	Neuroticism and openness to new experiences (NEO-FFI), anxiety and depression (HADS), mental and physical health (SF-12)	CS	+	Being able not to judge experienced feelings and the capacity to describe the feelings was negatively correlated with alexithymia, depression, anxiety, and neuroticism. The facets were not related to physical health.
Reappraisal, automatic thoughts, efficacy in emotion regulation						
Chronic pain (128)	Agar-Wilson & Jackson (2012) [134]	Assessing Emotions Scale (Efficacy, Appraisal and Utilization Subscales)	Quality of life (WHOQOL–BRIEF), pain-related disability (ODQ), pain coping (CSQ)	CS	++	Efficacy in emotion regulation was associated with higher quality of life. Other dimensions of AES did not contribute to the prediction of pain-related disability.

Chronic pain (224)	Wong & Fielding (2013) [101]	Emotion Regulation Questionnaire	Pain (CPQ), pain catastrophizing (PCS)	CS	++	Reappraisal ability was negatively associated with pain catastrophizing only in univariate analyses, but not in multivariate analyses, when negative affect and expressive suppression were taken into account.
Medically unexplained pain (100)	Chavooshi et al. (2016) [87]	Emotion Regulation Questionnaire	Pain intensity (NPRS), depression & anxiety (DASS- 21), quality of life (QOLI)	I	++	Patients treated with intensive short-term dynamic psychotherapy reported increased cognitive reappraisal capacity compared to patients who received treatment as usual. Their other psychosomatic complaints also improved to a greater extent.
Somatic symptom disorders (35) & healthy controls (35)	Erkic, Bailer, Fenske, et al., (2017) [100]	Emotion Regulation Questionnaire	Number and intensity of symptoms (SOMS), symptom severity (PHQ-15), life disruption (PDI), depression (BDI)	E	+++	Patients reported less cognitive reappraisal compared to healthy controls.
Medically unexplained symptoms (MUS) (138), MUS comorbid with major depressive disorder (MDD) (114), MDD (106), healthy controls (100)	Schwarz et al. (2017) [116]	Emotion Regulation Skills Questionnaire, (Modification and Self-support Subscales)	Physical complaints (SOMS-7T), depression (BDI-II), symptom checklist (SCL-90)	CC	++	MUS patients scored higher in their efficacy beliefs about modifying negative emotions compared to MUS+MDD patients and scored lower than healthy controls. MUS patients scored higher in being able to support oneself in emotionally demanding situations compared to MDD or MUS+MDD patients and lower than controls.
Fibromyalgia (403) & healthy controls (196)	van Middendorp et al. (2008) [96]	Emotion Regulation Questionnaire	Pain (MPI), fibromyalgia impact (FIQ), mental distress (MPI & FIQ)	CC	++	Reappraisal ability did not differ between groups.
Fibromyalgia (403)	Geenen et al. (2012) [102]	Emotion Regulation Questionnaire	Fibromyalgia impact (FIQ)	CS	++	Cognitive reappraisal was not related to fibromyalgia impact.
Psychogenic non- epileptic seizures (72) & healthy controls (72)	Gul & Ahmad (2014)[78]	Emotion Regulation Questionnaire	Psychological distress (DASS)	E	+++	The patient group demonstrated reduced cognitive reappraisal, which was also associated with reduced cognitive flexibility.
Functional neurological symptoms (19) & healthy controls (19)	Kienle et al. (2018) [137]	Emotion Regulation Questionnaire	Functional neurological symptoms (SDQ-20), psychological strain (SCL 90R)	E	++	Patients reported less of a tendency to use cognitive reappraisal than controls.

Tension-type headache (105) & healthy controls	Yucel et al. (2002) [138]	Automatic Thoughts Scale	Depression (BDI), assertiveness (RAS)	CC	+++	Patients had more frequent automatic negative thoughts, which were associated with higher depression scores. Chronic tension-type headache patients had more depression and negative automatic thoughts than episodic tension-type headache patients.
Irritable bowel syndrome (14) & healthy controls (14)	Kilkens, Honig, van Nieuwen-hoven, Riedel, & Brummer (2004) [155]	Affective Memory Performance Test	Experimental reduction of serotonin, visceral sensitivity, psychological functioning (HAMD, SCL-90, HADS)	E	+++	The reduction in serotonin synthesis caused impaired recall of positive words, but not of negative and neutral words in both patients and controls. The reduction of serotonin synthesis also increased pain and the urge to defecate and lowered the perceptual threshold.
Functional dyspepsia (43) & healthy controls (43)	Mazaheri et al. (2016) [136]	Cognitive Emotion Regulation Questionnaire, Positive reappraisal, Rumination and Other-blame Subscales	Rome III Interview	CC	++	Patients reported less frequent use of positive reappraisal, but more use of rumination and other-blame compared to healthy controls.

[1]Quality of the studies was rated with +, ++, or +++ when 25–49%, 50–79%, or 80% or more of the criteria were rated with "yes."

[2] The two article findings are based on the same sample data.

Abbreviations of the study designs

CS: Cross Sectional, **CC:** Case Control, **E:** Experimental, **L:** Longitudinal, **I:** Intervention/psychotherapy study

Abbreviations of the symptom measures & paradigms

BAI: Beck Anxiety Inventory, **BDI:** Beck Depression Inventory, **BSI:** The Brief Symptom Inventory, **CAS:** Colored Analog Scale, **CES-D:** Center for Epidemiology Studies-Depression Scale, CFQ: The Chalder Fatigue Questionnaire, **CPQ:** Chronic Pain Questionnaire, **CSDL:** Checklist for Symptoms in Daily Life, **CSQ:** The Coping Strategies Questionnaire, **DAS:** The Dyadic Adjustment Scale, **DASS:** Depression, Anxiety and Stress Symptoms, **DES:** Dissociative Experiences Scale, **DFI:** Disruption of Functioning Index, **FABQ:** Fear-Avoidance Belief Questionnaire, **FIQ:** The Fibromyalgia Impact Questionnaire, **FBL:** Freiburger Beschwerdeliste-Revised, **GSRS:** Gastrointestinal Symptom Rating Scale, **GAD:** Generalized Anxiety Disorder Questionnaire, **HADS:** Hospital Anxiety and Depression Scale, **HAM-A & -D:** Hamilton Rating Scale for Depression & Anxiety, **MADRS:** Montgomery and Asberg Depression Rating Scale, **MASC:** Movie for the Assessment of Social Cognition, **MINI:** Mini International Neuropsychiatric Interview, **MPI:** Multidimensional Pain Inventory, **MPQ:** McGill Pain Questionnaire, **MSS:** Mental States Stories Test , **NEO-FFI:** NEO Five-Factor

Personality Inventory, **NPRS:** Numerical Pain Rating Scale, **ODQ:** Oswestry Disability Questionnaire, **PANAS:** Positive and Negative Affect Scale, **PCS:** The Pain Catastrophizing Scale, **PHQ:** The Patient Health Questionnaire, **PSBS:** Perfectionistic Self-belief Scales, **RAS:** Rathus Assertiveness Schedule, RGQ: The Roles and Goals Questionnaire, **RSQ:** Responses to Stress Questionnaire, **QOLI:** Quality of Life Inventory, **SAS:** Somatosensory Amplification Scale, **SCID:** Structured Clinical Interview for Personality Disorders, **SCL-90:** Symptom Checklist-90, **SDQ:** Somatoform Dissociation Questionnaire, **SF:** Short form Health Survey, **SOMS:** Screening for Somatoform Disorders, **STAI:** State Trait Anxiety Inventory, **WHOQOL–BRE:** World Health Organization Quality of Life Scale-brief, **YSQ:** Young Schema Questionnaire

4. Discussion

Different models and approaches to chronic somatic symptom distress agree on the central role of affective processes in the maintenance of this condition (see the reviews from [24,139]). This present review aimed at systematically investigating the existing literature with regard to the question, how patients with somatic symptom and related disorders (SSD) regulate their emotions. This was intended by 1) assessing which ER processes in SSD were examined in the body of literature, 2) scrutinizing whether relationships between ER processes, and somatic and psychological symptoms in SSD could be established and 3) whether these ER processes differ between patients with SSD, healthy controls and patients with other mental or physical disorders and finally, 4) by a comprehensive description of the characteristic ER processes of patients with SSD. Although there is a vast amount of research that has examined facets of emotion regulation in patients with SSD, to our knowledge none of the previous studies have synthesized the findings systematically. A potential reason for such a gap might be the challenge of bringing two complex and interdisciplinary concepts together: emotion regulation and SSD [10,140]. In fact, the present review ended up with diverse diagnoses and ER constructs as a consequence of the various different terms and measurement methods.

With regards to the quality of the studies, the majority met the criteria for a moderate and about thirty percent for a good quality of methods. That indicates a relatively reliable quality to have confidence in the results. Moreover, the good and moderate quality studies did not diverge in their findings and interpretations regarding the association between ER and SSD. The most commonly observed limitation was the lack of consecutive sampling, which can be explained by the difficulties in reaching patients. Almost two thirds of the studies used established diagnostic labels, and one third used broadly defined diagnoses, reflecting the disagreements in classification of SSD.

In order to summarize and synthesize the findings, we categorized the studies based on the ER constituent predominantly targeted (attention, body, or knowledge) [52]. By doing so, we sought to understand the involvement and interaction of each modality in the disturbances of emotion regulation in SSD, rather than tackling numerous ER constructs elusive to other disciplines. Such an approach promises a more precise and dynamic understanding of the patterns of emotion regulation associated with SSD, which can inform the existing theories of SSD. It thus offers a mutually comprehensible and fertile language to promote further research and an interdisciplinary bridge among disciplines handling SSD and emotion regulation (psychology, various fields of medicine, and neuropsychobiology) [41,50]. Although it would go beyond the scope of this review to finally decide on theoretical drawbacks of the conceptual distinction, a potential overlap of multiple modalities should be carefully dealt with. A combination of theory- and empirical-based approach would be useful to determine the primarily regulated emotion component.

The findings of the present review provided insightful contributions for understanding the ER processes of patients suffering from SSD in a number of ways. The findings confirm that patients with SSD encounter ER difficulties. Of particular note, the literature has quite consistently shown patients' dysfunctional knowledge-oriented ER, such as reduced capacity of emotional awareness or emotion recognition. It was suggested that patients' difficulties in emotional awareness might be related to their restricted ability to mentally represent emotional experiences and in higher-order cognitive-emotional processing. It was also shown that patients experience disturbances in the body- and attention-oriented ER forms, such as autonomic aberrance, muscle reactivity, negative emotional expressions, and attentional rigidity. It is also essential to draw attention to the differences between self-report and observational studies. Although patients reported to suppress their emotions to a greater extent, majority of the observational studies showed that they are actually more expressive of negative emotions, especially through bodily behavior.

It also appears noteworthy that patients suffering from different SSD, such as bodily pain, fatigue, organ-specific, functional-neurological, or gastrointestinal symptoms, presented similar ER difficulties. Disturbances such as reduced emotional awareness and reflection capacity, rigid emotional attention, or aberrant autonomic activity were shared by many different diagnoses and types of SSD. These findings are consistent with the previous research that pointed out similar non-symptom characteristics and affective difficulties shared by various diagnoses of SSD [8,13,141]. Similar ER difficulties between different diagnoses support the new DSM-5 approach to somatic symptom disorders. Despite having distinct semiology associated with the functioning of certain organs or tissues, these disorders may have ER as a common factor, which may contribute to the development or course of the disorder. It should be also kept in mind that comorbidity with other mental disorders, such as depression or anxiety might also mediate the relationship between ER and different forms of SSD. In fact, as shown in a previous study, the patient group with only medically unexplained symptoms (MUS) showed higher skills in ER compared to MUS-patients with comorbid depression and anxiety [116]. These findings can be complemented by the view that even these mental disorders may reflect rater dimensional and variably interdependent constructs than clearly distinguishable disorder entities [63].

Furthermore, experimental and diary studies lend some support to a causal role of disturbances in ER in the development and course of somatic symptoms. These studies showed that patients' ER processes predicted and exacerbated their observed and reported somatic symptoms during experimental manipulation [80,95,97,115] or in due course [90,95,142]. Furthermore, disturbances in ER were more pronounced among patients with "medically unexplained symptoms" than among those with "medically explained" ones [25,31,94,122]. Such a difference between the two groups rules out a temporal hypothesis claiming disturbances in ER as a mere outcome of bodily distress.

The findings revealed a characteristic pattern of ER in patients with SSD. Knowledge-oriented regulation of emotions, which is related to how emotions are evaluated, made sense of, and experienced at the conscious level, seemed to be restricted in patients. The findings indicated a reduced engagement of higher-order cognitive functions with one's own and others' emotions, such as reduced capacities for emotional awareness, emotion recognition, and emotional theory of mind. On the other hand, studies on attention-oriented ER pointed out patients' difficulty in disengaging their attention from the emotional material. This finding was especially supported by rather automatic attentional regulation of emotions, as measured by the Emotional Stroop test [143,144] or the *Goals* Subscale of the DERS questionnaire [82]. Patients' bodily-oriented ER processes seemed to be concordant with the automatic attentional bias towards emotional stimuli shown in the patients. Vigilant physiological reactivity was shown by higher sympathetic activity and startle responses and difficulty in down-regulation of these parameters. The patients also presented increased impulsive behavior and negative expressions when emotionally distressed. Overall, the results suggest a course of emotion regulation among emotion components that proceed discordantly from each other. Attentional bias towards emotions and correspondingly vigilant and reactive autonomic functions, however, constrained conscious evaluation and reflection about emotions.

The relationship between somatic symptoms and discordant emotional processing through attentional, higher cognitive (knowledge), and bodily modalities was also supported by recent neuroimaging studies. Although the early research goes back to MacLean [145], only in the last two decades has this connection received attention once again. Currently, increasing findings converge to show that disintegrated processing of emotions between higher-order and subcortical structures play a role in dysregulated autonomic, immune, and HPA functioning and contribute to chronic somatic symptom [36,60,146].

The findings of this review, supported by the recent developments in neuroscience, contribute to current progress in science by moving beyond body–mind separation for understanding SSD. The results call for integrating holistic and embodied models of emotion-regulation interventions for the treatment of SSD. Treatment models working on regulation of attentional, knowledge, and bodily modalities of emotional process that go hand-in-hand can be of help. For example, in departments of psychosomatic medicine in Germany, integrative care involves body-based therapies (e.g., dance and movement therapy, Feldenkreis), creative psychotherapies (music, art), and physiotherapy, in addition to the usual individual and group psychotherapies, and these demonstrate to be effective [147]. Mindfulness-based psychotherapy that promotes mindful and non-judgmental attention to emotions [148], emotional awareness and expression therapies [119,149] have also shown patient improvement in emotion regulation and somatic symptoms. Similarly, biofeedback training aiming at altering automatic attentional and bodily processing in response to distressing stimuli might be useful. Moreover, as shown by Leong and colleagues [107] and Burns and colleagues [92] interpersonal problems associated with patients' disturbed ER might exacerbate their distress and symptoms. Therefore, it is highly recommended that examination and intervention related to interpersonal ER should be an integral part of dealing with chronic SSD.

4.1 Limitations and Future Directions

Some limitations appeared regarding the methodology and focus of the reviewed studies. Firstly, there is a scarcity of longitudinal designs, randomized controlled trials, experiments, and diary studies suited to investigate the short- and long-term causal relationship between ER and SSD. Although we could find some support for the role of ER in development of SSD, the literature is sparse and the causal mechanisms through which ER might contribute to SSD are not clear. Secondly, the measurement of ER processes is usually based on patient self-reports measured by very different questionnaires. However, assessing emotional reflection ability based on patients' self-judgments, which are presumably disturbed, raises an inherent contradiction, which limits the validity of the findings. In fact, self-evaluations of emotional reflection and non-self-reports might measure two different things, such as explicit (conscious) and implicit (unconscious) emotional processes [150]. Thirdly, ER targeted at body and attention has received less consideration in comparison to knowledge-oriented emotion regulation. This seems to present an additional paradox when one considers the phylogenetic and ontogenetic precedence [151] of these processes, which play fundamental roles in neurovisceral communication during ER [67]. Next, although emotion regulation is constituted and maintained by social interactions, there is a substantial lack of studies that consider the interpersonal aspects of ER in SSD. Finally, when drawing conclusions, one should take into account the publication bias towards positive results. The complex relationship between cognitive, emotional, and bodily processes of an organism embedded in its social and biological environment should be underlined. Refraining from reducing the etiology mainly to ER and psychological processes and acknowledging the role of whole biopsychosocial factors would pave the way for a better understanding of SSD.

We also acknowledge some limitations of our present review. Firstly, due to the breadth of our qualitative study goals and the heterogeneity of the reviewed studies, we did not compare the effect size of the findings. Future studies can overcome this limitation by narrowing down the specific pathways of attention-, body-, and knowledge-oriented emotion regulation. We recommend a further systematic review that statistically synthesizes the findings for the three primary ER modalities, aimed at a path analysis for prediction of SSD. Secondly, we narrowed down our emotion-related search terms only to “emotion/al regulation” and “affect regulation” but not included related search terms, such as cognitive coping, stress regulation. This might have led to missing some relevant papers that have examined emotion processing, emotional awareness, emotion recognition, cognitive emotion regulation, etc. Although these processes are accepted as regulatory by several models [41,46] including such related search terms is beyond the goals of the present manuscript, which primarily concerns investigating several diagnostic search terms considered as SSD. Thirdly, although we initially classified the studies based on objective measures (i.e., examined ER variables and diagnoses), in order to understand the mechanisms of ER in SSD, we additionally organized the studies based on components of ER, which is not an empirically established classification system. Potential drawbacks, such as overlap of multiple ER components might come into question; although it is usually the case that one distinct emotion component is primarily regulated. As a measure to this potential pitfall, we implemented a systematic method based on a combination of theory- and empirical-based approach (see the method section on organization of the studies). In addition to relying on previous studies` classification systems, we examined each item of the questionnaires, and instructions/procedures of the experiments, in order to determine the primarily examined components of ER. Fourthly, it should be kept in mind, that the studies, which examined attentional and bodily processes through questionnaires, in fact capture information about the explicit knowledge about these processes, rather than the processes themselves. This fact might result in differences in the findings of behavioral and self-report studies. In this present study, such a difference between behavioral and self-report measures was only observed in emotional expression studies. Fifthly, despite the role of feeling tone in providing a person with qualia of emotional experience, we did not include it in our analysis as it entails another corpus of extensive literature. Especially use of qualitative methods offers the potential to examine patients' subjective affective experiences and regulation. Another limitation that should be noted is that quality appraisal items were not weighted in terms of their importance when computing a total score of quality. Finally, we only included articles in English language, which might have resulted in exclusion of valuable information coming from studies in other languages.

In conclusion, the present systematic review supported the association between ER processes and SSD. ER processes and SSD diagnoses being studied are heterogeneous. Overall, the results showed a characteristic pattern of ER in SSD, which can be distinguished by differential processing of ER constituents. More specifically, patients with SSD encounter difficulties in flexibly disengaging their (spontaneous) attention from emotional material. Comparably, bodily constituents of ER also depict an over-reactive pattern, characterized by vigilant autonomic nervous system activity, startle response, impulsive behavior, and negative emotional expressions. On the other hand, at the knowledge level, patients tend to disengage from emotional information, such as reduced identification and awareness of emotions or emotion recognition. Future research should empirically test the role of simultaneous interaction of each ER modality in SSD.

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6. Appendices

6.1 Appendix A. Prisma checklist

Section/topic	#	Checklist item	Reported on page # of the article
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title Page
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3-8
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	8-9
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	-
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	9-11
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	9
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	9 & Appendix B

Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	10-11 & “S4 Fig”
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	10
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	9, 12-14
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	14-15 & “S5 Table”
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	NA
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	13-14

Page 1 of 2

Section/topic	#	Checklist item	Reported on page # of the article
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	NA
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	-
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	S4 Fig.
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	“S6-S10 Tables”
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	“S5 Table”
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	“S8-S10 Tables”
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	16-59

Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	NA
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	-
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	35-40
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	40-42
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	42
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Title page

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

6.2 Appendix B. Search terms for somatic symptom and related disorders in the databases PubMed and PsycINFO

somatoform disorder OR somatiz* OR somatis* OR conversion disorder* OR multisomatoform OR medically unexplained* OR organically unexplained* OR psychogenic OR nonorganic OR psychosomatic syndrom* OR functional somatic syndrom* OR functional syndrom* OR functional disorder* OR functional illness* OR functional symptom* OR irritable bowel* OR functional bowel* OR functional gastrointestinal* OR functional dyspepsia* OR nonulcer dyspepsia* OR food intolerance* OR fibromyalgia* OR chronic widespread pain* OR widespread musculoskeletal pain* OR myofascial pain syndrome* OR tension-type headache* OR chronic pain* OR atypical chest pain* OR nonspecific chest pain* OR non-specific chest pain* OR atypical face pain* OR facial pain* OR chronic low back pain* OR back pain* OR panalges* OR (psychogen* AND pain) OR idiopathic pain* OR idiopathic pain disorder* OR fatigue/*psychology OR chronic fatigue syndrome* OR Fatigue Syndrome, Chronic* OR myalgic encephalomyelitis* OR myalgic encephalopathy* OR chronic epstein barr virus* OR chronic mononucleosis* OR chronic infectious mononucleosis like syndrome* OR chronic fatigue and immune dysfunction syndrome* OR effort syndrome* OR low natural killer cell syndrome* OR neuromyasthenia OR post viral fatigue syndrome* OR postviral fatigue syndrome* OR post viral syndrome* OR postviral syndrome* OR post infectious fatigue* OR postinfectious fatigue* OR royal free disease* OR royal free epidemic* OR *royal free hospital disease* OR chronic lyme disease* OR candida hypersensitivity* OR candida syndrome* OR (mitral valve prolapse* AND psychology) OR hypoglycaemia/*psychology OR sleep disorder/*psychology OR nonorganic Insomnia* OR Multiple chemical sensitivit* OR idiopathic environmental intolerance* OR electromagnetic hypersensitivity OR electrohypersensitivity OR electrosensitiv* OR IEI-EMF OR environmental illness* OR Sick Building Syndrome* OR Persian gulf syndrome OR Amalgam hypersensitivity* OR Dental Amalgam/*toxicity OR dental amalgam/*adverse effects OR silicone breast implant* OR implant intolerance* OR burning mouth* OR glossalg* OR glossodyn* OR glossopyr* OR bruxism OR temporomandibular joint disorder* OR temporomandibular disorder* OR temporomandibular joint dysfunction* OR temporomandibular joint dysfunction* OR craniomandibular disorder* OR atypical odontalgia* OR prosthesis intolerance* OR (psychogen* AND gagging) OR chronic rhinopharyngitis* OR globus syndrome* OR globus hystericus* OR hyperventilation syndrome* OR dysphonia OR aphonia OR Vertigo OR

Dizziness OR repetitive strain injury *OR chronic whiplash syndrome* OR tension headache OR pseudoseizures OR hysterical seizures* OR (psychogen* AND dystonia) OR (psychogen* AND dysphagia) OR functional micturition disorder* OR functional urinary disorder* OR urethral syndrome* OR micturition dysfunction* OR (urinary retention* AND (psychogen* or psychology)) OR irritable bladder* OR painful bladder syndrome* OR interstitial cystitis* OR enuresis diurnal et nocturnal* OR anogenital syndrome* OR sexual dysfunction* OR chronic pelvic pain* OR (skin disease* AND (psychology or psychogen*)) OR (pruritus AND (psychology or psychogen* or somatoform)) OR culture-bound disorder* OR ((reduced OR impaired) AND well-being

6.3 Appendix C. References for emotion regulation measures used in the reviewed studies

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Chapter III: Assessing embodied interpersonal emotion regulation in somatic symptom disorders: A case study[2]

Abstract

The present study aimed to examine the intra- and interpersonal emotion regulation in patients with Somatic Symptom Disorders (SSD) during interactions with significant others (i.e., romantic partners). We presented two case couples for analysis. The first couple consisted of a patient with SSD and his healthy partner, while the second consisted of two healthy partners. The couples underwent an interpersonal experiment that involved baseline, anger, and relaxation tasks. The partners' cutaneous facial temperature, heart rate, and skin conductance levels were simultaneously measured during each task. Participants' trait-emotion regulation, state-affect reports for self and other, and attachment styles were also examined. The experimental phases successfully created variations in physiological processes and affective experience. As expected, emotion regulation difficulties predicted a higher increase in the temperature course at each phase. Besides, the patient showed restricted awareness and reflection of emotions despite his greater autonomic activity than healthy controls. Both partners of the first couple revealed limited ability in understanding the other's emotions, whereas the second couple performed relatively better in that domain. The temperature variations between the patient and his partner were significantly correlated, while the correlations of temperature changes between the second couple were negligible except anger task. The study supported the merits of an embodied interpersonal approach in clinical studies. The tentative results of the cases were discussed in light of findings in emotion regulation and attachment research.

Keywords: anger, embodiment, emotion regulation, interpersonal interactions, somatic symptom disorders, relaxation**.**

[2] This study was published, in a slightly modified form, as Güney, Z. O., Sattel H., Cardone, D., & Merla, A. (2015). Assessing embodied interpersonal emotion regulation in somatic symptom disorders: A case study. *Frontiers in Psychology, 6*(68). doi: 10.3389/fpsyg.2015.00068, Section Cognitive Science. The paper was reviewed by Timo Partonen, National Institute for Health and Welfare, Finland; Patrick Luyten, University of Leuven, Belgium; Claudia Subic-Wrana, University Medical Center of Johannes Gutenberg University Mainz, Germany. The paper was written by Okur Güney (first author) and co-authored by Heribert Sattel, Daniela Cardone, and Arcangelo Merla.

1. Introduction

Somatic symptom disorder (SSD) is characterized by persistent bodily disturbances, which cause severe impairment in patients' daily life (American Psychiatric Association, 2013). Excessive and dysfunctional thoughts, affects, behaviors, or health concerns accompany the symptoms. Psychological factors contribute to the development, course, and treatment of these disorders (Henningsen et al., 2003; Sattel et al., 2012). The overlap of multiple somatic symptoms, comorbidity with psychiatric and psychosocial disturbances, absence of clear diagnoses, and ineffective treatments make SSD difficult to treat and costly for society (Wessely et al., 1999; Henningsen et al., 2007). Such an overlap of multiple physical and psychological symptoms renders SSD neither purely physical nor mental but truly psychosomatic (Wessely et al., 1999; Henningsen et al., 2007).

An increasing number of studies highlight the presence of emotion regulation disturbances in SSD, such as emotion suppression (Burns et al., 2011; Gul and Ahmad, 2014), rumination, catastrophizing (Hadjistavropoulos and Craig, 1994; Garland et al., 2011), decreased ability to up-regulate positive emotions (Zautra et al., 2001), imbalance in physiological arousal (Pollatos et al., 2011a, b), and diminished emotional awareness (Waller and Scheidt, 2004; Subic-Wrana et al., 2010) and emotion recognition (Beck et al., 2013). In addition, difficult transference and countertransference in psychotherapy related to patients' resistance to experience emotions were reported (Yasky et al., 2013).

