Master Thesis

Emotions Within the Body: Effects of Interoceptive Awareness and Alexithymia on the Perception of Emotion-Related Body Sensations

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Gefühle im Körper: *Effekte interozeptiven Bewusstseins und Alexithymie auf die Wahrnehmung von emotionsbezogenen Körperempfindungen*

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Abstract

This study investigates interindividual differences in the perception of emotions. We relate the somatic marker hypothesis, a model of emotion processing, to the concepts of interoceptive awareness and alexithymia. These concepts are both descriptive of the capacity or lack thereof to use an interoceptive system assigned with the organization of afferent, emotion-related signals. Building on this theoretical framework, we discuss a recently developed, multimodal testing paradigm assessing the perception of emotions through topographies of bodily sensations. We hypothesized that measures indicative of high levels of interoceptive awareness and alexithymia will predict respective high and low levels of activity within such body topographies. Results validated previous emotion-induction capabilities of the assessment tool, but could not support the notion that individuals differ in the perception of feelings. Explanations for these findings are discussed, including a novel distinction between physiological and psychological aspects of emotion processing and suggestions for methodological improvement.

Zusammenfassung

Diese Studie untersucht interindividuelle Unterschiede in der Wahrnehmung von Gefühlen. Der theoretische Zusammenhang zwischen der Hypothese der somatischen Marker, ein Modell der Emotionsverarbeitung, und den Konzepten der interozeptiven Wahrnehmung und Alexithymie wird dargestellt. Interozeptive Wahrnehmung und Alexithymie beschreiben die Fähigkeit bzw. deren Abwesenheit, ein interozeptives System zu nutzen, welches mit der Organisation von afferenten, emotionsbezogenen Impulsen beauftragt ist. Aufbauend auf diesem threotischen Bezugssystem, wird ein kürzlich entwickeltes, multimodales Untersuchungsparadigma hinzugezogen, welches die Wahrnehmung von Emotionen durch Körpertopographien erfasst. Es wurde hypothetisiert, dass höhere Werte in Messinstrumenten von interozeptiver Wahrnehmung und Alexithymie jeweilig höhere und niedrigere Aktivitätismuster in den genannten Körpertopographien voraussagen. Die Ergebnisse konnten das Testungsparadigma validieren, aber nicht die Annahme unterstützen, dass Personen sich in der benannten Wahrnehmung von Gefühlen unterscheiden. Erklärungen für diese Ergebnisse werden diskutiert. Eine neue Untescheidung zwischen physiologischen und psychologischen Aspekten der Emotionsverarbeitung wird vorgestellt. Zusätzlich werden Vorschläge für methodische Verbesserungen präsentiert.

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Introduction

This study investigates interindividual differences in the perception of emotions. The conceptualization of an emotion in everyday language usually considers the subjective, present-moment experience of an emotional state, as for example fear or happiness. Within the scientific community, emotions are conceptualized in a more complex fashion, involving cognitive processes and physiological pathway systems (Lazarus, 1991a; Craig, 2002). We wish to investigate the differences in the perception of this multideterministic experience.

We will describe the somatic marker hypothesis, a popular model of emotion processing (Damasio, 2005). This theory focuses on the neurological pathway systems comprising the multideterministic construct of emotions, while also incorporating other, interdisciplinary components of emotion research. Explanations of the theory and associated reports of empirical evidence will provide the necessary framework which our central hypotheses can be build upon.

Further, we will introduce two concepts representing the investigated capacity in which we expect interindividual differences. Within the realm of mind-body approaches, interoceptive awareness represents a modern and more adaptive variant of body awareness, which, in the past, has been considered to be an amplified rumination about the body (Mehling et al., 2009). This contemporary approach involves an unattached, present-moment attention style towards the physiological sensations deriving in the body, similar but in contrast to the cognitive components of mindfulness (Kabat-Zinn & Hanh, 2013). Taking a different approach, alexithymia represents a pattern of behavior and cognition marked by impairments during social interactions (Sifneos, 1973; Taylor, Ryan, & Bagby, 1985). More precisely, this type of disability involves the limited capacity to accurately detect and meaningfully articulate emotional sensations and is associated with high levels of comorbidity with other mental disorders (Samur et al., 2013). We will relate the concepts of interoceptive awareness and alexithymia to the somatic marker hypothesis to form an underlying theoretical framework of our investigation.

Building on this theoretical structure, we will discuss the issue of multimodal assessment of emotion induction and resulting physiological and psychological sensations. Further, we will outline a novel, multimodal approach to this testing paradigm, promising to overcome previously determined shortcomings of other instruments: The emBODY tool provides an Internet-based self-report method, resulting in topographies descriptive of emotion-related physiological sensations (Nummenmaa, Glerean, Hari, & Hietanen, 2014). Building on both theoretical framework and measurement paradigm, we will finally synthesize and present our research hypotheses.

Emotion

Whenever we use the term “emotion” in our everyday language, we usually mean the very subjective experience of an emotion, a current state of fear, happiness, disgust or sadness, for example. Scientifically, emotion is comprised of much more than just this singular sensation, as it incorporates cognitive appraisal (Lazarus, 1991b) and is organized through neurophysiological processes (Craig, 2002). The construct of emotion becomes clearer, when one considers its utility. Levenson (2003) describes emotions as “short-lived psychological-physiological phenomena that represent efficient modes of adaptation to changing environmental demands” (p. 349) and declares their importance to survival. He argues that they guide our behavior, shift our attention, activate relevant memories, and organize biological systems that prepare us to respond to our surrounding environment.

Ultimately, emotions facilitate various kinds of decision-making processes. Do I engage or distance myself from an object of interest? Do the assumed benefits outweigh potential costs of my intended action? One of the most popular contemporary accounts of emotion theory builds on this premise and is called the somatic marker hypothesis, developed by Damasio (2005). The theory derived from the treatment of patients suffering from decision-making disabilities, especially in the domain of social and relational matters. The patients, suffering from damage in the prefrontal cortex of the brain, retained most other brain functions, but showed a very limited capacity in making decisions for themselves, disrupting their everyday lives and relationships.

Damasio argued these patients lacked the guidance emotions usually give in decision-making processes. He contrasts two reasoning strategies to illustrate: First, he names the "high-reason" approach, in line with philosophers like Descartes and Kant, who assumed that "we are at our decision-making best" (p. 171) when we try to achieve the maximum of "subjective expected utility" through each decision. In this, we apply a rigorous cost-benefit analysis to decisions, analytically comparing each component with regard to our needs. Most importantly though, it is assumed that we will always perform better, when emotions are left out of the process.

Damasio contends that this approach might appear logical, but is highly impractical in real life. Complicated decisions will become so overwhelmingly complex, that eventually, we will either never reach a conclusion or simply give up on the task. Thus, emotions are said to be not a luxury, but function as internal guides. When considering outcome scenarios to a complex problem, we imagine such scenarios in the form of flashing images, Damasio explains. Not as a full story, but as a brief reflection of the core element to what might happen. According to the somatic marker hypothesis, before any cost-benefit analysis is applied to the reasoning process, each of these outcome images will be associated with an immediate "gut feeling". This feeling, depending on whether it is conceived to be positive or negative, will indicate which decisions should be favored and which should be discarded. Thus, the cost-benefit analysis is still applied, but a preliminary, emotion-driven process narrows the range of decision-making options to a limited but more practical repertoire. The indicative feelings he calls "somatic markers", with "soma" being the Greek word for body and "markers" representing the notion that feelings "mark" the associated mental images.

Somatic markers are said to be acquired through experience, mostly during education and socialization. Situations are being linked with a somatic state, as for example the state of arousal during a school exam, where the threat of failure activates the body to become more alert and vigilant. Through a process similar to Pavlovian conditioning, linkages are created and stored in the brain, from where they will be recalled when a similar threat arises. Damasio explains such linkages to be culturally dependent, the psychological and physiological processes being relatively universal, but the context in which they are being created and recalled varying between societies.

In subsequent elaborations on the theory, its concepts have been refined, extended and brought into context with a neurophysiological system (Damasio & Carvalho, 2013). We will explain these components and the system they comprise in order to provide a theoretical framework which our own assumptions can be build upon. First, “action programs” are explained to be sets of “innate physiological actions triggered by changes in the internal or external environments” (p. 145). They function to maintain or restore a homeostatic balance, including changes in viscera and internal milieu (e.g., heart rate and breathing), striated muscle (e.g., facial expressions and running), and cognition (e.g., the focus of attention and whether to favor particular ideas and modes of thinking). Action programs are comprised of drives and emotions. Their resulting bodily changes are sensed by the so-called “interoceptive system”, are displayed in sensory maps of the body and are experienced, in some instances consciously, as feelings.

Drives are the types of action programs aimed at “satisfying a basic, instinctual physiological need” (p. 145) and include hunger, thirst, libido, exploration and play, care of progeny, and attachment to mates. Emotions, on the other hand, are action programs triggered by external stimuli, regardless whether such stimuli are currently perceived or recalled, and include disgust, fear, anger, sadness, joy, shame, pride, compassion, and admiration. Feelings, previously mentioned to be the “somatic markers”, represent both the physiological sensation that accompany the aforementioned action programs as well as the subjective, often very present experience of an emotional state.

Homeostasis is comprised by the process in which the physiological parameters of the internal milieu, such as temperature, pH and nutrient levels, and oxygenation, are being maintained. The aforementioned “interoceptive system” consists of a collection of nerve pathways and CNS nuclei, which are tasked with detecting and mapping homeostatic signals and relaying such signals towards the brain via the vagus nerve and the lamina I pathway. The system was originally conceived by Craig (2002), but was integrated into the action program processes of the somatic marker hypothesis (Damasio & Carvalho, 2013), to combine both information transfer and processing.

The term “interoception ” was originally introduced by Sherrington (1920) as “the material me”, but later redefined by Craig (2002) as “the sense of the physiological condition of the body”. In this, the term interoception describes a group of senses. Traditionally, we consider senses to be vision, hearing, smell, touch, and taste. Yet, such senses are of the exteroceptive kind, as they receive their input from the external environment. Interoceptive senses, on the other hand, receive their input signals from within the body and its organs. Thus, Craig describes, afferent (bottom-up) signals, originating within the body, are transferred through the lamina I and the vagus nerve towards the insular cortex. From here, the afferent signals converge within the prefrontal cortex, along with other sensory information.

Within the context of the somatic marker hypothesis, the interoceptive system is tasked with the monitoring of bodily states, the organization of responses to bodily changes and plays a central role in generating feelings. The previously mentioned patients, who lacked emotional guidance during reasoning, consistently demonstrated lesions within the ventromedial portion of the prefrontal cortex (VMPFC; Damasio, Everitt, & Bishop, 1996). In line with the theory, it is assumed that the patients received their disability through the subsequent inability to process information relayed by the interoceptive system and to activate stored somatic marker linkages.

Taking the components of the interoceptive system together, a two-way system of emotion processing emerges. As Damasio and Carvalho explain (2013), homeostatic regulation occurs either through drives or emotions. First, changes within the body are sensed by the interoceptive system and signaled through the aforementioned pathways towards the brain. From there, a drive is triggered, initiating an action program intended to respond to the initial stimulus with the ultimate goal of rebalancing towards homeostasis. In addition, a feeling is generated, comprised by the drive-related conscious experience as well as the resulting physiological sensation. To illustrate, the authors give the example of high blood osmolarity, a state of increased blood density caused by dehydration. This state is signaled to the brain, which initiates the drive action program for high blood osmolarity and triggers the internal feeling of a dry mouth, irritability and tiredness along with the feeling of thirst.

Second, signals are received through the exteroceptive senses from the outside environment and relayed to the brain. From here, again, an action program is activated, but this time an emotion. This emotion-related activation of the bodily systems is again aimed at maintaining homeostasis. Analogous to a drive, feelings are being generated. The authors provide another example for this second route. In this example, the sight of a bear triggers the emotion action program for fear. This causes increased heart and respiratory rates, secretion of cortisol and adrenaline, redistribution of blood flow, analgesia, feeling-specific facial expressions, and a shift in attention towards the perceived threat as well as the according subjective sensation of the emotion.

The somatic marker hypothesis provides a comprehensive explanation for what we usually consider to be an emotional experience. Its postulations underline the utility of emotions by incorporating them into the interoceptive system. With this bottom-up approach, Damasio builds on the James-Lange theory, which states that the experience of joy or fear derives from arousal of the viscera and circulatory system (James, 1884; Lange, 1887). The somatic marker hypothesis extends this theory, by providing meaningful explanations of a neurological pathway system and interrelated processes.

The hypothesis was tested through a series of experiments involving the mentioned patients suffering from reasoning disabilities and the Iowa Gambling Task (Bechara, Damasio, Damasio, & Anderson, 1994; Damasio et al., 1996). In this task, a situation of card gambling is recreated in the laboratory. During the game, participants gradually learn advantageous and disadvantageous strategies. Following either type of strategy is thus associated with a rewarding or punishing experience. Accordingly, the gambling task is very suitable to test the hypothesis, as emotion-derived guidance plays an important role in succeeding at the game. Results showed that performance of patients with damage to the VMPFC was measurably lower than of controls. The researchers argue that this is indicative for their “real-life inability to decide advantageously” (Damasio et al., 1996, p. 1418) and attribute their findings to the lack of somatic marker guidance.

Further empirical studies have been conducted to apply the hypothesis and test its assumptions. Findings similar to those of the original VMPFC patients were found in substance abusers (Bechara, 2003; Verdejo-García, Bechara, Recknor, & Pérez-García, 2006). Reasoning impairment due to an assumed lack of somatic markers was also found in risky sexual behaviors (Wardle, Gonzalez, Bechara, & Martin-Thormeyer, 2010). Yet, some remarks have been made questioning the scope of the hypothesis' explanations. As one study found, participants of the gambling task seem to hold more knowledge than previously thought (Maia & McClelland, 2004). Others criticize that, while physiological concepts are being well defined, psychological components of the decision-making process still remain unexplained (Dunn, Dalgleish, & Lawrence, 2006). The somatic marker hypothesis appears as an elegant description of the physiological processes underpinning emotion. While its conjectures still seem to require further empirical support, we consider the hypothesis as a fitting theoretical framework of our own study.

The aforementioned second, emotion-related pathway of the interoceptive system is of particular interest to this study. In this system, the concept of emotion is comprised by sensory input processing, signal relay, and the triggering of maintenance-oriented action programs. We argue that a system so complex in its functioning is very likely to be associated with interindividual differences. If people would differ in their functionality of the interoceptive system, it could explain various abnormalities in information processing, awareness of the body, and verbalization of one's internal sensations. In fact, evidence in support of this idea has been revealed. The interoceptive system is said to involve the insular cortex, close to the prefrontal cortex in the brain (Craig, 2002; Damasio, 2005). More recent publications have found indications for a relationship between increased accuracy in detecting bodily signals and size of the insula (Bird et al., 2010; Critchley, Wiens, Rotshtein, Öhman, & Dolan, 2004). Yet, the size of one brain region alone does not suffice in explaining differences in detection ability between individuals. We assert the need to investigate this relationship with a stronger focus on the tangible ability to accurately detect, process and articulate one's bodily sensations. In order to elaborate on this idea, we will explore the two concepts of interoceptive awareness and alexithymia in the subsequent sections. While the former describes a type of ability considered beneficial to one's health, the latter represents a long-researched challenge towards social interactions and an impairment in gaining insight into one's body.

Interoceptive Awareness

The research field of interoceptive awareness contains an often overlapping terminology. Mehling et. al (2009) reviewed the literature to clarify both the descriptions and objective measures used in the field. In this study, "body awareness", as an overarching term and starting point of investigation, was described to involve "an attentional focus on and awareness of body sensations" (p. 1). Traditionally, the term represented an exaggerated hypervigilance to one's bodily sensations, often called "somatosensory amplification" and commonly found in hypochondria, anxiety and somatization (Cioffi, 1991). Accordingly, increased awareness of somatic information has been considered to be largely maladaptive. Yet the review's authors argue, that there exists a different facet to body awareness, distinct from somatosensory amplification and genuinely beneficial in nature.

According to this more recent view, moving from a diffuse and abstract sense of rumination to a concrete form of experiential self-focus appears to beneficial and adaptive (Watkins & Teasdale, 2004). This approach is similar to the concept of mindfulness, a state of focused but unattached present-moment attention to events within the body and mind (Bishop et al., 2004; Kabat-Zinn & Hanh, 2013). Mindfulness is integrated in clinical approaches, as for example in acceptance and commitment therapy (Hayes, Luoma, Bond, Masuda, & Lillis, 2006), but also plays an important role in more traditional practices, such as yoga (Beddoe, Paul Yang, Kennedy, Weiss, & Lee, 2009) and

Tai Chi (Wall, 2005). In an attempt to operationalize mindfulness, a five-factor model of the construct is comprised by the dimensions of “non-reactivity to inner experience”, “observing / noticing / attending to sensations / perceptions / thoughts / feelings”, “acting with awareness / automatic pilot / concentration/nondistraction”, “describing / labeling with words”, and “nonjuding of experience” (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). Mehling et. al (2009) find the distinction between body awareness and mindfulness in this model. The authors explain that mindfulness not only encompasses an awareness to bodily sensations but also to cognitive thoughts arising in the mind. This cognitive aspect is said to be incompatible with the conceptualization of body awareness.

