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Improving Interoception and Subjective Power through the Practice of Power Posing in Individuals with and without Anorexia Nervosa

DISSEPTION

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By adopting a certain physical posture a resonant chord is struck in spirit.

*Bruce Lee*

A good stance and posture reflect a proper state of mind.

*Morihei Ueshiba*

Unless some misfortune has made it impossible, everyone can have good posture.

*Loretta Young*
Publications

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<tr>
<td>ALH</td>
<td>Allocentric Lock Hypothesis</td>
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<td>AN</td>
<td>Anorexia Nervosa</td>
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<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>CBT</td>
<td>Cognitive Behavioural Therapy</td>
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<td>HBTT</td>
<td>Heartbeat Tracking Task</td>
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<tr>
<td>HBDT</td>
<td>Heartbeat Detection Task</td>
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<tr>
<td>IAcc</td>
<td>Interoceptive Accuracy</td>
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<td>IS</td>
<td>Interoceptive Sensibility</td>
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<td>IAw</td>
<td>Interoceptive Awareness</td>
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<td>MMG</td>
<td>Multi-Motive Grid</td>
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<td>SAM</td>
<td>Self-Assessment Manikin</td>
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<td>SOPS</td>
<td>Personal Sense of Power Scale</td>
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Abstract/Summary

Interoception refers to the sensing and the processing of inner bodily signals. A growing body of research has highlighted its crucial role in domains such as emotion regulation and experience, intuitive judgment and decision-making as well as behavioural self-regulation and body image. Also, various psychiatric disorders have been associated with deficits in the different facets of interoception. Therefore, it is important to develop effective interventions that can enhance interoceptive ability. Previous studies have shown that the induction of subjective feelings of power (e.g. through cognitive priming) appears to improve interoception, hypothetically through increases in self-focus. From an evolutionary perspective, powerless individuals are more likely to direct their attention outwards to detect potential threat and get access to resources. They, therefore, have less capacity to direct their attention inwards. On the other hand, powerful individuals are less likely to experience threat and are also less reliant on others for personal resources. They, therefore, have more capacity to direct their attention towards themselves, which might make them more sensitive to bodily information. *Power posing* is an intervention that involves the adoption of an expansive bodily posture and has repeatedly been found to increase subjective feelings of power. Therefore, it is likely that it could have beneficial effects on interoceptive ability as it may promote self-focus, which could make it easier to notice inner bodily signals. **Study I** examined whether a single session- and one week of daily power posing practice could improve interoceptive ability and subjective feelings of power in a non-clinical sample. **Study II** explored whether power posing was superior to neutral posing after a single session and two weeks of training regarding interoception and anxiety (state and trait). **Study III** investigated whether individuals with anorexia nervosa (AN) could benefit from power posing, by testing whether a single session and one week of daily training would improve their interoceptive ability, compared to individuals without AN. The study further focused on affective states, such as self-reported positive affect, arousal and feelings of power. **Study IV** focused on feelings of power in women with and without AN by investigating explicit feelings of power as well as implicit power motives and by examining whether and how the discrepancies between these dimensions relate to anxiety. The central finding of this dissertation was that power
posing appears to increase interoceptive accuracy and subjective feelings of power and reduce state-anxiety as well as self-reported arousal in the short-term. However, it does not seem to be superior to adopting a neutral posture, as effects on interoceptive accuracy and state-anxiety were also observed in individuals that held a neutral pose. Regarding the findings on interoceptive accuracy, one reason therefore could be that both postures require the individual to maintain a mindful body-focus, whilst adopting the poses, which may have promoted self-focus. Also, the neutral postures were neutral in the sense that they lacked the bodily features of power, however, they may have been more open than the postures individuals usually adopt. Furthermore, in studies I-III, power posing has been repeatedly been found to increase subjective feelings of power, which is in keeping with previous research. Regarding AN, in particular, study III highlighted that individuals with AN also appear to benefit from power posing, as there was a significant short-term effect of time and no significant group effect regarding interoceptive accuracy. However, it is noteworthy that they showed significantly lower feelings of interoceptive sensitivity, feelings of dominance and positive affect than individuals without AN. Study IV further revealed that women with AN display significantly lower explicit feelings of power but similar levels of implicit power motives compared to women without AN. The discrepancy between explicit feelings of power and implicit power motives was related to anxiety in women with AN and may represent a potential vulnerability factor to illness maintenance. It was also found that women with AN showed similar levels of fear of losing power and hope for power, whereas, in women without AN, the fear of losing power was significantly lower than the hope for power. The findings of this dissertation are discussed with a focus on their clinical implications.
Zusammenfassung