1.1 Coherence between emotion response systems in SSD

Theories that explain the nature and development of SSD have emphasized the role of emotion regulation disturbances (see Waller and Scheidt, 2006 for a review of the affect regulation models). For example, early psychodynamic theories depicted somatic symptoms as defenses of the unconscious unresolved affective conflicts (Freud, 1961). Alexander (1950), one of the founders of psychosomatic medicine, posited that if affect-related physiological arousal is not realized into action, in time, it is experienced as disturbing physiological states. Deficits in symbolic affect representation, such as limited emotional awareness and ability to reflect on and describe emotions (i.e., alexithymia), were identified as typical to SSD (Sifneos, 1973; De Gucht and Heiser, 2003; Subic-Wrana et al., 2010). Similarly, an impaired integration of symbolic (i.e., language, imagery) and subsymbolic emotion schemas (i.e., sensory, somatic, and motoric forms) was asserted to feature SSD (Bucci, 1997). Attachment theories also point to the disequilibrium among stress regulating networks associated with insecure attachment style (Luyten et al., 2012). It is posited that having internalized certain dysfunctional attachment patterns and regulation strategies, patients with SSD tend to regulate stress by employing these strategies later in life. This may lead to an imbalance between stress response networks, which are associated with impairments in patients' ability of embodied mentalization (i.e., understanding one's own and others' feelings and intentions, and linking these internal processes with the body; Luyten et al., 2012).

The theoretical models mentioned above, and existing empirical research imply a pattern of emotion regulation in SSD, characterized by incoherence between emotion constituents. Supporting the postulation of incoherent emotional processing, a systematic review on emotion regulation in SSD (Okur Güney et al., 2019) revealed that patients with SSD tend to detach from the emotion by disengaging the cognitive-behavioral components of emotion from the emotional perturbations. For instance, patients were shown to have higher levels of alexithymia and reduced ability in emotion recognition and affective theory of mind (Subic-Wrana et al., 2010; Beck et al., 2013; Castelli et al., 2013; Haas et al., 2013; Stonington et al., 2013). On the other hand, the few available studies having examined somatic components of emotions demonstrated aberrant or vigilant somatic reactivity, such as greater startle responses, paraspinal muscle reactivity, sympathetic activity, or stress sensitivity in SSD (Seignourel et al., 2007; Burns et al., 2008; Twiss et al., 2009; Luyten et al., 2011; Pollatos et al., 2011a,b).

Emotion theories generally agree that the emotion response system has multiple components coordinating (Hollenstein and Lanteigne, 2014). The concordance among these physiological, behavioral, and experiential response systems, which facilitates adaptive and coordinated responses as the emotion unfolds over time, is described as emotional coherence (Mauss et al., 2005). Although almost all emotion theories agree on some degree of coherence between the emotion response systems, empirical studies show mixed findings (Mauss et al., 2005; Hollenstein and Lanteigne, 2014). Several theoretical and methodological issues related to emotional coherence were recently addressed in a special issue (Hollenstein and Lanteigne, 2014). It was argued that the inconsistent findings might be related to methodological errors, such as non-correspondent timing or modulation of concordance by individual differences, such as emotion regulation (Mauss et al., 2005; Butler et al., 2014; Hollenstein and Lanteigne, 2014). When taking precautions against these confounding factors, the authors could show moderate to high coherence among emotion response systems.

We also argue that, since the emotional process is a continuous, inseparable regulating and regulated system (Davidson, 1998; Kappas, 2011), a person’s own emotion regulation patterns constantly influence the emotional coherence. Therefore, it is probable that the level of coherence would vary between people having distinct patterns of emotion regulation, as would be the case in patients with SSD. A couple of studies have supported the effect of emotion regulation on coherence. For example, a study comparing participants with different body awareness levels showed that experienced Vipassana meditators (depicting awareness of visceral sensations) had the highest coherence between physiological changes and subjective experience. This was followed by experienced dancers (depicting awareness of somatic sensations) and then controls with no experience of bodily exercises (Sze et al., 2010). Deliberately employed emotion regulation strategies affect coherence as well. Emotion suppression decreased the coherence between physiological, behavioral, and experiential subsystems, although acceptance of emotions did not (Dan-Glauser and Gross, 2013). Lending support to these findings, reappraisal was reported to increase the coherence for positive emotions but decrease it for the negative ones (Butler et al., 2014).

1.2 Interpersonal emotional processes in SSD

Interpersonal factors, which play a role in the development of emotion regulation disturbances in SSD, continue to trigger and maintain the psychosomatic symptoms later in life. There is quite a consensus on the role of interpersonal interactions, attachment, and trauma history in the dysregulated affect of SSD that is linked to alterations in the endocrine, immune, and pain regulating systems (Henningsen, 2003; Luyten et al., 2013). Lending support to this linkage, a shared neural system for social pain, such as rejection, exclusion or loss, and physical pain is acknowledged (Kross et al., 2011; Eisenberger, 2012; Landa et al., 2012).

In the developmental history of SSD, an “emotional avoidance culture” with significant adults was described, which was associated with patients’ disconnection of awareness from stress reactions in the body (Bondo-Lind et al., 2014). Besides, insecure attachment history and related impairments in emotion regulation between the caregiver and child, such as non-expression of emotions, are commonly reported in SSD (Waller and Scheidt, 2006). Patients with SSD were reported to regulate stress by deactivating or hyper activating their early attachment strategies later in life that have adverse metabolic and interpersonal consequences (Luyten et al., 2012). For example, denial of attachment needs (Luyten et al., 2012), minimization of affective experience or expression (Waller and Scheidt, 2004) or impaired embodied mentalization (Luyten et al., 2012) as well as overexpression of negative affect concerning bodily complaints and clinging behavior (Waller and Scheidt, 2006) can govern the interpersonal interactions of the patients. These dysfunctional strategies, in turn, can generate a vicious cycle of further interpersonal distress, exacerbation of the symptoms, and additional stress and symptoms (Luyten et al., 2012). Such regulation strategies can be linked to incoherence among emotion response systems. For example, in participants with high avoidant attachment, discordance between psychological and endocrine stress measures was found. However, these measures were significantly correlated in participants with low avoidant attachment (Ditzen et al., 2008).

Although there are studies that examined the perceived social interactions with significant others in SSD, there is scarce literature on how ongoing affects during patients' interaction with significant others are co-regulated. Self-report studies have shown unsupportive and incohesive family environment, conflicts in a marital relationship (Mullins and Olson, 1990), frustration and helplessness of physicians, and rejecting behavior from significant others (Stuart and Noyes, 1999). A few available studies focusing on the dynamic interaction between couples have shown that interpersonal emotion regulation processes, such as validation or invalidation of a partner's affective experience, has predictive roles on the experience of pain (Cano et al., 2008; Leong et al., 2011). A psychotherapy study has also demonstrated how affective experience of patients and therapists influence each other, ensuing in an increased expression of negative affect (Merten and Brunnhuber, 2004).

We believe that studies from social cognition and developmental research on intersubjectivity can provide insight to clinical research by introducing the constitutive elements of a social interaction, such as coordination or reciprocity. It is highlighted that the process of social interaction cannot be sufficiently grasped by examining the mere static interaction of individual elements since social interactions possess dynamic features, such as self-organization and autonomy (Di Paolo and De Jaegher, 2012). In line with such developments in social cognition, emotion regulation research has integrated the dynamic parameters of interpersonal interactions, such as emotion contagion, reciprocity, coupling, synchronicity, or co-regulation, which describe the temporal emotional exchange and covariation between persons (Butler, 2011). These aspects can also uncover implicit emotion regulation patterns, described as processes operating free of conscious supervision (Koole and Rothermund, 2011).

1.3 Aims of the study

We know little on the dynamic coordination of physiological, experiential, and behavioral emotion response systems in patients with SSD at individual and dyad levels. This case study aims to outline a methodology to examine the dynamic relationship between affective experience, autonomic activity, and trait emotion regulation at intra- and inter-personal levels during emotional interaction of dyads. Such a paradigm would facilitate incorporating the embodied, dynamic and interpersonal approach to emotions into psychosomatic research and help better understand the mechanisms of SSD.

Based on the previous findings concerning the potential effects of emotion regulation on coherence between emotion response systems (Butler et al., 2014; Dan-Glauser and Gross, 2013; Sze et al., 2010), we argue that emotion regulation patterns, which patients with SSD unconsciously or deliberately deploy, might affect the coherence between emotional constituents. We predict that an incoherence in the emotional process characterizes the regulation patterns of patients with SSD, moderated by attachment and trait emotion regulation styles. This incoherent process is described by cognitive disengagement from the emotional perturbations, but greater physiological stress responses marked by higher activity or vigilance at the somatic components of emotion. Our proposed assessment of intrapersonal emotional incoherence relies on the extent of discrepancy between emotional responses, which is manifested by restricted expression of and reflection on emotions, yet an aberrant and reactive sympathetic nervous system response.

In the context of the recent developments in social cognition and emotion research, we also inquire how affect dysregulation occurs during interactions of patients with SSD with significant others (i.e., romantic partner). We propose that: (1) Intrapersonal emotional incoherence in SSD is more likely to be reciprocated by an emotional incoherence in the interaction partner. This may leave the affective exchange dysregulated and generate a system of incoherent interpersonal emotional processing. This persisting dysregulated affect at intra- and interpersonal levels might exacerbate bodily disturbances. Here, we define interpersonal emotional coherence as the correlation between interaction partners' physiological and subjective affective response systems. (2) The parameters of autonomic nervous system activity (heart rate, facial temperature, and skin conductance levels) will be less concordant during emotional interactions between dyads with SSD than healthy control dyads. This concordance will be moderated by the partners' attachment and trait emotion regulation styles.

We deemed it necessary to employ a paradigm involving real-time dyadic emotional interaction tasks (i.e., a dyadic stress interview paradigm) that allows the measurement of temporal affective exchange between persons. A baseline interpersonal task without emotional manipulation would enable the comparison between different affective states and the acclimation of the participants to the experiment. Following that, an emotional interaction task that elicits a high level of arousal and negative valence, ensued by a relaxation task low in arousal and positive in valence, would permit us to examine the down- and up-regulation of emotions.

Concerning participants, comparing patient-healthy partner dyads with both healthy partner dyads would be helpful to understand the affective interaction patterns that may exacerbate the symptoms, such as the reciprocal nature of dysregulated affect. To provide homogeneity in the sample of the forthcoming study, we focused on SSD with predominant pain.

Anger was reported as both a particular predictor and outcome of chronic pain (Fernandez and Turk, 1995; Burns et al., 2008; van Middendorp et al., 2010). Patients' appraisals concerning the chronic experience of pain, together with persistent treatment failures and not being heard by significant others and health professionals, generate habitual anger in patients (Fernandez and Turk, 1995). Furthermore, high trait anger experience and suppressing anger were shown to exacerbate pain by activating the body's endocrine and muscular systems (Bruehl et al., 2007; Burns et al., 2011). Therefore, we chose anger as a central theme of the dyadic interaction task. In addition, dysfunctional regulation of positive affect was found as a distinctive feature of somatoform pain instead of "medically explained" pain (Zautra et al., 2001, 2005). In line with these findings, we aimed to examine the interplay of both downregulation of anger and up-regulation of positive affect in somatoform pain patients during interpersonal interactions. To activate the attachment styles that can arouse characteristic emotion regulation patterns, we included a significant person (i.e., romantic partner) as the interaction partner. To assess intra-personal emotional coherence and affective exchange, measures for multiple components of emotion, namely, state affect, trait emotion regulation and autonomic nervous system activity were included. Below, we demonstrate the two case studies that we conducted employing our proposed paradigm.

2. Materials and method

2.1 Participants

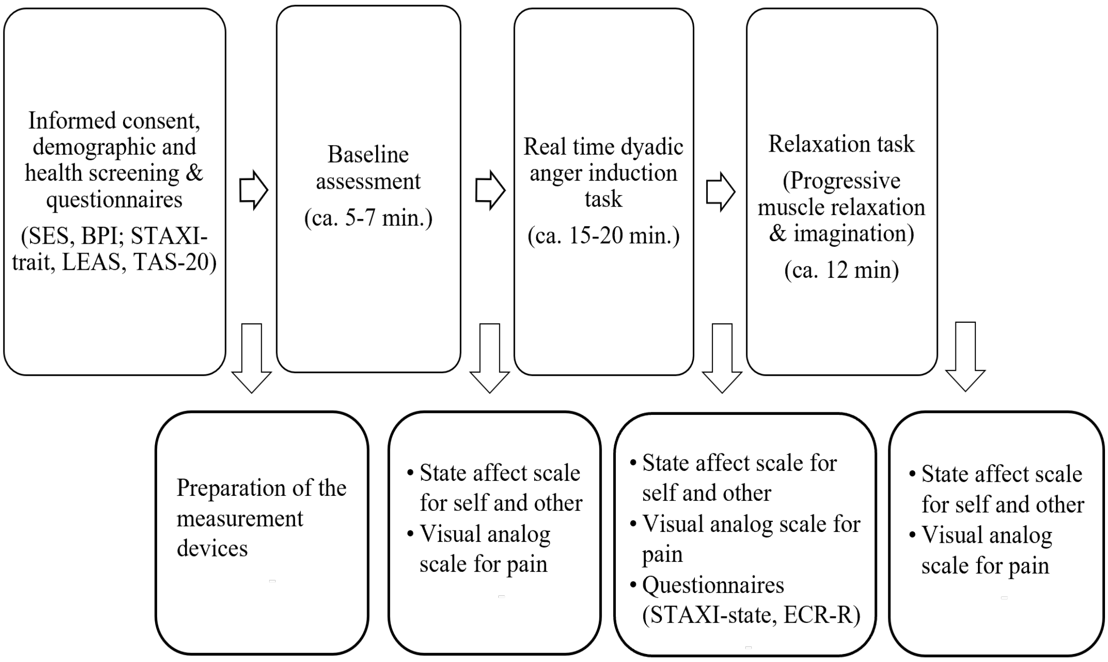
This study was approved by the Ethics Commission for the Faculty of Medicine of the Technical University of Munich (TUM). The first couple invited to participate in the study consisted of a 44 years-old patient with SSD and his partner (40 years-old). The patient was admitted to the Department of Psychosomatic Medicine at TUM and fulfilled the diagnostic criteria of persistent somatoform pain disorder (ICD-10 F45.40). As a comparison case, a healthy control couple (32 and 36 years old) reached through the internal communication network of TUM was recruited to the study.

2.2 Procedure

The experiment appointments were arranged by telephone interviews. In these interviews, participants were screened for any medical or psychological disturbance, as well as for the use of painkillers or any other medication, particularly for control purposes. Participants were asked not to take any stimulants (e.g., coffee, tea, nicotine) two hours before testing. Upon arrival at the laboratory, couples were given an oral and written briefing about the experiment, and informed consent was obtained. All participants were screened for medical and psychological health status, medication use, pain, or any received treatment with an anamnestic questionnaire. The control couple and the patient's partner did not report any health-related disturbances. Following the demographic and health screening, both partners filled in questionnaires on emotion regulation and pain experience. After that, participants were invited to the experiment room and prepared for the physiological measurement. Couples underwent three phases during the experiment that included emotionally varying interactions. A trained interviewer, blind to the study hypotheses, moderated the couple interactions. During the entire three phases of the experiment, video data and physiological responses of both partners were recorded. Immediately after each phase, participants reported on their affect and their perceptions of their partner's affect. In addition, after the dyadic anger induction task, participants were given questionnaires to assess attachment styles and state-anger (See Figure 1 for a schematic plan of the study process).

Figure 1

A schematic plan of the study process.



SES, Pain Experience Scale; BPI., Brief Pain Inventory; STAXI, Spielberger Anger Expression Inventory; LEAS, Level of Emotional Awareness Scale; TAS, Toronto Alexithymia Scale; ECR, Experiences in Close Relationship-Revised.

2.2.1 Emotion induction tasks

2.2.1.1 Baseline

For the baseline assessment, the interviewer facilitated a five to seven minutes dialog between couples about an emotionally neutral event, such as the trip to the lab, events of the day, or the weather as suggested by previous studies (Gottman and Levenson, 1999).

2.2.1.2 Real-time dyadic interaction phase for anger induction

Compared to other methods, such as movie clips or punishment tasks, interview methods have been shown to be more effective in eliciting emotions and creating physiological variations (Lobbestael et al., 2008). Furthermore, compared to other methods, such as showing participants pictures or videos, autobiographical recall and reliving past experiences are more effective in eliciting emotions, mainly because they are self-relevant (Ellsworth and Scherer, 2003; Kross et al., 2009). Therefore, the interview method was applied to elicit a dynamic emergence of anger in the couples. For this task, the couples were instructed to identify a mutual past event that generated a strong anger to each other, which could be well recalled for the experiment. One of the partners was asked to verbally describe the event. Then, both partners were invited to talk about the event, the nature of the stressor, and their thought and feelings as genuinely as possible (see Dimsdale et al., 1988). The interviews lasted between 15 and 20 minutes.

2.2.1.3 Relaxation phase

After the anger induction task, participants were instructed to extricate themselves from the negative state by pursuing an audio progressive-muscle relaxation and imagination exercise that lasted about twelve minutes.

2.3 Measures

2.3.1 Physiological recordings

Continuous thermal imaging recordings of the face and measures of heart rate (HR) and electrodermal activity were taken from each partner simultaneously during the entire phases of baseline, anger, and relaxation.

2.3.1.1 Thermal imaging

Thermal imaging is a contact-free method that records thermal infrared signals emitted from the skin to examine variations in the cutaneous temperature. This method is a non-invasive and robust way of measuring autonomic activity during emotional interactions (Ebisch et al., 2012; Ioannou et al., 2014). Thermal imaging was performed using two digital cameras: FLIR, SC660 (640 × 480 bolometer, FPA, sensitivity: <30 mK @ 30◦C), and FLIR SC655 (640 × 480 bolometer, FPA, sensitivity: <50 mK @ 30◦C). The cameras were positioned behind and just over each partner's head so that each camera could record the partner opposite to its position. The sampling rate was five frames/second. Variations in the cutaneous temperature of the facial regions of interest were analyzed using customized Matlab programs (http://www.mathworks.com). Our primary regions of interest, the nose, and the forehead, were selected based on previous studies in primates and humans (Merla and Romani, 2007). After the thermal imprints were inspected visually for the recording quality, the thermograms were corrected for movement artifacts.

2.3.1.2 Heart rate

Heart rate was assessed with a continuous electrocardiogram (ECG) recorded with Nexus-10 equipment (Biotrace, Mind Media BV). Signals were recorded (sampled at 256 Hz) and analyzed by the Biotrace software system. A three electrodes array for each partner, which simultaneously recorded the ECG of both, was used. One electrode was placed on the left and another on the right shoulder of the participant. The third electrode was placed on the left side, below the lead on the left shoulder, under the 10th rib. Before placing the electrode, the skin was cleaned to improve the quality of the signal. After the signal stabilization was achieved, data acquisition was registered. Following the data collection, the ECG data curves were visually inspected for possible movement artifacts, and no abnormalities were detected in any participant.

2.3.1.3 Skin conductance level (SCL)

Skin conductance level was recorded using the Nexus-10 device of Biotrace system, following the standard published guidelines (Boucsein, 2012). Velcro straps were attached to the II and III fingers of the participants' non-dominant hands. Before placing the electrode, the skin was scrubbed to improve the quality of the signal. After the signal stabilization was achieved, data acquisition was registered at a 32 Hz sample rate.

2.3.2 Subjective reports

Before the experiment, participants' trait emotion regulation was assessed by subjective measures of emotional awareness (Level of Emotional Awareness Scale, LEAS; Subic-Wrana et al., 2001), alexithymia (Toronto Alexithymia Scale-20, TAS-20; Bach et al., 1996), and anger regulation (Spielberger State-Trait Anger Expression Inventory, STAXI; Schwenkmezger et al., 1992). TAS is the most commonly used self-report measure of alexithymia, differentiating three areas of emotion regulation difficulties: difficulty identifying feelings, difficulty describing feelings, and externally oriented thinking. Despite being the best-validated instrument for alexithymia, its use may be biased due to its paradoxical reliance on patients' insight on their own ability of emotional self-reflection (Waller and Scheidt, 2004). On the other hand, LEAS is a performance-based instrument consisting of twenty emotion-eliciting scenarios where the subjects report how they and the other person in the scene would feel (Lane et al., 1990). The advantage of this scale is that it enables an assessment of both conscious and subconscious levels of awareness of both one's own (LEAS-self) and other's (LEAS-other) emotions (Subic-Wrana et al., 2014). This instrument was shown to be related to a capacity of mentalization, which reflects the ability to interpret one's own and others' feelings, thoughts, and intentions (Subic-Wrana et al., 2010).

Participants' experience of pain intensity and sensations was examined by the Brief Pain Inventory (BPI; Radbruch et al., 1999) and the Pain Experience Scale (SES; Geissner, 1995). To assess participants' affective experience and pain during each experimental phase, participants were given a scale for pain and affective experience immediately after each phase. This scale consisted of a visual analog scale for pain and a non-verbal, pictorial affective scale that assesses the pleasure, arousal, and dominance aspects of affect (Self-Assessment Manikin, SAM; Fischer et al., 2002). SAM was advocated to be a quick and more implicit way of measuring affective experience, mainly because it is a non-verbal cartoon-like graphical assessment of affect (Fischer et al., 2002). It has a nine-point scoring system for measuring pleasure (unhappy to happy), arousal (calm to excited), and dominance (controlled to controlling). Arousal describes the perceived vigilance as a psychological and physical state, while pleasure describes the positive or negative feelings. Dominance describes how much a person feels in control of a situation. In addition to SAM, right after the anger task, participants were given the state anger subscale of the STAXI, as well as the Experiences in Close Relationship Scale-Revised (ECR-R; Ehrenthal et al., 2009). ECR-R is a validated self-report instrument that assesses attachment anxiety and attachment avoidance in adults (Fraley et al., 2000). For all scales, validated German translations were used.

2.4 Data analysis procedure

For thermal imaging data, the temporal course of the temperature change was analysed. For heart rate and skin conductance levels, the arithmetic mean of the continuous data within each experimental phase was calculated.

Firstly, we tested whether experimental condition and participant status (i.e., patient, partner of the patient, and healthy controls) could predict the temporal change of the nose tip and forehead temperature. We applied hierarchical linear models with the experimental condition, participant status, and temporal course (i.e., number of frames) as fixed effects and the participant as a random factor (Singer, 1998). To model the specified characteristics of the temporal course for each participant, we added a condition $*$ temporal course $*$ participant interaction term to the model. Individual temperature changes were estimated by analyzing each participant separately, and slopes for each condition were computed. To compare slopes between the patient and healthy controls, confidence intervals of each slope were calculated.

We examined the effect of emotion regulation and anger regulation on thermal changes by including the scores of the corresponding questionnaires (i.e., LEAS, TAS-20, and STAXI) as covariates in the model. We tested the influence of these psychological measures by introducing them as fixed effects. Additionally, we included a condition ∗ course ∗ psychological measure interaction in the model to allow condition-specific analyses of their association with the temperature changes. Each psychological domain was tested separately to prevent possible effects due to multicollinearity. We did not include the attachment scores in the model due to missing data in Couple 1.

To examine the relationship between partners' facial temperature, based on a previous study (Ebisch et al., 2012), we performed Pearson correlation analyses for each condition.

To explore the coherence and relationship between emotion components, we descriptively analysed each participant's response in autonomic, subjective, and trait domains.

In the following sections, firstly, the results of the statistical analyses are presented. Following that, the results of heart rate, skin conductance levels, and subjective report measures are described in detail for each couple.

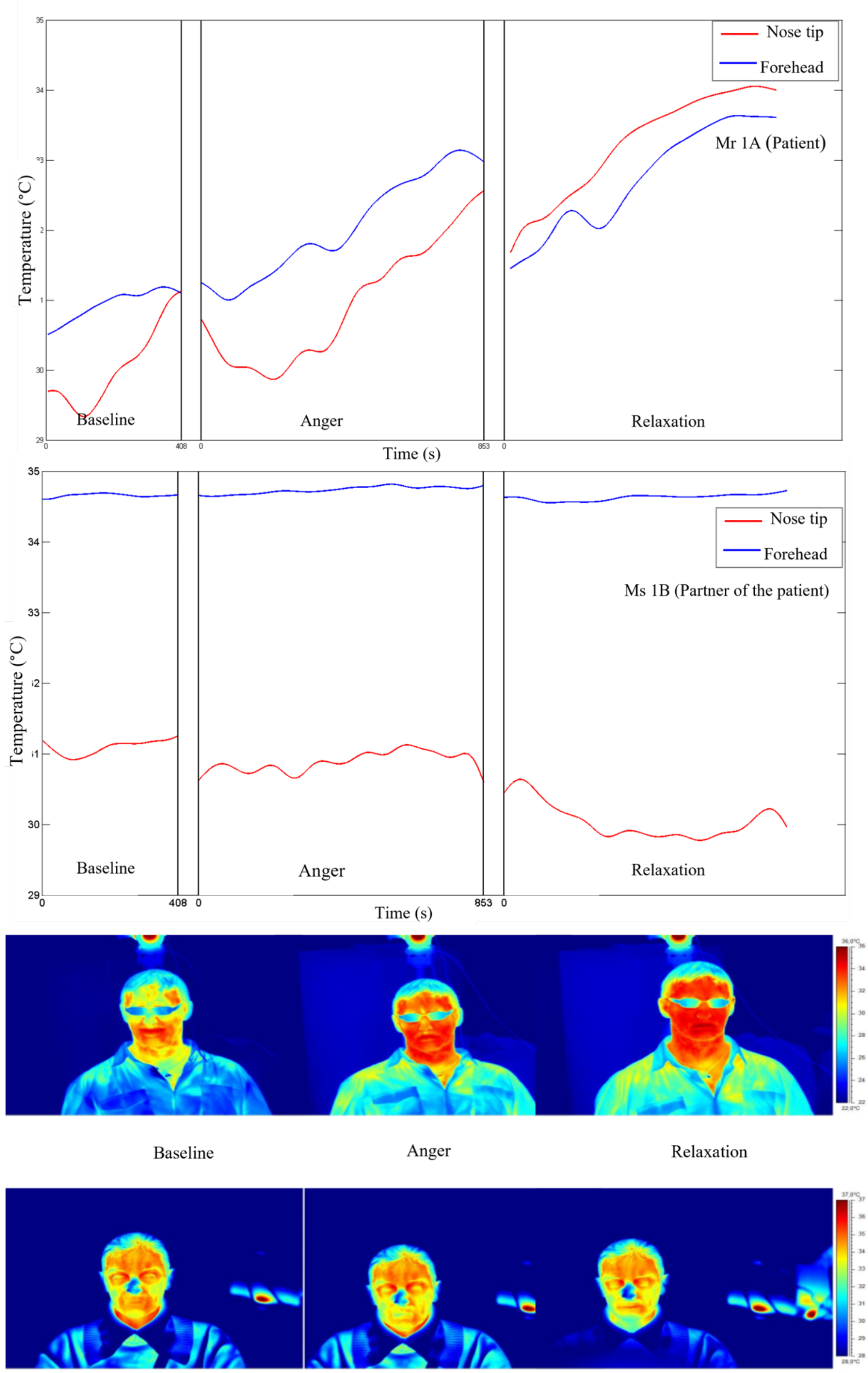
3. Results

3.1 Temporal thermal changes on the nose tip and forehead

During the experiment, the average skin temperature of the nose tip was rising for all participants except for the patient's partner, whose nose tip temperature slightly decreased (see Figures 2 and 3). The forehead temperature did not show a comparable pattern, and related observed changes were comparably small.