Taken together, the authors argue that body awareness has to be differentiated between a “diffuse, emotion-based hypervigilance” (p. 2) and a present-moment awareness of “immediately experienced feelings” (p. 2) that is limited to the body. While the former is analogous to dysfunctional rumination, the latter provides therapeutic advantages. In later parts of the review, the focus is put upon this more adaptive perception of the construct and it is being related to interoception and interoceptive awareness. They define interoception to be “the processing of sensory input from inside the body” (p. 2), similar to the previously mentioned definition by Craig (2002). Further, proprioception and interoception are said to relate to sensory perception, meaning the overall processing of peripheral input. Proprioception, similar to interoception, is another sense usually not used in everyday language, involving the perception of one’s relative position of the body within the environment.

Body awareness, as they eventually define it, represents “the subjective, phenomenological aspect of proprioception and interoception that enters conscious awareness, and is modifiable by (...) mental activities” (Mehling et al., 2009, p. 2). From this point forward, the authors stop to distinctively differentiate between body awareness and interoceptive awareness, but rather use the terms interchangeably. Also, they do not further mention proprioceptive awareness in their conceptualizations. In a later paper, Mehling et. al (2012) define interoceptive awareness to be the “conscious perception of sensations from inside the body that create the sense of the physiological condition of the body" (p. 2). In order to not further obfuscate this rather broad variety of terminology and given the similarity to the definitions of Damasio, we will continue to use this definition in our conceptualization of interoceptive awareness.

With regard to the objective measures of the construct, a lack of appropriate assessment methods was reported (Mehling et al., 2009). The authors declare that existing instruments do not name key dimensions, do not differentiate between adaptive and maladaptive aspects, and show psychometric limitations. Thus, they state that a new, multidimensional measurement is required in order to address these issues. In response, the Multidimensional Assessment of Interoceptive Awareness was developed by the research group (Mehling et al., 2012; MAIA). Given the proximity of interoceptive awareness to mindfulness, the researchers created focus groups consisting of mind-body therapy instructors and patients. Following this approach, they anticipated to achieve a concise and reliable item pool close to the core concepts of the construct.

Through focus groups, extensive reviews, and exhaustive testing five final theoretical dimensions with a total of eight subscales were generated. The dimensions were named "Noticing", "Emotional Reactions and Attentional Response to a Sensation", "Capacity to Regulate Attention", "Mind-Body Integration", and "Trusting Body Sensations". In this study, we will focus on the dimensions of Noticing and Mind-Body Integration. We consider them to be the key domains of the concept, as they reflect the most crucial features of interoceptive awareness: the capacity to consciously detect physiological changes within the body and to accurately process them. Further, we find these dimensions to be complementary to the interoceptive system of the somatic marker hypothesis. While the interoceptive system comprises the neurological pathways, connections and activation systems related to bodily changes, interoceptive awareness represents the underlying ability that facilitates the use of this system.

A body of research has been dedicated to investigate the potential differences in using the interoceptive system. In a validation study of the MAIA, pain patients were found to differ in their ability of interoceptive awareness in comparison with mind-body trained individuals (Mehling et al., 2013). Given that pain disorders are often heavily influenced by the patient's direction of attention, the authors propose that future research endeavors could identify efficient mind-body therapies aiming at altering attention styles. Interoceptive sensitivity was also found to mediate the relationship between state anxiety and joint hypermobility, a risk factor of anxiety disorders (Mallorquí-Bagué et al., 2014). Another study found that the training of interoceptive awareness through yoga facilitates emotion regulation (Daly, Haden, Hagins, Papouchis, & Ramirez, 2015). Furthermore, a lack of interoceptive ability has been associated with suicidal ideation, planning, and attempts (Forrest, Smith, White, & Joiner, 2015). Given the novelty of the MAIA and its associated conceptualization of interoceptive awareness, further empirical evidence is still required to consolidate this operationalization. Still, preliminary findings appear promising and underline the connection between interoception-based systems and associated abilities.

We have now established the concept of interoceptive awareness as the first of two ways in which individuals can differ in their use of the interoceptive system. While interoceptive awareness reflects an ability associated with beneficial consequences, research about alexithymia stems from the clinical field. It would be erroneous to describe both concepts as two sides of the same coin, but they are useful in the comparison made in this study. Nonetheless, indications of an inverse relationship between the two have been revealed in the past (Herbert, Herbert, & Pollatos, 2011). As we are interested in possible interindividual differences regarding the detection and processing of bodily changes, both the ability as well as the inability to do so pose as useful approaches of investigation.

Alexithymia

The term alexithymia was coined by Sifneos (1973), stemming from the Greek “a” meaning lack, “lexis” meaning word, and “thymos” meaning mood or emotion. In his clinical work, Sifneos discovered a particular pattern of behavior in patients suffering from psychosomatic symptoms. He described an avoidance of conflicting stressful situations, marked constrictions in experiencing and labeling emotions, and an utilitarian way of thinking. Previously, French researchers had already elaborated on this mechanical type of thinking, naming it a "pensée operatiore" (De M'Uzan & Marty, 1963). Sifneos (1973) described alexithymic patients not only suffering from a previously unmentioned mental disorder, but also described their behavior to be disruptive to the therapeutic process. He explained that the "inability to express emotions verbally" (p. 261) and an impoverished "fantasy life" (p. 261) would sabotage a process in which verbal expression and the capacity for emotional interaction is of paramount importance.

The key aspects of alexithymia mentioned by Sifneos were later picked up, conceptualized into a theoretical construct and used to generate an objective measure, the Toronto Alexithymia scale (Taylor et al., 1985). Both construct and test were later revised and refined, resulting in a twenty item questionnaire with the following dimensions: "Difficulty Identifying Feelings", "Difficulty Describing Feelings", and "Externally-Oriented Thinking" (Bagby, Parker, & Taylor, 1994). The first and second dimension relate to the aforementioned, impaired capacity for emotional interaction. Testing the notion of an impoverished fantasy life resulted in questionnaire items with a limited psychometric quality. Thus, the concept was incorporated into the dimension of a mechanical, outside-focused thinking style, which provided better results in psychometric testing.

The questionnaire was subsequently used to identify subpopulations of clinical patients also presenting alexithymic characteristics. A large body of epidemiological research revealed that patients who presented alexithymic behavior also suffered from depression (Honkalampi, Hintikka, Tanskanen, Lehtonen, & Viinamäki, 2000), eating disorders (Schmidt, Jiwany, & Treasure, 1993), and schizophrenia (van 't Wout, Aleman, Bermond, & Kahn, 2007). Alexithymia was also found to be associated with self-injurious behavior (Zlotnick et al., 1996) and disorders of the autism spectrum (Bird et al., 2010). Further, alexithymia has been described to reflect a dimensional personality trait, distinct from DSM-based personality disorders (Taylor & Bagby, 2012). A recent review of the literature criticizes that while the construct itself has been thoroughly investigated, only few steps have been taken to translate empirical findings into treatment approaches (Samur et al., 2013). The authors illustrate preliminary evidence advocating clinical advances, including the training of emotional processing and language facilitation as well as the application of intranasal oxytocin and the use of neurofeedback.

The causes of alexithymia have not yet been fully established, but a few studies provide preliminary insights. With regard to physiological aspects, alexithymia might be associated with genetic dispositions (Kano et al., 2012) and the development of the syndrome is found to be much more likely after traumatic brain injury (Williams & Wood, 2010). Further, research conducted on the idea that alexithymia might be caused by disruptions in interhemispheric transfer, has been revealed to be faulted by methodological flaws (Tabibnia & Zaidel, 2005). Focusing on psychological factors, alexithymia has been found to be associated with childhood abuse and personality disorders (Berenbaum, 1996). Another study found a relationship between the syndrome and emotional neglect (Aust, Härtwig, Heuser, & Bajbouj, 2013). It has to be pointed out here that, while this body of research provides valuable ideas for further investigations, results are largely correlative and can thus not be taken for reliable indicators of causal relationships.

The cited literature paints a clear picture of the detrimental effects of alexithymia. Given the high comorbidity with other mental disorders, the inability to accurately identify and articulate emotions seems highly dysfunctional in interpersonal relationships. In line with our previous argumentation, we postulate that this incapacity is to be associated with faulty behavior within the interoceptive system. We argue that individuals demonstrating high levels of alexithymia will show substantial difficulties when tasked to use said interoceptive system.

We have now established a theoretical framework of emotions and the associated ability, or lack thereof, to process them. Still required is an appropriate testing paradigm, in which the illustrated relationships can be investigated. In the next section, we will elaborate on which measurement instruments have formerly been used to investigate said relationship. Further, we will present a new assessment tool, promising to overcome the limitations of formerly used paradigms.

The emBODY tool

Several methods to assess both emotional stimuli and interoceptive awareness ability have been developed. The most popular one to date has been the heart rate detection task (Schandry, 1981), in which participants are asked to count their heart beats between the playing of sounds within differing intervals. Subjects are connected to a heart rate monitor during the task, so that counted and actual heart beats can be compared. A greater accuracy in heart rate detection is assumed to be indicative of greater interoceptive awareness. Results of various studies have demonstrated relationships between the task, the ability to accurately perceive bodily sensations, and the intensity of emotional stimuli (Herbert, Pollatos, & Schandry, 2007; Zoellner & Craske, 1999). Another approach to assessment is the measurement of gastric motility (Whitehead & Drescher, 1980), investigating the accuracy of detecting the synchronous presentation of light signals and stomach contractions. Further, detection accuracy appears to be consistent across these modalities (Herbert, Muth, Pollatos, & Herbert, 2012), indicating an underlying ability.

While these methods provide intricate ways to assess emotion-related stimuli and the ability to perceive them, they come with several limitations. First, such testing is experimental in nature, requiring substantial amounts of time and resources. Second, testing usually only involves one modality, limiting the entirety of assessment to a singular region of the body. In response, an Internet-based self-report measure was developed, presenting an assessment paradigm in which the effects of emotional stimuli could be assessed without restrictions to specific body regions.

The emBODY tool uses a unique self-report method, resulting in topographical descriptions of bodily changes (Nummenmaa et al., 2014). Subjects are shown emotional stimuli along with two body silhouettes and are then asked to color body regions in which a change of bodily activity was experienced. Marking patterns are aggregated to emotion-specific activation maps, revealing said topographies. In their paper, the authors describe several studies in which they used their prototype. Various stimuli formats have been used, namely emotion words, guided emotional imagery in the form of short stories, emotional movies, and images of facial expressions. Short stories and movie material were said to be the most powerful emotion induction techniques (Gerrards-Hesse, Spies, & Hesse, 1994; Philippot, 1993). The produced topographies indicated distinct, emotion-specific activity patterns across the body (Nummenmaa et al., 2014), especially with regard to basic emotions. This method stands out to former single-modality approaches, which were unable to produce data from more than only a few body regions. In addition, the authors report culturally universal results, after having exercised their method with both a Finnish and Taiwanese sample population, who presented similar topographies.

Given the novelty of the method, only a few publications mention its use. Still, the emBODY tool was successfully used in documenting the development of bodily sensations associated with basic emotions in children (Hietanen, Glerean, Hari, & Nummenmaa, 2016). Another study used it in the context of social touching and emotional bonds (Suvilehto, Glerean, Dunbar, Hari, & Nummenmaa, 2015). Subjects from five countries were asked to indicate where they would allow relatives, friends, and strangers to touch their body. Results identified relationship-specific maps, in which “the total area was directly related to the strength of the emotional bond between the participant and the touching person” (p. 13811). The tool was also used side-by-side with measures of brain activity patterns (Saarimäki et al., 2016). Here, patterns of the subjective experience of emotion was comparable with patterns of neutral activities, indicating a link between them. While potential shortcomings of the method still remain to be explored, we consider the emBODY tool a substantial addition to the repertoire of emotion measurements and a fitting paradigm for our own investigation.

We have now discussed a model of emotion processing and reviewed two forms of the inward-oriented capacity to detect, label and process physiological sensations and their associated emotional experience. This constitutes the theoretical framework which we wish to investigate. Further, we have presented the required measurement paradigm in which this framework shall be tested. In the following section, we will ask several research questions and further synthesize related directional hypotheses detailing said questions assessment.

Hypotheses

The somatic marker hypothesis established a model of emotional processing, outlining a neurophysiological system that detects intero- and exteroceptive stimuli, processes them and responds to them with the intent of maintaining homeostasis (Damasio, 2005). Further, interoceptive awareness describes the “conscious perception of sensations from inside the body that create the sense of the physiological condition of the body” (Mehling et al., 2012). Alexithymia involves the challenge to identify and articulate emotions, while being limited to a mechanical, passionless style of thinking (Taylor et al., 1985). Both concepts represent facets of the capacity, or lack thereof, to accurately detect, process, integrate, and communicate the subjective experience and associated physiological sensations prescribed to the construct of emotion.

In this study, we wish to assess whether levels indicative of high interoceptive awareness or alexithymia predict a differing use and functioning of the interoceptive system. Notable differences in the use of the interoceptive system would support the notion that the perception, processing, and integration of physiological sensations, which accompany emotional experiences, is dependent on an individualistic ability. Such a finding would promote the importance of the interoceptive system when considering training and treatment approaches in the domains of interoceptive awareness and alexithymia.

In order to investigate this relationship, we intend to use the emBODY tool (Nummenmaa et al., 2014), an Internet-based self-report measure of body topographies, as a testing environment. Thus, we will use the tool to induce a variety of emotions, measure the according response and compare these results with questionnaire measurements.

This framework gives rise to two research questions with associated directional hypotheses.

Our first research question involves the responsibility to recreate the emBODY environment, asking whether the original findings can be validated. Thus, our *first hypothesis* states that respective activation or deactivation of body areas, specific to selected emotions, will be higher when compared to a corresponding neutral condition. The associated statistical test of this hypothesis will investigate mean differences in proportionate activation or deactivation of emotion-specific body areas for each comparison between emotion and neutral conditions.

With regard to our own outset of investigation, we pose the question whether levels indicative of high interoceptive awareness and alexithymia predict aforementioned activity patterns. Accordingly, our *second hypothesis* states that higher scores in the MAIA subscales of Noticing, Emotional Awareness, Self-Regulation, and Body Listening will correlate positively with respective activation or deactivation of body areas, specific to selected emotions. Further, our *third hypothesis* states that higher scores in the TAS subscales of Difficulties Identifying Emotions and Difficulties Describing Emotions will correlate negatively with respective activation or deactivation of body areas, specific to selected emotions. The statistical assessment of both hypotheses two and three will involve testing for the significance of correlative relationships between selected questionnaire subscales and respective activation or deactivation of body areas, specific to selected emotions.

Method

Participants

The final sample consisted of 259 people, with 226 females (83%), 47 males (15%), and five persons who answered the question about gender non-binary or without comment (2%), at a mean age of 27.35 years (*SD* = 11.34). Most participants had a high level of education, with 159 (61%) holding the German Abitur, 78 (30%) university graduates, and 22 (9%) graduating from the German Haupt- and Realschule. Subjects were mainly recruited through a mailing list of the University of Koblenz-Landau, where psychology students are required to complete a set amount of participatory hours in research experiments. The study was also advertised on Facebook, on the survey pool website https://www.surveycircle.com, and among friends and family of the author.

Materials

The survey ran on https://www.soscisurvey.de, an online software package with included PHP functions to build surveys, and was licensed to be a non-commercial research project, given that its purpose was to conduct research for a master thesis. The emotion assessment tool “emBODY” was developed by Nummenmma, Glerean, Hari, and Hietanen (2014), who released the source code and related files under an open source license on GitHub [1].

For our purposes, the tool was translated to German and modified to fit our survey procedure. The feature to resume the survey with a unique ID was removed due to a redirection between servers, from where the survey ran and where the tool was hosted. Further, the registration page only assessed whether someone had visited a psychologist, excluding questions regarding a psychiatrist or neurologist. We made this change in order to avoid confusion between the professions and as only the information about psychologists was of interest to us. The video material used together with the emBODY tool was compiled by Tettamanti, Rognoni, Cafiero, Costa, Galati, and Perani (2012), who kindly made the movies available upon request. A selection of these videos, namely “Disgust_8”, “Fear_20”, “Happiness_12”, “Neutral_4”, and “Sadness_7”, was converted to GIF format to be used within the image mode of the emBODY tool.