1. Introduction

In our everyday language, many expressions highlight a close connection between our emotions and the body. For example, more than 2000 body-related idioms can be found in English (Kövecses, 2001), such as "my heart sank", "I felt tong-tied", "I got it off my back", "I got cold feet", "I turned a blind eye", "I had a broken heart" or "a weight lifted off my shoulders". The interplay between the body and affective states has also long been the subject of philosophical debate and scientific research (James, 1894). In this context, a significant number of studies have focused on how our cognitions and emotions influence bodily postures or movements and vice versa (Bargh, Chen, & Burrows, 1996; Michalak et al., 2009; Oosterwijk, Rotteveel, Fischer, & Hess, 2009; Schneider et al., 2013; Veenstra, Schneider, & Koole, 2017).

Regarding research in this domain, a broad distinction has been made between top-down and bottom-up processing (Grabbe & Miller-Karas, 2018; Ochsner et al., 2009; Taylor, Goehler, Galper, Innes, & Bourguignon, 2010). Top-down processing involves the recruitment of higher-order brain regions (e.g. the prefrontal cortex) to modulate responding in emotion-generative brain areas (e.g. the amygdala) (Buhle et al., 2014). Bottom-up processing, on the other hand, refers to the direct reactivity of emotion-generative brain regions without active recruitment of higher-order brain areas (Westbrook et al., 2013). Bottom-up processes can, for example, occur through the stimulation of various sensory receptors (e.g. those responsible for movement or limb position) and influence neural activity via ascending pathways from the periphery to the brainstem and the cerebral cortex (Taylor et al., 2010).

In a therapeutic context, especially in mainstream cognitive behavioural therapy, many interventions rely on the activation of top-down processing. For example, through cognitive restructuring and correcting maladaptive thinking, changes in emotional experiences and individuals' behaviour are anticipated (DeRubeis, Siegle, & Hollon, 2008). Thereby, the therapist and the patient primarily engage through dialogue and reflection, often sitting across from each other. In this constellation, the patients' body often receives only very little attention (Elkjaer, Mikkelsen, Michalak, Mennin, & O'Toole, 2020).
On the one hand, top-down control is highly valuable and can predict positive therapeutic outcomes (Szeszko & Yehuda, 2019). However, recent research has called for a better integration of research findings on the effects of bodily focus, postures and movements (i.e. bottom-up processes) into the therapeutic context (Grabbe & Miller-Karas, 2018; Stinson, 2019).

There are several reasons for this demand. Firstly, evidence emerged which highlighted that the integration of the body could yield better therapeutic outcomes than relying primarily on top-down emotion regulation strategies. For example, Artoni et al. (2020) implemented a body perception training (BPT) that integrated interoceptive-, proprioceptive- (e.g. self-movement and body position in space) and tactile perception into therapy and found that it led to better therapy outcomes (e.g. reduced body image disturbance) than treatment as usual. Also, recent research by Peper et al. (2019) showed that individuals who adopted an upright bodily position, took a breath, and then reframed their negative thoughts were significantly more successful in reducing their anxiety compared to individuals who reframed their negative thoughts without adopting an upright bodily posture.

Furthermore, research has shown, that cognitive-reappraisal (i.e. a form of top-down emotion regulation) may not be effective when a negative emotion has been generated via bottom-up processing (McRae, Misra, Prasad, Pereira, & Gross, 2012; Otto, Misra, Prasad, & McRae, 2014). In this case, a therapeutic strategy that uses mechanisms of bottom-up processing may be more appropriate.