Figure 2

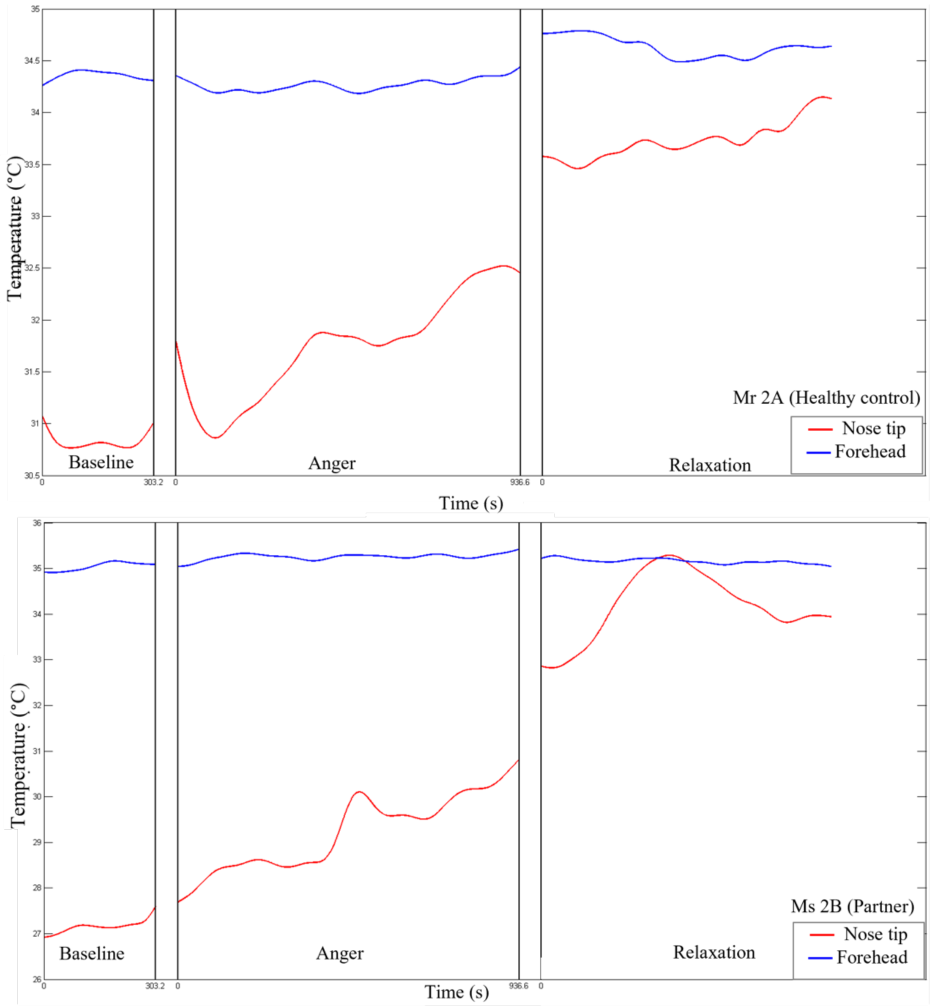
Graphical and pictorial representation of variations in the facial thermal imprints of Mr 1A and Ms 1B, respectively.

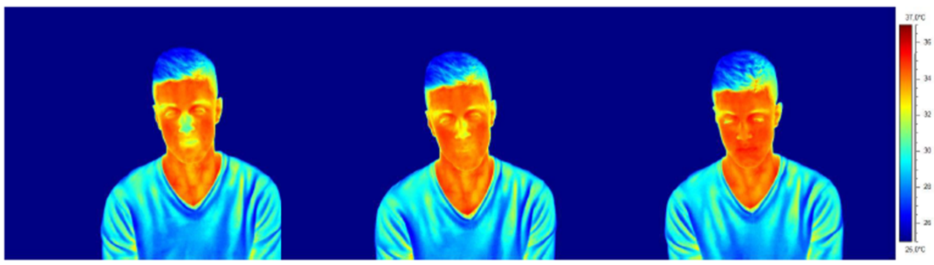


The first illustration belongs to Mr 1A (wears eyeglasses) and the second to Ms 1B.

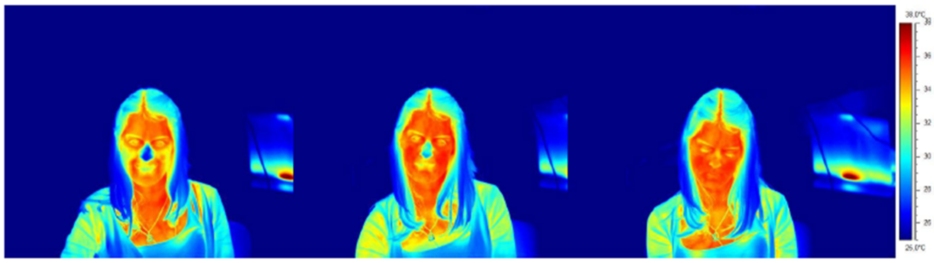
Figure 3

Graphical and pictorial representation of variations in the facial thermal imprints of Mr 2A and Ms 2B, respectively.





Baseline Anger Relaxation



The first illustration belongs to Mr 2A and the second to Ms 2

All temporal courses were significantly different for each participant for the whole session (Table 1). This could be demonstrated for the forehead temperature, too. The full model – again including all participants – confirmed individually different slopes for each condition and all patients. When we compared the slopes of the temperature change between participants, we found that the forehead temperature of the patient increased significantly in anger and relaxation phases.

Table 1

Temporal course of the changes in cutaneous temperature of the participants

Participant		**Baseline**	**Slope***	**Anger**	**Slope***	**Relaxation**	**Slope***	**Sig. *p* (condition*frame)**
		M (SD)		***M (SD)***		***M (SD)***		
Patient (Mr 1A)	Nose tip	30.03 (0.55)	0.258	30.93 (0.84)	0.188	33.24 (0.72)	0.182	0.000
	Forehead	30.95 (0.20)	0.099	32.04 (0.71)	0.171**	32,74 (0.73)	0.184**	0.000
Patient's partner (Ms 1B)	Nose tip	31.09 (0.10)	0.040	30.89 (0.13)	0.023	30.03 (0.24)	-0.035	0.000
	Forehead	34.66 (0.02)	0.002	34.73 (0.05)	0.011	34.62 (0.04)	0.009	0.000
Healthy partner (Mr 2A)	Nose tip	30.82 (0.07)	-0.004	31.74 (0.49)	0,100	33.73 (0.17)	0.042	0.000
	Forehead	34.36 (0.04)	-0.002	34.27 (0.06)	0.008	34.63 (0.10)	-0.016	0.000
Healthy partner (Ms 2B)	Nose tip	27.15 (0.12)	0.069	29.22 (0.81)	0.170	34.18 (0.73)	0,055	0.000
	Forehead	35.04 (0.09)	0.053	35.25 (0.07)	0.007	35.16 (0.05)	-0.011	0.000
Full model								0.000

*Temperature change: degree centigrade per minute

** Temperature changes were significantly greater for the patient compared to healthy participants

When the psychological factors (i.e., TAS-20, LEAS, STAXI) were included in the model, condition-specific associations of these factors with the thermal variations were observed. Although the relationship of the psychological factors with the overall temperature was negligible, strong associations were found between these psychological measures and condition-specific temperature changes (Table 2). All the psychological factors were significantly associated with temperature changes in each condition, but not with the absolute temperature levels. Changes in the relaxation phase tended to be smaller compared to the initial phases. Higher scores in STAXI and TAS were associated with more pronounced temperature changes. Likewise, lower scores in emotional awareness measured by LEAS were associated with greater temperature changes.

Table 2

Psychological predictors of change in nose tip temperature within experimental conditions

	Overall * *b*	***p***	***b*** for temperature change per condition per psychological measure**		
			Baseline	**Anger**	**Relaxation**
TAS	0.003	0.96	0.0051	0.0027	0.0005
LEAS self	-0.070	0.42	0.0001	0.0010	0.0015
LEAS others	-0.043	0.69	-0.0014	-0.0008	-0.0009
LEAS total	-0.015	0.87	-0.0023	-0.0017	-0.0019
Staxi-trait	0.015	0.85	0.0103	0.0051	0.0001
Staxi-in	0.084	0.93	0.0118	0.0052	-0.0012
Staxi-out	-0.016	0.87	0.0119	0.0056	0.0003
Staxi-control	0.311	0.41	0.0012	-0.0029	-0.0067

*Regression coefficient b; mean temperature predicted by the respective psychological measure. **Regression coefficient b; change in temperature per minute (degree C/min) predicted by the respective psychological measure (per point of the corresponding subscale). In all condition-specific associations with psychological measures: $p < 0.001$.

3.2 Correlation of temperature changes between partners

Correlation analysis of nasal tip temperature of the dyads showed significant relationships at $p < 0.01$ (Table 3). As forehead temperature did not vary significantly across phases, we did not include it in the analysis. At baseline, the nasal tip temperature of the partners of Couple 1 was positively correlated (patient-partner; $r = 0.89$), while for Couple 2 (healthy control-partner), no correlation was found. At the anger phase, a positive correlation between the partners' nose tip temperatures in both Couples 1 and 2 was revealed ($r = 0.62$ and 0.84, respectively). At the relaxation phase, a strong negative correlation between the nasal tip temperature of the first dyad ($r = -0.71$) and a weak one ($r = 0.20$) for the second dyad was found.

Table 3

Correlation coefficients of the relationship between partners' nasal tip temperature during each experimental phase.

Couples	r_{dyads}		
	Baseline	**Anger**	**Relaxation**
Couple 1 (Patient & partner)	.89*	.62*	. -71*
Couple 2 (Healthy control & partner)	-. 007	.84*	.20*

*$p < .01$

3.3 Case-based analyses

3.3.1 Couple 1: The patient and his partner

3.3.1.1 Pain and psychological symptoms.

Mr 1A (patient) suffered from somatoform pain disorder. His pain involved a chronic widespread pain and local pain, which is elicited by stimuli that normally do not provoke pain (i.e., allodynia). The pain concentrated especially on his back, arms, legs, and joints, which has strongly impaired his life for more than five years. In the last two weeks, he had a very intense level of pain that had affected his overall activity, his work, as well as his relationships with others. His level of affective pain, meaning his evaluative and emotional reaction to pain, was very high and fell within the 100th percentile of the normative sample of pain patients. On the other hand, his level of sensory pain, that is, his perceptual ratings of pain intensity, fell within 46.2 % of the normative pain patient sample. The patient described a moderate depressive state characterized by sadness, hopelessness, and little interest or joy in life. He took the medications of duloxetine (a serotonin-norepinephrine reuptake inhibitor), amitriptyline (a tricyclic antidepressant), and quetiapine (a short-acting atypical antipsychotic).

Ms 1B did not report experiencing pain except a little pain in some body parts that affect her at a minimum level. She described her health as very good, although she reported some general life stress to a small extent and some relationship difficulties with her partner.

3.3.1.2 Emotion regulation reports.

The TAS-20 reports of Mr 1A classified him as alexithymic (raw score = 65) according to the cut-off scoring method, which underlined his difficulties in identifying and describing his feelings. Supporting this finding, his total level of emotional awareness score ($LEAS_{sumscores}$ = 47, *M* = 2.35) measured by LEAS put him around the 12th percentile of the healthy men sample (Subic-Wrana et al., 2001). This mean LEAS-total score corresponded to the range of scores of somatoform patients in a previous study (*M* = 1.93, *SD* = 0.58; Subic-Wrana et al., 2010). Moreover, according to a recent evaluation criterion of four-item LEAS (Subic-Wrana et al., 2014), his mean score of LEAS denoted his emotional awareness at an implicit level (i.e., a preconscious level of emotional awareness; affective arousal is expressed as bodily sensations or action tendency). Similarly, his mean scores for awareness of his own emotions (LEAS-self) and other (LEAS-other) were 2.2, which again indicated an implicit level of emotional awareness (Table 4).

Regarding anger regulation, he reported a high trait-anger, which means a general disposition to become angry (within the 99th percentile of the men sample). He reported expressing anger in a poorly controlled manner (99th percentile) or suppressing his anger (99th percentile). Yet, his energy expenditure to monitor and control his anger was at a moderate to a high level (70th percentile).

Ms 1B's TAS-20-based alexithymia score (raw score = 37) indicated her good ability to be aware of her feelings and identify and describe them. Similarly, her total LEAS score (LEAS sum scores = 0 59, *M* = 2.59) put her into the 35th percentile of the women sample and almost on a level of explicit emotional awareness, indicating her ability to experience emotions consciously and express them verbally (Subic-Wrana et al., 2014). Interestingly, her mean LEAS-self (*M* = 2.85) and LEAS-other (*M* = 2.25) scores were quite discrepant from each other compared to other participants of our study. Her LEAS-other score was almost at an implicit level of emotional awareness.

Her anger scales showed a moderate to high trait anger (75th percentile of the women sample). She reported an increased tendency to suppress anger expression (80th percentile) and a low-moderate tendency (50th percentile) to express anger in an outwardly negative and poorly controlled manner. She also reported a moderate to high (70th percentile) level of effort to monitor and regulate her anger.

Table 4

Participants' scores for measures of emotion regulation and attachment styles

Participant	TAS-20 Total	LEAS Total (*M*)	LEAS-Self (*M*)	LEAS-Other (*M*)	STAXI-Trait Anger	STAXI Anger-out	STAXI Anger-in	STAXI Anger-control	ECR-R Anxiety	ECR-R Avoidance
Mr 1A	65	47 (2.35)	44 (2.2)	44 (2.2)	30	29	29	25	-	-
Ms 1B	37	59 (2.95)	57 (2.85)	45 (2.25)	20	19	12	24	-	-
Mr 2A	44	61 (3.05)	49 (2.45)	53 (2.65)	22	16	12	24	1.72	1.72
Ms 2B	38	66 (3.3)	62 (3.1)	60 (3)	18	11	11	21	3.44	1.55

Toronto Alexithymia Scale-20 (TAS-20), Level of Emotional Awareness Scale (LEAS), Spielberger Anger Expression Inventory (STAXI), Experiences in Close Relationships-Revised (ECR-R)

3.3.1.3 Heart rate (HR) and skin conductance levels (SCL)

The mean HR of Mr 1A, which was greater compared to his partner, did not change much from baseline (*M* = 101.8, *SD* = 4.7, *Min* = 83.5, *Max* = 112.1) to anger (*M* = 101, *SD* = 5, *Min* = 83.5, *Max* = 110.5) but decreased at the relaxation phase (*M* = 90.3, *SD* = 2.7, *Min* = 81.7, *Max* = 97.8) while the HR of Ms 1B remained relatively stable at almost all phases (Baseline: *M* = 71.3, *SD* = 5.4, *Min* = 56, *Max* = 86.2; Anger: *M* = 72.9, *SD* = 6.3, *Min* = 53.3, *Max* = 91.9; Relaxation: *M* = 69, *SD* = 6, *Min* = 56.9, *Max* = 101).

With regard to SCL, Mr 1A showed a slight increase from baseline (*M* = 3.9, *SD* = 0.1, *Min* = 3.7, *Max* = 4.7) to anger phase (*M* = 4.0, *SD* = 0.2, *Min* = 3.7, *Max* = 4.9) and then a decrease at the relaxation phase (*M* = 3.8, *SD* = 0.2, *Min* = 3.4, *Max* = 6.5). On the other hand, Ms 1B showed a slight decrease from baseline (*M* = 3.5, *SD* = 0.2, *Min* = 3.05, *Max* = 4.04) to anger phase (*M* = 3.4, *SD* = 0.2, *Min* = 3.1, *Max* = 4.1), and a pronounced decrease at the relaxation phase (*M* = 3.03, *SD* = 0.5, *Min* = 2.68, *Max* = 5.69; see Figure 4).

3.3.1.4 State-affective experience

Mr 1A reported a pronounced increase in pain experience at the relaxation phase compared to other phases. In terms of the experience of pleasure, arousal, and dominance, he reported himself as quite unhappy, a bit aroused, and a bit being controlled at almost all phases, which did not show much variance (Table 5). He evaluated his partner’s affect similar to his own, as quite unhappy and a bit aroused. In terms of dominance, he reported Ms 1B as quite controlling at baseline, while his interpretation of her dominance decreased at the anger and relaxation phase.

Ms 1B reported quite varying affective experiences for herself and her partner among phases. At baseline, she reported to be happy, and her arousal and dominance were at low levels, while she reported feeling quite unhappy, a bit aroused, and a bit controlled at the anger phase. At the relaxation phase, she reported feeling happy, relaxed, and a bit controlled. Similar to her own ratings, she rated her partner also as quite happy, relaxed, and controlled at baseline. At the anger phase, she appraised Mr 1A's affective experience, similar to her own; quite unhappy, a bit aroused but quite controlling. At the relaxation phase, she also rated her partner as relaxed again with a higher level of pleasure and an average level of dominance.

3.3.2 Couple 2: healthy control and partner

3.3.2.1 Pain and psychological symptoms

The couple presented no pronounced pain, depression, anxiety, or stress. In addition, they described their health condition as very good. They did not report any chronic disease or use of medication.

3.3.2.2 Emotion regulation reports

According to the TAS scores, both partners reported a good ability in identifying and describing feelings and were in the range of no-alexithymia according to the cut-off scoring. Yet, Mr 2A had a slightly higher score than his partner (TAS 20 total raw scores were 44 and 38, respectively for Mr 2A and Ms 2B; Table 4). Parallel with the TAS scores, the total level of emotional awareness of Mr 2A was around the 45th percentile of the healthy man sample (LEAS-total raw score = 61). Yet, Mr 2A was the only participant who had a lower LEAS-self score (M = 2.45) than the LEAS-other (M = 2.65) score, which indicated almost an implicit level of emotional awareness. The LEAS-total score of Ms 2B was also consistent with her TAS score, and she could be placed within the 52nd percentile of the healthy women sample. In addition, her LEAS-self and -other scores counted her at an explicit level of emotional awareness (M = 3.1 and 3, respectively).

Regarding anger regulation, Mr 2A reported a high level of trait anger (80th percentile). His tendency to suppress anger, express anger negatively, and try to control and modulate his anger was at a moderate level (55, 55, and 60th percentile, respectively). On the other hand, Ms 2B had a moderate level of trait anger (55th percentile) and anger modulation (50th percentile), but a low level of suppressing anger (15th percentile) and expressing anger negatively (40th percentile).

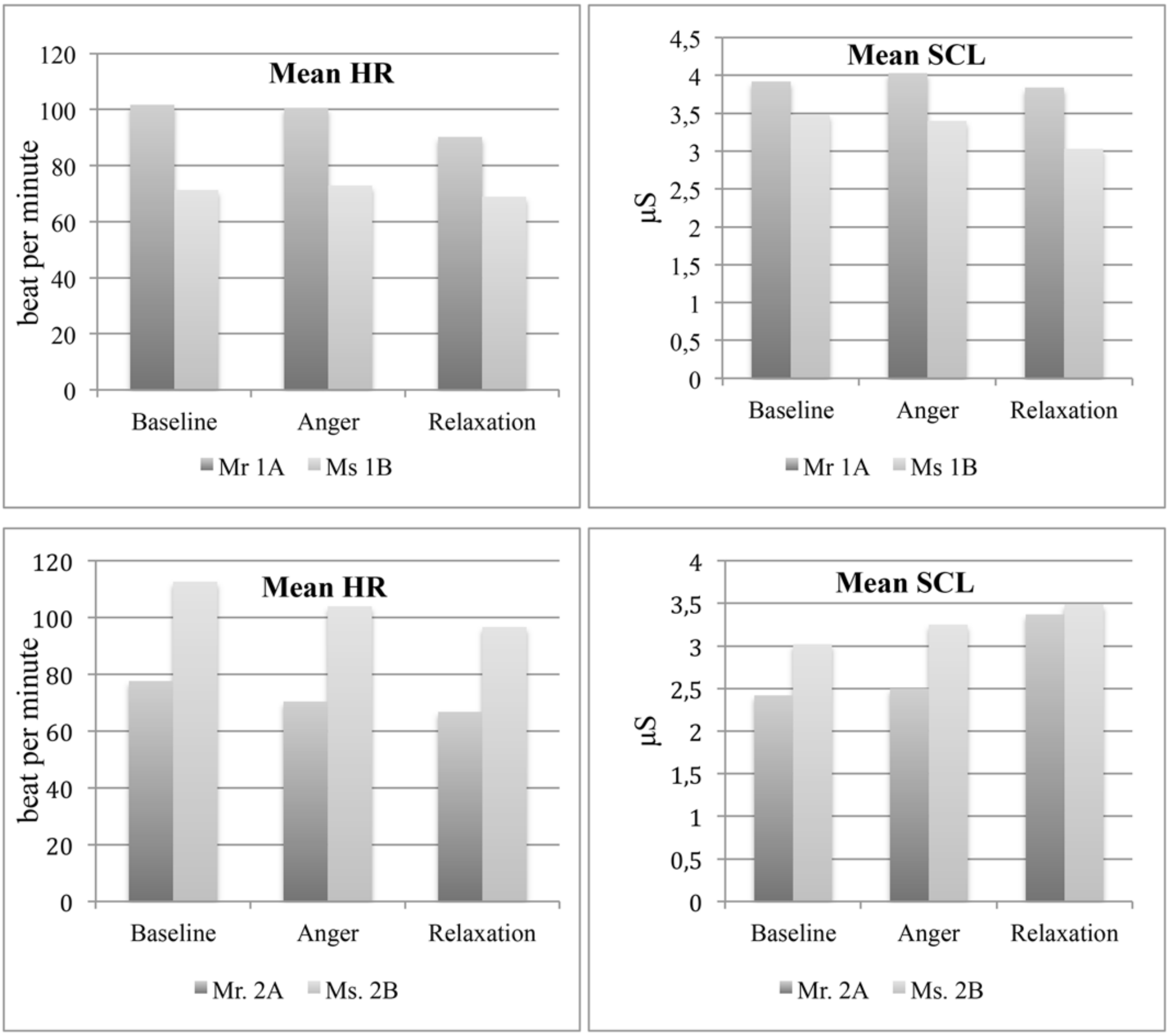
According to the ECR-R, which assesses attachment styles, Ms 2B had a high score in anxious attachment style (*M* = 3.44), which was within the range of clinical sample in a previous validation study with German sample (*M* = 3.08, *SD* = 1.27, Ehrenthal et al., 2009). The ECR-R scores of Mr 2B were within the range of healthy controls.

3.3.2.3 Heart rate and skin conductance levels

The mean HR of both partners decreased from baseline (Mr 2A: *M* = 77.6, *SD* = 6.3, *Min* = 60, *Max* = 101; Ms 2B: *M* = 112.6, *SD* = 5.2, *Min* = 96, *Max* = 120) to anger (Mr 2A: *M* = 70.4, *SD* = 6.5, *Min* = 56, *Max* = 89; Ms 2B: *M* = 100.4, *SD* = 6.5, *Min* = 76, *Max* = 112), and then to relaxation phases (Mr 2A: *M* = 66.8, *SD* = 5.6, *Min* = 52, *Max* = 88.8; Ms 2B: *M* = 97.2, *SD* = 5.4, *Min* = 76.8, *Max* = 109.7). On the other hand, mean SCL increased in both partners from baseline (Mr 2A: *M* = 2.4, *SD* = 0.03, *Min* = 2.37, *Max* = 2.53; Ms 2B: *M* = 3.02, *SD* = 0.02, *Min* = 2.86, *Max* = 3.76) to anger (Mr 2A: *M* = 2.50, *SD* = 0.04, *Min* = 2.38, *Max* = 2.59; Ms 2B: *M* = 3.25, *SD* = 0.17, *Min* = 3.01, *Max* = 3.7), with a more pronounced increase at the relaxation phase (Mr 2A: *M* = 3.37, *SD* = 0.11, *Min* = 3.28, *Max* = 3.68; Ms 2B: *M* = 3.49, *SD* = 0.07, *Min* = 3.04, *Max* = 3.72; see Figure 4).

Figure 4

Mean heart rate and skin conductance levels of the couples at three experimental phases



3.3.2.4 State-affective experience.

Mr 2A reported his pleasure level to decrease at the anger phase. Yet, his arousal and dominance levels did not vary much across phases, depicting almost a relaxed and dominant state. However, he appraised his partner's pleasure and arousal as quite changing and compatible with the content of the experimental phases. He reported his partner's pleasure level as decreasing and arousal increasing at the anger phase and vice versa at the relaxation phase. As in Couple 1, the anger task was the only phase when he felt more dominant than his partner.

Ms 2B reported very few variances in her and her partner's pleasure levels, remaining almost stable across phases. She reported herself and her partner feeling quite happy. On the other hand, she reported both herself and her partner to be a bit aroused at baseline and anger phases and then relaxed at the relaxation phase. Consistent with her partner's appraisal, she felt less dominant at the anger phase than her partner.

Table 5

Affective experience ratings of the participants for self and other

	Affect								
	Pleasure			Arousal			Dominance		
	Base	Anger	Relax	Base	Anger	Relax	Base	Anger	Relax
Mr 1A (self*)	3	4	4	4	4	4	4	4	4
Mr 1A (other*)	3	4	4	3	3	4	6	4	4
Ms 1B (self)	9	3	8	1	6	1	1	4	2
Ms 1B (other)	8	4	7	2	5	2	1	8	4
Mr 2A (self)	9	5	8	3	1	1	7	6	8
Mr 2A (other)	9	3	8	5	6	1	7	5	8
Ms 2B (self)	8	7	8	4	5	2	5	3	5
Ms 2B (other)	8	7	7	4	4	2	5	4	5

*"Self" stands for participant's report about own affective experience. "Other" stands for participant's evaluation of partner's affective experience.

4. Discussion

The theoretical accounts of SSD accentuate a network of relationship between interpersonal interactions, emotion regulation, and bodily disturbances (Waller and Scheidt, 2006; Henningsen et al., 2007; Subic-Wrana et al., 2010; Luyten et al., 2012). Despite this close linkage, only a few available studies have examined real-time, interpersonal emotional interactions of patients with SSD (e.g., Merten and Brunnhuber, 2004; Cano et al., 2008; Leong et al., 2011). These studies have shown that both partners in an ongoing interaction reciprocally contribute to the emotion regulation process, which can become a precipitating and/or maintaining factor for the somatic symptoms. However, the literature requires empirical research that examines the coordination of multiple components of emotion (i.e., physiology, behavior, experience) of both parties in real-time dyadic interaction.

This case study aimed to draw a methodology to examine how intra- and interpersonal emotion regulation at physiological and experiential levels are related to SSD. Previous studies suggest a discordance between physiological, experiential, and behavioral components of emotional process in SSD (Ditzen et al., 2008; Luyten et al., 2011; Pollatos et al., 2011b; Bondo-Lind et al., 2014; Okur et al., 2019). In line with earlier studies, we proposed that the patient would present an intrapersonal incoherence among emotion response systems, characterized by higher autonomic activity but restricted affective experience than healthy controls. Moreover, trait emotion regulation patterns would affect the physiological changes during the affective interactions. At the interpersonal level, we predicted that emotional incoherence would be more likely reciprocated by a complementary incoherence of emotional processing in the partner. This pattern would generate an interpersonal emotional incoherence represented by low correlations between partners in physiology and affective experience.

Following an introduction of the accounts of emotion regulation in SSD, we presented an experimental interpersonal paradigm that included two case couples consisting of a patient with somatoform pain and his partner, and a healthy couple. We chose anger and positive affect to focus as these were reported to play particular roles in chronic pain (Fernandez and Turk, 1995; Zautra et al., 2005; van Middendorp et al., 2010). We measured participants' cutaneous temperature, heart rate, and skin conductance levels as imprints of autonomic activity during the interaction. Besides, we examined the participants' self-report and performance-based emotion regulation, affective experience, and attachment styles. We investigated not only participants' affect but also their perception of their partner's affective experiences.

The paradigm successfully generated physiological and experiential changes in an ecologically valid and structured interpersonal setting, which allowed dynamic emotional interaction. Trait emotion regulation, namely, alexithymia, level of emotional awareness, and anger regulation, predicted the course of cutaneous temperature changes across phases. The patient, his partner, and the healthy couple showed some distinctive patterns of emotion regulation. However, the results should be interpreted with caution as we examined only two cases in this study.