Two questionnaires were used. First, the Multidimensional Assessment of Interoceptive Awareness (Mehling et al., 2012; MAIA) in its German version (Bornemann,

[1] The emBODY tool is available under an open source license at https://git.becs.aalto.fi/eglerean/embody/tree/master

Herbert, Mehling, & Singer, 2015), assessing with 32 items on eight subscales the different facets of interoceptive awareness, namely “Noticing”, “Not-Distracting”, “Not-Worrying”, “Attention Regulation”, “Emotional Awareness”, “Self-Regulation”, “Body Listening”, and “Trusting”. Second, the Toronto Alexithymia Scale (Leising, Grande, & Faber, 2009; TAS), in its German 26-item version (Kupfer, Brosig, & Brähler, 2001). This questionnaire measures the construct of alexithymia on the three subscales “Difficulty Identifying Feelings”, “Difficulty Describing Feelings”, and “Externally-Oriented Thinking”.

Procedure

The landing page of the survey gave information about the topic, overall process and length of the study. Informed consent was requested and information about voluntary participation, anonymity and data protection was presented. Finally, contact details of the principal researchers were given.

Participants were subsequently redirected to a separate university server, which hosted the emBODY tool. Here, participants were asked to indicate their sex, age, weight, height, handedness, highest level of education, and whether they ever had sought out psychological treatment due to a psychological problem. Then, instructions about the assessment of emotions were displayed. It was explained that videos with the intention to elicit particular positive or negative emotions will be played. Further, two body silhouettes would be displayed to the left and right of the videos. Here, subjects would have to mark where they experienced changes in bodily activation or deactivation. Participants were to indicate in the silhouette on the left side of the screen where they felt strengthened and activated. On the right side, they were to indicate where they feel weakened or deactivated. Markings for activation were colored in red and markings for deactivation were colored in blue. After confirming to have read the instructions, participations would start the assessment. For emotion induction, we used stimuli reflecting the four emotions happiness, disgust, fear, sadness, and a neutral condition. The overall display never changed, but the order of stimuli was randomized.

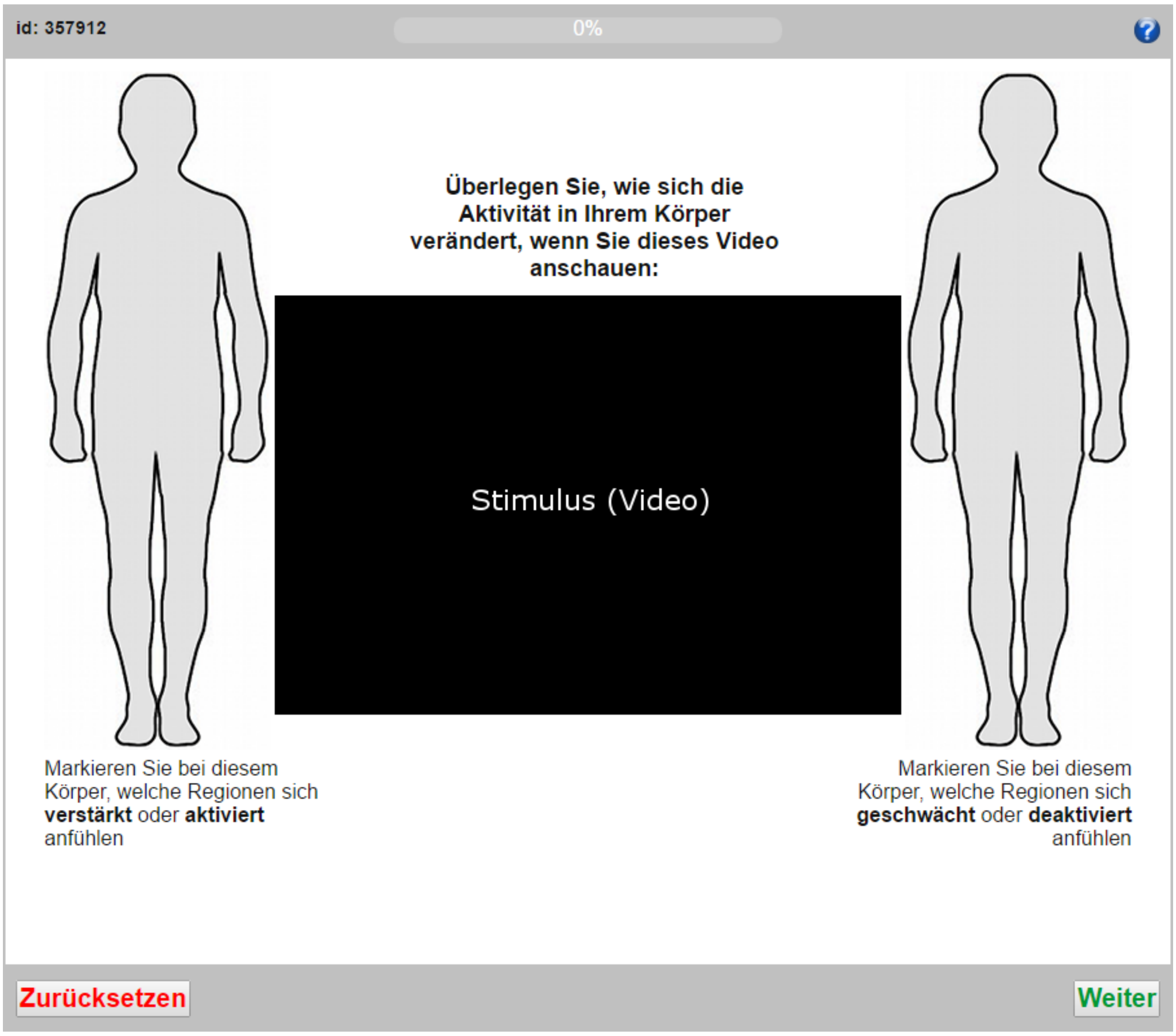


Figure 1: emBODY interface. The stimulus is displayed in the center, while body silhouettes are positioned to its sides. Activation was to be painted into the left silhouette in red, deactivation into the right one in blue. Markings were done with the mouse courser. Placed markings were displayed in a disk shape.

The layout of the tool is displayed in Figure 1.

After completing the emBODY tool, participants were redirected to the original server. Here, they were informed that the video part of the study was now complete and, as the last part of the study, questions had to be answered. Participants were instructed that statements will be displayed, to which they would have to indicate either the frequency of occurrence or their felt agreement. Also, it was stated that answers could be neither right or wrong, but should reflect one's genuine opinion or disposition. On the next pages, items of the MAIA and TAS were presented in groups of eight and six, so that items were displayed in even numbers and participants did not have to scroll the page.

At the end of the study, a debriefing text was shown. It was explained that, according to recent findings, experienced emotions can be localized within the body with relative ease. Upon this premise, the emBODY tool was developed. Further, people appear to differ in their ability of interoceptive awareness. This study thus intends to investigate the relationship between experienced emotions and the ability of bodily awareness. Finally, participants were encouraged to contact principal researchers with comments, critique and questions.

Analysis

Data

Statistical analysis was carried out through R (R Core Team, 2016) within the environment of RStudio (RStudio Team, 2015). Used analysis packages included apaStyle (Vreeze, 2016), car (Fox & Weisberg, 2011), corrgram (Wright, 2016), data.table (Dowle & Srinivasan, 2016), dplyr (Wickham & Francois, 2016), ggplot2 (Wickham, 2009), grid (R Core Team, 2016), plyr (Wickham, 2011), png (Urbanek, 2013), psych (Revelle, 2016), reshape2 (Wickham, 2007), stringr (Wickham, 2016) and xml2 (Wickham, Hester, & Ooms, 2017). The original preprocessing script was written for Matlab (Nummenmaa et al., 2014). We created our own script, in line with the original, for both preprocessing and analysis in R.

All data was read from the subject folders and compared to our data from SoSci-Survey to exclude drop outs. The emBODY data consisted of XY-coordinates, a time stamp, and two other files including demographical and technical data. The display shown in Figure 1 is made up by 900 times 600 pixels. This display was reduced to only include data within the two silhouettes, with Y ranging from 70 to 591, X on the left from 33 to 203, and X on the right from 696 to 866 pixels. Given that images are constructed with the zero point in the top left corner, but graphs are constructed with this point in the lower left corner, Y-values had to be inverted. This was done by subtracting 601 from each Y-value. Further, X-coordinates were reduced by an individual offset to norm the axis, with X on the left minus 32 pixels and X on the right minus 695 pixels. The same was done for the other axis, with Y minus 69 pixels. Accordingly, the final grid which encompassed every single possible data point consisted of 171 times 522 pixels, totaling in 89,262 data points.

Regions of Interest

As a next step, regions of interest (ROIs) were specified. A ROI is a "user-specified rectangle that can be used to limit certain compositing calculations to within its boundaries" (Brinkmann, 1999). We intended to pick the most prominent region of each stimulus condition that became evident in the original data of Nummenmaa et. al. (2014). The respective ROIs are: the head for happiness, the throat for disgust, the heart for fear and the legs for sadness. The XY-coordinates of the respective ROIs in the grid are displayed in Table A1. While the most prominent feature for happiness, disgust, and fear was represented by activation in the respective ROIs, for sadness, deactivation was most representative. Regarding the ROI for legs in the sadness condition, a single rectangle could not appropriately encompass the area of interest, so that several ROIs were specified, merged and partially reduced. This, along with the masking that describes the grid mentioned above, is displayed in Figure 2, with red lines indicating included and blue lines indicating excluded areas.

Matching

On the basis of said grid, a referential data set was created. This set included one grid for each participant, described by respective XY-coordinates. The coordinates of this reference set were then reduced to the limits of a particular ROI, excluding all data points lying outside of it. This step reduced calculation load, as the reference set for 278 participants for only one stimulus already included 23,118,858 observations. The reduced set was extended by a matching variable, consisting of the ID of the

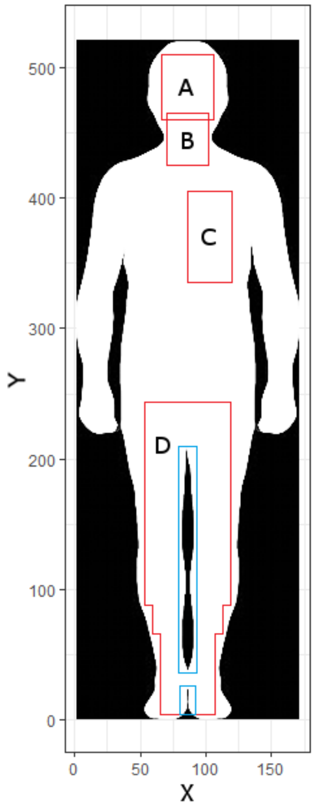


Figure 2: Body map with mask and emotion-specific regions of interest. The 171 times 522 pixel grid upon which the data is mapped is shown. Only data within the white area is assessed. Respective, emotion-specific ROIs are: A) head for happiness, B) throat for disgust, C) heart for fear, and D) legs for sadness. Red lines mark the data points of interest. Blue lines mark the areas extracted from the larger region D, which accounted for negative space not intended for calculations.

participant, the stimulus label, and XY-coordinates. The recorded data, which also included such a matching variable, was compared to the reference set, resulting in two binary variables, indicating activation or deactivation at each combination of ID, stimulus, X, and Y.

During assessment, the silhouettes were painted with a disk-shaped brush. Yet, the recorded data only indicated the coordinate at the center of this disk, so that the gathered data had to be extended by size of the brush. The disk was round and had a diameter of 15 pixels. In order to extend the data precisely, an exemplary 15 pixel circle was painted on a 15 by 15 pixel canvas in Microsoft Paint. With this image as a visual aide, the 177 pixel disk was translated to a data frame in R. The disk is shown in Figure

A1. Coordinates in the reduced, ROI-specific data sets, which were already indexed to mark activation or deactivation, were extended by this disk. So that other coordinates, which lay in a fifteen pixel-wide circle around an indexed coordinate, were also set to be respectively activated or deactivated. Finally, indices were aggregated for each region and subject, so that a final score between zero and one resulted, indicating the respective proportion of activation and deactivation in the region of interest.

Results

Statistical Analysis

Preprocessing

Before conducting the statistical analysis, the sample data was cleaned of non-responders, false completers and manipulation failures. In a first step, we checked whether subjects had no activation or deactivation in all conditions, removing 19 non-responders from the original sample of 278 to 259 people.

Further, we assessed whether any subjects had zero activation or deactivation within a particular ROI for both emotion condition and neutral condition. So that, if one subject scored zero in both happiness and neutral condition within the head ROI, scores were dropped, as it was assumed that this part of the survey was not appropriately completed.

In a final step, subjects who still presented a zero score in a particular emotion condition were partially excluded to remove failed manipulations. Given the step before, this would only target those subjects who detected bodily changes in the neutral condition while none in the emotion condition. We removed such scores, following the assumption that participants, who would not provide activation or deactivation within the most prominent ROI of a particular emotion condition, but instead in the neutral alternative, had not been successfully influenced by the stimulus material. The preprocessing procedures dropped sample sizes by 31 to 55%, depending on the respective emotion condition. Given the large overall sample size, we can still be confident in our inferential statistics, but will provide the corresponding group sample sizes with the test statistics in the reports below. We will discuss the theoretical implications of this drop in sample size in the subsequent section.

First hypothesis

Our *first hypothesis* stated that respective activation or deactivation of body areas, specific to selected emotions, will be higher when compared to a corresponding neutral condition. In order to test this hypothesis, we intended to conduct four t-tests, one for each ROI-specific comparison between emotion and neutral condition. Yet, inspections of the data distribution revealed strong floor effects. This violated assumptions of normality, despite our data cleaning efforts. An illustration of the skewed distributions is found in Figures 3 and A2. In response, we deviated from regular testing procedures and decided upon the Wilcoxon signed-rank test (Wilcoxon, 1945), a non-parametric alternative. In this test, pairs of observations are ranked and compared with regard to their difference scores. The underlying null hypothesis states that differences between observations follow a symmetric (but not normal) distribution around zero. For this procedure, all assumptions were met, as comparison groups were dependent while pair drawing was independent and all involved variables shared a continuous scale. Each test was carried out with respect to group sample size. Results are reported in Table 1.

As each of the tests revealed strongly significant results, the null hypothesis that observation differences are distributed around zero was refuted. Thus, it was clearly shown that the induction of emotions was successful in expected regions of interest, resulting in distinctive activity patterns between emotion and neutral conditons. The investigated proprotionate differences between conditions are also shown in Figure 3. Therefore, we can safely assume that the emBODY tool worked as intended and the topographical descriptions of emotion-dependent body changes are validated. Further, the data not only included expected results in the specified ROIs, but also in the form of an overall pattern. We have illustrated this in Figure 4. Here, we can see that

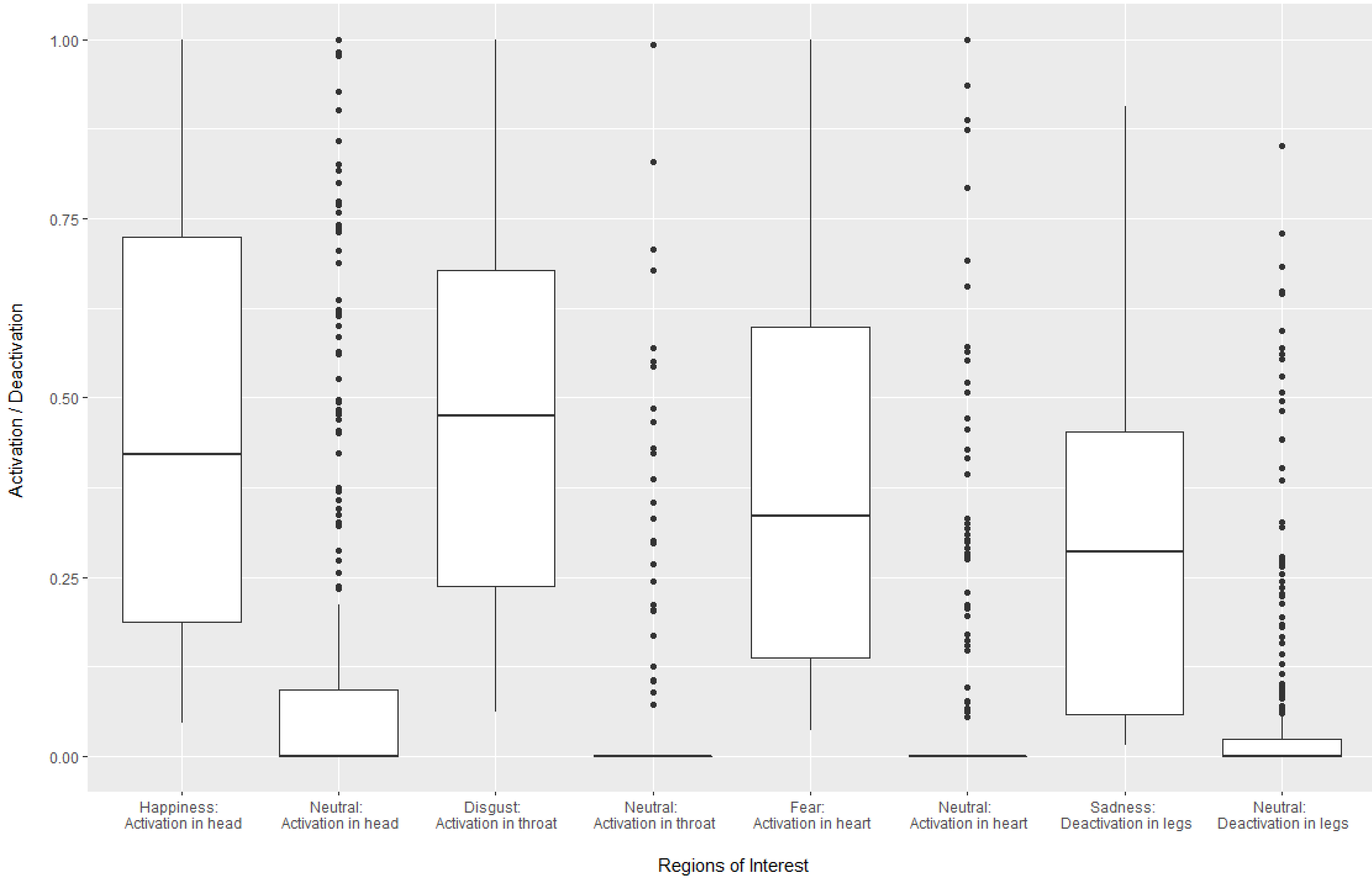


Figure 3: Boxplot depicting distribution of scores of emotion and neutral condition within respective region of interest. Activation / deactivation on the Y-axis represents the full range of the variable, from zero to one. Happiness, disgust, fear, and their comparison show activation. The counterpart comparison of sadness shows deactivation.