The temporal analysis of the course of temperature changes on nose tip and forehead showed significant variances across phases, pointing to the effectiveness of experimental manipulation. Nasal tip temperature increased from baseline to relaxation in all participants except the patients' partner, whose nasal tip temperature slightly decreased. This regulation pattern of the patients' partner might suggest a complementary down-regulation of physiology in her interaction with the patient, who showed higher autonomic activity. In fact, as predicted, the patient showed higher stress responses than his partner, and healthy controls depicted by significant temperature increase on the forehead in anger and relaxation phases. In addition, his mean SCL and HR were higher than his partner throughout the experimental phases. Such vigilant autonomic activity in SSD has been shown in previous studies (Seignourel et al., 2007; Burns et al., 2008; Twiss et al., 2009; Luyten et al., 2011; Pollatos et al., 2011a,b).

Trait emotion regulation also predicted the course of temperature changes. Higher alexithymia, increased anger regulation difficulties, and lower scores in emotional awareness predicted greater changes in nasal tip temperature. This result supports the previous findings that have connected emotion regulation deficits with aberrant and higher physiological stress responses (Luyten et al., 2011; Pollatos et al., 2011a,b). Parallel with this finding, as expected, the patient exhibited more restricted awareness and reflection on his own and others' emotions, high trait anger, and poorer anger regulation. The patient's partner also showed a moderate to high level of trait anger. This prevailing anger in both partners might reflect the contagious nature of affects in interpersonal interactions (Hatfield et al., 1993). The patient's affective pain, the evaluative and emotional reaction to pain, also ranged at a very high end, although his sensory pain was at a moderate level. This can illustrate how SSD patients' symptom-related affective appraisals amplify the symptoms (Hadjistavropoulos and Craig, 1994).

The second couple consisting of healthy partners, showed relatively improved emotion regulation. They both showed greater ability to be aware of, identify and describe their own and others' emotions. However, some degree of trait anger existed in both partners' reports classifying Mr 2A as having high trait anger and a moderate level of anger regulation difficulties and Ms 2B as having a moderate level of trait anger.

The relationship of state affective experience and accompanying physiological changes were quite distinctive between participants. Although the patient's cutaneous temperature showed noticeable variations across experimental phases and showed a relatively high HR and SCL, he reported a relatively stable and moderate level of arousal and pleasure, inconsistent with his higher autonomic reactivity. This discrepancy might point to incoherence between his affective experience and bodily concomitants. The patient's high alexithymia and low emotional awareness scores could explain his restricted access to his feelings and accompanying autonomic changes. The subjective reports of Ms 1B, on the other hand, were, as expected, much more consistent with her physiological changes except for the baseline. The lack of consistency at baseline might be due to the possible performance stress at the beginning and her attempt to give the desired response suitable to a neutral baseline task.

For the partners of the control couple, the concordance of the subjective reports and physiological changes seemed to be greater compared to the patient to a certain extent. At the anger phase, both partners showed an increase in the nasal tip temperature and reported a decrease in pleasure. Ms 2B stated that her arousal rose at the anger phase, accompanied by a rise in nasal tip temperature and mean SCL, although her mean HR declined. At the relaxation phase, she reported lower arousal, but her SCL and facial temperature continued to increase, except for her decreasing mean HR. However, Mr 2A described few changes in terms of arousal and pleasure, despite his declining mean HR and increasing mean SCL and thermal imprints from baseline to relaxation. Explaining this discordance, he scored low in the LEAS-self subscale, indicating some difficulties in consciously experiencing and describing his own emotions.

The interpersonal level of emotion regulation analyses has brought forward more multifaceted results than we proposed. The graphical trends of temporal changes in nasal tip temperature suggested discordance between the patient-partner dyads (Couple 1) and concordance in healthy control-partner dyads (Couple 2). However, the correlation analysis of the temporal courses between partners, apparently more sensitive than visual inspection, suggested higher concordance in the first couple compared to the second one. At baseline, a positive correlation between nose tip temperatures of the partners was found only in the patient-partner couple. At the anger phase, the partners of both Couples 1 and 2 presented strong positive correlations in the nose tip temperature. At relaxation, a strong negative correlation of temperature change was found only between the patient and partner. The patient and his partner seem to show greater interdependence in facial temperature compared to the control couple, a relationship that is quite the reverse of our predictions.

The strong correlations of temperature in the first couple might be explained by the reciprocal nature of social interactions and the couples' difficulty in down-regulating physiological arousal and co-regulation. For example, the patient reported experiencing almost similar levels of pleasure and arousal, while his partner reported experiencing more variance in these domains. The patient also underrated his partner's pleasure and arousal levels, while his partner overrated these affective experiences of him. The couple's poor performance on recognizing the other's affective experience was consistent with previous studies that reported emotion recognition difficulties in patients with SSD (Pedrosa Gil et al., 2008; Beck et al., 2013). Supporting these findings, both the patient and his partner showed low scores in LEAS-other, denoting difficulties in understanding the other's emotions at an explicit level (Subic-Wrana et al., 2014).

The second couple with the healthy partners performed well in the LEAS-other subscale, implying a better capacity to be aware of the other's emotions than the first couple. They also performed relatively better in perceiving the partner's affective change. They correctly evaluated each other's arousal to decrease at the relaxation phase and dominance to lessen at anger and rise at the relaxation phases. Mr 2A was also accurate in perceiving the increase of his partner's arousal at anger, although Ms 2B was not. The couple also could not accurately assess the changes in the other's feeling of pleasure. It seems that Mr 2A attributed some emotionality and fluctuating emotional responses to his partner. It may be speculated that the anxious attachment style of Ms 2B could contribute to her partner's attributions.

Our study has several limitations. Although our study demonstrates how embodied and intersubjective emotion models can be integrated into psychosomatic research, it involves only two cases and provides scarce evidence for our hypotheses. Future empirical research with greater sample size and robust statistical methods should examine the affective processes of interacting partners. Secondly, we could not include continuous measures of subjective experience, such as dial rating methods (Mauss et al., 2005), in order to avoid patients' exposure to their own conflictual video recordings. Thirdly, since we included only two case couples, we did not statistically analyze the continuous temporal changes of electrodermal and electrocardiac data within and between individuals. Nevertheless, we demonstrated a tentative example to examine the relationship between emotion regulation and the temporal course of cutaneous temperature changes at intra- and interpersonal levels. Future research should adopt statistical approaches with high temporal sensitivity (e.g., time-sequence analysis, cross-correlation analysis, actor-partner interdependence models) to examine the course and coordination of multiple emotion response systems at these multi-levels (Hollenstein and Lanteigne, 2014). Likewise, we did not include observational measures of emotional interaction, a measure that is helpful to understand the relationship between behavioural and physiological constituents of emotion. In our following study, we plan to employ observational measures to assess emotion regulation and affective interactions. Finally, future research should statistically control for sex differences and medication use as they can have potential effects on emotional processing and physiology. Also, ceiling or bottom effects are possible because factors such as pain and alexithymia can be confounded with the patient status. Therefore, causal assumptions should be made tentatively.

Our study illustrates the scientific yield of an embodied interpersonal paradigm for studying emotion regulation in SSD, particularly for the regulation of anger and positive affect. An enhanced understanding of this intra- and interpersonally and dynamically regulated phenomenon will provide the potential for an optimized treatment and psychotherapy.

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Chapter IV: Interpersonal emotion dynamics in couples with somatic symptom disorder: Dyadic coherence in facial temperature during emotional interactions[1]

Abstract

Objective: Disturbances in emotional processes are commonly reported in patients with a Somatic Symptom Disorder (SSD). Although emotions usually occur in social interactions, little is known about interpersonal emotion dynamics of SSD patients during their actual emotional encounters. This study examined physiological coherence (linkage) between SSD patients and their partners, and in healthy couples during their emotional interactions. Secondarily, we explored group-level relationships between participants' and their partners' subjective affect.

Methods: Twenty-nine romantic couples (16 healthy and 13 SSD patient-couples) underwent a dyadic conversation task with neutral and anger-eliciting topics followed by a guided relaxation. Partners' cutaneous facial temperature was recorded simultaneously by functional infrared thermal imaging. Immediately after each condition, participants reported on their pain intensity, self-affect, and perceived partner-affect.

Results: Emotional conditions and having a partner with an SSD significantly affected coherence amplitude on the forehead, $F(2, 54) = 4.95$, $p = .011$, and nose tip temperature, $F(2, 54) = 3.75$, $p = .030$. From baseline to anger condition, coherence amplitude significantly increased in the patient-couples while it decreased in the healthy couples. Correlation changes between partners' subjective affect comparably accompanied the changes in physiological coherence in healthy and patient-couples.

Conclusions: Inability to reduce emotional interdependence in sympathetic activity and subjective affect during a mutual conflict observed in SSD patient-couples appear to capture emotion co-dysregulation. Interventions should frame patients' emotional experiences as embodied and social. Functional infrared thermal imaging confirms to be an ecological and

[1] This study was published as Okur Güney, Z.E., Cardone, D., Sattel, H., Ariens, S., Merla, A., Kuppens, P., Witthöft, M, Henningsen, P. (2022). Interpersonal emotion dynamics in couples with somatic symptom disorder: Dyadic coherence in facial temperature during emotional interactions. *Psychosomatic Medicine*, V 84(2), 188-198, doi: 10.1097/PSY.0000000000001032. The paper was written by Okur Güney (first author) and co-authored by Daniela Cardone, Heribert Sattel, Sigert Ariens, Michael Witthöft, Arcangelo Merla, Peter Kuppens, and Peter Henningsen Citation:

reliable method for examining autonomic changes in interpersonal contexts.

Keywords: Somatic symptom disorder; couples, interpersonal emotion dynamics; physiological linkage; functional infrared thermal imaging; wavelet coherence analysis.

Registration page: https://osf.io/8eyjr

Summary

Physiological coherence (covariance) between persons during emotional interactions can be either functional or dysfunctional for well-being depending on context. **Okur Güney** et al. compared couples with a patient with somatic symptom disorder (SSD) and healthy couples on the coherence of cutaneous facial temperature during their emotional interactions. While patient-couples increased their facial temperature coherence from neutral to anger-eliciting conversations, healthy couples reduced it. Between-couple relationships in partners' subjective feelings followed a similar pattern. Results suggest that interdependence might be dysfunctional in conflictual situations and indicate emotion dysregulation. Interventions can aim to facilitate patients' emotion regulation without getting absorbed by the dyadic conflictual system.

1. Introduction

Somatic Symptom Disorder (SSD) is a disturbing condition for the patient and her/his social system, prevalent in the population, and costly for society (Levenson, 2020; Witthöft & Hiller, 2010). One or multiple bodily symptoms combined with excessive thoughts, feelings, and behaviors concerning the complaints, and significant dysfunction portray the disorder (American Psychiatric Association, 2013). Most common bodily symptoms include pain in different locations, functional disturbances (e.g., dizziness, constipation, diarrhea), fatigue, and exhaustion (Henningsen, Zipfel, et al., 2018). Cooccurrence of depression and anxiety (Levenson, 2020), neurocognitive dysfunction in case of comorbid depression (de Vroege et al., 2017), personality disorders (Bass & Murphy, 1995), and other emotional disturbances, such as alexithymia are also reported in SSD (De Gucht & Heiser, 2003; de Vroege et al., 2018).

There is abundant evidence for an association between disturbances in emotion processing and regulation and somatic symptoms (Koechlin et al., 2018; Levenson, 2019; Okur Güney et al., 2019). However, little is known about emotional processes during SSD patients' actual interpersonal interactions. Psychosomatic research has generally investigated emotions and social interactions as distinct and separate fields (Smith & Weihs, 2019; Uchino & Eisenberger, 2019). This gap is especially problematic under the assumption that emotions have evolved through social interactions (Beckes & Coan, 2011; Mesquita & Boiger, 2014; Nummenmaa et al., 2012) and are closely connected with interoceptive inference about bodily states associated with SSD (Van den Bergh et al., 2017). Examining how interpersonal emotion dynamics (i.e., interdependent emotional change between individuals) (Randall & Schoebi, 2018) emerge during patients' emotional encounters can help understand the biopsychosocial mechanisms of emotional and bodily disturbances in SSD.

The present study aimed to investigate one aspect of interpersonal emotion dynamics in couples with an SSD patient and healthy couples during their emotional interactions: Physiological linkage[2] (PL), defined as the covariance of two or more people's physiology in time (Levenson & Gottman, 1983). PL between individuals has attracted increasing attention

[2] In the literature, the overarching term "physiological linkage" is generally used. However, depending on the analysis method, several terms exist in different fields referring to PL, such as synchrony, coupling, co-regulation, etc. See the reviews (Butler, 2011a; Palumbo et al., 2016; Timmons et al., 2015) for an overview. Throughout this paper, we use the overarching term "linkage" when reviewing the literature but specify it as "physiological coherence" in our work, which reflects the analysis method we used (Wavelet Coherence Analysis).

due to its psychosocial and health-related implications (Butler & Barnard, 2019; Creaven et al., 2014; Laws et al., 2015; Lunkenheimer et al., 2018; Palumbo et al., 2016; Timmons et al., 2015; Wilson et al., 2018). Especially the last decade has witnessed an exponential interest along with technological developments that enabled complex measurement and analytical methods (Palumbo et al., 2016). However, to date, PL has been investigated mostly in healthy populations, and it remains unclear how it is manifested during SSD patients' emotional interactions.

Emotions do not occur in a vacuum; *persons* live through them, mostly during social encounters. When people engage in emotional interaction, they share and coordinate their feelings, movements, behaviors, and even physiological responses. Social and dynamical systems framework underlines this coordination as a continuously changing process that ensues interdependently between interactants (Butler, 2015; Kuppens & Verduyn, 2017; Mesquita & Boiger, 2014). One of the channels where emotional interdependence occurs is physiology, whereby physiological response systems of two or more persons covary (Levenson & Gottman, 1983).

Research has shown competing evidence regarding the health-related implications of PL. On the one hand, it has several positive associations, such as empathy and understanding (Ebisch et al., 2012; Manini et al., 2013; Ruef, 2001), relationship satisfaction (Helm et al., 2014), emotion coregulation (Feldman et al., 2011), sharing of emotional burden (Lougheed et al., 2016), adaptive mother-child functioning (Creaven et al., 2014), and lower risk for psychopathology (Lunkenheimer et al., 2018). On the other hand, PL during conflict appears to have adverse psychological and physical implications, such as relationship dissatisfaction (Laws et al., 2015) and distress (Levenson & Gottman, 1983), negative affect reactivity, and high inflammatory markers (Wilson et al., 2018).

Overall, the studies suggest that the context in which an emotional interaction occurs matters in the implications of PL. It might facilitate attunement and understanding in a positive context; and sharing of burden in situations against external stimuli. However, when reacting to each other, such as a mutual conflict, PL may have disruptive effects, such as negative affect reciprocity, escalation, and emotion co-dysregulation (Butler, 2015; Timmons et al., 2015). A recent study supports this proposition, which found that interacting persons felt good when they were high in movement synchrony but felt less capable of self-regulation (Galbusera et al., 2019).

During a conflict, PL was associated with endocrinological distress signatures. In a study with healthy couples, increased linkage in heart rate variability during conflict predicted heightened inflammatory markers across the day of interaction (S. J. Wilson et al., 2018). Another study showed significant associations between partners' daily cortisol levels, which was more significant when the couples were together, a relationship that diminished as the marital satisfaction improved (Saxbe & Repetti, 2010). Partner's linkage in cortisol levels was also shown to be present in a longer time scale. A longitudinal study has observed significant linkage in newly married healthy spouses' cortisol trajectories during the conflict, a pattern that became more robust as their relationship matured (Laws et al., 2015).

Although the studies suggest a relationship between PL and health outcomes in healthy couples, to our knowledge, no study examined PL in patients with SSD and their partners. The present work aimed to compare whether and how PL in SSD patient-couples is different from that in healthy couples in neutral, anger-eliciting, and relaxing contexts in a laboratory setting. We also explored the relationship between both partners' subjective affect, and their perceived partner-affect following these emotional interactions to complement the physiological findings.

We examined PL by measuring cutaneous temperature on the facial regions of interest via functional infrared thermal imaging (fIRI). fIRI is a widespread and contactless method to examine autonomic physiology (Anbar, 2002; Cardone & Merla, 2017; Clay-Warner & Robinson, 2015; Ioannou et al., 2014; Merla & Romani, 2007). It records the dynamic distribution of skin temperature by imaging the infrared radiation emitted from the skin at a distance. Cutaneous temperature is regulated by the autonomic nervous system to maintain homeostasis against changing external conditions. It reflects sympathetic and parasympathetic regulation mainly through cutaneous perfusion and sweat gland activation (Anbar, 2002; Ioannou et al., 2014; Merla & Romani, 2007). Especially through vasoconstriction and vasodilation, the autonomic nervous system can regulate the skin blood flow that helps an organism to get into a fight or flight response or socially engage (Ioannou et al., 2014; Kistler et al., 1998). For example, skin blood flow and thermal prints coincided in 92 % of vasoconstrictions during stressful occasions in a study (Kistler et al., 1998).

fIRI has a high temperature and time-spatial resolution and does not require the attachment of electrodes or cables, enabling experiments in ecological settings (Merla & Romani, 2007). Therefore, interpersonal paradigms have utilized this measure (Clay-Warner & Robinson, 2015; Ebisch et al., 2012; Manini et al., 2013). Also, in human-robot interactions, researchers develop algorithms to develop autonomous systems to classify emotions with the help of fIRI, reaching up to 60 to 90 % accurate classification (Khan et al., 2009).

There is compelling evidence for disturbances in emotional processing and regulation in SSD (Koechlin et al., 2018; R. W. Levenson, 2019; Okur Güney et al., 2019). Accordingly, during a conflict, we expect a higher physiological coherence in SSD patient-couples than baseline, which is associated with stress reactivity or escalation in a mutual conflict (Butler, 2015; Timmons et al., 2015; Wilson et al., 2018), and diminished self-regulation (Galbusera et al., 2019). On the other hand, based on previous evidence for the functionality of PL in facilitating empathy and attunement in positive or neutral contexts, we expect healthy couples to show higher PL at baseline but to attenuate it during anger, as an adaptive means to disengage from the conflict.

As a secondary aim, the present study examines how the relationship between partners' affect changes among experimental conditions. We investigate the group-level relationships between the partners' a) actual affect (emotional similarity); b) self-affect and perceived partner-affect (assumed similarity), and c) perceived partner-affect and the partners' actual affect (empathic sensitivity) (Kenny et al., 2006). Based on the studies above, which suggested PL to reflect psychological interdependence; we expect that SSD patient-couples will show a greater between-dyad emotional interdependence (i.e., relationship) at anger than baseline condition, while healthy couples show the opposite pattern of a weaker emotional interdependence during anger compared to the baseline condition.

2. Methods

2.1 Participants

An a priori analysis with G-power (Faul et al., 2009) suggested a sample size of 28 with an expected power of 80 % and medium effect size for a within-between interaction effect in a mixed-effects Analysis of Variance (ANOVA) (2 groups, three measures, alpha = .05). We consecutively recruited thirty-one committed couples to the study. One patient-couple dropped the study during baseline, and one partner of a healthy couple reported long-term migraine and back pain during our pain screening. After excluding these two couples, the final sample consisted of 29 couples ($N = 58$) in two groups: Healthy couples ($n_{\text{couples}} = 16$, aged between 21 – 61 years old, $M_{\text{age}} = 38.2$, $SD = 13.1$) and couples with a partner with an SSD (SSD patient-couples) ($n_{\text{couples}} = 13$, aged between 30 – 61 years old, $M_{\text{age}} = 45.9$, $SD = 7.8$). With two exceptions, patients were female. Approximately one-third of the couples' relationship length ranged from 1 to 4 years, and another third ranged from 4 to 15 years. There was no significant difference in relationship length between couples (Table 1).

Table 1

Sample Characteristics

Variable	**Mean ± *S.D.* or *N* (%)**				**ANOVA/ χ^2-test F/χ^2-value**	**Post-hoc group comparison**
	1 Patients (*n*=13)	**2 Partners of patients (*n*=13)**	**3 Healthy controls (*n*=16)**	**4 Partners of healthy controls (*n*=16)**		
Mean age in years	42.58 (*SD* = 6.98)	49.64 (*SD* = 7.12)	37.07 (*SD* = 13.38)	39.27 (*SD* = 13.32)	2.98*	2 > 3 (p_{bonf} = .04)
Sex in number of female (%)	11 (85 %)	2 (15 %)	14 (87 %)	2 (13 %)	30.46***	1>2, 3>4 (p_{bonf}<.05)
Education in years	14.20 (*SD* = 4.56)	15.85 (*SD* = 3.95)	16.88 (*SD* = 2.50)	16.38 (*SD* = 2.96)	1.33	-
Cohabitation in number of yes (%)	9 (75 %)		12 (75 %)		1.00	-
Relationship length						
1-12 mo.	0		1 (6.3 %)		.97	-
1-4 yrs.	6 (46 %)		6 (37.5 %)			
4-15 yrs.	5 (38.5 %)		5 (31 %)			
15 yrs. -	2 (15 %)		4 (25 %)			
Somatic Pain-PHQ-15 (*M* ± *SD*)	12.80 ± 6.81	3.18± 3.65	3.88 ± 3.51	3.00 ± 2.90	15.83***	1 > 2, 3, 4 (p_{bonf}<.001)
Relationship distress (PHQ-10d)	.92 ± .79	.62 ± .77	.40 ± .63	.36 ± .50	1.84	-
Stress (PHQ-10)	9.92 ± 4.38	4.85 ± 4.56	4.00 ± 2. 80	2.93 ± 2.1	8.78***	1 > 2, 3, 4 (p_{bonf}= .008, .001, .000)

*p < .05, **p < .01, *** p < .001, PHQ : Patient Health Questionnaire

We recruited patient-couples through the in- and out-patient units of the Department of Psychosomatic Medicine and Psychotherapy at the Technical University of Munich. To keep homogeneity in the sample, we focused on SSD with predominant pain. The in- and exclusion criteria and the clinical diagnoses for all the patients were established by experienced and trained clinicians of the department, by conducting an extensive interview in order to evaluate the clinical characteristics for the diagnoses in question, including a detailed somatoform disorders and hypochondria symptom assessment. Healthy couples were recruited through advertisements in the departments' internal magazines, intranet and flyers, or local newspapers.

The inclusion criteria were:

a) a diagnosis with somatoform pain (ICD-10 F45.40) or chronic pain with psychological factors (F45.41) for the patients. (A DSM-V/SSD diagnosis was confirmed post-hoc by checking the complete B-criterion)

b) being free of any chronic somatic complaints, for the healthy controls.

c) a current romantic relationship for at least one month, and the partner's consent for participation for all the participants.

Exclusion criteria for all participants were a) age younger than 18 years, b) inadequate command of German, c) severe and chronic physical disease, d) severe comorbid mental disorder causing significant impairment of social functioning, e) severe conflict in the relationship.

The data were collected in March 2014. The Ethics Commission of the Department of Medicine of the Technical University of Munich approved the study. All participants were informed about the study and signed informed consent before starting the experiment. Couples received 100 Euro for participation.

2.2 Procedure

Participants were asked not to take any stimulants (e.g., coffee, tea, nicotine) less than 2 hours before testing and not to wear any makeup. Upon arrival at the laboratory, they filled in questionnaires on demographic information, somatic complaints (Patient Health Questionnaire, PHQ-15), psychosocial stressors (PHQ-10) (Löwe et al., 2002). Next, the couples underwent a dyadic interaction paradigm that consisted of three conditions (Figure 1). An intern-psychotherapist blind to the study hypotheses moderated the interactions. During the three conditions, the cutaneous temperature of both partners was measured. After each condition, participants reported their current affect and perceived partner-affect by a self-report instrument explained below.

2.2.1 Dyadic emotion induction tasks

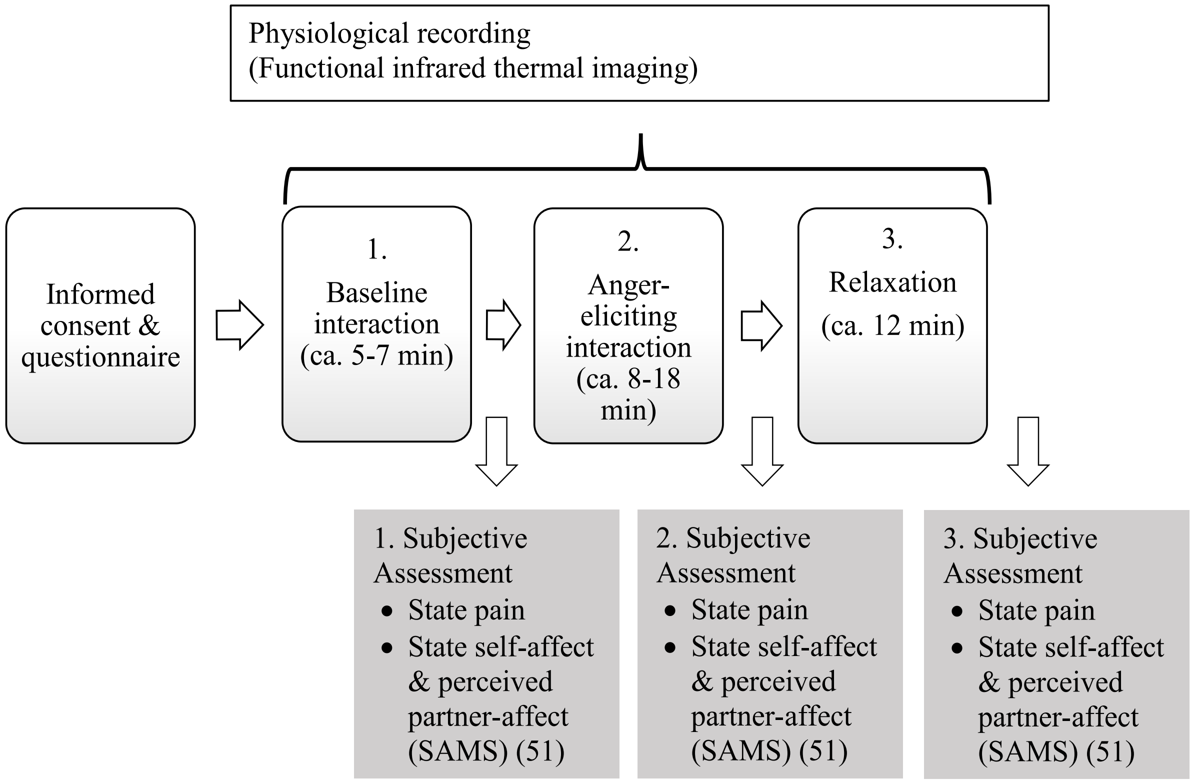
Baseline interaction. Couples had an approximately five-minute conversation about an emotionally neutral event such as the trip to the lab, events of the day, or the weather, as suggested by previous studies (Levenson & Gottman, 1983).

Anger-eliciting interaction. Based on previous research having underlined anger-regulation difficulties in patients experiencing chronic pain (Bruehl et al., 2006; Okur Güney et al., 2019), we focused on an anger context. Interview methods are more effective in creating physiological variations than other methods, such as movie clips or punishment tasks (Lobbestael et al., 2008). Therefore, we chose the dyadic interview method for anger induction. For this task, the interviewer instructed the partners to identify a mutual past event that generated a strong feeling of anger towards each other on both sides, an experience that could still be well recalled by the two. One of the partners was instructed to describe the event verbally. The interviewer then instructed them to discuss the event, their thoughts, and feelings as genuinely as possible (Dimsdale et al., 1988). The interviews lasted between 8 and 18 minutes (M = 15.73, SD = 2.29 minutes).

Relaxation. To down-regulate the negative affect, the couples followed a guided audio progressive-muscle relaxation and imagination exercise that lasted about 12 minutes.