Table 1: Descriptive and Inferential Statistics of Activation and Deactivation of Emotion and Neutral Comparisons Within Regions of Interest.

		Descriptives		Inferential		
		M	*SD*	*n*	*W*	
Head	Happiness: Activation	0.31	0.34			
	Neutral: Activation	0.12	0.24	179	16378	***
Throat	Disgust: Activation	0.28	0.31			
	Neutral: Activation	0.04	0.13	162	13704	***
Heart	Fear: Activation	0.20	0.28			
	Neutral: Activation	0.06	0.17	140	9963	***
Legs	Sadness: Deactivation	0.12	0.21			
	Neutral: Deactivation	0.06	0.15	116	7415	***

Note. M = proportion of activation or deactivation in ROI; *SD* = standard deviation; *n* = comparison-specific sample size; *W* = Wilcoxon signed-rank test statistic.
**p* < .05; ***p* < .01; ****p* < .001

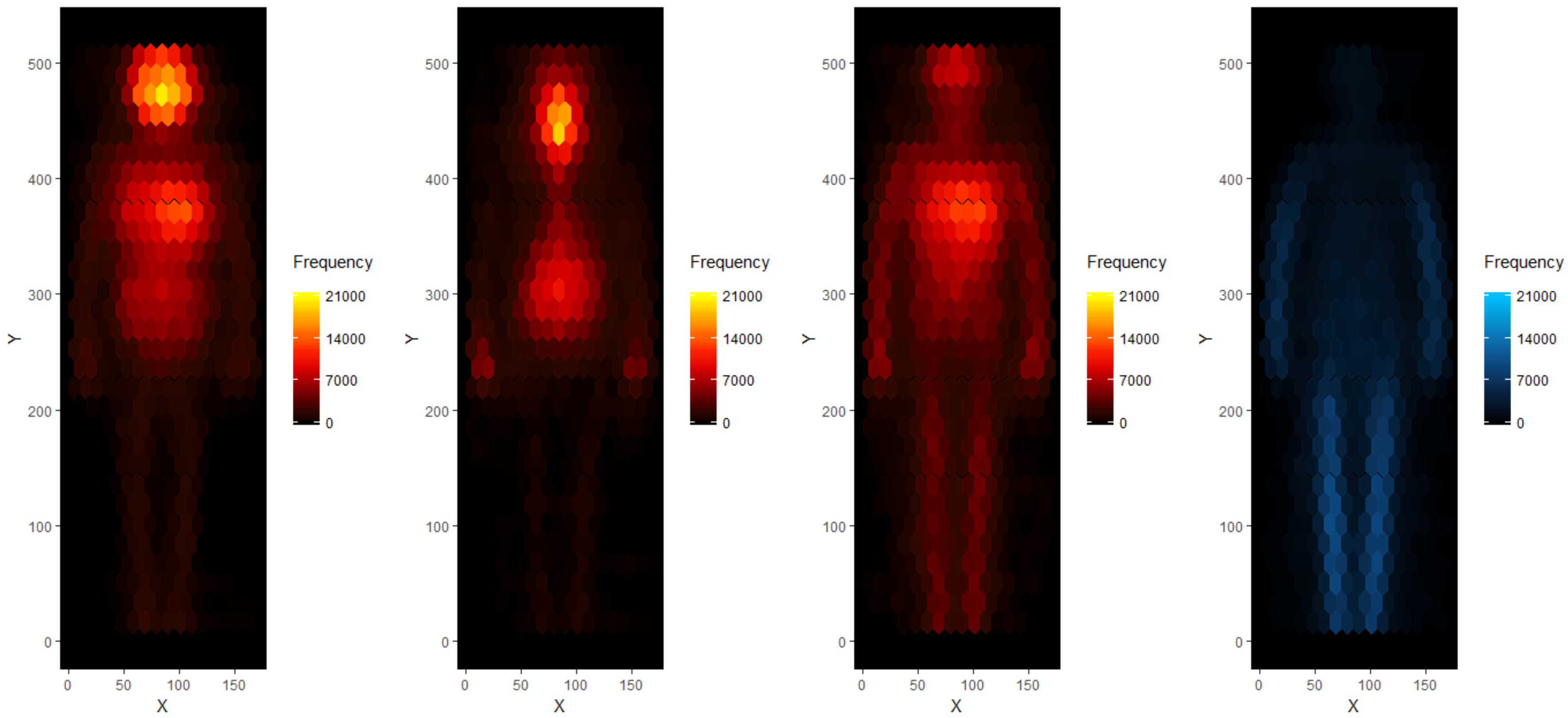
respective activation or deactivation is manifested the strongest in the ROIs but also fits the overall patterns originally identified by Nummenmaa et. al. (2014).

It has to be noted that our presentation of bodily sensation maps is not the same as the original one. The original publication included maps in which activation and deactivation have been plotted against each other in the form of a t-statistic. We, on the other hand, illustrated our data through activation or deactivation specific frequency counts, a simpler but also more straightforward approach to presenting the data. Further, activation and deactivation are not plotted against each other and thus overlaps between the two are not accounted for. Yet, given the intention of our underlying hypothesis, this does not represent itself as a shortcoming of plotting, but rather as a different approach to illustrate the data. Building upon the fact that we recreated the required testing paradigm, we investigated the other hypotheses.

Second and third hypotheses

In our *second hypothesis*, we stated that higher scores in the MAIA subscales of Noticing, Emotional Awareness, Self-Regulation, and Body Listening will correlate positively with respective activation or deactivation of body areas, specific to selected emotions. In our *third hypothesis*, we predicted that higher scores in the TAS subscales of Difficulties Identifying Emotions and Difficulties Describing Emotions will correlate negatively with respective activation or deactivation of body areas, specific to selected emotions. In order to investigate, we first calculated scores for the subscales of the respective questionnaire. The distributions of these subscales are displayed in Figures A3 and A4.

Questionnaire data was distributed normally to a satisfying degree, in contrast to the emBODY recordings. Our sample thus resulted in questionnaire scores with appropriate comparability. Still, originally intended multiple regression analyses could not be carried out with due diligence, as the assumption of normality remains violated. Thus, we will limited the analyses of hypotheses two and three to a comprehensive assessment of correlations. Accordingly, we again used a non-parametric variant of a statistical test to assess the data. For each combination of questionnaire subscales and activation or deactivation in ROIs, we tested the corresponding pairwise Spearman rank correlation (Spearman, 1904). Similar to the test by Wilcoxon, testing Spearman's rho includes ranking and comparing pairwise differences of observations. For this procedure, all assumptions were met, as all involved variables shared a continuous scale and were monotonically related. Testing results, along with according illustrations of the distribution of relationships in the form of scatter plots, are reported in Figure 5.



(a) Happiness **(b)** Disgust **(c)** Fear **(d)** Sadness

Figure 4: Frequency hexagon plots of emotion conditions. X- and Y-axis depict locations within the grid. Color indicates frequencies within hexagon bins. Activation of happiness, disgust, and fear conditions are depicted in black to red, deactivation of the sadness condition in black to light blue. All plots share the same frequency scale. The maximum of the scale was chosen in accordance with the lowest possible maximum score. The highest frequency score at the shown hexagon bin size lay between 20,500 and 21,000 frequencies. Scale maximum was accordingly set to 21,000 across all plots.

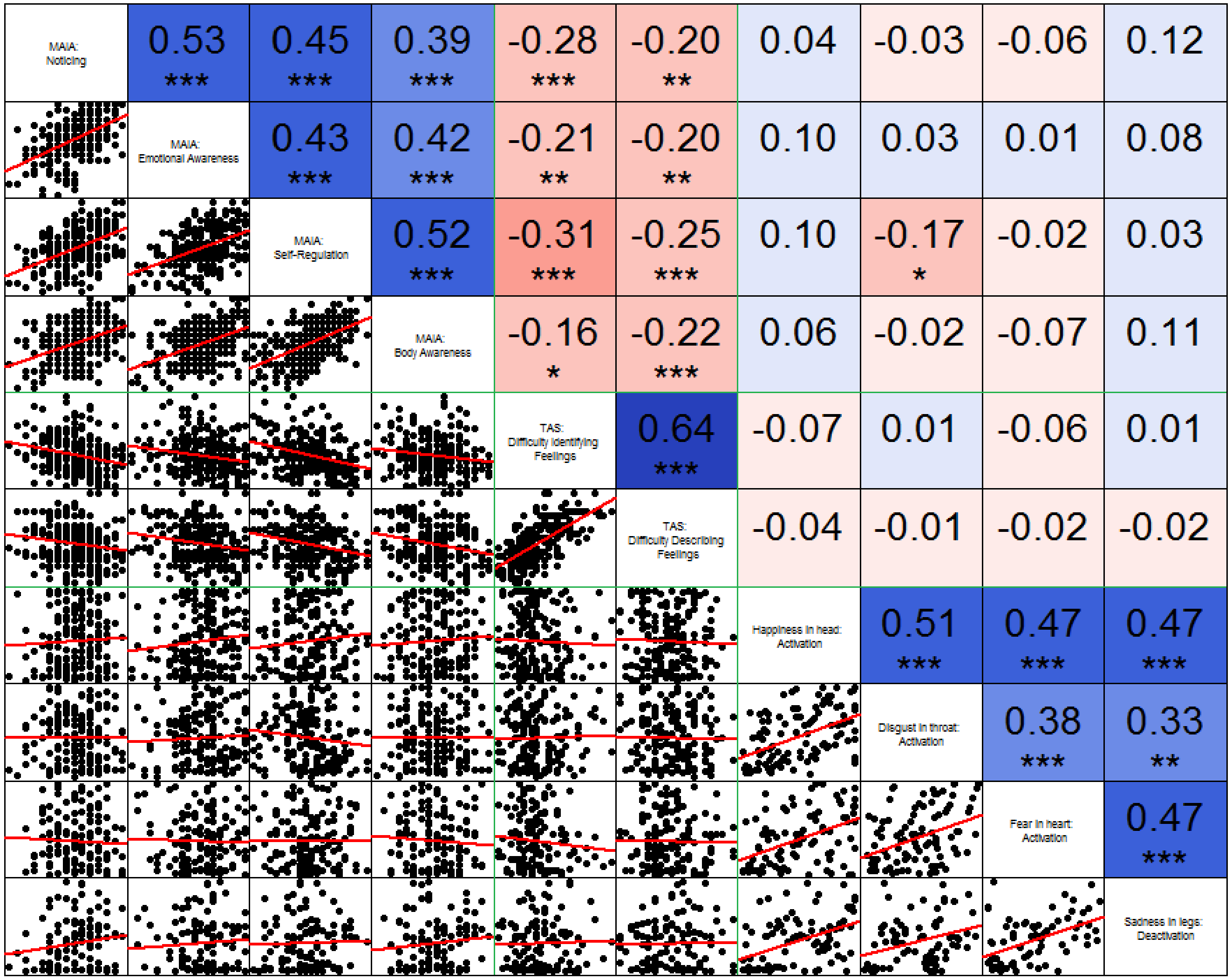


Figure 5: Correlogram of questionnaire and ROI-specific emBODY measures. Spearman correlation scores with indication of significance in the upper half. Scatter plots including a least-squares regression line of selected questionnaire subscales and respective ROI activation and deactivation in the lower half. *p < .05; **p < .01; ***p < .001

The correlogram illustrates clearly how different study elements correspond with one another: MAIA subscales positively correlate to a significant degree. The same can be said for the TAS subscales. This indicates that the subscales of respective questionnaires appear to investigate the same construct, being interoceptive awareness and alexithymia respectively. Further, MAIA and TAS share significant negative correlations. Thus, subjects with higher scores in one questionnaire would be expected to correspond with lower scores in the other. Given the previously identified inverse relationship between both concepts, this outcome resulted as expected.

Similarly, the activation and deactivation in respective ROIs also corresponds with another, as it would be expected. Further, the scatter plots in the lower left half of the plots show that the data is distributed in a way that testing results are argumentatively robust. Results of the relationships within questionnaires and ROIs show clustered data with clear positive and negative trends. Relationships including the ROIs are somewhat clustered at the bottom of the frequency scale, but the overall pattern of each relationship remains the same.

Yet, the striking exception to this strong pattern of significant relationships are the actual relationships of interest. Correlations of ROIs and questionnaire subscales are close to zero, with the only exception being the relationship between the Self-Regulation scale of the MAIA and activation through disgust in the throat region. While we try to elaborate in the section to come, it has to be noted here that a significant result in a large sample at an alpha level of .05 fails to be a safe foundation for any argument. Therefore, the hypotheses that measures of MAIA and TAS would result in positive and negative correlations respectively, were not supported by our findings.

Exploration

The analysis of our central hypotheses revealed unexpected results. Thus, we intended to explore further ideas about why the data failed to include the relationships we hypothesized. First, we carried out another analysis of correlation coefficients, now without the restriction to ROIs of the emBODY data. Rather, we were interested whether the hypothesized relationships would would become evident through whole-body activation and deactivation patterns. The correlogram of this analysis is shown in Figure A5.

Questionnaire coefficients did not change, as the lifting of restrictions only affected emBODY data. Relationships between emotion conditions strengthened. This is likely to stem from the fact that an increased amount of markings, whether it be activation or deactivation, is relatively dependent on the subject. Thus, subjects with high indices in one emotion condition will probably also have high indices in other conditions, with the obvious exception of the neutral condition. With regard to the relationships between questionnaires and emBODY data, the picture remains largely the same. The significant finding between Self-Regulation and disgust is not evident in this second test. Instead, Noticing now shows significant positive correlations with activation in fear and deactivation in sadness. Also, Emotional Awareness positively correlates with activation in the happiness condition. While we will elaborate on these findings in the discussion section as well, our statistical concerns remain the same.

In a second step, we intended to check whether response patterns to the emBODY tool could identify groups with alternating scoring in both MAIA and TAS. Thus, we specified two sub groups of the sample. The first group (G1) involved subjects with excluded scores in all emotion ROI conditions after data preprocessing. This group accounted for false completers and failed manipulations in all conditions. The second group (G2) included participants with excluded scores in any emotion ROI conditions after data preprocessing. This group only included failed manipulations in at least one condition.

Through this grouping process, we wanted to investigate whether groups could be identified that showed disrupted response patterns. The assumption here was, that questionnaire scores of low interoceptive awareness or high alexithymia might be indicative of an overall disrupted response pattern to the emBODY tool. Results of these comparisons are displayed in Table A2. G1 was comprised by 13 and G2 by 216 subjects. Given the discrepancy in group size, we did not deem any inferential tests to be statistically feasible. Still, an interesting pattern emerged. While scores and standard deviations are fairly similar, given the same similarity of sample sizes, G1 shows a different pattern of scoring. Whereas MAIA scores are consistently higher in G1 than in the full sample or G2, TAS scores are similarly slower, indicating a higher level of overall bodily awareness. Similar to above, we will subsequently elaborate on this pattern.

Discussion

Interpretation of Findings

First hypothesis

Our *first hypothesis* stated that respective activation or deactivation of body areas, specific to selected emotions, will be higher when compared to a corresponding neutral condition. Inferential testing of our data confirmed this hypothesis for each comparison of emotion and neutral condition in a particular ROI. This outcome is presented in Table 1. Therefore, we have successfully established the required testing paradigm in which the subsequent central hypotheses of this investigation can be assessed.

The activity patterns of our bodily sensation maps appear quite similar to the original findings. Nonetheless, we have to acknowledge a difference in intensity across conditions. Comparing the emotions happiness and fear in Figure 4, differences in overall activation intensity are clearly evident. This stands in contrast to the findings of Nummenmaa et. al (2014), who showed that activation in the principal ROIs of emotions was similarly high. We attribute this discrepancy to a lack of stimulus variety. Given that we used only one movie for each emotion, video-specific differences in emotion induction are plausible. Unfortunately, technical limitations of the emBODY tool prohibited us from using a more broad variety of stimuli, including nested randomization.

Second and third hypotheses

Our *second hypothesis* stated that higher scores in the MAIA subscales of Noticing, Emotional Awareness, Self-Regulation, and Body Listening will correlate positively with respective activation or deactivation of body areas, specific to selected emotions. In our *third hypothesis*, we predicted that higher scores in the TAS subscales of Difficulties Identifying Emotions and Difficulties Describing Emotions will correlate negatively with respective activation or deactivation of body areas, specific to selected emotions. The correlations illustrated in Figure 5 provide no indications of relationships predicted by both hypothesis. Thus, the assumption that high scores in the selected MAIA subscales show significantly positive correlations with activation or deactivation in respective, emotion-specific ROIs did not hold true. In a similar fashion, the postulation that high scores in the selected TAS subscales show significantly negative correlations with activation or deactivation in respective, emotion-specific ROIs was not supported.

The only significant finding with regard to our central hypotheses was the relationship between the Self-Regulation subscale of the MAIA and disgust-related activation in the throat ROI. We find this relationship representative of our initial hypotheses: the capacity to appropriately process bodily sensations influences the location and intensity in which such feelings are being perceived. In this, a person with high self-regulation capacity would not be influenced as much by a disgust-eliciting stimulus, as such information would be perceived, processed, and integrated with regulatory stability. Still, given the large sample size of this comparative investigation, a significant result at the most minimal alpha level cannot be utilized to provide reliable evidence for any hypothesis. While being symbolically representative of our presumptions, we consider this erratic finding to be due to statistical noise.

Nevertheless, measures of the same instrument or construct displayed correlative relationships as intended. MAIA subscales correlated positively with one another. The same could be identified for subscales of the TAS. In this, subscales of the same instrument appear to assess the same construct. Further, subscales of one questionnaire correlated negatively with the other questionnaire. This indicates that interoceptive awareness and alexithymia seem to share the inverse relationship, which had been previously reported (Herbert et al., 2011). Finally, increasing amounts of respective activation or deactivation in ROIs shared a positive relationship. These findings taken together confirm the validity of our testing paradigm, as all assumptions that were previously made about our testing situation were supported.

Given that the no evidence for the central assumptions of our investigations could be provided, attempts have to be made in order to explain the findings. In the following, we will explore several explanation approaches. First, the potential shortcomings of self-report methods have to be addressed. As both questionnaires require self-assessment, some trust is always involved in the ability of the participant to accurately judge his or her dispositions. It has been scientifically established that assessment with such measures is often prone to social desirability bias (Mortel & F, 2008). In this, participants respond in a pattern indicative of an adherence to common social norms. In order not to break with such norms, respondents deviate from their genuine answer due to a threat to the positive perception of oneself.

Questionnaire results thus might not reflect the true capacity to accurately detect, process, and articulate emotion-related bodily changes, but rather the subjective opinion whether one holds this capacity. More specifically, questions asking whether one notices how breathing feels more easily, when something positive happened, are not free of social preconceptions. Being aware of and in touch with one's body is an ability people would easily consider socially advantageous. Accordingly, questionnaire respondents have to often counter their positive self-perception in order to provide genuine answers. While this methodological issue represents the natural trade off between experimental and self-report instruments, its potential consequences should not be underestimated.

Such bias is cause for systematic error in self-report instruments. Consequently, additional questionnaire items sensitive to such bias are recommended (Nederhof, 1985). Unfortunately, none of the methods used in our study include such items. Thus, we have to acknowledge the potential distortion of our data. Still, given the psychometric properties of our testing instruments, we judge this threat to be relatively small. Considering the novelty of both MAIA and emBODY, further empiric assessment whether such bias-sensitive improvements are necessary, remains to be conducted.

The assessment approach incorporating ROIs as measurement locations might have been the cause for a non-significant result. In our initial design of the study, the use of ROIs represented the adherence to common scientific practice. Arguably, this might have been the wrong approach. Variance in the investigated capacities might not be associated with lesser or higher activation or deactivation in the prominent regions, as expected, but with such markings in different areas.

Accordingly, not only the ROIs should be investigated, but the overall response patterns. Maybe, mentioned subjects provide enough activation or deactivation within our selected areas to invalidate our inferential tests, but also show a similar level of detected changes in regions not principally associated with the currently induced emotion. Thus, activity patterns are not focused on respective ROIs, but rather spread out in adjacent body areas. For example, fear-based activation would not only be evident in the heart region, but would also diffuse into the opposite side of the torso, lower abdomen, and shoulder area. This would lead to insignificant tests, which would not have appropriately assessed the response pattern of interest.

In order to investigate this assumption, one would have to filter activity patterns corresponding with differing levels of interoceptive awareness and alexithymia and check whether such levels are indicative of differences in response focus to expected areas. Such an idea could not only give rise for a completely separate investigation, but could also be explored within our current data set. Given the already extensive efforts that were undertaken for an adapted analysis of emBODY outcomes, such further explorative endeavors would extend beyond the scope of this thesis.

As a compromise, we intended to investigate whether the hypothesized relationships between questionnaire measures and emBODY outcomes could be identified in the overall activity patterns. Thus, we conducted another correlation analysis, this time without the restriction to particular ROIs, but rather encompassing the entire body.

Results are presented in Figure A5. Here, we find a similar pattern as before. The MAIA subscale Noticing correlated positively with activation in fear and deactivation in sadness. Accordingly, one's ability to accurately detect the location of bodily changes leads to an increased intensity of felt respective activation or deactivation. Further, the Emotional Awareness subscale of the same instrument correlated positively with activation in happiness. This represents that individuals with a heightened awareness of the subjective emotional experience also sense accompanying bodily changes more intensively.

We find such a pattern analogous to our previous relationship between Self-Regulation and disgust: While illustrative of our initial hypotheses in general, the conclusion that such findings are erratic at best remains the same. Given that we lifted ROI-specific restrictions in this analysis, the amount of data tested substantially increased. In this, significant results at the most marginal of alpha levels continue to be unreliable.

Another explanation stems from the finding that emotion-specific group sizes varied to a notable degree. After data preprocessing, emotion condition group sizes had dropped by 31 to 55% (see Table 1). This gave rise to the question whether subjects might respond erratically to the emBODY tool in general. The assumption here was, that differences in interoceptive capacity or disability might not predict the intended emBODY outcome, but rather the overall compliance to and ease of using the tool. Accordingly, we split the data into two groups, one with excluded scores in all emotion ROI conditions after data preprocessing (G1). This group accounted for false completers and failed manipulations in all conditions. The other, with excluded scores in at least one emotion ROI condition after data preprocessing (G2). This group only included failed manipulations in at least one condition. Group differences are illustrated in Table A2. Again, a large difference in group size was evident, so that no further inferential testing of group differences was feasible.

While G2 showed a pattern of MAIA and TAS scores quite similar to the full sample, G1 showed an inverse trend. Interestingly, MAIA and TAS scores were persistently higher and lower, respectively, when compared to the full sample and G2. Still, this trend is the exact opposite of what we assumed at the outset of our exploration. Possibly, participants who are apt in the processing of bodily changes respond to the emBODY tool in a fashion not accounted for in our study design. Yet, the size of the G1 group was too small to make any reliable inferences. Nonetheless, we consider the addition of assessment targeting participation compliance as a useful extension of the emBODY tool.

Focusing on the drop of group sample sizes in emotion comparisons, concerns arise regarding the validity of the used instruments. Given that sample groups dropped by more than half in some instances, the question has to be asked whether such drop rates are systematic. Our differentiation into groups differing in faulty response patterns did not reveal any significant insight. Thus, it can be postulated that the use of the emBODY tool might not be as intuitive as originally suggested. If, for example, participants would have systematic difficulties in transferring the perceived sensations of one's abdomen to the lower half of the body silhouette's torso, insignificant findings might be easily explained.

Additionally, the original publication and subsequent validation of the tool did not provide any kind of statistic pertaining potential drop outs or erratic response patterns (Nummenmaa et al., 2014; Hietanen et al., 2016). Further, results of the tool are very hard to investigate for potentially deviant patterns. If one would be interested in determining whether participants would show systematically erroneous responses, a manual, image-by-image inspection would be necessary. Thus, we question whether the emBODY tool responses can be taken at face value without additional measures addressing data consistency.

From a theoretical perspective, another compelling explanation for our findings relates to the conceptualization of the interoceptive system and its associated use. The interoceptive system is fundamentally defined to be an interconnected pathway system, relaying interoceptive and exteroceptive sensory signals to brain cortices, in which sensory information is integrated and processed (Craig, 2002; Damasio & Carvalho, 2013). At the outset of this study, we argued that contemporary measures of the capacity to use this system would provide reliable indications for interindividual differences in the perception of feelings (Damasio, 2005). Given the outcome of our investigation, such hypotheses could not be supported. Why? We argue, that our findings potentially reveal that the effects of interoceptive awareness and alexithymia on the interoceptive system have previously been conceptualized with limited discrimination.

Potentially, the biological pathway system we discuss is not as prone to interindividual differences as previously imagined. Thus, if structural damage is absent, as compared to the VMPFC patients in Damasio's initial work (2005), afferent signals will be detected, processed, and integrated with reliable consistency. Accordingly, people do not differ in how information is transfered, but rather vary in how such information is consciously perceived, associated with the context of origin, and meaningfully articulated. Put in more simple terms, interoceptive awareness and alexithymia do not affect the process in which we receive information, but only describe our capacity to use information.

Therefore, the investigated capacity would be mostly psychological, even if dependent on physiological input. The emBODY tool measures the felt location and intensity of bodily changes due to an induced emotion. Following this alternative conceptualization, such measures would be without substantial outcome if related to instruments assessing said capacity, as the underlying assumption is based on a system that does not differentiate between individuals. In this, we compare the interoceptive system to the same invariant systems of other senses, as for example the eye. While structural differences are relatively common, as the issue of shortsightedness illustrates, humans do not possess the trainable ability to see better. Rather, the underlying system that receives and relays sensory input is mostly congenital and invariant. Our findings would support such an alternative interpretation of the interoceptive system. Ultimately, this would implicate that the previously conceived avenue of investigation, which focuses on a trait-like capacity influential to the interoceptive system, appears redundant to follow. Given that the assumed invariance is real, further endeavors attempting to assess potential influencing factors will be without fruition.

Limitations

Despite all explanation efforts, we also wish to outline a few suggestions for methodological improvement. First, we had to make compromises in the compilation of used stimuli material. The emBODY tool provides the possibility to define an order of presented stimuli. This order can then be randomized if desired. We originally intended to define groups of stimuli, which induce the same emotion. Further, we wished to create nested randomizations, in which not only the order of emotions would be random, but also the particular stimuli drawn from a respective stimulus group. Such a design could not be implemented with the current functionality of the tool. Rather, one would have to include all emotion groups on the same level and then randomize those across the whole process. Such a design has the shortcoming of being substantially longer in duration. Given the additional use of questionnaires, participation would have extended much further than 45 minutes, adding the risk of dropouts. Accordingly, we suggest to extend the tool by this feature.

Another potential source of error special to our study was the translation of instructions. We paid significant attention to keeping the German translation close the original, while trying to create meaningful alternatives when the literal translation did not fit. Still, to verify the translation, both versions of the tool should be used side-by-side in a future investigation, so that potential language effects could become evident.

Related to the issue of translation is the potential misunderstanding of instructions. Some subjects reported back to the author that they had only clicked into regions in which they experienced bodily changes, instead of dragging the cursor across such an area. This might have resulted in much smaller amounts of data for these subjects, despite potentially equal amounts of felt body sensations. We therefore suggest to improve the instructions in subsequent studies by clearly indicating that “marking an area” involves painting it. Thus, one is supposed to drag the cursor across the region, instead of simply clicking in particularly sensational spots.

Finally, we have to note that our sample was comprised by a relatively homogeneous demographic. Subjects were mostly female, relatively young, and held a high level of education. Such a sample might still provide useful insights into human behavior, but is hardly representative of the general population. Accordingly, subsequent studies should strive to extend their sampling population to demographics of older ages, different professions and other levels of education.

Outlook

In this last section we wish out outline ideas with regard to future research endeavors. First, we propose to keep physiological and psychological aspects more distinct. Both should still be considered parts of the same system, but the capacity of interest seems to be only influential to its psychological facet. Future studies should emphasize the skills involved in attributing physiological sensations to the according feeling type, whether such information is used in providing context for the subjective experience component of feelings, and with which accuracy this information is articulated in social interactions.

Focusing on interoceptive awareness, this would implicate that the already established approach of mind-body-therapies, which involves the aforementioned unattached present-moment self-focus (Watkins & Teasdale, 2004), should be continuously developed. If the interoceptive system is as invariable as here assumed, potential growth in the capacity to shift attention towards perceived sensory input should be emphasized. With regard to alexithymia, we wish to reiterate the conclusions of Samur et. al (2013). The advancement of therapeutic approaches in the treatment of alexithymia continue to be urgently required. Training of language and processing capacities appears equally promising as the application of facilitative hormonal medication.

With regard to methodological factors, we encourage the refinement of the emBODY tool. Elaborate randomization mechanics provide the option for intricate study designs. Further, we acknowledge the need to validate instruction translations and the use of a more representative sample. Most importantly, we emphasize an alternative study design in which assessment focus does not aim at particular regions of interest, but rather attempts to detect diffused patterns of respective activation or deactivation.

Most prominently, our alternative interpretation of the use of the interoceptive system requires assessment. In order to validate the alleged futility of investigating differences in interoceptive system usage, one would have to provide consistent evidence that such differences are absent. Such an assessment would require the continued induction of various forms on emotional stimuli, similar to the broad repertoire used by Nummenmaa et. al (2014). The perception of resulting physiological sensations would have to show an consistently reliable pattern across emotion types and stimuli modalities. Further, efforts would have to be made to generate a representative and large sample, so that persistent null findings prove to be reliable. Given that the absence of a causal relationship is hard to prove, inverse findings would be required as well. Accordingly, the mentioned training of interoceptive awareness as well as treatment of alexithymia should provide greater benefit in emotional interactions than previously conceived interventions on the interoceptive system. An aggregated pattern of such findings would provide the necessary evidence to consolidate the assumptions of our alternative explanation.

Appendices

A Tables and Figures

Table A1: XY-Coordinates of ROI Corners of Respective Emotion Conditions.

ROIs	BL	BR	TL	TR
Head	(66, 461)	(106, 461)	(66, 511)	(406, 511)
Throat	(70, 426)	(102,426)	(70, 466)	(102, 466)
Heart	(86, 336)	(120, 336)	(86, 406)	(120, 406)
Legs 1	(65, 4)	(107, 4)	(65, 244)	(107, 244)
Legs 2a	(53, 88)	(66, 88)	(53, 244)	(66, 244)
Legs 2b	(106, 88)	(119, 88)	(106, 244)	(119, 244)
Legs 3a	(59, 66)	(66, 66)	(59, 89)	(66, 89)
Legs 3b	(106, 66)	(113, 66)	(106, 89)	(113, 89)
Legs 4	(79, 36)	(93, 36)	(79, 210)	(93, 210)
Legs 5	(80, 4)	(92, 4)	(80, 26)	(92, 26)

Note. ROIs = regions of interest, BL = bottom left; BR = bottom right; TL = top left; TR = top right; a = left side of body; b = right side of body. Leg areas 1 through 3 were included in the analysis. Leg areas 4 and 5 represented negative space and were excluded from the analysis.