Figure 1

Experimental procedure



2.3 Measures

2.3.1 Thermal variations on the face

Infrared imaging was run using two digital cameras: FLIR, SC660 (640 × 480 bolometer, FPA, sensitivity: <30 mK @ 30◦C), and FLIR SC655 (640 × 480 bolometer, FPA, sensitivity: <50 mK @ 30◦C). The sampling rate was five frames/second. The cameras were positioned behind and just over each partner's head so that each camera could record the partner's face. The experiment room had an average temperature between 20-23°, 60-65 % humidity, and was isolated from direct ventilation and sunlight. Variations in the cutaneous temperature of the facial regions of interest were analyzed using customized Matlab programs developed for tracking purposes and validated in previous studies (Ebisch et al., 2012; Filippini et al., 2020). Our primary regions of interest, 1) the nose, and 2) the forehead, were selected based on previous studies (Ebisch et al., 2012; Ioannou et al., 2014; Merla & Romani, 2007). The thermal signals were obtained as pixels' average values on the regions of interest over time.

After the thermal imprints were inspected visually for the recording quality, the thermograms were corrected for movement artifacts.

2.3.2 Subjective reports for pain and affect

Immediately after each condition, participants rated their pain with a visual analog scale. They also rated their affect and perceived partner-affect on a paper-based scale. This method enabled us to quantify subjective emotional interdependence at a between-couple level. The scale involved items that assess the pleasure, arousal, and dominance dimensions for both self and partner (e.g., "How do you feel right now?" "How does your partner feel right now?"). (adapted from Self-Assessment Manikin, SAM (Fischer et al., 2002); see Appendix A for example items). SAM is a cartoon-like visual assessment of affect, hence a quick and implicit scale. It has a nine-point scoring system for measuring feelings of valence (unhappy to happy), arousal (calm to excited), and dominance (controlled to controlling), with a pictorial representation for each point.

2.4 Data analysis strategy

Firstly, we performed mixed-model ANOVAs for unbalanced designs to examine the within-subjects effect of experimental condition (baseline, anger, relaxation) and between-subjects effect of individual groups (patients, their partners, healthy controls, and their partners) on each affect dimension (i.e., valence, arousal, and dominance). Post-hoc tests were adjusted for Bonferroni corrections. To test the effect of experimental conditions on pain experience, we compared pain reporters' self-ratings by paired samples t-tests.

To examine coherence between partners' cutaneous facial temperature, we performed Wavelet Coherence Analysis (WCA) for each couple. WCA is a frequency and time-domain analysis that evaluates similar patterns of variations between two signals. It decomposes time-series data into components with different frequencies or rhythms at a time-frequency space (Fujiwara & Daibo, 2018; Grinsted et al., 2004).

Autonomic data are usually non-stationary; that is, the statistical properties of the data, such as mean, and variance change over time. WCA does not assume the data's stationarity and can detect the cyclical changes at different frequency bands (Fujiwara & Daibo, 2018). Many physiological signals contain frequency bands related to biological and clinical indications, such as respiratory sinus arrhythmia of an electro-cardiac signal or the frequency bands of cutaneous blood flow. WCA can detect different frequency components and inform about a thermal signal's physiological origins (Shastri et al., 2009). Besides, it requires little parameter estimates (Fujiwara & Daibo, 2018). Other methods to quantify linkage, such as windowed cross-correlation, are sensitive to parameter estimates and requires informed decisions, making it prone to subjectivity.

WCA on thermal signals was performed via the Matlab package provided by Grinsted, Moore, and Jevrejeva (Grinsted et al., 2004) (http://noc.ac.uk/using-science/crosswavelet-wavelet-coherence) using the Morlet wavelet as the mother wavelet. Based on previous studies we distinguished five frequency bands for cutaneous temperature: metabolic (0.008-0.02 Hz), neurogenic (0.02-0.05 Hz), myogenic (0.05-0.15 Hz), respiratory (0.15-0.4 Hz) and cardiac origins (0.4-2 Hz) (Geyer et al., 2004; Podtaev et al., 2015). (Geyer et al., 2004; Podtaev et al., 2015). For each experimental condition of each couple and frequency band, the average coherence amplitude over time was computed. Furthermore, the percentage of in-phase and anti-phase values were calculated, replicating the approach employed in previous studies (Fujiwara & Daibo, 2018; Schmidt et al., 2012). While low-frequency bands (i.e., metabolic, myogenic, and neurogenic) carry information about modulation of microvascular flow-motion at a local level, high-frequency bands (i.e., cardiac and respiratory) reflect hemodynamic modulation by breathing and heartbeat (Clough et al., 2017), making them prone to short-time emotional changes. Therefore, we tested our hypothesis on the cardiac band, which exhibits the highest frequency. As it is not established, which frequency band to focus on during emotional contexts, we also exploratively ran the analysis for each frequency band.

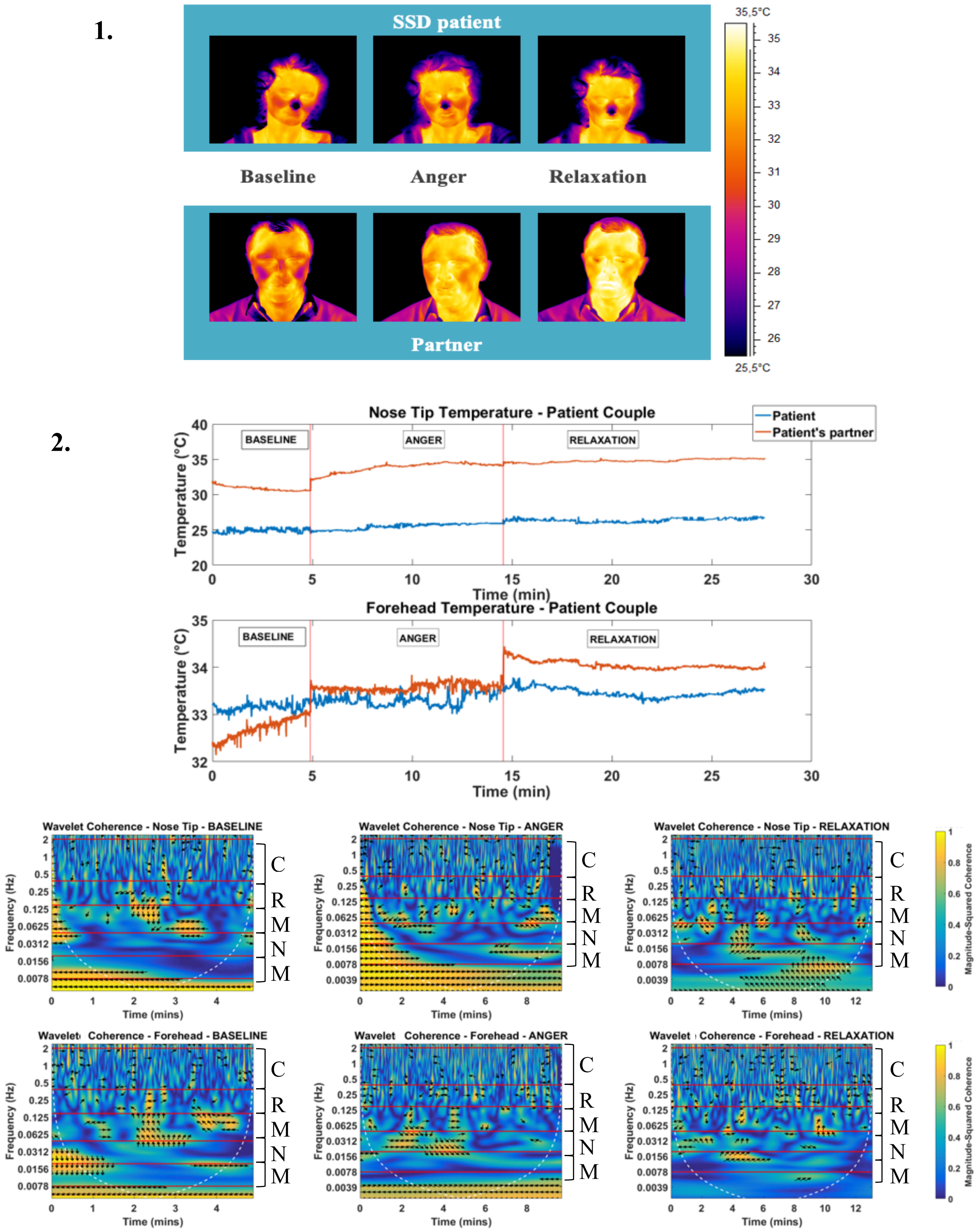
Coherence amplitude values indicate the strength of the linkage between signals, regardless of the direction, which is the main interest of our study. Coherence amplitude values range between 0 and 1, with 0 representing no linkage and 1 indicating a total linkage in temperature. In-phase and anti-phase values provide information on the relative phase angle of two signals: the covariation of timing. If two signals are in-phase, they move in the same part of a cycle simultaneously, comparable to a positive correlation. If the signals are in anti-phase patterning, they move in the opposite part of a cycle (See Figure 2 for an illustration of a couple's temperature time series mapped on a WCA plot).

We then performed two 2X3 mixed-model ANOVAs to test the interaction effect of the couple type and experimental conditions on the coherence amplitude at the cardiac band in the nose tip and forehead temperature.

Finally, to explore the between-couple level interdependence in partners' subjective affect, we performed non-parametric correlation analyses. We did not include the relaxation condition beyond this study's primary focus to reduce the number of analyses.

Figure 2

An illustration of a couple's fIRI image frame (1), temperature change on the forehead & nose tip on a time-series plot (2), and on a wavelet coherence plot (3).



C = Cardiac band: [0.4,2] Hz
R = Respiratory band: [0.15,0.4] Hz
My = Myogenic band: [0.05,0.15] Hz
N = Neurogenic band: [0.02,0.05] Hz
M = Metabolic band: [0.008,0.02] Hz

In 3, the x-axis represents the time, and the y axis represents the frequency band. The wavelet coherence amplitude is represented by color. The relative phase is signified by the arrows' direction: The horizontal right arrows indicate complete in-phase patterning, whereas the horizontal left arrows indicate complete anti-phase patterning, and the downward arrow indicates no coherence. The average value was calculated from these plots for analyzing the wavelet coherence amplitude and the relative phase.

3. Results

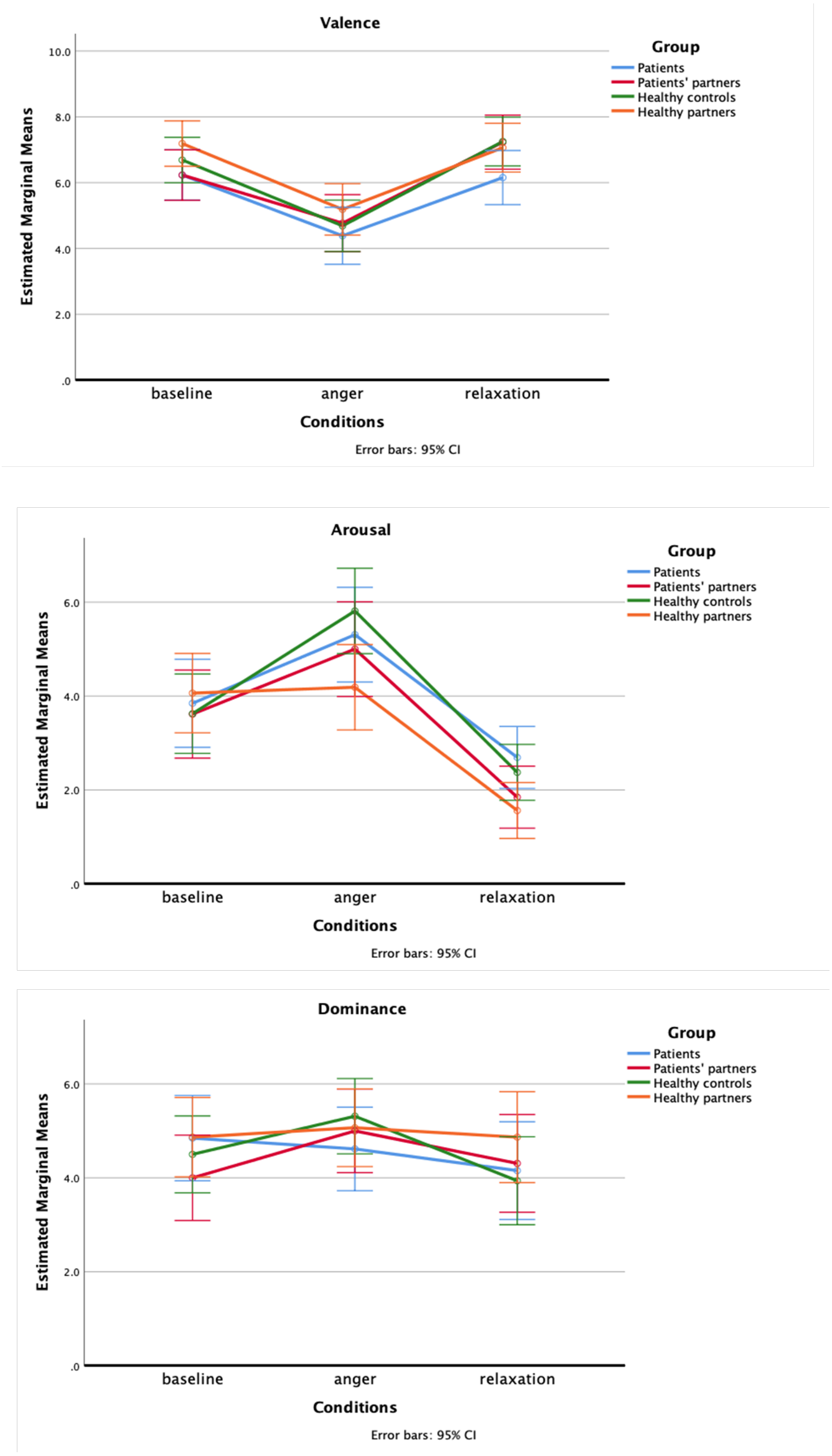
3.1 Preliminary analyses: Effect of experimental conditions on individual responses

3.1.1 Change of affect

Experimental conditions significantly changed participants' positivity (valence), $F(2, 108) = 43.48$, $p < .001$, $\eta^2 = 0.29$), arousal, $F(2, 108) = 84.84$, $p < .001$, $\eta^2 = 0.36$), and dominance $F(2, 106) = 3.22$, $p = .044$, $\eta^2 = 0.03$ (Figure 3). As expected, positive affect significantly decreased from baseline to anger ($MD= -1.84$, $SE = .26$, $t = -7.16$, $d = -0.94$, $p_{bonf} < .001$) and increased at relaxation ($MD = -2.17$, $SE = .26$, $t = -8.34$, $d = -1.09$, $p_{bonf} < .001$). When couples were compared, SSD patient-couples reported a slight lower positive affect than healthy couples, $F(1,56) = 3.82$, $p = .056$, $\eta^2 = 0.64$. Arousal followed an opposite pattern to valence; a significant increase from baseline to anger ($MD = 1.27$, $SE = 2.25$, $t = 5.19$, $d = 0.68$, $p_{bonf} < .001$) and relaxation ($MD = 1.69$, $SE = 2.23$, $t = 7.49$, $d = 0.98$, $p_{bonf} < .001$) and a decrease from anger to relaxation ($MD = 2.97$, $SE = .23$, $t = 12.93$, $d = 1.70$, $p_{bonf} < .001$). Feeling of dominance declined significantly from anger to relaxation ($MD = .70$, $SE = .27$, $t = 2.55$, $d = 0.34$, $p_{bonf} = .044$). The four groups (patients, their partners, healthy controls and partners) did not show statistically significant differences from each other in their affect ratings.

Figure 3

Change of affect dimensions among experimental conditions.



3.1.2 Change of pain

Because not all the participants reported pain in the experiment, to maintain normal distribution, we selected those who reported pain in all three conditions[3] ($N = 12$) and performed paired samples t-tests. Pain reports increased significantly from baseline ($M = 4.16$, $SD = 2.33$) to anger ($M = 5.33$, SD = 2.06), $t(11) = -3.19$, $p = .009$, $d = 0.92$, 95 % CI = [-1.59, -.22], and slightly decreased from anger to relaxation ($M = 4.17$, $SD = 2.69$), $t(11) = 1.76$, $d = 0.51$, $p = .10$, 95 % CI = [-.104, 1.103].

3.2 Do couple-group and emotional conditions affect coherence in partners' facial temperature?

3.2.1 Coherence in partners' forehead temperature at the cardiac band

Coherence amplitude ranged between .24 ($SD = .019$) and .32 ($SD = .014$). As expected, coherence amplitude between partners' forehead temperature significantly changed as a function of couple type and experimental condition, $F(2, 54) = 4.95$, $p = .011$, with a medium effect size ($\eta^2 = 0.1$), (Figure 4). Planned follow-up paired sample t-tests showed that coherence significantly decreased in the healthy couples from baseline to anger, $t(15) = 2.13$, $p = .025$, $d = 0.53$) and increased in the SSD patient-couples, $t(12) = -1.91$, $p = .040$, $d = 0.53$)

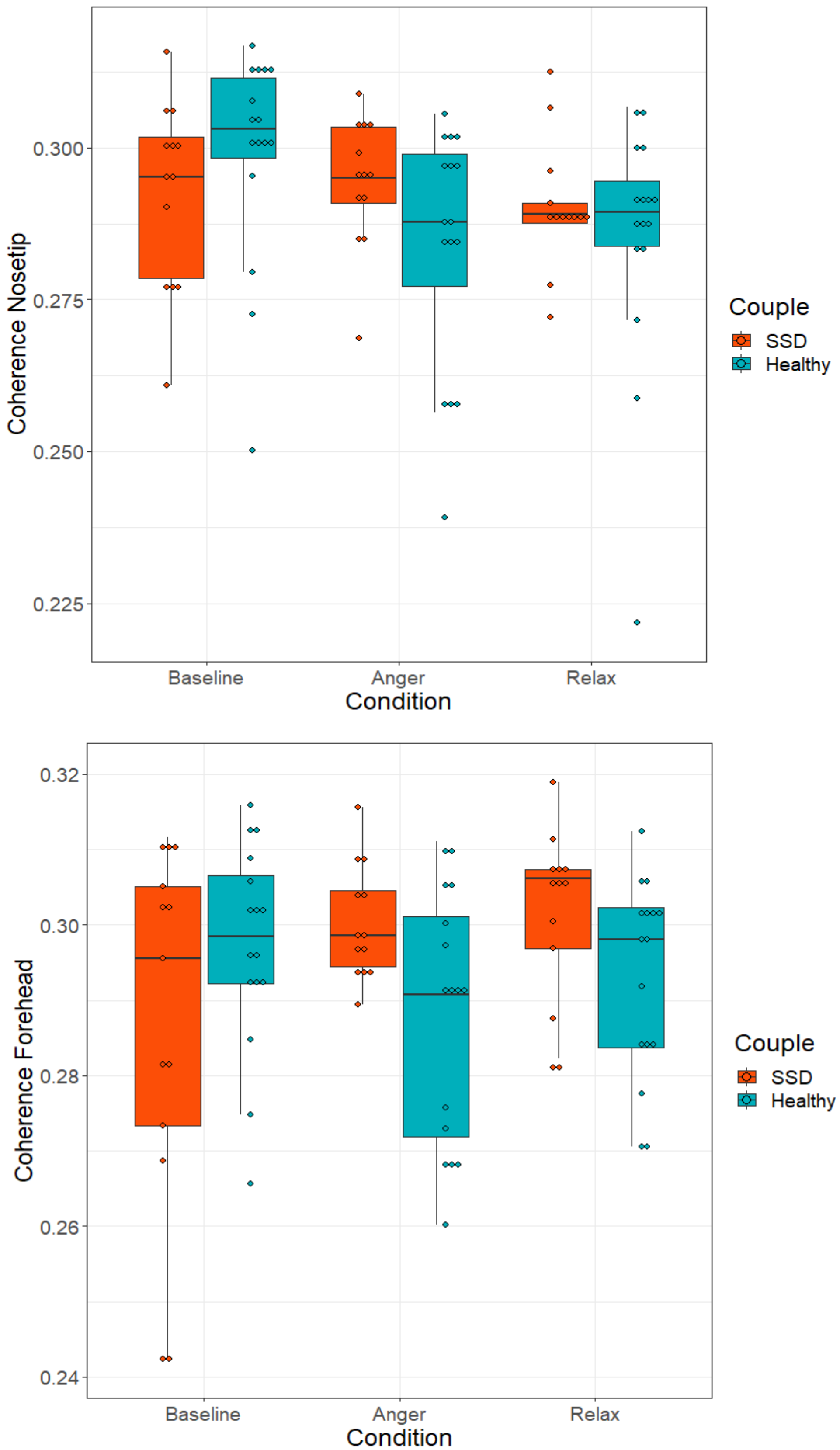
3.2.2 Coherence in partners' nose tip temperature at the cardiac band

The amplitude of coherence values between partners' nose tip temperature ranged between .22 ($SD = .017$) to .31 ($SD = .016$). As expected, a significant interaction effect of couple type and experimental conditions on the coherence amplitude was found, $F(2, 54) = 3.75$, $p = .030$, with a small to medium effect size ($\eta^2 = 0.04$), (Figure 4). Planned follow-up paired samples t-tests showed that the coherence amplitude of healthy couples' nose tip temperature significantly decreased from baseline ($M = .30$, $SD = .02$) to anger ($M = .28$, $SD = .02$), $t(15) = 4.59$, $p < .001$, $d = 1.15$. No statistically significant change was observed in the patient-couples from baseline to anger condition ($p = .34$, $d = -0.11$).

[3] When the whole sample is included, pain reports again increased significantly from baseline ($M = 0.98$, $SD = 1.99$) to anger ($M = 1.26.33$, $SD = 2.36$), $t(56) = -2.08$, $p = .042$, $d = 0$ .27, 95 % CI = [-0.54, -.01].

Figure 4

Change of coherence amplitude in forehead and nose tip temperature among experimental conditions in healthy and SSD patient-couples



3.3 Secondary analyses

3.3.1 Subjective emotional interdependence at between-couple level

3.3.1.1 Valence

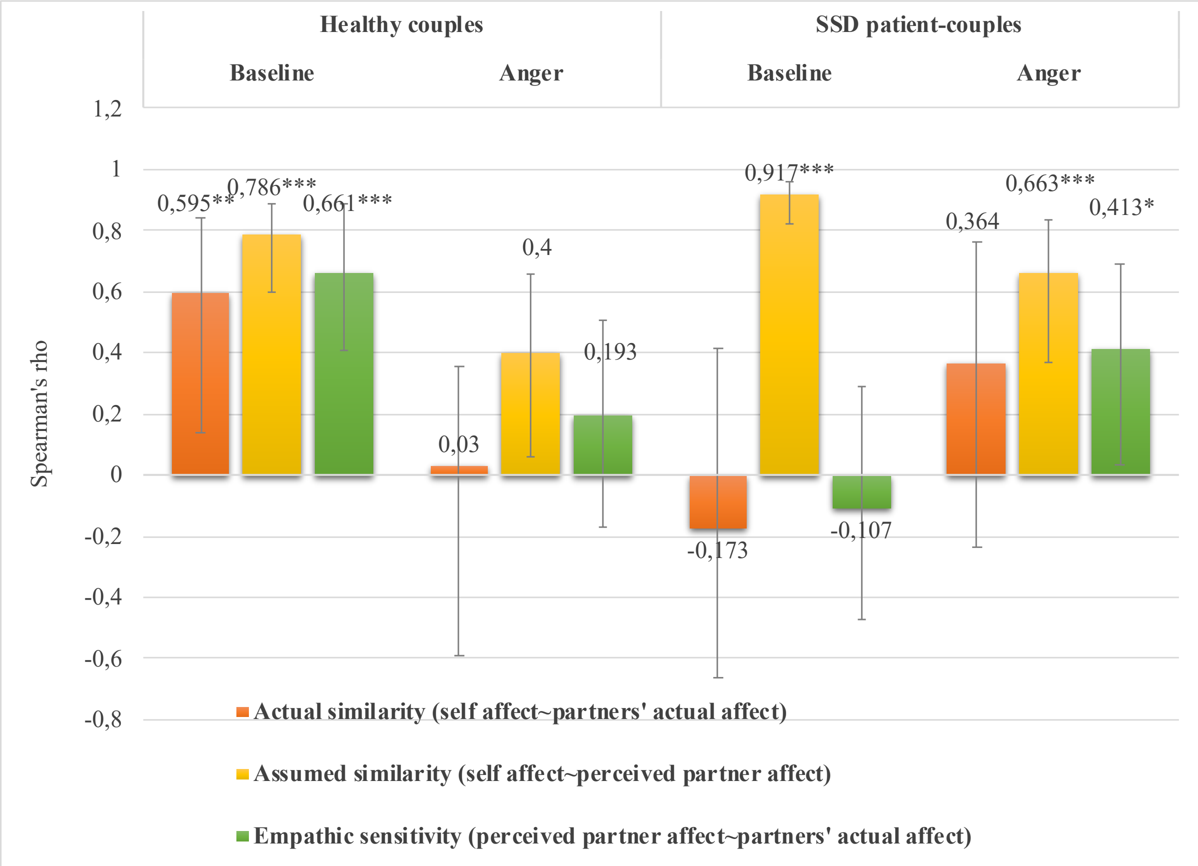
Relationship between partners' valence (i.e., actual similarity). At baseline, while self-valence ratings showed a significant positive relationship in healthy couples, $r_s = .595$, $p = .015$, $N = 16$, 95% CI [.141, .842], they showed a non-significant negative relationship in SSD patient-couples ($r_s = -.173$, $p = .57$, $N = 13$), Fisher's $z = -2.045$, $p = .020$. In the anger condition, this relationship decreased in the healthy couples, $r_s = .030$, $p = .91$, Fisher's $z = 1.67$, $p = .047$, while we observed a non-significant yet descriptively increasing positive relationship in the SSD patient-couples, $r_s =. 364$, $p = .22$, $N = 13$, Fishers' $z = 1.24$, $p = .107$. (Figure 5).

Relationship between subjects' self-valence and perceived partner's valence (i.e. assumed similarity). At baseline, in both couple groups, participants´ valence and perceived partner-valence were strongly positively correlated; patient-couples, $r_s = .917$, $N = 26$, p<.001, 95% CI [.821, .962], healthy couples, $r_s = .786$, $N = 32$, $p < .001$, 95% CI [.602, .891]. This relationship remained strong in the patient couples from baseline to anger, $r_s = .663$, $N = 26$, $p < .001$, 95 % CI [.371, .836]. Yet, it significantly decreased to a medium-sized correlation in the healthy couples, $r_s = .400$, $N = 32$, $p = 0.023$, 95 % CI [.06, .66], Fisher's z; 2.34, $p = .008$.

Relationship between perceived partner-valence and partners' actual valence (i.e., empathic sensitivity). At baseline, in the patient-couples, perceived partner-valence and partners' true valence were not related to each other ($r_s = -.107$, $N = 26$), as opposed to the healthy couples who presented a strong relationship ($r_s = .661$, $N = 32$, p < .001, 95% CI [0.406, 0.891], (Correlation difference between healthy and patient-couples, Fisher's $z = 3.19$, $p = .001$). On the other hand, the pattern reversed in the opposite direction at the anger phase: Perceived partner-valence and partners' actual valence were related only in the patient-couples, $r_s = .413$, $N = 26$, $p = .036$, 95% CI [0.031 to 0.690]. (Correlation difference between baseline and anger condition in the patient-couples: Fisher's $z = 1.85$, $p = .032$). However, there was no relationship between estimated and actual feelings of partners in healthy couples ($r_s = .193$, $N = 32$). (Correlation difference between baseline and anger condition in the healthy couples: Fisher's $z = 2.28$, $p = .011$).