Table A2: Descriptive Statistics of MAIA and TAS Subscales Across Different Response Pattern Groups

		Full: n = 259		G1: n = 13		G2: n = 216	
		M	*SD*	*M*	*SD*	*M*	*SD*
MAIA	Noticing	3.55	(0.72)	3.71	(0.83)	3.52	(0.74)
	Emotional Awareness	3.65	(0.80)	3.86	(0.97)	3.65	(0.79)
	Self-Regulation	2.44	(1.11)	2.94	(1.21)	2.46	(1.14)
	Trusting	2.56	(1.08)	2.79	(1.52)	2.52	(1.08)
TAS	Difficulty Identifying Feelings	16.20	(5.26)	15.15	(6.68)	16.31	(5.09)
	Difficulty Describing Feelings	13.81	(4.31)	13.15	(4.20)	13.96	(4.24)

Note. Full = complete sample; G1 = subjects with excluded scores in **all** emotion ROI conditions after data preprocessing; G2 = subjects with excluded score in **any** emotion ROI conditions after data preprocessing; *M* = questionnaire subscale score; *SD* = standard deviation.

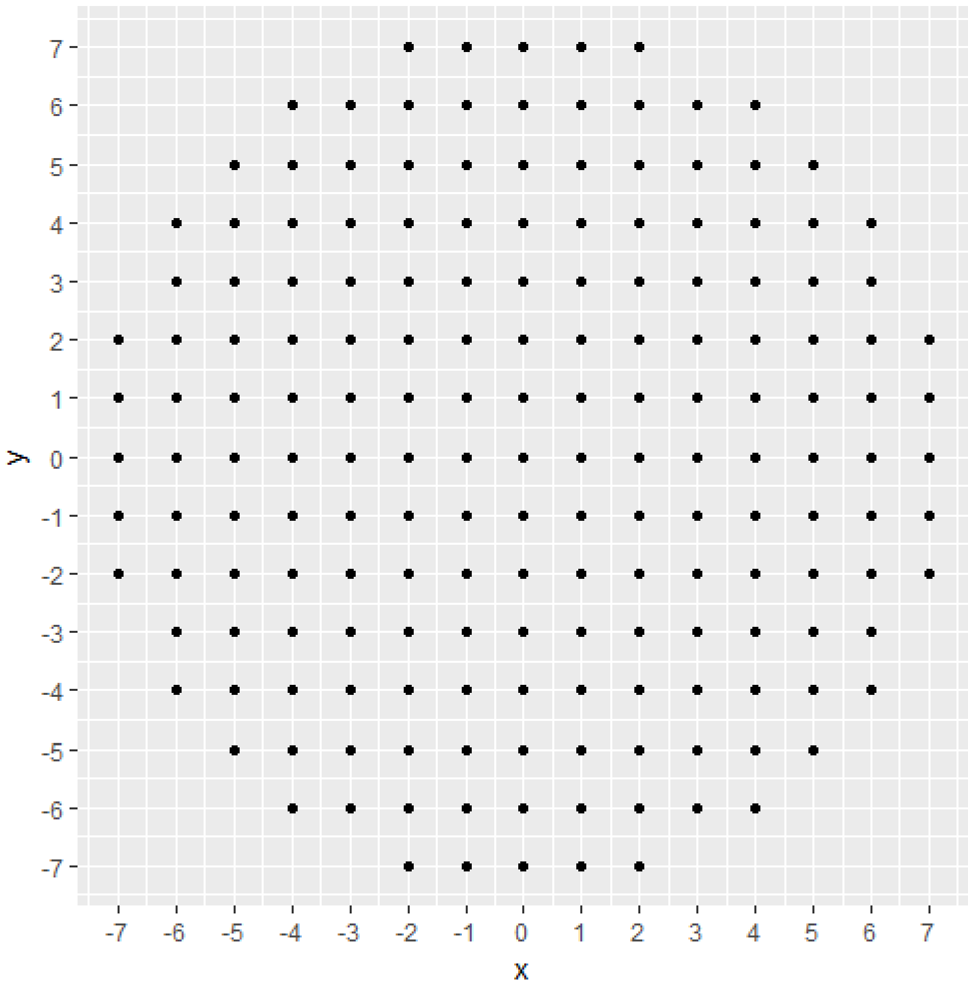


Figure A1: Scatter plot depicting the disk-shaped brush used while painting in the emBODY tool.

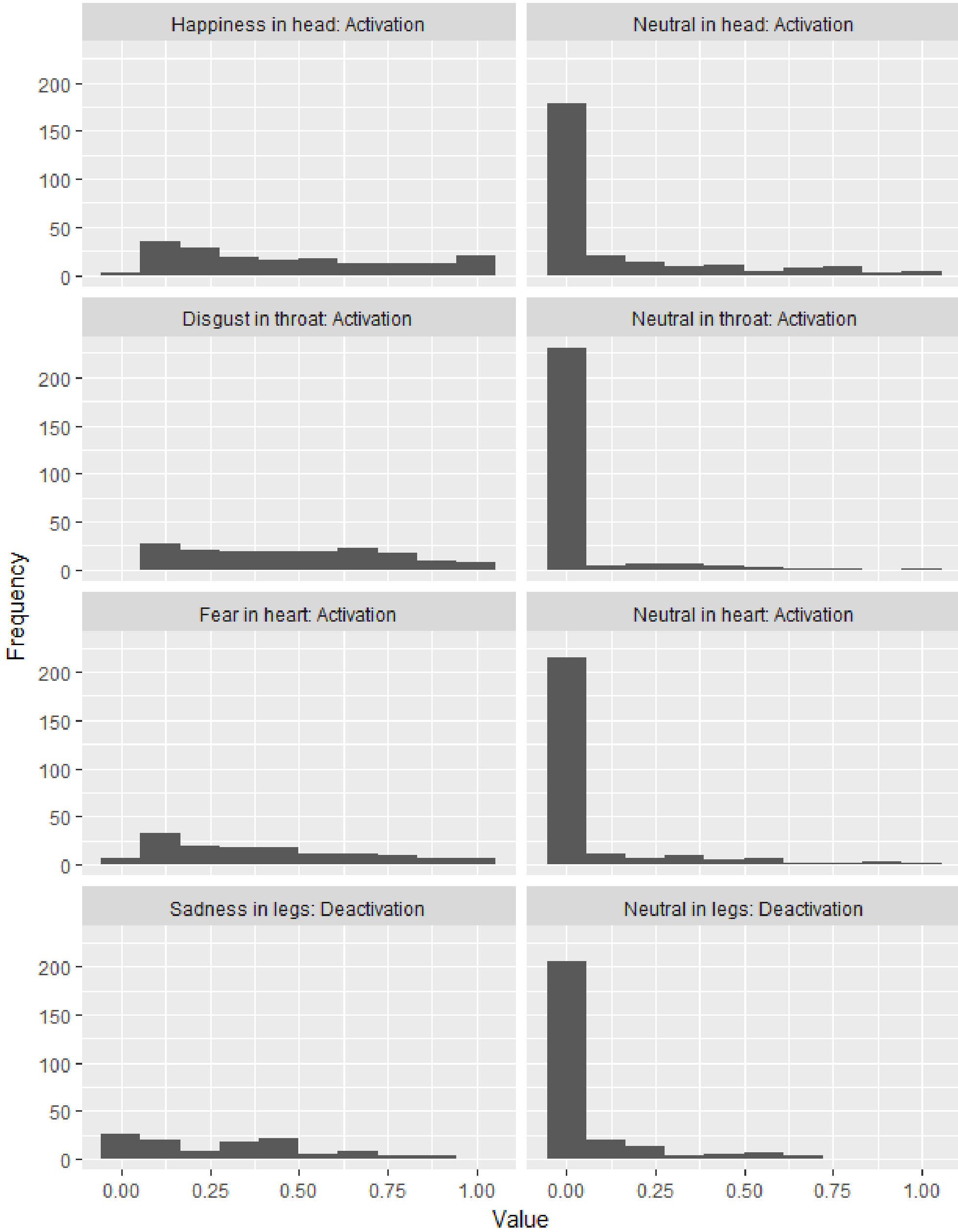


Figure A2: Matrix of histograms showing the frequency distributions of activation and deactivation in respective regions of interest.

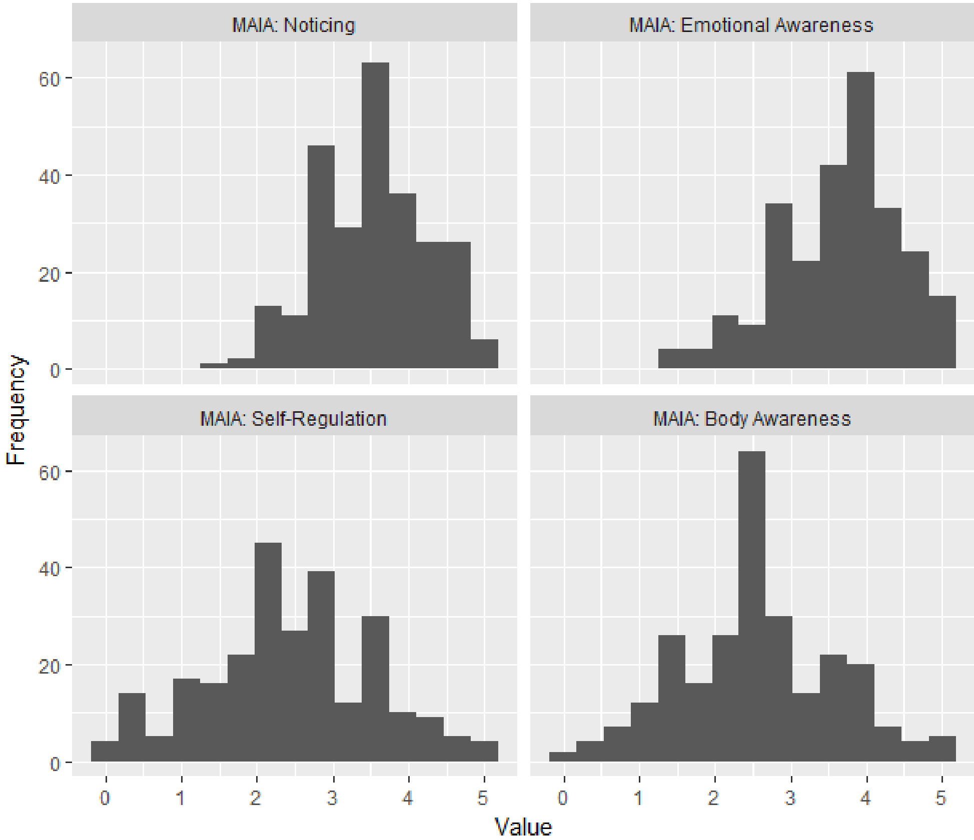


Figure A3: Histograms showing the frequency distributions of MAIA subscale scores.

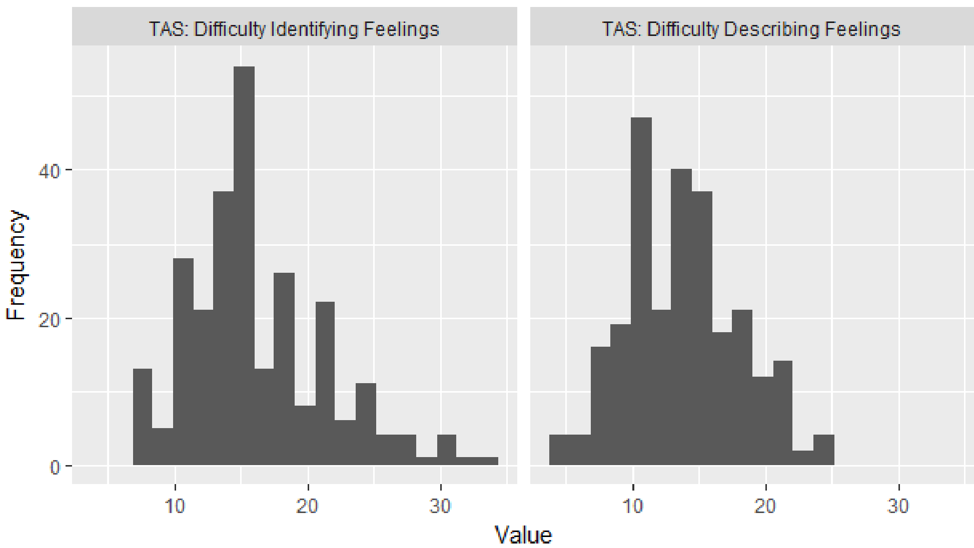


Figure A4: Histograms showing the frequency distributions of TAS subscale scores.

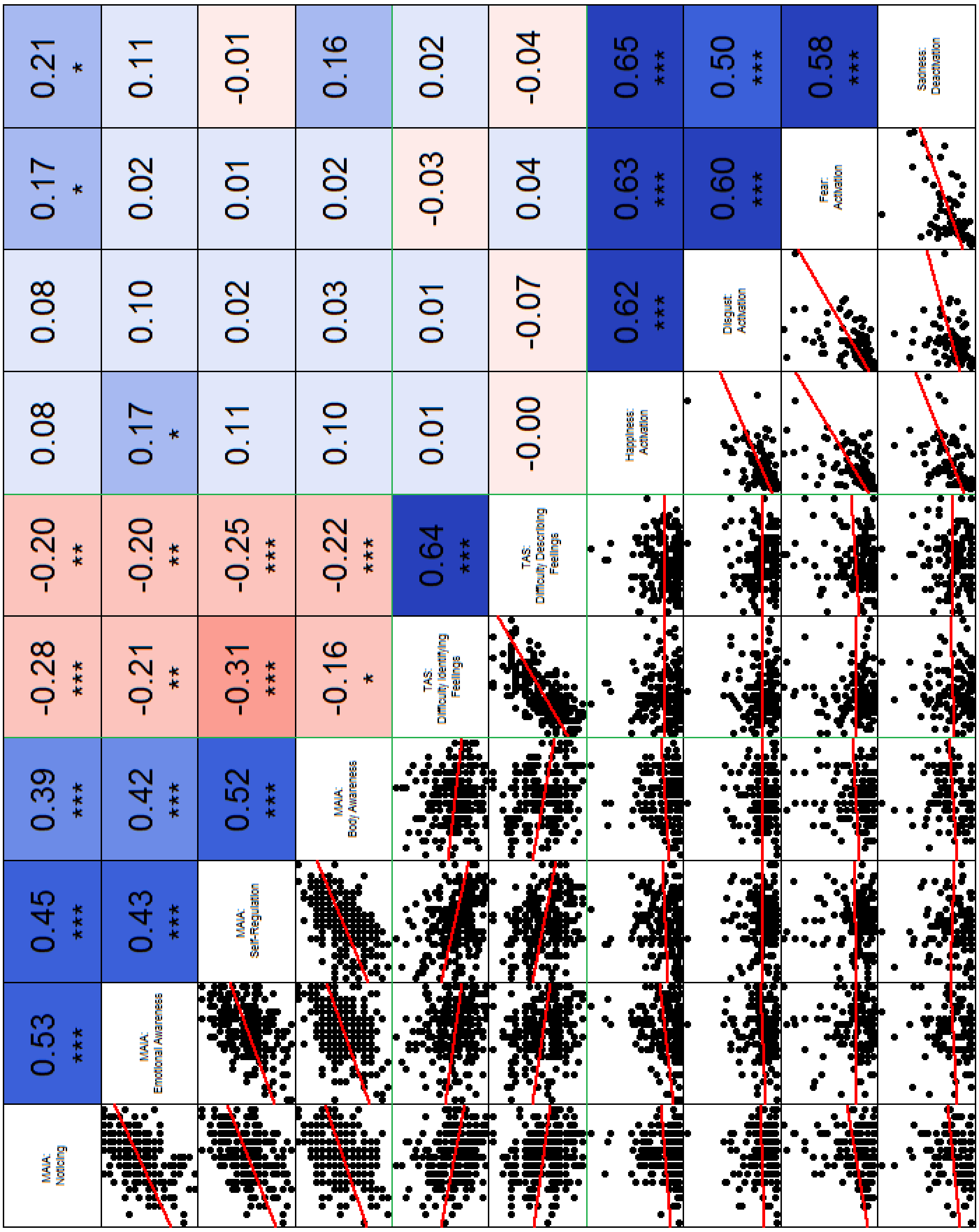


Figure A5: Correlogram of questionnaire and full-body emBODY measures. Spearman correlation scores with indication of significance in the upper half and scatter plots including least-squares regression line of selected questionnaire subscales and respective ROI activation and deactivation in the lower half. *p < .05; **p < .01; ***p < .001

B Questionnaires

Multidimensional Assessment of Interoceptive Awareness (MAIA)

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GERMAN TRANSLATION: Boris Bornemann (Leipzig) and Wolf Mehling (Dec. 2012)

Benutzerrecht und Copyright

Der MAIA ist urheberrechtlich geschützt. Gleichwohl ist seine Benutzung gebührenfrei und bedarf keiner ausdrücklichen schriftlichen Genehmigung. Mit seiner Anwendung erkennt man die folgenden Regeln an:

- Bei Bezugnahme auf den Fragebogen bitten wir den vollen Namen zu nennen: Multidimensional Assessment of Interoceptive Awareness.
- Modifikationen sind ohne unser schriftliches Einverständnis erlaubt. Allerdings bitten wir darum, dass jegliche Veränderung in den entsprechenden Publikationen klargestellt und uns mitgeteilt wird.
- Falls Sie Teile des MAIA benutzen wollen, empfehlen wir nicht Einzelfragen sondern komplette Subskalen zu verwenden, damit die psychometrischen Eigenschaften erhalten bleiben.
- Bitte benutzen Sie die engliche Originalversion and senden Sie uns eine Kopie, falls Sie eine Übersetzung in eine Fremdsprache vornehmen.
- Falls sich andere Kollegen für den MAIA interessieren, verweisen Sie bitte auf die Originalpublikation (Mehling WE et al. (2012) PLoS ONE 7(11): e48230. doi:10.1371/journal.pone.0048230) und dieWebsite www.osher.ucsf.edu/maia/, damit sie die jüngste Version und Scoring-Anleitung erhalten.