Figure 5

Relationship between participants' valence reports for self and partner in healthy and SSD patient-couples among baseline and anger conditions



Error bars represent 95 % confidence intervals for r values. *p < .05, **p < .01, ***p < .001

Arousal and Dominance. Correlation analyses for dominance and arousal dimensions mostly produced non-significant results; therefore, the results are reported in Appendix B. However, different patterns of change from baseline to anger condition were observed in SSD patient- and healthy couples. The results suggested an increasing between-couple interdependence in arousal and a decreasing one in dominance from baseline to anger condition in the patient-couples.

3.3.2 Relative phase patterning in cutaneous temperature coherence

For the change of relative phase patterning (in-phase and anti-phase) among conditions, the results were inconclusive (see Appendix C that demonstrates the difference in relative phase).

3.3.3 Coherence at the metabolic, neurogenic, myogenic, and respiratory bands of the cutaneous temperature

In the lower frequency bands, coherence amplitude ranged between .048 and .701. Temperature coherence in these frequency bands in the forehead region changed as a function of experimental condition only. In both groups, coherence values in the lower frequency bands (i.e. metabolic, neurogenic and myogenic) decreased from baseline to anger and slightly increased during relaxation; metabolic, $F(2, 54) = 3.28$, $p = .045$, $\eta^2 = .09$, neurogenic, $F(2,54) = 3.41$, $p = .040$, $\eta^2 = .08$, myogenic, $F(2, 54) = 2.05$, $p = .14$, $\eta^2 = .05$. (Appendix D). For the nose tip temperature, the results were inconclusive.

4. Discussion

This study demonstrated that couples with an SSD patient and healthy couples showed different trajectories in emotional interdependence depending on the emotional context. From baseline to anger-eliciting interaction, healthy couples could decrease their physiological coherence while SSD patient-couples showed a stronger coherence amplitude. Between-couple level subjective emotional interdependence between partners followed a similar course to physiological coherence in both couple groups. Notably, in the SSD patient-couples, interdependence of emotional valence seemed completely absent at baseline, whereas healthy couples showed evidence for a strong relationship during this condition. This relationship between partners took an opposite direction in the anger condition; SSD couples showing a stronger, and healthy couples showing a weaker emotional interdependence.

Our findings are in line with previous reviews, which concluded that the implications of PL depend on the context (Butler, 2015; Palumbo et al., 2016; Timmons et al., 2015). Healthy couples' higher temperature coherence at baseline might point to their emotional connectedness and understanding, as indicated by previous studies (Ebisch et al., 2012; Manini et al., 2013; Ruef, 2001). This interpretation is supported by their greater between-couple level subjective emotional interdependence at baseline, conveying higher assumed similarity, actual similarity, and empathic sensitivity between partners. However, at the anger condition, the decrease in emotional interdependence in the healthy couples can denote a functional and adaptive shift to a more independent emotional processing to prevent escalation and dyadic emotional overload (Timmons et al., 2015).

On the other hand, SSD patient-couples' stronger temperature coherence and emotional interdependence at the anger condition can convey inability to disengage from a negative emotional exchange, featured by patterns of reactivity and counter reactivity (Butler, 2015; Timmons et al., 2015; Wilson et al., 2018). Patient-couples' slightly lower valence ratings in general, and the increasing positive relationship between partners' arousal from baseline to anger, in contrast to the negative one in the healthy couples, lend support to our conclusions.

4.1 Limitations and future directions

Some characteristics of this study limit the conclusions we can draw about the effect of having an SSD patient partner and emotional context on physiological coherence. First and foremost, the sample size was small; and healthy, and patient-couples were not matched based on age and sex, limiting the results' generalizability. Future studies with a larger sample size are called for to replicate or extend the study findings. Secondly, we observed considerable variability in physiological coherence across couples that future studies can examine by including possible couple characteristics such as attachment styles or emotion regulation variables. This heterogeneity might be an essential feature associated with individual differences in the relationship between psychological and physical health (Kelly et al., 2020). Third, the measured physiological system (e.g., hypothalamic-pituitary-adrenal axis, autonomic nervous system, sympathetic or parasympathetic branch) can play a role in coherence. Future research can compare coherence in other physiological indices. Fourth, the current goal of the study was not to elicit a specific anger response but rather to compare the changes in physiology and emotional experience during presentation of autobiographical anger-eliciting and relaxing content. Therefore, the results don't intend to distinguish whether, or under which conditions, the physiological reaction is explicitly linked to anger and not to a non-specific emotional arousal or an actual experience of pain during the experiment. Finally, we measured subjective affect by one time-point measure after each condition and then conducted nomothetic analyses (i.e., correlation) to examine between-couple level interdependence. Therefore, it is an open question, whether continuous measurement of subjective affect such as a rating dial method (R. W. Levenson & Gottman, 1983) and dyad-level analyses would yield comparable results.

Despite its limitations, this research offers novelty and insight in several ways. The present study integrates the most recent theoretical and methodological developments in emotion research into research on SSD. It enhances our understanding of emotions from an individual state to a multi-componential, dynamic and interpersonal process to discern the mechanisms of SSD. The interpersonal and ecological design of the research provides critical insight into dynamic and real-time processes taking place during patients' interactions with significant others. Moreover, the study illustrates the potential usefulness of advanced interdisciplinary tools such as WCA or fIRI in psychosomatic research for examining emotional processes.

The present findings provide insights to the healthcare communities for assessing and treating disturbances in emotion regulation (Koechlin et al., 2018; Okur Güney et al., 2019) in patients with SSD. Patients are embedded in their social networks, and it is usually a social encounter where strong emotions such as anger arise and linger. The findings suggest that conflictual situations, such as anger-eliciting ones, can increase SSD patients' autonomic and emotional interdependence with their partners, which appears to be disruptive for physical health (S. J. Wilson et al., 2018). These effects are valuable for clinical interventions: During psychotherapy, patients' awareness can be improved on how negative emotions arise and resonate on the body in both interacting parties during emotional exchanges and how they are connected with bodily symptoms. With the patient, self-regulation techniques for dealing with strong emotions during such situations, without getting absorbed by the interdependent dyadic conflictual system, can be developed. Based on the rationale that the quality of interpersonal relationships is likely to constitute and/or influence physical complaints (Sattel et al., 2012), those approaches will be suited to enrich and extend the spectrum of useful therapeutic interventions.

To sum up, the present study showed that having an SSD patient-partner and emotional condition affected within-couple level autonomic and between-couple level subjective emotional interdependence. Emotional interdependence can be seen as a "double-edged sword" (Timmons et al., 2015), which might indicate connectedness and empathy in positive situations or as a response to the external world's demands. Nevertheless, it can denote emotion co-dysregulation during partners' negative emotions directed at each other and might embody being trapped in an adverse affect-mutuality (Butler, 2015), losing autonomy and self-regulation (Galbusera et al., 2019). Investigating such dynamic emotional processes in SSD patients' real-time social interactions is essential to understand the psychobiological mechanisms of SSD.

5. References (Chapter IV)

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6. Appendices

6.1 Appendix A: Scale for self-affect and perceived partner-affect[6]

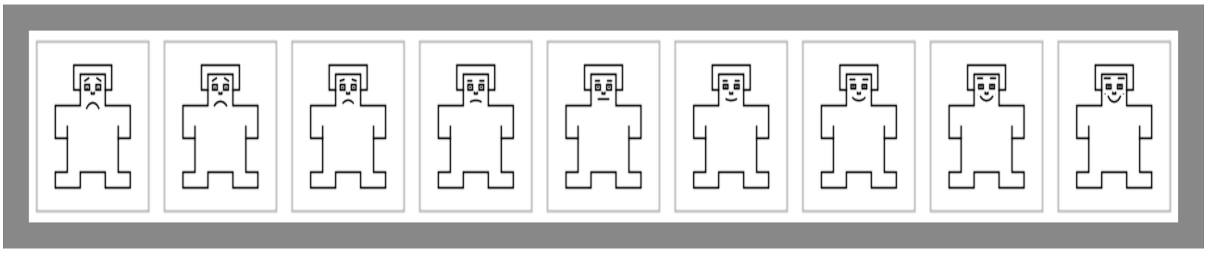
Bitte markieren Sie auf dem Bild.

i) Wie sie sich fühlen jetzt im Augenblick ein? ii) Wie Ihr/e Partner/in sich fühlt jetzt im Augenblick ein? Entscheiden Sie spontan, ohne langes Nachdenken.

A. Stimmung

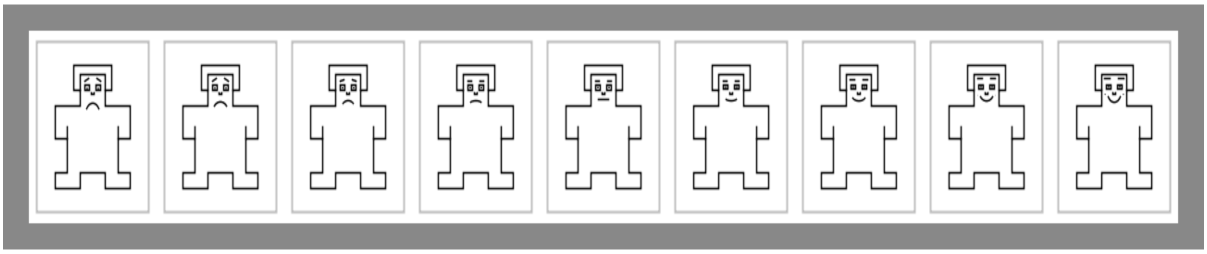
i) Sie

Unglücklich --Glücklich



ii) Ihr/e Partner/in

Unglücklich --Glücklich



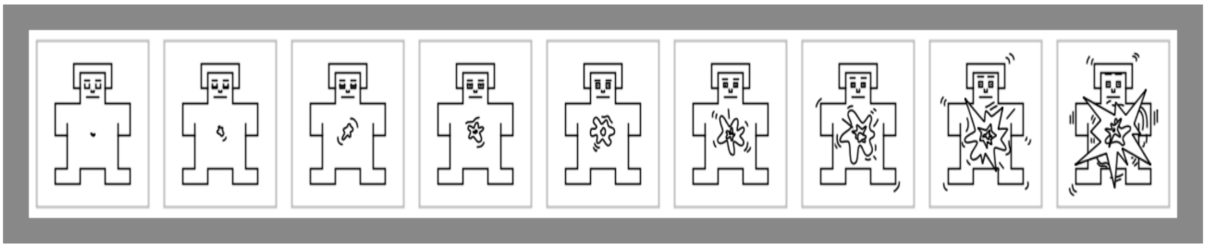
[6](Adapted from Self-Assessment Manikin, SAM; Fischer et al., 2002)*.

*Fischer L, Brauns D, Belschak F. Zur Messung von Emotionen in der angewandten Forschung: Analysen mit den SAMs - Self-Assessment-Manikin. Pabst Science Publishers; 2002. p. 320.

B. Aufregung

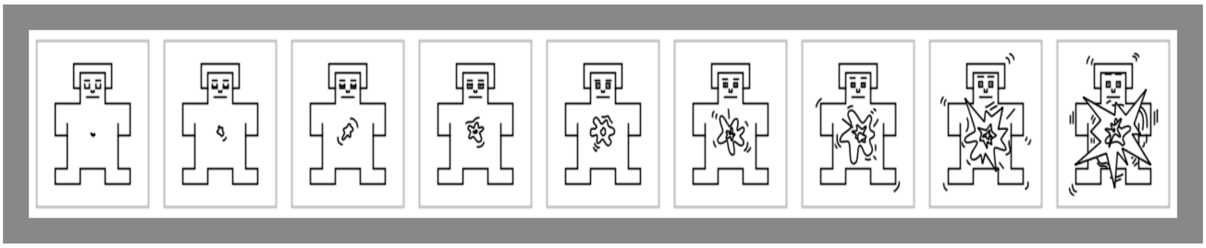
i) Sie

Ruhig --Erregt



ii) Ihr/e Partner/in

Ruhig --Erregt

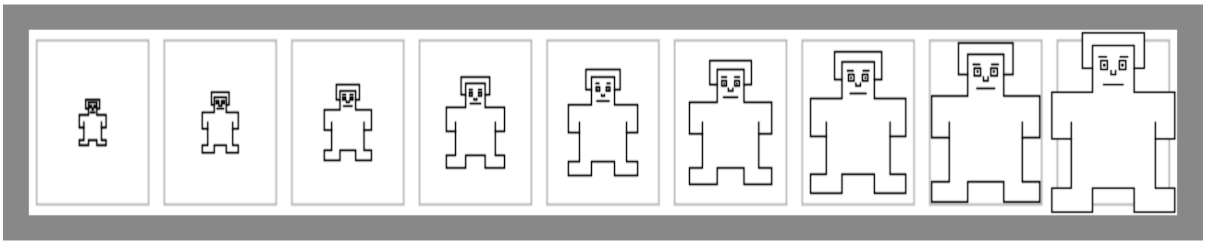


C. Kontrolle

-

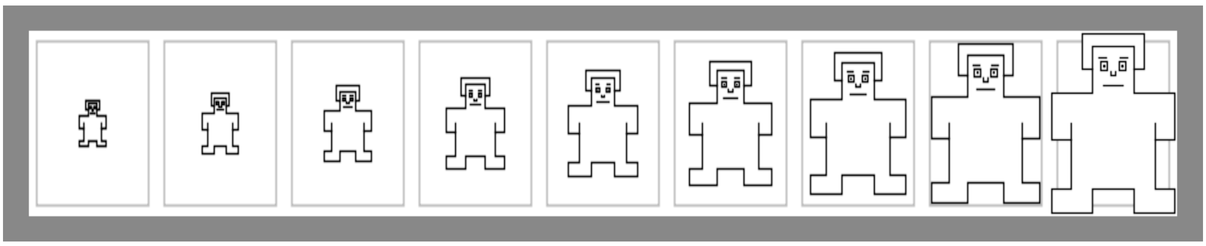
i) Sie

Kontrolliert --Kontrollierend



ii) Ihr/e Partner/in

Kontrolliert --Kontrollierend



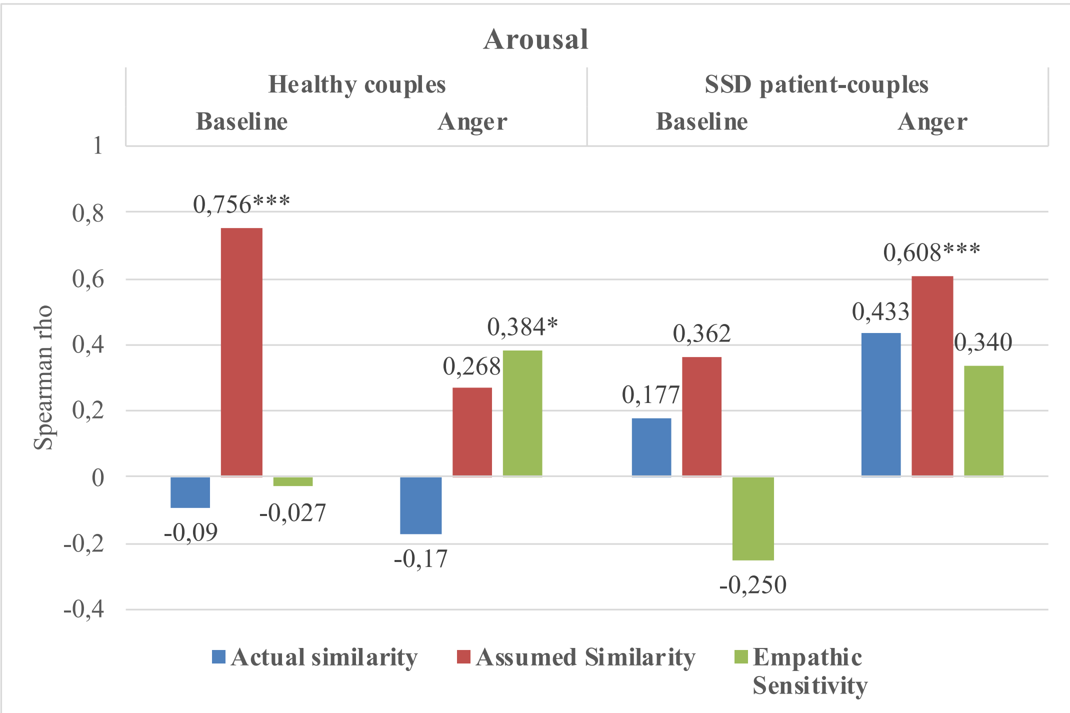
6.2 Appendix B: Group-level relationships between partners in dominance and arousal

Arousal

Actual similarity. The relationship between partners' feeling of arousal at the anger condition in the SSD patient-couples (r_s = .433, N = 16, p = .14) was slightly higher compared to those in healthy couples (r_s =.-.17, N = 16, p = .53), Fisher's z = 1.51, p = .06.

Assumed similarity. An increasing relationship between participants' self-arousal and perceived partners' arousal in the patient-couples from baseline (r_s =.362, N = 26, p = .07) to anger, r_s =.608, N = 26, p < .001, 95% CI [0.289, 0.806], as opposed to a decreasing one in the healthy couples was observed, (Baseline: r_s =.756, N = 32, p < .001, 95% CI [0.552, 0.874], Anger, r_s =.268 N = 32, p = .14, 95% CI [-0.096, 0.568], Fisher's z = 2.71, p = .003).

Empathic sensitivity. At baseline, the relationship between perceived partner's feelings and partners' actual feelings was negative (r_s -.25, p = .22, N = 26) in the patient couples, which significantly changed to a positive one at the anger condition (r_s = .34, p = .09, N = 26), Fishers's z: 2.07, p = .02. Similarly, the correlation for empathic sensitivity became significant at the anger condition in the healthy couples, r_s =.384, N = 32, p = .04, 95% CI [0.03, 0.65], although it was non-significant at baseline (r_s = -.027, N = 32)



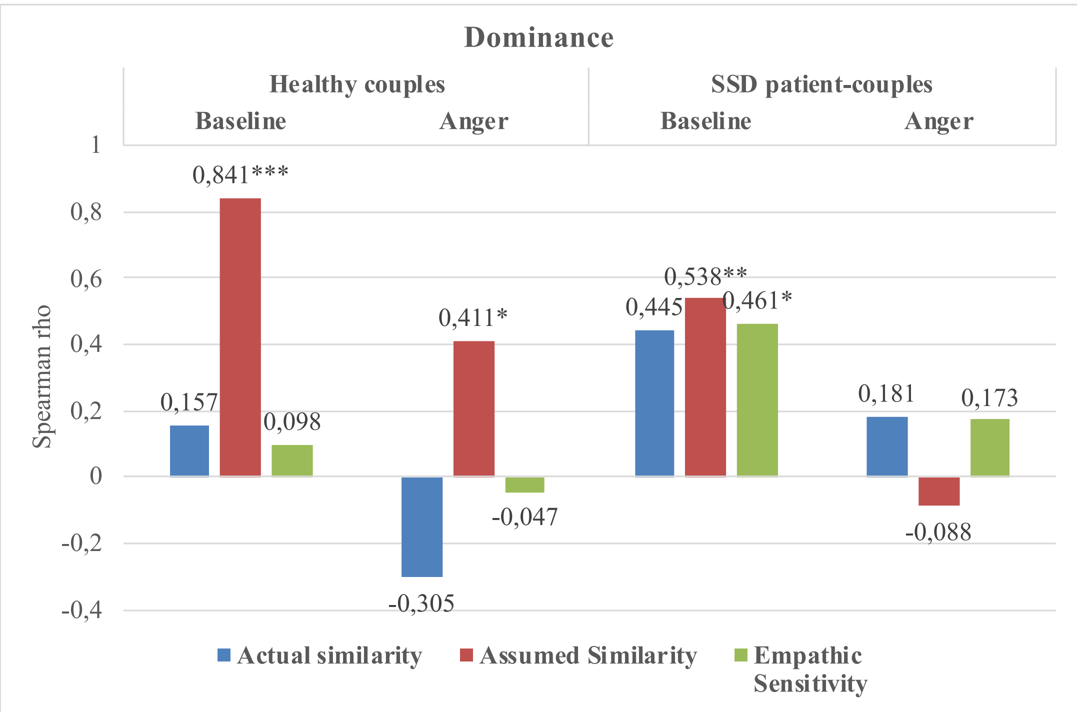
*p < .05, ***p < .001

Dominance

Actual similarity. Although not being statistically significant, the relationship between partners' felt emotion slightly decreased from baseline (r_s = .445, p = .13, N = 13) to anger (r_s = .181, p = .55, N = 13) in the patient couples (Fisher's z = .661, p = . 25). However, it slightly increased in the negative direction in the healthy couples from baseline (r_s = .157, N = 16, p = .56) to the anger condition (r_s = -.305, N = 16, p = .27), Fisher's z = 1.21, p = .11.

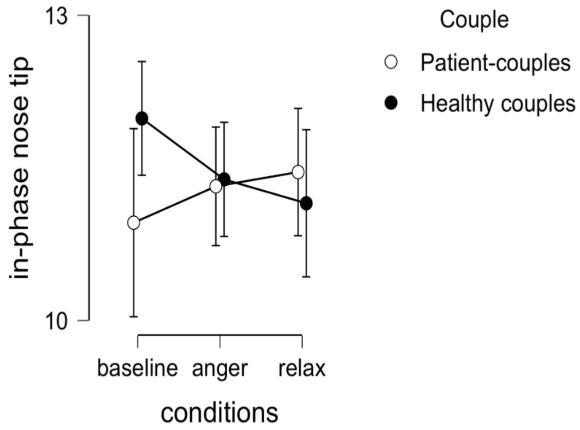
Assumed similarity. At baseline in both patient- and healthy couples, there was a significant relationship between participants' feelings of dominance and perceived partners' dominance (patient-couples: rs =.538, N = 26, p = .005, 95% CI [0.191, 0.766] and healthy couples: rs = .841, N = 32, p < .001, 95% CI [0.6971, 0.920]. However, at the anger condition, this significant relationship waned towards non-significance in the patient couples rs -.088, p = .67, N = 26, Fisher's z = 2.34, p = .01, and towards a moderate relationship in the healthy couples, rs = .411, N = 32, p = .02, 95% CI [0.066, 0.668].

Empathic sensitivity. In the patient-couples, the relationship between participants' perceived partners' dominance and partners' actual feeling of dominance was moderately correlated at baseline, r_s =.461, N = 26, p = .018, 95% CI [0.09, 0.72], although at the anger condition this relationship was non-significant, r_s = .173, p = .39, N = 26. In the healthy couples this relationship was very weak both at baseline (r_s = .098, p = .60, N = 32) and anger condition (r_s = -.047, p = .80, N = 32).

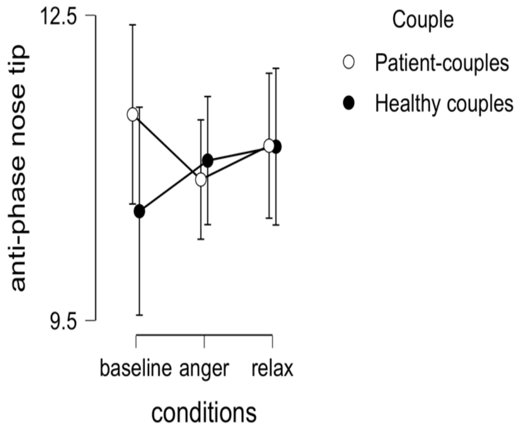


*p < .05, **p < .005, ***p < .001

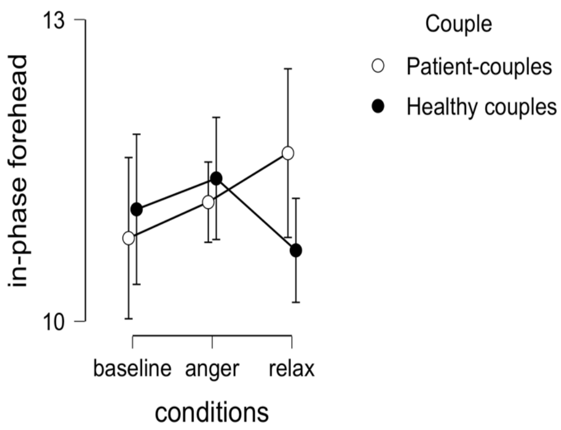
6.3 Appendix C: Phase patterning in nose tip and forehead coherence among experimental conditions



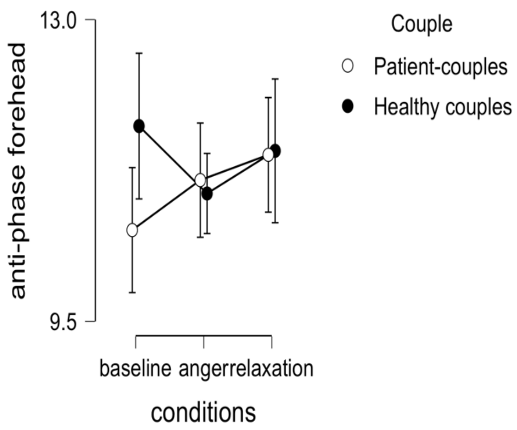
$F(2,54) = 2.43$, $p = .10$, $\eta^2 = .05$



$F(1.56, 42.11) = 1.34$, $p = .27$, η^2



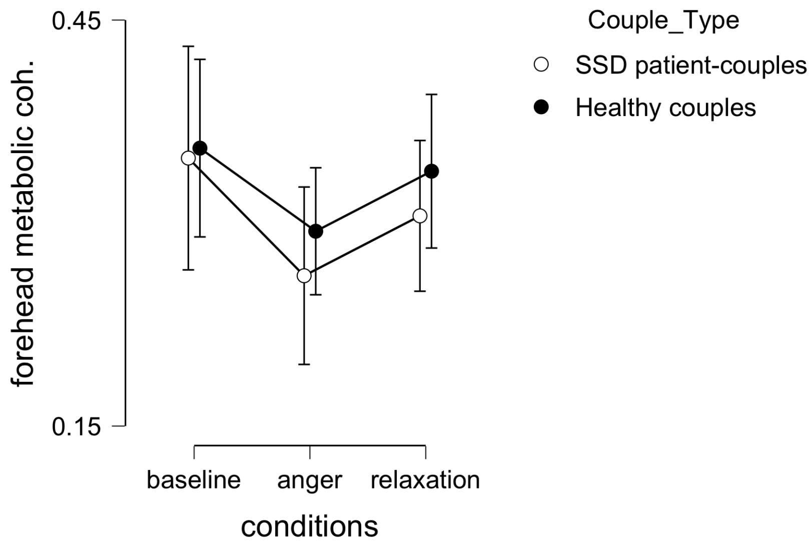
$F(2,54) = 2.6$, $p =. 08$, $\eta^2 = .05$



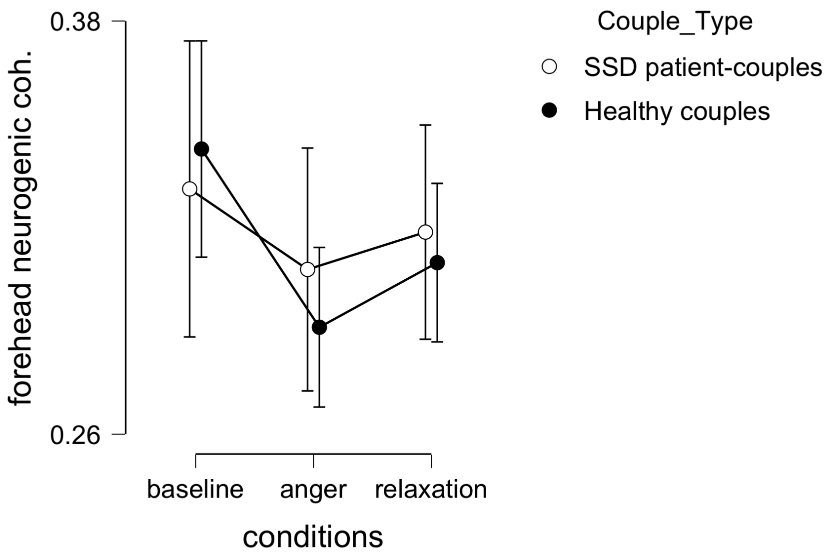
$F(2,54) = 2.37$, $p = .10$, $\eta^2 = .05$

Error bars represent 95 % confidence interval

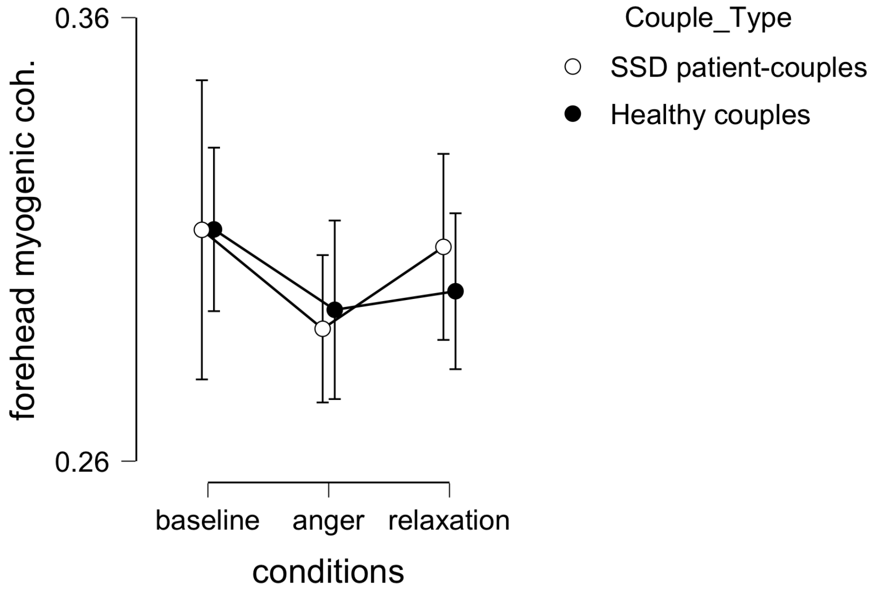
6.4 Appendix D: Coherence at the metabolic, neurogenic, myogenic and respiratory bands of the forehead temperature.