Scoring-Anleitung

Kalkulieren Sie den Mittelwert (mean) sämtlicher Antwort-Werte separat für jede Subskala.

Bitte beachten Sie: Die Werte für die Fragen 5, 6 und 7 für Nicht-Ablenken, und die Fragen 8 und 9 für Sich-Keine-Sorgen-Machen werden umgekehrt.

1. Bemerken: Gewahrsein von unangenehmen, angenehmen und neutralen Körperempfindungen.

   F1___ +F2___ +F3___ +F4___/4 = _____

2. Nicht-Ablenken: Die Tendenz, unbequeme Empfindungen nicht zu ignorieren oder sich nicht abzulenken

   (5 - F5)___ + (5 - F6) ___ + (5 - F7)___ /3 = _____

3. Sich-Keine-Sorgen-Machen: Die Tendenz, sich bei Schmerz oder unbequemen Empfindungen keine Sorgen zu machen und nicht in emotionalen Stress zu geraten

   (5 - F8)___ + (5 - F9)___ +F10 /3 = _____

4. Aufmerksamkeits-Regulation: Die Fähigkeit, Aufmerksamkeit auf Körperempfindungen zu richten und aufrechtzuerhalten.

   F11___ + F12___ + F13___+ F14___ + F15___ + F16___ + F17___ /7 = _____

5. Emotionales Gewahrsein: Das Gewahrsein eines Zusammenhanges von Körperempfindungen mit Emotionen

   F18___ + F19___ + F20___ + F21___ + F22___ /5 = _____

6. Selbst-Regulation: Die Fähigkeit, Ungemach zu regulieren, indem die Aufmerksamkeit Körperempfindungen zugewendet wird

   F23___ + F24___ + F25___ + F26___ /4 = _____

7. Auf-den-Leib-Hören: Das aktive Auf-den-eigenen-Leib-Hören um von ihm zu lernen

   F27___ + F28___ + F29___ /3 = _____

8. Vertrauen: Den eigenen Leib als sicher und vertrauenserweckend erfahren

   F30__ + F31___ + F32___ /3 = _____

Unten finden Sie eine Liste von Aussagen. Geben Sie bitte für jede der folgenden Aussagen an, wie oft sie generell im täglichen Leben auf Sie zutrifft.

.	**Kreisen Sie in jeder Reihe eine Zahl ein**					
	Nie					**Immer**
1. Wenn ich angespannt bin, merke ich wo in meinem Körper die Anspannung auftritt.	0	1	2	3	4	5
2. Ich merke es, wenn ich mich in meinem Körper nicht wohlfühle.	0	1	2	3	4	5
3. Ich merke, wo in meinem Körper ich mich wohlfühle.	0	1	2	3	4	5
4. Ich bemerke Veränderungen in meiner Atmung, zum Beispiel ob ich langsamer oder schneller atme.	0	1	2	3	4	5
5. Ich ignoriere körperliche Anspannung oder Unwohlsein bis diese stärker werden.	0	1	2	3	4	5
6. Ich lenke mich von unangenehmen Empfindungen ab.	0	1	2	3	4	5
7. Wenn ich Schmerz oder Unbehagen empfinde, versuche ich mich durchzubeißen.	0	1	2	3	4	5
8. Wenn ich körperliche Schmerzen habe, ärgere ich mich.	0	1	2	3	4	5
9. Wenn ich mich unwohl fühle, fange ich an mir Sorgen zu machen, dass irgendetwas nicht stimmt.	0	1	2	3	4	5
10. Ich kann unangenehme Körperempfindungen spüren, ohne dass sie mich beunruhigen.	0	1	2	3	4	5
11. Ich kann auf meine Atmung achten ohne von dem, was um mich herum geschieht, abgelenkt zu werden.	0	1	2	3	4	5
12. Ich kann meiner inneren Körperempfindungen gewahr bleiben, auch wenn um mich herum eine Menge los ist.	0	1	2	3	4	5
13. Ich kann auf meine Körperhaltung achten, während ich mich mit jemandem unterhalte.	0	1	2	3	4	5
14. Wenn ich abgelenkt bin, kann ich mit meiner Aufmerksamkeit zu meinem Körper zurückkehren.	0	1	2	3	4	5
15. Ich kann meine Aufmerksamkeit vom Denken auf das Spüren meines Körpers zurücklenken.	0	1	2	3	4	5
16. Ich kann den gesamten Körper auch dann weiter bewusst wahrnehmen, wenn ich in einem Teil Schmerz oder Unbehagen empfinde.	0	1	2	3	4	5

Geben Sie bitte für jede der folgen Aussagen an, wie oft sie generell im täglichen Leben auf Sie zutrifft.

	Kreisen Sie in jeder Reihe eine Zahl ein					
	Nie					**Immer**
17. Ich kann meine Aufmerksamkeit bewusst auf meinen Körper als Ganzes richten.	0	1	2	3	4	5
18. Ich bemerke, wie mein Körper sich verändert, wenn ich wütend bin.	0	1	2	3	4	5
19. Wenn etwas in meinem Leben nicht stimmt, kann ich das in meinem Körper spüren.	0	1	2	3	4	5
20. Ich merke, dass mein Körper sich anders anfühlt, wenn ich etwas friedliches und entspannendes erlebe	0	1	2	3	4	5
21. Ich merke, dass meine Atmung freier und leichter wird, wenn ich mich wohlfühle.	0	1	2	3	4	5
22. Ich merke, wie mein Körper sich verändert, wenn ich glücklich oder fröhlich bin.	0	1	2	3	4	5
23. Wenn mir alles zu viel wird, kann ich einen Ort der Ruhe in mir finden.	0	1	2	3	4	5
24. Wenn ich meine Aufmerksamkeit auf meinen Körper richte, empfinde ich ein Gefühl innerer Ruhe.	0	1	2	3	4	5
25. Ich kann meinen Atem dazu benutzen, innere Spannungen abzubauen	0	1	2	3	4	5
26. Wenn ich in meine Gedanken verstrickt bin, kann ich meinen Geist beruhigen, indem ich auf Körper und Atem achte.	0	1	2	3	4	5
27. Ich höre auf meinen Körper, was er über meine emotionale Verfassung sagt.	0	1	2	3	4	5
28. Wenn ich aufgebracht bin, nehme ich mir Zeit herauszufinden, wie mein Körper sich anfühlt.	0	1	2	3	4	5
29. Ich höre auf meinen Körper um zu erkennen was zu tun ist.	0	1	2	3	4	5
30. Ich bin in meinem Körper zu Hause.	0	1	2	3	4	5
31. Ich empfinde meinen Körper als einen sicheren Ort.	0	1	2	3	4	5
32. Ich vertraue meinen Körperempfindungen.	0	1	2	3	4	5

Fragebogen
Toronto-Alexithymie-Skala - 26 TAS-26

Im Folgenden geht es um den Umgang mit Gefühlen. Bitte geben Sie an, wie sehr die folgenden Aussagen auf Sie zutreffen oder nicht zutreffen. Kreuzen Sie bitte *diejenige Antwort* an, die am besten auf Sie persönlich zutrifft (1 = trifft gar nicht zu, 2 = trifft eher nicht zu, 3 = trifft teilweise zu/teilweise nicht zu, 4 = trifft eher zu, 5 = trifft völlig zu).

	trifft gar nicht zu	**trifft eher nicht zu**	**teils/ teils**	**trifft eher zu**	**trifft völlig zu**
1 Wenn ich weine, weiß ich immer warum.	1	2	3	4	5
2 Tagträumen ist Zeitverschwendung.	1	2	3	4	5
3 Ich wünschte, ich wäre nicht so schüchtern.	1	2	3	4	5
4 Mir ist oft unklar, was ich gerade fühle.	1	2	3	4	5
5 Ich habe oft Tagträume über die Zukunft.	1	2	3	4	5
6 Ich glaube, ich kann genauso leicht wie andere Freundschaften schließen.	1	2	3	4	5
7 Es ist wichtiger, Lösungen für Probleme zu kennen, als zu wissen, wie die Lösungen entstanden sind.	1	2	3	4	5
8 Es ist schwierig für mich, die richtigen Worte für meine Gefühle zu finden.	1	2	3	4	5
9 Ich teile anderen Menschen gerne meinen Standpunkt zu Dingen mit.	1	2	3	4	5
10 Ich habe körperliche Empfindungen, die selbst Ärzte nicht verstehen.	1	2	3	4	5
11 Es reicht mir nicht, daß etwas funktioniert, ohne zu wissen, warum und wie es funktioniert.	1	2	3	4	5
12 Es fällt mir leicht, meine Gefühle zu beschreiben.	1	2	3	4	5
13 Ich analysiere Probleme lieber, als sie nur zu schildern.	1	2	3	4	5
14 Wenn ich aufgeregt bin, weiß ich nicht, ob ich traurig, ängstlich oder wütend bin.	1	2	3	4	5

	trifft gar nicht zu	trifft eher nicht zu	teils/ teils	trifft eher zu	trifft völlig zu
15 Ich nutze sehr viel meine Vorstellungskraft.	1	2	3	4	5
16 Ich verbringe viel Zeit mit Tagträumen, wenn ich nichts zu tun habe.	1	2	3	4	5
17 Ich bin oft verwirrt über meine körperlichen Empfindungen.	1	2	3	4	5
18 Ich habe selten Tagträume.	1	2	3	4	5
19 Ich ziehe es vor, Dinge geschehen zu lassen, als verstehen zu wollen, warum sie gerade passieren.	1	2	3	4	5
20 Ich habe Gefühle, die ich nicht richtig verstehen kann.	1	2	3	4	5
21 Gefühle verstehen zu können ist wesentlich.	1	2	3	4	5
22 Ich finde es schwierig zu beschreiben, wie ich anderen gegenüber fühle.	1	2	3	4	5
23 Andere sagen, ich soll meine Gefühle mehr zeigen.	1	2	3	4	5
24 Man sollte nach den genaueren Erklärungen suchen.	1	2	3	4	5
25 Ich weiß nicht, was in mir vorgeht.	1	2	3	4	5
26 Ich erkenne oft nicht, wann ich wütend bin.	1	2	3	4	5

Wir benötigen von Ihnen noch folgende Angaben:

Name / Code-Nr.: ....

Welchen Schulabschluß haben Sie?
( ) keinen
( ) Hauptschule
( ) Mittlere Reife / POS
( ) Abitur

Geschlecht ( ) männlich ( ) weiblich

Wie alt sind Sie? .... Jahre

Auswertungsbogen TAS-26

Name/Kenn-Nr.: .... Geschlecht: ☐ männlich ☐ weiblich Alter: ....Jahre

Schulabschluß: ....

Testleiter/Auswerter: ....

Datum: ....

	RW	T/PR
Skala 1:		
Skala 2:		
Skala 3:		
Gesamtwert:		

Prozentrang 0,1 0,6 2,3 6,7 15,9 30,9 50 69,1 84,1 93,3 97,7 99,4 99,9

T 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80

Skala 1: Schwierigkeiten bei der Identifikation von Gefühlen	wenig ausgeprägt		stark ausgeprägt
Skala 2: Schwierigkeiten bei der Beschreibung von Gefühlen	wenig ausgeprägt		stark ausgeprägt
Skala 3: Extern orientierter Denkstil	wenig ausgeprägt		stark ausgeprägt
Alexithymie-Gesamtwert	wenig ausgeprägt		stark ausgeprägt

C Eidesstattliche Erklärung

Hiermit bestätige ich, dass die vorliegende Arbeit von mir selbständig verfasst wurde und ich keine anderen als die angegebenen Hilfsmittel – insbesondere keine im Quellenverzeichnis nicht benannten Internet-Quellen – benutzt habe und die Arbeit von mir vorher nicht in einem anderen Prüfungsverfahren eingereicht wurde. Die eingereichte schriftliche Fassung entspricht der auf dem elektronischen Speichermedium (CD-ROM).

Landau, den 13.04.2017

References

Aust, S., Härtwig, E. A., Heuser, I., & Bajbouj, M. (2013). The role of early emotional neglect in alexithymia. *Psychological Trauma: Theory, Research, Practice, and Policy*, *5*(3), 225-232. doi: 10.1037/a0027314

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment*, *13*(1), 27-45. Retrieved from http://journals.sagepub.com/doi/abs/10.1177/1073191105283504 doi: 10.1177/1073191105283504

Bagby, R. M., Parker, J. D. A., & Taylor, G. J. (1994). The twenty-item toronto alexithymia scale-i. item selection and cross-validation of the factor structure. *Journal of Psychosomatic Research*, *38*(1), 23-32. Retrieved from http://www.sciencedirect.com/science/article/pii/0022399994900051 doi: 10.1016/0022-3999(94)90005-1

Bechara, A. (2003). Risky business: Emotion, decision-making, and addiction. *Journal of Gambling Studies*, *19*(1), 23-51. Retrieved from https://link.springer.com/article/10.1023/A:1021223113233 doi: 10.1023/A:1021223113233

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, *50*(1-3), 7-15. Retrieved from http://www.sciencedirect.com/science/article/pii/0010027794900183 doi: 10.1016/0010-0277(94)90018-3

Beddoe, A. E., Paul Yang, C.-P., Kennedy, H. P., Weiss, S. J., & Lee, K. A. (2009). The effects of mindfulness-based yoga during pregnancy on maternal psychological and physical distress. *Journal of Obstetric, Gynecologic, & Neonatal Nursing*, *38*(3), 310-319. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1552-6909.2009.01023.x/abstract doi: 10.1111/j.1552-6909.2009.01023.x

Berenbaum, H. (1996). Childhood abuse, alexithymia and personality disorder. *Journal of Psychosomatic Research*, *41*(6), 585-595.

Bird, G., Silani, G., Brindley, R., White, S., Frith, U., & Singer, T. (2010). Empathic brain responses in insula are modulated by levels of alexithymia but not autism. *Brain: A Journal of Neurology*, *133*(Pt 5), 1515-1525. doi: 10.1093/brain/awq060

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., ... Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice*, *11*(3), 230-241. Retrieved from `http://onlinelibrary.wiley.com/doi/10.1093/clipsy.bph077/abstract` doi: 10.1093/clipsy.bph077

Bornemann, B., Herbert, B. M., Mehling, W. E., & Singer, T. (2015). Differential changes in self-reported aspects of interoceptive awareness through 3 months of contemplative training. *Frontiers in Psychology*, *5*. Retrieved from `http://journal.frontiersin.org/article/10.3389/fpsyg.2014.01504/full` doi: 10.3389/fpsyg.2014.01504

Brinkmann, R. (1999). *The art and science of digital compositing*. Morgan Kaufmann.

Cioffi, D. (1991). Beyond attentional strategies: A cognitive-perceptual model of somatic interpretation. *Psychological Bulletin*, *109*(1), 25-41. doi: 10.1037/0033-2909.109.1.25

Craig, A. D. (2002). How do you feel? interoception: the sense of the physiological condition of the body. *Nature Reviews Neuroscience*, *3*(8), 655-666. Retrieved from `http://www.nature.com.ubproxy.ub.uni-heidelberg.de/nrn/journal/v3/n8/full/nrn894.html` doi: 10.1038/nrn894

Critchley, H. D., Wiens, S., Rotshtein, P., Öhman, A., & Dolan, R. J. (2004). Neural systems supporting interoceptive awareness. *Nature Neuroscience*, *7*(2), 189-195. Retrieved from `http://www.nature.com/neuro/journal/v7/n2/abs/nn1176.html` doi: 10.1038/nn1176

Daly, L. A., Haden, S. C., Hagins, M., Papouchis, N., & Ramirez, P. M. (2015). Yoga and emotion regulation in high school students: A randomized controlled trial. *Evidence-Based Complementary and Alternative Medicine*, *2015*, e794928. Retrieved from `https://www.hindawi.com/journals/ecam/2015/794928/abs/` doi: 10.1155/2015/794928

Damasio, A. R. (2005). *Descartes' error: Emotion, reason, and the human brain* (Reprint ed.). London: Penguin Books.