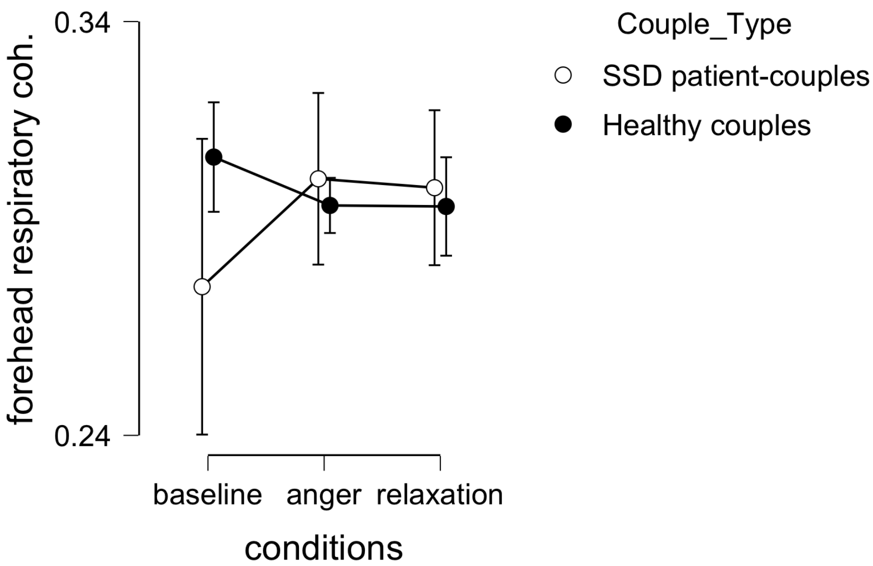
Condition effect: $F(2, 54) = 3.28$, $p = .045$, $\eta^2 = .09$.



Condition effect, $F(2,54) = 3.41$, $p = .04$, $\eta^2 = .08$



Condition effect (non-significant): $F(2, 54) = 2.05$, $p = .14$, $\eta^2 = .05$.



Condition X group effect: $F(2, 54) = 3.03$, $p = .056$, $\eta^2 = .06$.

Error bars represent 95 % confidence intervals.

Chapter V: General Discussion

Emotional processes and regulation play a significant role in the development and/or the course of several illnesses, from depression to asthma or Somatic Symptom Disorders (SSD) (Aldao et al., 2010; Austin et al., 2007; Bailer et al., 2017; Gratz & Roemer, 2003; Kring & Werner, 2004; Mund & Mitte, 2012; Okur Güney et al., 2019; Rosenkranz & Davidson, 2009; E. Sloan et al., 2017). In the case of SSD, emotional processes are integrated into several models explaining the mechanisms of the disorder either as primary (Alexander, 1950; Bucci, 1997; Lane et al., 2009; Thayer & Brosschot, 2005; Waller & Scheidt, 2006) or secondary factors (Brown, 2004; Henningsen, Gündel, et al., 2018; Kirmayer & Gómez-Carrillo, 2019; Van den Bergh et al., 2017; Witthöft & Hiller, 2010). In the field of emotion research, contemporary models pose emotions as dynamic and social systems consisting of components (i.e., subjective affect, physiology, cognitive processes, and behavior) (Butler, 2017; Gendron & Barrett, 2018; Gross, 2015; Kappas, 2011; Kuppens et al., 2009; Lewis, 2005; Scherer, 2009). Such recent advances in emotion research seem not to be adequately integrated into research on SSD, despite the attention paid to emotional processes in SSD. For example, the issue of how the components of emotion function in real-life situations is limitedly addressed. Additionally, most research has been conducted with static and individualistic paradigms although emotional events rarely occur in social isolation. This dissertation investigated emotional processes and regulation in SSD from a dynamical systems and interpersonal perspective.

The main objective of the first empirical section was to systematically review existing studies on emotion regulation in SSD by including several labels given to patients and to classify the results based on which component of emotion is primarily investigated (i.e., attention, knowledge, and body). The second empirical part attempted to develop an experimental paradigm that can examine intra- and inter-personal coherence of bodily (i.e., cutaneous facial temperature) and cognitive components of emotions (i.e., state subjective affect) during SSD-patients' emotional interactions with significant others (i.e., partners). The third empirical part aimed to employ the paradigm tested in the second study with a larger sample. This part investigated how bodily and cognitive components of the emotional process change between patients and their partners among neutral, conflictual, and relaxing conditions and compared this with those in healthy couples.

In this final chapter, the findings of the empirical parts are summarized and discussed. Limitations of the studies are identified, implications for the treatment of SSD, and open questions for future research are elaborated. The chapter ends with respective concluding remarks.

1. Summary and integration of findings

1.1 Emotion regulation in patients with somatic symptom and related disorders: A systematic review

The study aimed to identify the relationship between ER and SSD by including several forms of ER processes as well as different labels given to SSD. To better understand the mechanisms of the relationship between ER and SSD, based on the framework of Koole (2009), we classified the findings of the reviewed studies based on which component of emotion (i.e., attention, body, and knowledge) is primarily targeted. Such an approach allowed us to scrutinize the role of each emotion constituent in the disturbances of emotion regulation in SSD, rather than listing numerous ER constructs elusive to other disciplines handling SSD and emotion regulation (psychology, various fields of medicine, and neuropsychobiology), as previously highlighted (Lewis, 2005; Thompson et al., 2008). When doing that, we applied a combination of theory-based (top-down) and empirical (bottom-up) approaches to determine the primarily regulated emotion component.

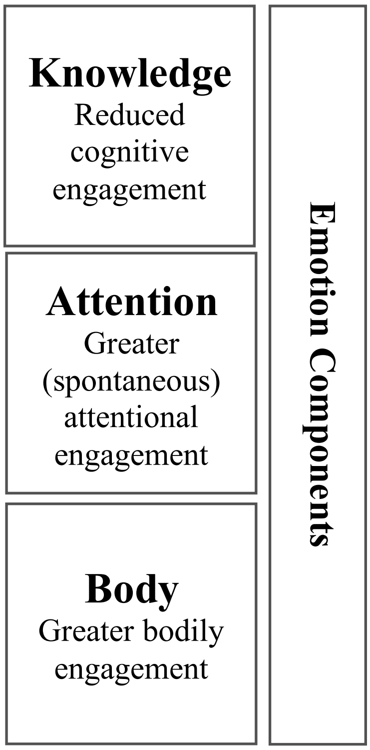
The review finally included 64 articles, the majority of which were methodically of moderate to good quality: The majority met the criteria for a moderate and about thirty percent for a good quality of methods. The good and moderate-quality studies did not diverge in their findings and interpretations regarding the association between ER and SSD. However, there was a scarcity in consecutive sampling, randomized controlled trials, experiments, diary, and longitudinal studies that can help understand the short- and long-term causal relationship between ER and SSD. Also, the labels given to SSD and measures to assess ER were heterogeneous, making a meta-analysis and comparison of the studies difficult. Almost two-thirds of the studies used several established diagnostic labels, and one-third used broadly defined diagnoses, a picture that reflects the disagreements in the classification of SSD.

The review findings largely supported the existence of disturbances in ER processes in patients with SSD, and different diagnoses of SSD shared these. These findings were consistent with several theoretical models that include ER as a contributor of SSD, either primarily or secondarily (Henningsen, Gündel, et al., 2018; Landa et al., 2020; Thayer & Brosschot, 2005; Van den Bergh et al., 2017; Waller & Scheidt, 2006; Witthöft et al., 2012). The available experimental and diary studies also lend some support to a causal role of disturbances in ER in the development and course of somatic symptoms. These studies showed that patients' ER processes predicted and intensified their observed and reported somatic symptoms during experimental manipulation (Burns et al., 2008, 2011; Elsenbruch et al., 2010; van Middendorp et al., 2010) or in time (Bruehl et al., 2012; van de Putte et al., 2007; van Middendorp et al., 2010). Furthermore, disturbances in ER were more pronounced among patients with "medically unexplained symptoms" than among those with "medically explained" ones (Brown et al., 2013; Demartini et al., 2014; Faramarzi et al., 2013; Sayar et al., 2004). Such a difference between the two groups rules out a temporal hypothesis claiming disturbances in ER as a mere outcome of bodily distress.

A heuristically helpful pattern in the findings was also observed. The results suggested that patients with SSD tend to show a particular pattern of ER as a function of emotion components: While they tend to cognitively disengage on emotional information, they tend to depict an overreactive or aberrant bodily behavior to emotions (See Figure 1). For example, reduced capacity to mentally represent and reflect on emotions, higher alexithymia, and limited emotional awareness were frequently reported (e.g., Burger et al., 2016; Schwarz et al., 2017; Subic-Wrana et al., 2010). On the other hand, higher startle responses, negative emotional expressions, or autonomic reactivity, such as higher HR, EDA, or lower HRV were observed (e.g., Fournier et al., 2018; Koenig et al., 2016; Pollatos et al., 2011; Rimes et al., 2016; Roberts et al., 2012; Twiss et al., 2009). Patients also showed an inclination towards difficulty in flexibly disengaging their spontaneous attention from the emotional material (Burns et al., 2011; Gul & Ahmad, 2014; Rimes et al., 2016; Wingenfeld et al., 2011). The findings underlined the significance of the functioning of each emotion component and the dynamic interaction between them to understand the mechanisms of ER in SSD more deliberately. The results were also consistent with the view that integrated processing of emotions between higher-order and subcortical structures contribute to optimal regulation of autonomic, immune, and HPA functioning and facilitate emotional and physical well-being (Craig, 2002; Ehlert et al., 2001; Heimer & Van Hoesen, 2006; Kanbara & Fukunaga, 2016; Maclean, 1949; Rosenkranz & Davidson, 2009; Shackman et al., 2011; Siegel, 2001; Smith et al., 2017; Thayer & Lane, 2000).

Figure 1

A graphical model summarizing the behavior of emotion components in response to emotional perturbations in the patients with SSD based on the overall findings of the review



Another important aspect was that the disturbances in ER were shared by different diagnoses given to SSD, such as pain disorders and functional somatic syndromes, including gastrointestinal or psychogenic neurological symptoms. These findings are consistent with previous research that mentioned similar non-symptom characteristics and affective difficulties shared by various diagnoses of SSD (Fink & Schröder, 2010; Wessely et al., 1999). The results suggest that ER functions as a common factor, which contribute to the development or course of the disorder, regardless of the regions of bodily complaints being involved. The similarity in ER difficulties between different diagnoses given to the patients supports the new DSM-5 approach to SSD.

Regarding the specificity of emotions, we also observed some particular patterns pertaining to specific disorders. Anger regulation was mainly studied in patients with chronic pain symptoms. Experimental, cross-sectional, and diary studies provide evidence for anger regulation problems in this patient group, such as expressive anger suppression or uncontrolled anger expression (Bruehl et al., 2007, 2012; Burns et al., 2008, 2016; Castelli et al., 2013; Sayar et al., 2004; van Middendorp et al., 2010). Cognitive, biological, and psychosocial mechanisms were put forward as antecedents and consequences of the experience of pain (Bruehl et al., 2006; Fernandez & Turk, 1995). The interested reader can also refer to Levenson's article (2019), which provided an account of how specific emotions could be related to different somatic and disease-related physiological changes.

To sum up, the systematic review supported the association between ER processes and SSD. Overall, the results suggested a characteristic pattern of ER in SSD as a function of emotion constituents. Patients with SSD seem to encounter difficulties in flexibly disengaging their (spontaneous) attention from emotional material. Comparably, bodily constituents of ER depict an over-reactive pattern, characterized by a vigilant autonomic nervous system activity, startle response, and negative emotional expressions. On the other hand, patients tend to disengage from emotional information at the knowledge level, such as showing reduced identification and awareness of emotions or emotion recognition. Interpersonal, experimental, longitudinal, and diary studies were scarce. Future research should empirically test the role of dynamic and simultaneous interaction of emotion components in SSD during emotional perturbations.

1.2 A methodological case study to examine the variations in emotion components at intra- and inter-personal levels in real-time

Drawing on the findings of our systematic review and the theory of emotions as dynamical and social processes (Butler, 2017; Kuppens & Verduyn, 2015), we aimed to develop and test a method to assess the intra- and inter-personal emotion regulation in SSD, which simultaneously comprised body and knowledge as targets of the regulation (Koole, 2009). In addition to investigating physiological processes, state affect, and trait emotion regulation at the individual level, we examined how these processes in two interacting partners relate to each other. We examined two case couples, an SSD patient-couple and a healthy couple, during a dyadic discussion paradigm (Levenson & Gottman, 1983) that consisted of neutral, anger-eliciting, and relaxation conditions.

This study showed that the interpersonal paradigm employed effectively created variations in physiology and state affect in both couples. In addition, the results encouraged us to continue with a similar paradigm to test our interpersonal hypotheses in our third study. Hierarchical linear models for the effect of trait emotion regulation on temporal course of temperature showed that trait emotion regulation, namely, alexithymia, level of emotional awareness, and anger regulation predicted the course of cutaneous temperature changes among phases. We also observed a substantial increase in the reported pain of the patient in the anger condition. In addition, we observed greater alexithymia, lower levels of emotional awareness in the patient as opposed to his partner or healthy couples. Anger levels were high in both patient and his partner. At the interpersonal level, the partners of the patient-couple presented a strong positive correlation in the nose tip temperature at baseline and anger condition. Moreover, the patient underrated his partner's pleasure and arousal levels, while his partner overrated his affective experiences.

The methodology of the study has brought about a number of strengths, as well as limitations and challenges. These issues were explained in detail in the subsequent section on the study's strengths and limitations. We considered these matters, which provided important insights for our following experimental study.

To conclude, the methodological case study successfully created variations in emotion components at intra- and inter-personal levels and distinguished SSD patient-couples and healthy couples to a reasonable extent. The study has also informed us about the strengths as well as the drawbacks and challenges of an ecological, interpersonal, multidimensional, and dynamic approach to studying emotional processes in SSD.

1.3 An experimental investigation of interpersonal emotion dynamics in couples with somatic symptom disorder

This study examined physiological and subjective interdependence in couples with an SSD and healthy couples during neutral, anger-eliciting, and relaxation conditions. The results showed that physiological coherence changed as a function of couple type and emotional condition. At baseline, SSD patient-couples showed a lower coherence than healthy couples, while they displayed a higher coherence in the anger condition. In other words, physiological coherence decreased in the healthy couples during the anger condition but increased in the SSD patient-couples. Between-couple level relationship between partners' subjective affect also followed a similar pattern from baseline to anger condition, with an increasing interdependence in arousal and valence in the SSD patient-couples as opposed to a decreasing one in the healthy couples. The findings are in line with previous studies, which reported physiological coherence during dyadic conflictual discussions to be linked with adverse health associations (Laws et al., 2015; Levenson & Gottman, 1983; Wilson et al., 2018). The results also suggest that coherence can function as a "double edge sword" (Timmons et al., 2015), providing connectedness in positive or neutral interactions but might be associated with emotional dysregulation and escalation in conflictual interactions.

We also observed that the reported pain significantly increased following the neutral interaction to the conflictual one and decreased again following the relaxation phase. This finding is in line with several studies concluding that negative affect alters symptom perception (Bogaerts et al., 2005; Burns et al., 2008; Constantinou et al., 2013; Van den Bergh et al., 2017). Neural connectivity of pain and emotion processing systems (Craig, 2009; Orenius et al., 2017), as well as cognitive-behavioral processing of pain-related stimuli (Van den Bergh et al., 2017), appear to play a role in this relationship between bodily pain and affect.

Between-group correlations among participants' actual feelings, perceptions about their partners' feelings, and their partners' actual feelings revealed some remarkable results, especially in the valence dimension of affect. Correlation values demonstrating perceptual accuracy and actual similarity in emotional valence were almost absent at baseline in the patient-couples but were significant in the healthy couples. In the anger condition, however, perceptual accuracy and actual similarity in emotional valence decreased in the healthy couples, whereas they became significant in the patient-couples. It seems that the anger condition facilitated more interdependence and sensitivity in the patient-couples while it facilitated a separateness and individuation in the healthy couples. The increased group-level perceptual accuracy in the SSD patient-couples at the anger condition is in line with a previous study showing superior emotion recognition in SSD patients, particularly for anger (Erkic et al., 2018). This study's finding is, in fact, in contradiction with some other studies, which reported patients' difficulty in recognizing emotions (e.g., Beck et al., 2013; Pollatos et al., 2011). Based on our results, it can be speculated that SSD patients might be even more perceptually sensitive to emotions, such as anger or hostility in real-life interactions, which might be different from computerized paradigms on emotion recognition.

Taken together, the present study concludes that SSD patients and their partners as an emotional system showed different interpersonal emotion dynamics in physiology and subjective feelings compared to healthy couples. A neutral or positive interaction seemed to facilitate connectedness and empathy for healthy couples. In contrast, an interaction around an anger-related issue might absorb the patients with SSD and their partners into a more connected and sensitive dynamic in both bodily and subjective layers.

1.4 Summary: A model of interpersonal ER processes in SSD

Drawing on the dynamical and social models of emotion (Butler, 2011, 2017; Butler & Gross, 2009; Lewis, 2005; Scherer, 2009), and the cognitive-neurobiological accounts of SSD (Henningsen, Gündel, et al., 2018; Smith et al., 2017; Thayer & Brosschot, 2005; Van den Bergh et al., 2017), we posit that emotions exert three pathways of recursive influence on the symptoms: a) Altering biological functions, such as the effect of stress on immune, hormonal, cardiovascular or musculoskeletal systems, thus directly influencing symptoms, b) altering cognitive processes related to symptoms, such as increased sensitivity and selective attention to the symptoms and prediction errors related to sensory information, and c) how emotions are processed and regulated through their constituents (i.e., cognitive, behavioral and physiological) at intra-personal and inter-personal levels. Several studies that were reviewed in the introduction have illustrated the first and the second pathways between emotions and somatic experiences. In my dissertation, I focused mainly on the third route by examining 1) how regulation of emotions is associated with SSD as a function of emotion components, 2) how to investigate the functioning of emotion components at intra- and inter-personal levels dynamically in real-time, 3) whether patients and their partners as a social system behave differently in terms of interpersonal emotion dynamics compared to healthy controls. In the systematic review, we concluded that there is convincing evidence that disturbances in ER are associated with SSD. Moreover, emotion components seemed to have a particular regulatory pattern in SSD, with attention and body engaged in, but knowledge disengaged from emotions.

In the methodological case study, we strived to establish a paradigm to examine emotion components simultaneously and dynamically in an interpersonal and self-relevant context. The paradigm effectively created variations in subjective affect, physiology, emotional behavior and even pain experience. However, we observed several challenges in the dynamical analysis of intensive longitudinal physiological data, the coordination between emotion components at the inter-personal level, as well as the measurement of continuous subjective affect and emotional behavior.

In the experimental study, we examined the change in interpersonal emotion dynamics, namely emotional interdependence, in two emotion components (physiology and subjective affect) during SSD patients' interactions with significant others (i.e., partners) and compared them with those in healthy couples. We found that patients with SSD and their partners displayed different amplitudes of interdependence, i.e., coherence, as a function of emotional context. This change was different from that in healthy couples. Physiological coherence and between-couple correlations in subjective affect increased from baseline to anger condition in the SSD patient-couples, while these decreased in the healthy couples. Moreover, patients' pain significantly increased from baseline to anger condition.

This combination of findings in the present dissertation provides support for the conceptual premise that emotion and regulation processes take an important place in understanding the mechanisms of SSD. Moreover, investigating functioning of emotion components and their interaction in real-time social exchanges promises theoretical, empirical, and clinical use in understanding the complex nature of emotions and SSD.

2. Strengths and limitations

The present dissertation substantially contributes to the field in terms of the findings and the methodology. We began with a systematic review which allowed us to gain an elaborative overview of the findings and the research gaps on the relationship between ER and several diagnoses of SSD. Moreover, by integrating a top-down (theory-based) and a bottom-up (empirical) approach, we could deduce the patterns of emotion regulation based on the emotion component targeted for regulation. We expect that such an approach that integrates several ER terms elusive to different disciplines dealing with SSD can facilitate interdisciplinary communication.

The experiments we conducted also provide several strengths in terms of the insights gained from the findings, as well as the participants, design of the study, assessment methods and analytic techniques used. First, to our knowledge, this is the first experimental study that examined not only SSD patients' but also their partners' affective experience and physiology in their real-time emotional interactions. The multimodal, interpersonal, and ecological approach is especially called forth in emotion research to understand the mechanisms, the "why and how" (Randall & Schoebi, 2018) of emotional processes. Secondly, we used a case-comparison design with three emotional contexts, which allowed us to compare the couples with an SSD-patient with healthy couples and elaborate on the effects of the emotional context or type of emotions. In fact, the kind of emotions and emotional context has been reported to impact the degree of interdependence between partners (Sels, Cabrieto, et al., 2019; Timmons et al., 2015).

The methodology of the experimental study has demonstrated several potentials and strengths. A paradigm involving real-time dyadic emotional interaction tasks (i.e., dyadic stress interview paradigms) allowed us to examine the temporal affective exchange between persons. In line with previous research, having shown interview methods to be more effective in eliciting anger and creating physiological variations than other methods, such as movie clips or punishment tasks (Lobbestael et al., 2008), we observed a substantial increase in anger behavior in the couples. Furthermore, the autobiographical recalling and reliving of past experiences of the couples improved the self-relevancy of the paradigm and facilitated the effectiveness of the paradigm in eliciting emotions (Kross et al., 2009). The widely accepted function of emotion per se involves giving meaning and significance to an event (Izard, 2010), which is inherently linked to motivation and action. Without self-relevance, paradigms might fail to detect subjects' most valid emotional reactions. We mainly focused on an anger-eliciting event, for the previous studies as well as our systematic review (Okur Güney et al., 2019) revealed anger to play a particular role in pain and chronic pain (Bruehl et al., 2012; Fernandez & Turk, 1995; Polman, 2011; van Middendorp et al., 2010). The baseline interpersonal condition without emotional manipulation enabled us to compare different affective states and familiarize the participants with the experiment. The following anger condition elicited a high level of arousal and negative valence. Finally, the relaxation condition with low arousal and high positivity endorsed high contrast between tasks. The relaxation exercise also allowed us to relieve the participants from the experienced stress and leave the lab in a better mood.

The measures we used also promise some potentials. It is recommended to assess multiple emotion response systems at a time for a reliable emotion measurement, such as several autonomic imprints, emotional expression, trait, and state emotional variables (Cole et al., 2004; Izard, 2010; Scherer, 2005; Seeley et al., 2015). Accordingly, we measured multiple physiological indices in the case study, such as cutaneous facial temperature, heart rate, HRV, and skin conductance levels as imprints of autonomic activity during the couples' emotional encounters. This method can permit an analysis of interaction and concordance between physiological emotion response systems. Besides, the literature distinguishes between self-report and performance-based emotion regulation tests and also suggests that attachment styles are linked to ER. Therefore, in the second study, we employed two questionnaires to distinguish between participants' beliefs about their ER (TAS) and their conceptual ER performance (LEAS). We also utilized an attachment questionnaire in close relationships (ECR-R), an assessment that we applied right after the dyadic conflict condition.

For examining the SNS activity, we employed an innovative assessment method: functional thermal infrared imaging. This method is non-invasive and versatile to assess peripheral physiology, which has been utilized in examining emotional processes in ecological settings, interpersonal interactions and also promises its future applicability in human-computer interactions (Aghedu et al., 2020; Clay-Warner & Robinson, 2015; Filippini et al., 2020; Ioannou et al., 2014). A vast amount of research has examined electro-cardiac or electrodermal variables or a couple of hormones when examining the biological dynamics of interpersonal emotional processes, which are viewed as critical (Butler, 2018). The current research contributes to the literature with the findings on the interpersonal dynamics of facial temperature.

Another strength of the measurement approach was that we investigated not only participants' own affect but also their perception of their partners' affect. With this inventive approach, we aimed to examine several dimensions of subjective interpersonal emotional processes. To attain this goal, we used the Self-Assessment Manikins (SAM) (Fischer et al., 2002) for investigating not only how participants felt but also for how they perceived their partners' feelings, and then we calculated several interpersonal parameters, such as actual emotional similarity, perceived emotional similarity or empathic accuracy at a group-level (Kenny et al., 2006).

Finally, our study highlights the potential usefulness of Wavelet Coherence Analysis (WCA) when examining interpersonal physiological coherence. WCA is an advanced method employed in complex and dynamic data, such as EEG or the weather (Fujiwara & Daibo, 2018; Grinsted et al., 2004). This analytic approach allowed us to analyze temperature coherence in dyads at different frequency bands in time. It can detect various frequency components temporally, informs a thermal signal's physiological origins, requires little parameter estimates, and does not assume stationarity in the data, which makes it a good candidate for analyzing physiological data.

The findings of the dissertation are also limited by several factors regarding the scope of the work, sample size, methodology, and the analytical approach. First of all, the systematic review included several terms of ER as well as different diagnoses of SSD depending on the health specialty or terms used (e.g., functional somatic syndromes, medically unexplained symptoms, somatoform disorders, etc.). Despite the integrative and transdiagnostic function of such a broad scope, the heterogeneity of the measures and diagnostic group requires a note of caution in interpreting the findings. Additional uncertainty arises because the ER patterns that we classified and deduced from the results are not derived from a meta-analysis of findings acquired by the same measures but from a heterogeneous bundle of findings based on several ER measures. Therefore, it is essential to examine emotion components simultaneously in the SSD patient group in real-time to test whether these components really function in a distinctive pattern.

The experimental paradigm has also carried several limitations and challenges. Firstly, the intensive longitudinal data extracted by physiological measurement is non-stationary, each physiological system has its own pace, and the frequency of the signals represents different biological origins. Therefore, analyzing the temporal course and the interaction between physiological systems requires advanced measurement approaches, preferably dynamical rather than linear methods. Another challenge was cast by the interpersonal design, which demands an extensive theoretical background and statistical and mathematical proficiency in the field of interpersonal emotion dynamics. For example, using correlation or cross-correlation analysis to examine time-series data is lately discouraged due to statistical issues, such as autocorrelation (Dean & Dunsmuir, 2016). Hence, the correlational analyses that we performed in the case study or cross-correlation seemed unsuitable for interpersonal data, which require more advanced modelling approaches.

Another challenge lies in the unestablished definitions of the terms describing interpersonal emotion dynamics; several terms have been used in different disciplines from developmental psychology to cognitive or movement science (Butler, 2011a; Palumbo et al., 2016; Sels et al., 2018), such as synchrony, coordination, coherence, co-regulation, etc. Different mathematical modelling or statistical methods have been applied accordingly. Therefore, it is difficult to draw conclusions, make comparisons or choose the most appropriate analytical approach for examining temporal emotional interactions. An elegant and heuristically helpful guideline can be found in the works of Butler (2011, 2017) and Sels et al. (2018).

One of the main obstacles in emotion research is that recording a real-time temporal course of subjective feeling is not possible while participants are engaging with an emotion eliciting task. In the literature, a retrospective moving rating dial system is used where participants can continuously move a dial as they watch their video recordings to rate how they were feeling at that moment (Levenson & Gottman, 1983). The disadvantage of moving rating dial is the ethical concerns related to letting the patients in treatment watch their own video recordings during a conflict with their partners. In addition, this method is retrospective and hence prone to attribution and self-confirmation biases. Therefore, in our study, we did not use this method. Instead, right after the experiment, the participants rated how they felt at that moment in one time-point measure. As an outcome of this one-time point measure of subjective affect, we performed correlation analysis between groups to examine interpersonal interdependence of subjective affect (i.e., assumed similarity, actual similarity, empathic accuracy) instead of a within-group analysis, such as cross-correlation analysis between partners' continuous ratings. This approach posed a problem for analyzing how physiological and subjective data covariate (intra-personal coherence), as well as how two persons' real time subjective feelings covariate (coherence of interpersonal subjective affect) in time. This investigation would provide important insights about the interaction of subjective feelings and physiology.

The experimental study that we conducted also shows a number of limitations. First, with a small sample size, caution must be applied, as the findings might not be reproducible on a broad scale, especially when additional potential confounding sociodemographic or psychological factors are controlled for. In addition, despite the advantages of involving an ecological and self-relevant paradigm, the nature of the emotion eliciting stimuli, such as intensity or duration of the conflict and anger condition, is not the same for all the couples. This fact might affect the differences in physiology and subjective affect across the couples. Finally, we did not code and analyze emotional behavior, which is highly interesting in a context where it is still unclear whether SSD patients show more vs. less emotional behavior.

In sum, this body of work enhances our understanding of ER in SSD by specifying what patterns of emotion regulation processes are observed in the patients with SSD as a function of emotion components in a shared language for several disciplines dealing with the disorder. Moreover, it adds to a growing literature on how these emotion components interact at intra- and inter-personal levels during emotional perturbations, an insight that is promising for understanding the mechanisms of ER in SSD. However, further research with larger samples and more precise assessment and analysis methods that analyze the dynamic interaction of multiple emotion components at intra- and inter-personal levels is needed.

3. Clinical implications

Emotional processing and regulation are transdiagnostic elements of mental and physical conditions owing to their strong cognitive, biological, and neural underpinnings. A vast amount of research has underlined how emotional processes can play a role in psychopathology, somatic conditions, and even in "medical" conditions, such as heart diseases, asthma, or cancer (Bogaerts et al., 2005; Cohen & Herbert, 1996; Crowell et al., 2015; Dima et al., 2013; Levenson, 2019; Sloan, et al, 2017; Thayer & Lane, 2000). Accordingly, several psychotherapy methods have already integrated emotion-related interventions, including effective emotion regulation, emotional awareness, and expression (Burger et al., 2016;

Kleinstäuber et al., 2019; Liu et al., 2019; Rottenberg & Gross, 2007; Sattel et al., 2012; Sloan & Kring, 2007; Zipfel et al., 2016).

The results of the present dissertation add to a growing body of evidence that suggests that patients with SSD show disturbances in ER, and extend this by showing tentative evidence that each emotion component, namely, attention, body, and knowledge, tend to act in a particular pattern. These findings have considerable implications for developing emotion-related therapeutic techniques. Patients can be educated on how emotions are processed through automatic and effortful attention, knowledge, and bodily functions. A simple neurobiological framework can be complemented, for example, on how emotions are processed in different regions of brain and body, or which physiological, hormonal, and other biological changes occur in response to short- and long-term emotional exposure and stress. The close connection between emotional, biological, and bodily processes can be explored together with the patient. In addition, when assessing patients' emotion regulation patterns, psychotherapists can examine how patients deal with emotions in terms of each emotion modality. Do they attend to their emotions? Can they elaborate on them and engage with the emotional information? How do they bodily respond and regulate their emotions? Are they aware of their bodily changes in response to emotional information? The therapist and the patient can develop techniques to deal with emotions coherently through a holistic narrative of emotions involving each emotion component. In this way, the patients' understanding of their bodily complaints can be transformed into a view of an embodied mind.

The results that showed that patient couples' physiological and subjective interdependence and their reported pain changed as a function of emotional context also draw our attention to the importance of interpersonal emotional interactions, especially during conflict. Patients' awareness can be raised that people's physiology and emotional experiences can become connected to each other, which can be "good or bad" depending on the context. In situations where there is a mutual conflict between each other, self-regulation can be endorsed rather than interdependence with the other, which might lead to escalation. Moreover, the therapist and the patient can elaborate on the potential effect of social interactions on the patients by underlining that emotions and bodily complaints do not occur in a social vacuum. For example, how the responses of the others, such as health care providers, partners, friends, family members, contribute to the course of patients' emotional and somatic disturbances can be worked through, as having already been applied in some interventions (de la Vega et al., 2018).

Understanding the interpersonal emotion dynamics of the patients with SSD will help us understand why and how specific emotional processes come about in patients' relationships. A recognized emotion researcher, Butler (2018), envisages that it can be possible to recognize and predict real-time patterns of interpersonal emotion dynamics through the technological innovations. For example, a psychotherapist can detect and predict patterns of interpersonal emotion dynamics, feedback loops, attractors and tailor the interventions accordingly. An accumulation of studies on interpersonal emotion dynamics can also facilitate technological intervention systems for healthy emotional interactions, such as "real-time relationship app" (Butler, 2018) or a real-time emotional intervention app.

Participants' increase in pain following anger-themed interaction and the patients' higher trait anger-regulation problems point out that pain patients' and significant others' anger and related behaviors, such as hostility or stonewalling, can be particularly addressed in psychotherapy. How to recognize anger and associated emotions, bodily concomitants of such feelings, and how to deal with such emotions in relationships would provide particular benefits. The multidimensional nature of pain, as an elicitor and outcome of emotions (Bruehl et al., 2006; Burns et al., 2016; Fernandez & Turk, 1995; Polman, 2011), is necessary to deliver to the patient.

Several psychotherapy approaches can integrate such emotional interventions into intervention. Emotional awareness and expression therapies can help the patients internalize how their bodily conditions are influenced by central nervous system psychological processes, and foster their awareness and expression of emotions related to emotional disturbances, psychological trauma, or conflict (Burger et al., 2016). Patients can benefit from relaxation exercises, yoga, and bodily oriented psychotherapies (Evans et al., 2014; Röhricht, 2009) to be able to regulate their bodily processes during emotional perturbations; or from mindfulness-oriented psychotherapies to become aware of their emotions and regulate them (Roemer et al., 2015). Cognitive or dynamic-oriented psychotherapies can help work on perceptions, thoughts, or mentalization related to emotional elicitors and somatic experiences (Henningsen, Zipfel, et al., 2018; Luyten et al., 2012; Witthöft & Hiller, 2010). To help patients deal with interpersonal emotional issues and institutional difficulties, such as communication with healthcare providers, interpersonal psychotherapies can be valuable (Sattel et al., 2012). Finally, biofeedback training aiming at altering automatic attentional or physiological processes in response to distressing emotional stimuli might be beneficial.

In treatments including emotional interventions, the heterogeneity in the patients' symptoms, such as co-existence of other affective symptoms (i.e., depression or anxiety) or habitual coping mechanisms and affect regulation styles of the patients, should be considered.

Without an individualized case formulation that contextualizes a patient's characteristic maladaptive affect regulation styles, their meanings, and functions for the patient, the effects of a standard emotion regulation intervention might not endure in time. A comprehensive randomized controlled trial that compared cognitive-behavioral therapy (CBT) with CBT complemented with emotion regulation training that included mindfulness principles supports this claim (Kleinstäuber et al., 2019). This study found that CBT and CBT complemented with mindfulness based ER training were both equally successful in reducing symptom severity, and the latter was more helpful for patients with a comorbid mental disorder. The study also showed similarities and disparities in the improvement and stability of secondary therapy outcomes between the two therapy methods. Although the CBT with ER was superior to standard CBT at the end of therapy, in six months follow-up, they were similar in decreasing secondary outcomes, such as health anxiety, emotional symptom distress, and psychological symptoms of SSD. Moreover, behavioral coping strategies and compassionate self-support improved in the combined ER-CBT therapy only after six months of follow-up. Such findings highlight the importance of an optimal therapy length to attain enduring secondary therapy goals, allowing patients to internalize and adapt to the newly acquired ER skills and more extended follow-up measurements to assess these goals.

It is crucial to keep in mind that a holistic approach is desirable for the treatment and prevention of SSD, which entails management elements that are not mutually exclusive. This management system conceives a healthy lifestyle and nourishing emotional interactions embedded in a salubrious socio-cultural context and supportive health care system as preconditions for well-being. Such preconditions, such as healthy physical activity or diet, cannot be overseen, and further interventions might be futile without them. For example, with ambulatory monitoring it was shown that patients with chronic pain have different physical activity patterns, such as increased lying time, reduced leisure-time physical activity, and increased physical activity during morning hours compared to healthy adults, which is accompanied by higher heart rate and reduced HRV (Hallman & Lyskov, 2012). In support of this, an animal study that induced muscle pain in mice also showed that regular physical activity prevents the development of chronic pain, hyperalgesia and diminish autonomic dysfunction (Sabharwal et al., 2016). Hence, it is vital to ensure that the basic needs, such as physical activity are met in SSD, and methods should be developed to facilitate them in case of disabling bodily conditions. For example, the multimodal therapies in some of the departments of psychosomatic medicine in Germany that combine psychotherapy in individual and group formats are complemented by physical activity such as nordic walking, stress reduction techniques, physiotherapy, body psychotherapy, and creative therapies (art and/or music therapy) (Zipfel et al., 2016).

To sum up, the results draw our attention to the necessity of taking emotional processes seriously for understanding the symptoms and course of the disorder, as well as for treatment planning. One of the initial steps would be to raise awareness in mental and medical health specialties on the role of intra- and inter-personal emotional processes in SSD. Another important step would be towards altering the attitude of separating physical and mental in health care services and tailoring the interventions accordingly. Despite the increasing number of studies from various disciplines showing the entangled relationship of mental and physical conditions, there is still a mainstream dichotomy in treating illnesses as physical and psychological (Cohen & Herbert, 1996). Creating a culture of social-body-mind medicine/treatment would help the patients to feel less stigmatized and foster mental health professionals' and physicians' cooperation and communication, which are essential to cover the irreducible needs of the patients.

4. Future directions

The present dissertation can prompt several potential research questions in terms of methodology and content in the fields of psychosomatic and emotion research.

The systematic review that we conducted by classifying emotion regulation processes based on the targets/components of the regulation (i.e., attention, knowledge, body) has suggested that each emotion component functions in a particular pattern in patients with SSD. This can be further elaborated in a meta-analysis for each component separately, for example, whether it can be confirmed that (automatic) attention is engaged with emotional stimuli and higher-order cognitive processes are disengaged from them. Secondly, experimental work is necessary to examine the dynamic interaction between the emotion components during an emotional perturbation. Our present study could investigate the subjective affect and physiology in patients' real-time emotional interactions with significant others. However, it is still not clear how real-time subjective affect, attention, and physiology together work out in response to emotional perturbations. A multimodal investigation of these components simultaneously would be possible through advanced temporal measures and complex analysis methods, such as quantification of linear and non-linear dynamics, change point detection (Cabrieto et al., n.d.), wavelet coherence analysis (Grinsted et al., 2004), cross recurrence quantification analysis (Wallot & Leonardi, 2018) or some commercial tools, such as "Observer" (Zimmerman et al., 2009).

Another topic derived from the systematic review was the particular focus of the existing research on the connection between pain and anger regulation. Although there are experimental and self-report studies that confirmed anger as an outcome and elicitor of chronic and acute pain (Bruehl et al., 2006, 2012; Burns et al., 2016; Fernandez & Turk, 1995), experience sampling methods would be helpful to understand the extent and content of how the patients experience anger-eliciting events. The frequency of such happenings, the intensity of experienced feelings, the meaning given to such experiences by the patients, how they are resolved, with whom they are usually experienced, would be helpful to understand the role of anger as a potential mechanism to pain. In addition, other anger-related feelings and behaviors that emerge within close relationships, such as stonewalling or hostility that were found relevant in SSD (Burns et al., 2006; Haase et al., 2016) can be further explored.

Our experimental study should be replicated with a larger sample that can allow controlling for potential confounding variables for coherence, such as sociodemographic (i.e., cohabitation status, relationship longevity) or psychological factors (e.g., closeness, attachment, or depression). Although a previous study has not confirmed the main effect of the type of emotion and the moderating effect of time spent together, relationship longevity, and cohabitation status on subjective emotional interdependence, and how such variables would affect physiological interdependence are questions in need of research (Sels, Cabrieto, et al., 2019). What is notable here is that the interpersonal design of such a study requires entering each partner variable into the model with several combinations. Therefore, a large sample size would be necessary for possible analytic methods, such as actor-partner interdependence modelling with structural equation models or multi-level analysis (Stas et al., 2018).

In the present study, we could not find a meaningful pattern in the degree of coherence (i.e., phase patterning) in healthy and SSD patient-couples. Phase patterning that entails in- and anti-phase patterning can provide information on the style of emotional interaction, for example, in-phase indicating partners' physiology moving in the same direction, or anti-phase characterizing their physiology complementing each other by moving in the opposite direction, which probably indicate a co-regulation (Reed et al., 2013). This patterning can be related to health and well-being (Reed et al., 2013). Therefore, another study with SSD patient dyads with a particular focus on phase patterning would be insightful.

The several components of autonomic physiology, such as cardiovascular activity (e.g., HR, HRV), electrodermal activity, hormonal responses, are also curious areas to examine in short and long-time windows. Whether and how the findings that we observed in cutaneous facial temperature would be replicated in these other peripheral physiological systems would be an interesting query. More sophisticated data analysis that can examine the dynamic interaction between these physiological components simultaneously can help understand the mechanisms involved in the relationship between emotional processes and somatic disturbances. The comparison of these different physiological processes, the time latency between them, the shape and duration of each trajectory are still little examined areas (Davidson, 2015). Ambulatory assessment, such as experience sampling methods for assessing subjective affect or experienced somatic complaints (Sels, Ruan, et al., 2019) or wearable systems for physiological monitoring (Wac & Tsiourti, 2014), can open up new directions to understand the interpersonal emotion dynamics in SSD. In addition, virtual reality to induce emotions can provide standardization to a certain extent and elicit an intense immersion of the patients to the emotional condition and therefore offer the reliability of the method (Marín-Morales et al., 2018).

Several other parameters of interpersonal emotion dynamics are also very intriguing to examine, although they require advanced techniques for analysis. Affective chronometry parameters that describe the temporal dynamics of affective responding and characterize one's affective style, such as the threshold for reactivity, the peak amplitude of response, rise time to peak, and recovery time (Davidson, 1998) in both interacting partners would help how partners affect each other's' emotions. More differentiated interpersonal emotion dynamics described elsewhere (Kuppens & Verduyn, 2015; Sels et al., 2018) can also inform several vital aspects. In addition to coherence (e.g., how emotions of interaction partners covary across time), that we examined in our present study, the following parameters are revealing research venues to track: (1) emotional influencing (how a person's emotion in a time point influences the partner's emotion at the next time point), (2) emotional variability (how much fluctuation occurs in an interpersonal emotional system), or (3) emotional inertia (how is the carryover of an emotional state of an interpersonal system from one time to the next time point (Sels et al., 2018). The interested reader can refer to some helpful works of Sels and colleagues (2018) or Butler (2011) for an overview of statistical or modelling approaches to this variety of parameters.

Another task not to miss would be to compare different analytical approaches for the same construct of interdependence. Several terms have been used for emotional interdependence/coherence in various disciplines, and with the technological development and introduction of new methods, there is not an established analysis method for a specific construct. Therefore, it is conducive and recommended to rerun the analysis for a particular construct with other analytic approaches. For example, cross-correlation, recurrence quantification analysis, or multi-level modelling, examine co-variation or co-occurrence of emotional states of different subjects. There are several reasons for not using cross-correlation (Dean & Dunsmuir, 2016) for example, but several studies have employed this method in interpersonal designs. As the curriculum of social scientists lacks advanced mathematical training needed for dynamic systems applications (Butler, 2018), collaborations with persons with expertise in sophisticated measurement and mathematical modelling would be fruitful to follow this pursuit.

The developmental course of coherence, especially in mother-child emotional interactions and its longitudinal somatic outcomes, should be another step towards understanding the interpersonal emotion dynamics of SSD. It is a curious question how emotional coherence between mothers with and without somatic complaints and their children in different emotional contexts changes over time. Previous studies with mother-child interactions have reported different amplitude in the physiological linkage between high and low-risk families (Suveg et al., 2016) or with and without a maternal history of major depression (Woody et al., 2016), by concluding that physiological linkage can be disruptive in a negative context but can be linked to co-regulation in the context of functional mother-child dyads.

One of the promising methodological directions would be towards examining participants' subjective affect by a continuous measure. The commonly used method to overcome the challenge of continuously assessing one's affect is a dial-rating system where the participant moves a dial with a stick/mouse to the right or left to score their own emotion during watching their video recording right after the experimental session (Brown et al., 2019; Levenson & Gottman, 1983). This method also has its drawbacks, such as exposing the patients to a negative stimulus once again or retrospective biases of the participants. In case of using a rating dial system with the patients in treatment, assistance by a psychotherapist while watching the videos would be useful for ethical precautions. With such a measurement approach, assessment of interpersonal subjective affectivity, such as assumed emotional similarity (i.e., projection), actual emotional similarity (concordance or coherence), or empathic accuracy between partners (Kenny et al., 2006) through dyadic intensive longitudinal data would be possible. It is then an open question whether the results with correlation analysis methods are replicable in other timescales (second-to-second vs. day to day) and methods (one point vs. several measuring points, linear or non-linear methods).

A crucial yet unanswered question is the interplay between intra and interpersonal levels of interaction between emotion components. Does coherence between physiological and subjective components at the intra-personal level predict the inter-personal emotional coherence and other interpersonal emotion dynamics? This question is not only one of the main issues in emotion research (Butler, 2018) but also of high relevance to research on SSD. As several theories note a disequilibrium between emotion components in SSD, such as alexithymia, lower emotional awareness, aberrant or hypervigilant ANS, a real-time assessment of these emotion components would be an asset. Investigations on how the coordination between these components within individuals predict symptoms and how this within-person coordination predict interpersonal emotion dynamics will help to understand the mechanisms on the relationships between SSD and emotion regulation.

There are also further intriguing questions in the fields of both SSD and emotion research: Does inter-personal physiological coherence predict subjective emotional interdependence or other interpersonal parameters, such as projection or empathic accuracy? Do trait characteristics, such as attachment in close relationships or trait anger regulation play a role in interpersonal emotion dynamics? What kind of emotional interactions serve as attractors, i.e., absorbing repetitive states, for patients with SSD? How is physiological and subjective emotional interdependence between people represented at the neuronal level? Are specific emotions responsible for particular physiological responses and stress-related illnesses, as shown by some studies (Haase et al., 2016; Levenson, 2019)? The current developments in data science and measurement can open new avenues of research for these questions.

5. Concluding remarks

The present study adopted a contemporary approach to emotions as componential, dynamic, embodied, and social processes in an attempt to understand the mechanisms of the relationship between emotional processes and SSD. The systematic review confirmed that patients from various medical specialties diagnosed with somatic symptom and related disorders suffer from disturbances in emotion regulation. The components of emotion seem to depict a distinctive pattern characterized by disengagement of effortful cognitive components (i.e., knowledge) from emotions but immersion into emotions through spontaneous attention and body. To examine the dynamic interaction between emotion components at both intra- and inter-personal levels, an ecological interpersonal paradigm with different emotional tasks facilitating inter-subjectivity and self-relevance is promising. With such a paradigm and an advanced analytical method, the present work showed that the emotional system of SSD patients and their partners showed different physiological and inter-subjective patterns as a function of an emotional context compared to healthy couples. Specifically, physiological coherence and relationship between partners' subjective feelings increased from baseline to anger condition in the SSD patient-couples, while these decreased in the healthy-couples. Still, there are several open questions regarding the role of possible factors, such as sociodemographic or psychological variables, in the interpersonal emotion dynamics of SSD patients. Interdisciplinary collaborations to model the complex interactions in emotion components at intra- and inter-personal levels are essential. Given the consistent findings on the role of emotions and interpersonal processes in SSD, interventions should be tailored to include these interpersonal emotion processes into the therapy.

6. References (Chapter V)

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Zusammenfassung

Somatische Belastungsstörung und verwandte Störungen (SSD) gehören zu den am weitesten verbreiteten Erkrankungen im Gesundheitssystem. Patienten mit SSD leiden unter einer oder mehreren körperlichen Beschwerden und damit verbundenen psychischen Problemen, wie z. B. übermäßige Gedanken, Gefühle und Verhaltensweisen im Zusammenhang mit den Symptomen. SSD kann zu einer hohen Einschränkung der Patienten führen und ihre Lebensqualität und ihr soziales Funktionsniveau erheblich einschränken.

Mehrere Studien haben emotionale Prozesse und deren Regulierung als einen der wichtigen Faktoren dokumentiert, die zur Entwicklung, Aufrechterhaltung und Verschlimmerung der somatischen Symptome beitragen. Wie Gross & Thompson (2007) jedoch feststellten, "müssen wir, um die Emotionsregulation zu verstehen, zunächst wissen, was reguliert wird" (übersetzt aus dem Englischen, S. 4). Obwohl die zeitgenössische Emotionsforschung eine dynamische und „embodied" Perspektive eingenommen hat, die auch die soziale Natur von Emotionen betont (Butler, 2015; Kuppens & Verduyn, 2015; Lewis, 2005; Scherer, 2009), hat die Forschung zu SSD diese Entwicklungen nicht in das Feld entsprechend integriert. Diese Einschränkung stellt eine Lücke im Verständnis der biopsychosozialen Mechanismen der Beziehung zwischen Emotionen und SSD dar.

Die vorliegende Dissertation zielte darauf ab, die emotionale Verarbeitung und Regulierung bei SSD mit einer aktuellen Rahmenkonzeption von Emotionen zu untersuchen, die Emotionen als einen sich ständig verändernden Prozess (d. h. ein dynamisches System) erfasst, der aus seinen Subsystemen wie subjektivem Affekt, Körper/Physiologie und kognitive Bewertungen besteht. Darüber hinaus wird in dieser Arbeit die soziale Natur von Emotionen berücksichtigt, indem sozio-emotionale Mechanismen untersucht werden, die in den zwischenmenschlichen Interaktionen von SSD-Patienten ablaufen.

In der ersten Studie wurden die empirischen Studien zur Untersuchung von ER-Prozessen, die für SSD charakteristisch sind, systematisch überprüft. Wir haben die Studienergebnisse auf der Grundlage der Ziele/Komponenten der Regulation (d. h. Aufmerksamkeit, Körper, Wissen) zusammengefasst. Die Durchsicht der 64 Artikel unterstützte weitgehend den Zusammenhang zwischen SSD und Störungen in der ER, die in der Regel von verschiedenen SSD-Diagnosen geteilt werden. Der Überblick über die Ergebnisse zeigt, dass die Patienten eine verminderte Auseinandersetzung mit dem kognitiven Inhalt von Emotionen zeigen, während ihre körperlichen ER-Prozesse ein überreaktives Muster zu zeigen scheinen. Ebenso haben die Patienten tendenziell Schwierigkeiten, ihre (spontane)

Aufmerksamkeit flexibel von emotionalem Material abzukoppeln. In der Forschung über ER bei SSD wurde ein Mangel an experimentellen und interpersonellen Studien festgestellt.

In der zweiten Studie wurde versucht, eine Methodik zur Bewertung embodied und interpersoneller emotionaler Prozesse bei Paaren mit einem SSD-Patienten und gesunden Paaren zu entwickeln. Diese Fallstudie zeigte den Nutzen der experimentellen Manipulation und Methodik, die erfolgreich Variationen in physiologischen Prozessen und subjektivem Affekt bei den Paaren erzeugte.

Aufbauend auf der Methodik der Fallstudie untersuchte die dritte Studie, ob sich die interpersonelle Emotionsdynamik zwischen interagierenden Partnern, nämlich die physiologische Kohärenz, zwischen Paaren mit einem SSD-Patienten und gesunden Paaren unter verschiedenen emotionalen Bedingungen unterscheidet. Die Ergebnisse zeigten, dass emotionale Zustände und das Vorhandensein eines Partners mit SSD die physiologische Kohärenz zwischen den Partnern signifikant beeinflussen. Von der Baseline Bedingung bis zur Ärger auslösenden Bedingung nahm die physiologische Kohärenz zwischen Patienten mit SSD und ihren Partnern signifikant zu, während sie zwischen den gesunden Partnern abnahm. Die Interdependenz zwischen den subjektiven Affekten der Partner, gemessen an den Korrelationen zwischen den Gruppen, folgte einem vergleichbaren Muster wie die physiologische Kohärenz bei gesunden und SSD-Patienten-Paaren. Die Unfähigkeit, die bei SSD-Patientenpaaren beobachtet wurde, die emotionale Interdependenz der Sympathikusaktivität und des subjektiven Affekts während eines gegenseitigen Konflikts zu reduzieren, scheint eine Emotions-Ko-Dysregulation zu erfassen.

Diese Daten liefern empirische Beweise für eine Störung der ER-Prozesse bei SSD auf intra- und interpersoneller Ebene. Die Untersuchung der dynamischen Interaktion der verschiedenen ER-Modalitäten gleichzeitig auf intra- und interpersoneller Ebene verspricht Erkenntnisse für ein besseres Verständnis der ER-Mechanismen bei SSD. Die Forschungsergebnisse stellen einen weiteren Schritt in Richtung der Entwicklung eines ganzheitlichen Behandlungsansatzes für SSD dar, der emotionale Interventionen integriert und sie als embodied und sozial einordnet.

Erklärung

Hiermit erkläre ich, Zeynep Emine Okur Güney, dass ich die eingereichte Dissertation selbstständig, ohne fremde Hilfe verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe. Die wörtlichen und dem Inhalt nach aus fremden Arbeiten entnommenen Stellen, Zeichnungen, Skizzen und bildlichen Darstellungen sind als solche genau kenntlich gemacht.

Die Arbeit ist noch nicht veröffentlicht oder in gleicher oder anderer Form an irgendeiner Stelle als Prüfungsleistung vorgelegt worden.

Groß-Gerau, den 14.10.2022

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