Damasio, A. R., & Carvalho, G. B. (2013). The nature of feelings: evolutionary and neurobiological origins. *Nature Reviews Neuroscience*, *14*(2), 143-152. Retrieved from `http://www.nature.com.ubproxy.ub.uni-heidelberg.de/nrn/journal/v14/n2/full/nrn3403.html` doi: 10.1038/nrn3403

Damasio, A. R., Everitt, B. J., & Bishop, D. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex [and discussion]. *Philosophical Transactions: Biological Sciences*, *351*(1346), 1413-1420. Retrieved from `http://www.jstor.org/stable/3069187`

De M'Uzan, M., & Marty, P. (1963). La pensée opératoire. *Rev Fr Psychol*, *27*, 345-355.

Dowle, M., & Srinivasan, A. (2016). *data.table: Extension of 'data.frame'*. Retrieved from `https://CRAN.R-project.org/package=data.table`

Dunn, B. D., Dalgleish, T., & Lawrence, A. D. (2006). The somatic marker hypothesis: A critical evaluation. *Neuroscience & Biobehavioral Reviews*, *30*(2), 239-271. Retrieved from `http://www.sciencedirect.com/science/article/pii/S0149763405001053` doi: 10.1016/j.neubiorev.2005.07.001

Forrest, L. N., Smith, A. R., White, R. D., & Joiner, T. E. (2015). (dis)connected: An examination of interoception in individuals with suicidality. *Journal of Abnormal Psychology*, *124*(3), 754-763. doi: 10.1037/abn0000074

Fox, J., & Weisberg, S. (2011). *An r companion to applied regression* (Second ed.). Thousand Oaks CA: Sage. Retrieved from `http://socserv.socsci.mcmaster.ca/jfox/Books/Companion`

Gerrards-Hesse, A., Spies, K., & Hesse, F. W. (1994). Experimental inductions of emotional states and their effectiveness: A review. *British Journal of Psychology*, *85*(1), 55-78. Retrieved from `http://onlinelibrary.wiley.com/doi/10.1111/j.2044-8295.1994.tb02508.x/abstract` doi: 10.1111/j.2044-8295.1994.tb02508.x

Hayes, S. C., Luoma, J. B., Bond, F. W., Masuda, A., & Lillis, J. (2006). Acceptance and commitment therapy: Model, processes and outcomes. *Behaviour Research and Therapy*, *44*(1), 1-25. Retrieved from http://www.sciencedirect.com/science/article/pii/S0005796705002147 doi: 10.1016/j.brat.2005.06.006

Herbert, B. M., Herbert, C., & Pollatos, O. (2011). On the relationship between interoceptive awareness and alexithymia: Is interoceptive awareness related to emotional awareness? *Journal of Personality*, *79*(5), 1149-1175. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1467-6494.2011.00717.x/abstract doi: 10.1111/j.1467-6494.2011.00717.x

Herbert, B. M., Muth, E. R., Pollatos, O., & Herbert, C. (2012). Interoception across modalities: On the relationship between cardiac awareness and the sensitivity for gastric functions. *PLOS ONE*, *7*(5), e36646. Retrieved from http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0036646 doi: 10.1371/journal.pone.0036646

Herbert, B. M., Pollatos, O., & Schandry, R. (2007). Interoceptive sensitivity and emotion processing: An eeg study. *International Journal of Psychophysiology*, *65*(3), 214-227. Retrieved from https://www.sciencedirect.com/science/article/pii/S016787600700089X doi: 10.1016/j.ijpsycho.2007.04.007

Hietanen, J. K., Glerean, E., Hari, R., & Nummenmaa, L. (2016). Bodily maps of emotions across child development. *Developmental Science*, *19*(6), 1111-1118. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/desc.12389/abstract doi: 10.1111/desc.12389

Honkalampi, K., Hintikka, J., Tanskanen, A., Lehtonen, J., & Viinamäki, H. (2000). Depression is strongly associated with alexithymia in the general population. *Journal of Psychosomatic Research*, *48*(1), 99-104. Retrieved from http://www.sciencedirect.com/science/article/pii/S0022399999000835 doi: 10.1016/S0022-3999(99)00083-5

James, W. (1884). What is an emotion? *Mind*, *9*(34), 188-205.

Kabat-Zinn, J., & Hanh, T. N. (2013). *Full catastrophe living (revised edition): Using the* *wisdom of your body and mind to face stress, pain, and illness* (Rev Upd edition ed.). New York: Bantam.

Kano, M., Mizuno, T., Kawano, Y., Aoki, M., Kanazawa, M., & Fukudo, S. (2012). Serotonin transporter gene promoter polymorphism and alexithymia. *Neuropsychobiology*, *65*(2), 76-82. Retrieved from http://www.karger.com/Article/Abstract/329554 doi: 10.1159/000329554

Kupfer, J., Brosig, B., & Brähler, E. (2001). *Toronto-alexithymie-skala-26 (tas-26).* Hogrefe. Retrieved from https://www.testzentrale.de/shop/toronto-alexithymie-skala-26.html

Lange, C. (1887). Über gemütsbewegungen. *Leipzig, Germany: Thomas Theodor*.

Lazarus, R. S. (1991a). *Emotion and adaptation.* New York [u.a.]: Oxford Univ. Pr.

Lazarus, R. S. (1991b). Progress on a cognitive-motivational-relational theory of emotion. *The American Psychologist*, *46*(8), 819-834.

Leising, D., Grande, T., & Faber, R. (2009). The toronto alexithymia scale (tas-20): A measure of general psychological distress. *Journal of Research in Personality*, *43*(4), 707-710. Retrieved from http://www.sciencedirect.com/science/article/pii/S0092656609000828 doi: 10.1016/j.jrp.2009.03.009

Levenson, R. W. (2003). Blood, sweat, and fears. *Annals of the New York Academy of Sciences*, *1000*(1), 348-366. Retrieved from http://onlinelibrary.wiley.com/doi/10.1196/annals.1280.016/abstract doi: 10.1196/annals.1280.016

Maia, T. V., & McClelland, J. L. (2004). A reexamination of the evidence for the somatic marker hypothesis: What participants really know in the iowa gambling task. *Proceedings of the National Academy of Sciences of the United States of America*, *101*(45), 16075-16080. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC528759/ doi: 10.1073/pnas.0406666101

Mallorquí-Bagué, N., Garfinkel, S. N., Engels, M., Eccles, J. A., Pailhez, G., Bulbena, A., & Critchley, H. D. (2014). Neuroimaging and psychophysiological investigation of the link between anxiety, enhanced affective reactivity and interoception in people with joint hypermobility. *Frontiers in Psychology*, *5*. Retrieved from http://journal.frontiersin.org/article/10.3389/fpsyg.2014.01162/abstract doi: 10.3389/fpsyg.2014.01162

Mehling, W. E., Daubenmier, J., Price, C. J., Acree, M., Bartmess, E., & Stewart, A. L. (2013). Self-reported interoceptive awareness in primary care patients with past or current low back pain. *Journal of Pain Research*, *6*. Retrieved from http://escholarship.org/uc/item/2982j6pg doi: 10.2147/JPR.S42418

Mehling, W. E., Gopisetty, V., Daubenmier, J., Price, C. J., Hecht, F. M., & Stewart, A. (2009). Body awareness: Construct and self-report measures. *PLOS ONE*, *4*(5), e5614. Retrieved from http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0005614 doi: 10.1371/journal.pone.0005614

Mehling, W. E., Price, C., Daubenmier, J. J., Acree, M., Bartmess, E., & Stewart, A. (2012). The multidimensional assessment of interoceptive awareness (maia). *PLOS ONE*, *7*(11), e48230. Retrieved from http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0048230 doi: 10.1371/journal.pone.0048230

Mortel, V. D., & F, T. (2008). Faking it: Social desirability response bias in self-report research. *Australian Journal of Advanced Nursing, The*, *25*(4), 40. Retrieved from http://search.informit.com.au/documentSummary;dn=210155003844269;res=IELHEA

Nederhof, A. J. (1985). Methods of coping with social desirability bias: A review. *European Journal of Social Psychology*, *15*(3), 263-280. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/ejsp.2420150303/abstract doi: 10.1002/ejsp.2420150303

Nummenmaa, L., Glerean, E., Hari, R., & Hietanen, J. K. (2014). Bodily maps of emotions. *Proceedings of the National Academy of Sciences*, *111*(2), 646-651. Retrieved from http://www.pnas.org/content/111/2/646 doi: 10.1073/pnas.1321664111

Philippot, P. (1993). Inducing and assessing differentiated emotion-feeling states in the laboratory. *Cognition and Emotion*, *7*(2), 171-193. Retrieved from http://

dx.doi.org/10.1080/02699939308409183 doi: 10.1080/02699939308409183

R Core Team. (2016). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Revelle, W. (2016). *psych: Procedures for psychological, psychometric, and personality research*. Evanston, Illinois: Northwestern University. Retrieved from https://CRAN.R-project.org/package=psych

RStudio Team. (2015). *Rstudio: Integrated development environment for r*. Boston, MA: RStudio, Inc. Retrieved from http://www.rstudio.com/

Saarimäki, H., Gotsopoulos, A., Jääskeläinen, I. P., Lampinen, J., Vuilleumier, P., Hari, R., ... Nummenmaa, L. (2016). Discrete neural signatures of basic emotions. *Cerebral Cortex*, *26*(6), 2563-2573. Retrieved from https://academic.oup.com/cercor/article/26/6/2563/1754140/Discrete-Neural-Signatures-of-Basic-Emotions doi: 10.1093/cercor/bhv086

Samur, D., Tops, M., Schlinkert, C., Quirin, M., Cuijpers, P., & Koole, S. L. (2013). Four decades of research on alexithymia: moving toward clinical applications. *Frontiers in Psychology*, *4*. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3832802/ doi: 10.3389/fpsyg.2013.00861

Schandry, R. (1981). Heart beat perception and emotional experience. *Psychophysiology*, *18*(4), 483-488. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8986.1981.tb02486.x/abstract doi: 10.1111/j.1469-8986.1981.tb02486.x

Schmidt, U., Jiwany, A., & Treasure, J. (1993). A controlled study of alexithymia in eating disorders. *Comprehensive Psychiatry*, *34*(1), 54-58. Retrieved from http://www.sciencedirect.com/science/article/pii/0010440X93900364 doi: 10.1016/0010-440X(93)90036-4

Sherrington, C. S. (1920). *The integrative action of the nervous system*. New Haven Yale University Press. Retrieved from http://archive.org/details/

integrativeactio00sheruoft

Sifneos, P. E. (1973). The prevalence of 'alexithymic' characteristics in psychosomatic patients. *Psychotherapy and Psychosomatics*, *22*(2-6), 255-262. Retrieved from http://www.karger.com/Article/Abstract/286529 doi: 10.1159/000286529

Spearman, C. (1904). The proof and measurement of association between two things. *The American journal of psychology*, *15*(1), 72-101.

Suvilehto, J. T., Glerean, E., Dunbar, R. I. M., Hari, R., & Nummenmaa, L. (2015). Topography of social touching depends on emotional bonds between humans. *Proceedings of the National Academy of Sciences*, *112*(45), 13811-13816. Retrieved from http://www.pnas.org/content/112/45/13811 doi: 10.1073/pnas.1519231112

Tabibnia, G., & Zaidel, E. (2005). Alexithymia, interhemispheric transfer, and right hemispheric specialization: A critical review. *Psychotherapy and Psychosomatics*, *74*(2), 81-92. Retrieved from http://www.karger.com/Article/Abstract/83166 doi: 10.1159/000083166

Taylor, G. J., & Bagby, R. M. (2012). The alexithymia personality dimension. Retrieved from http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780199735013.001.0001/oxfordhb-9780199735013-e-30

Taylor, G. J., Ryan, D., & Bagby, R. M. (1985). Toward the development of a new self-report alexithymia scale. *Psychotherapy and Psychosomatics*, *44*(4), 191-199.

Tettamanti, M., Rognoni, E., Cafiero, R., Costa, T., Galati, D., & Perani, D. (2012). Distinct pathways of neural coupling for different basic emotions. *NeuroImage*, *59*(2), 1804-1817. Retrieved from http://www.sciencedirect.com/science/article/pii/S1053811911009050 doi: 10.1016/j.neuroimage.2011.08.018

Urbanek, S. (2013). *png: Read and write png images*. Retrieved from https://CRAN.R-project.org/package=png

van 't Wout, M., Aleman, A., Bermond, B., & Kahn, R. S. (2007). No words for feelings: alexithymia in schizophrenia patients and first-degree relatives. *Comprehensive Psychiatry*, *48*(1), 27-33. doi: 10.1016/j.comppsych.2006.07.003

Verdejo-García, A., Bechara, A., Recknor, E. C., & Pérez-García, M. (2006). Executive dysfunction in substance dependent individuals during drug use and abstinence: An examination of the behavioral, cognitive and emotional correlates of addiction. *Journal of the International Neuropsychological Society*, *12*(3), 405-415. Retrieved from https://www.cambridge.org/core/journals/journal-of-the-international-neuropsychological-society/article/div-classtitleexecutive-dysfunction-in-substance-dependent-individuals-during-drug-use-and-abstinence-an-examination-of-the-behavioral-cognitive-and-emotional-correlates-of-addictiondiv/194D799FABBFC9624FE2BE91FEEA9865 doi: 10.1017/S1355617706060486

Vreeze, J. d. (2016). *apastyle: Generate apa tables for ms word*. Retrieved from https://CRAN.R-project.org/package=apaStyle

Wall, R. B. (2005). Tai chi and mindfulness-based stress reduction in a boston public middle school. *Journal of Pediatric Health Care*, *19*(4), 230-237. Retrieved from http://www.sciencedirect.com/science/article/pii/S0891524505001094 doi: 10.1016/j.pedhc.2005.02.006

Wardle, M. C., Gonzalez, R., Bechara, A., & Martin-Thormeyer, E. M. (2010). Iowa gambling task performance and emotional distress interact to predict risky sexual behavior in individuals with dual substance and hiv diagnoses. *Journal of Clinical and Experimental Neuropsychology*, *32*(10), 1110-1121. Retrieved from http://dx.doi.org/10.1080/13803391003757833 doi: 10.1080/13803391003757833

Watkins, E., & Teasdale, J. D. (2004). Adaptive and maladaptive self-focus in depression. *Journal of Affective Disorders*, *82*(1), 1-8. doi: 10.1016/j.jad.2003.10.006

Whitehead, W. E., & Drescher, V. M. (1980). Perception of gastric contractions and self-control of gastric motility. *Psychophysiology*, *17*(6), 552-558. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8986.1980.tb02296.x/abstract doi: 10.1111/j.1469-8986.1980.tb02296.x

Wickham, H. (2007). Reshaping data with the reshape package. *Journal of Statistical Software*, *21*(12), 1-20. Retrieved from http://www.jstatsoft.org/v21/i12/

Wickham, H. (2009). *ggplot2: Elegant graphics for data analysis*. Springer-Verlag New York. Retrieved from http://ggplot2.org

Wickham, H. (2011). The split-apply-combine strategy for data analysis. *Journal of Statistical Software*, *40*(1), 1-29. Retrieved from http://www.jstatsoft.org/v40/i01/

Wickham, H. (2016). *stringr: Simple, consistent wrappers for common string operations*. Retrieved from https://CRAN.R-project.org/package=stringr

Wickham, H., & Francois, R. (2016). *dplyr: A grammar of data manipulation*. Retrieved from https://CRAN.R-project.org/package=dplyr

Wickham, H., Hester, J., & Ooms, J. (2017). *xml2: Parse xml*. Retrieved from https://CRAN.R-project.org/package=xml2

Wilcoxon, F. (1945). Individual comparisons by ranking methods. *Biometrics Bulletin*, *1*(6), 80-83. Retrieved from http://www.jstor.org/stable/3001968 doi: 10.2307/3001968

Williams, C., & Wood, R. L. (2010). Alexithymia and emotional empathy following traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology*, *32*(3), 259-267. Retrieved from http://dx.doi.org/10.1080/13803390902976940 doi: 10.1080/13803390902976940

Wright, K. (2016). *corrgram: Plot a correlogram*. Retrieved from https://CRAN.R-project.org/package=corrgram

Zlotnick, C., Shea, M. T., Pearlstein, T., Simpson, E., Costello, E., & Begin, A. (1996). The relationship between dissociative symptoms, alexithymia, impulsivity, sexual abuse, and self-mutilation. *Comprehensive Psychiatry*, *37*(1), 12-16. Retrieved from http://www.sciencedirect.com/science/article/pii/S0010440X96900449 doi: 10.1016/S0010-440X(96)90044-9

Zoellner, L. A., & Craske, M. G. (1999). Interoceptive accuracy and panic. *Behaviour Research and Therapy*, *37*(12), 1141-1158. Retrieved from http://www.sciencedirect.com/science/article/pii/S0005796798002022 doi: 10.1016/S0005-7967(98)00202-2