Finally, several studies have shown that there is still a large minority of patients with anxiety and mood disorders who display suboptimal treatment responses to cognitive-behavioural therapy (CBT) (Farabaugh et al., 2012; Hofmann, Asnaani, Vonk, Sawyer, & Fang, 2012; Newman et al., 2011), prompting the need to develop alternative treatment options.

Based on these observations, it is important to design interventions that make use of the body and bottom-up processing to enhance symptom reduction in a clinical context and to offer therapists multiple pathways of enhancing emotion-regulation with their clients (Elkjaer et al., 2020).
One way of integrating the body in a therapeutic context is by manipulating the posture of the body to achieve beneficial affective-states (Niedenthal, 2007). A particular bodily posture that has received increasing interest over the past years is the so-called "power pose" (Carney, Cuddy, & Yap, 2010). It is characterized by bodily features associated with power such as expansive positions of the arms and legs, an upwards-tilted chin and gaze and the adoption of an open bodily position (Carney, Hall, & LeBeau, 2005) (Figure 1 (Weineck et al., 2019)).

**FIGURE 1 | Examples of power poses**

There is now a growing body of research that has highlighted beneficial effects of adopting powerful postures on individuals' subjective feeling of power (Carney, Cuddy, & Yap, 2015; Cesario, Jonas, & Carney, 2017; Cuddy, Schultz, & Fosse, 2018; Elkjaer et al., 2020; Gronau et al., 2017; Jonas et al., 2017). Thus, if individuals adopt a powerful posture, they also tend to feel more powerful. Feeling powerful, in turn, appears to have further positive effects. For example, subjective feelings of power have repeatedly been found to increase interoception (Kunstman et al., 2016; Moeini-Jazani, Knoeferle, de Moliere, Gatti, & Warlop, 2017). Interoception refers to the perception and processing of bodily signals (Craig, 2003) (e.g. the individuals' heartbeat) and has been found to play a crucial role in many areas of mental functioning, including emotion processing and regulation (Füstös, Gramann, Herbert, & Pollatos, 2012; Wiens, Mezzacappa, & Katkin, 2000), intuitive decision-making (Dunn et al., 2010) and coping with stress (Schultchen, Bayer, Kuhnel, Melchers, & Pollatos, 2019a) (also see chapter 1.1-1.3).
One pathway in which the induction of power could influence interoceptive ability is by increasing self-focus (Moeini-Jazani et al., 2017). From an evolutionary perspective, powerless individuals are more likely to direct their attention outwards to get access to resources and to detect potential social threat (Keltner, Gruenfeld, & Anderson, 2003). They, therefore, have less capacity to direct their attention inwards (Fiske & Dépret, 1996). On the other hand, powerful individuals are less likely to experience threat and are also less reliant on others for personal resources (Guinote, 2007). They, therefore, have more capacity to direct their attention inwards, which might make them more sensitive to bodily information (Guinote, 2010).

In this context, it is noteworthy that studies, which have focused on increasing interoceptive ability through the induction of power, have primarily induced power through cognitive priming, for example, by asking individuals to recall a situation where they felt very powerful (Kunstman et al., 2016). To date, no previous study examined whether power posing - i.e. a purely non-verbal intervention - could also increase interoceptive ability. As power posing appears to increase subjective feelings of power and these, in turn, seem to improve interoception - it is likely that power posing could also improve interoceptive ability (Figure 2).

**FIGURE 2** | Possible pathway of how power posing could increase interoception

The central aim of this dissertation was to explore whether power posing could improve different facets of interoception and subjective power. **Study I** explored this topic in regards to healthy individuals and focused on short-term effects, as well as one-week training effects. **Study II** compared power posing to neutral posing in regards to interoception and anxiety. This study is particularly relevant regarding the recent call to conduct more studies that compare powerful and neutral postures (Crede, 2018; Elkjaer et
al., 2020). **Study III** explored whether individuals with AN could also benefit from power posing in regards to improving interoception, feelings of power and positive affect as well as reducing self-reported arousal. This group of patients has been chosen as several previous studies highlighted interoceptive deficits in this disorder (Martin, Dourish, Rotshtein, Spetter, & Higgs, 2019), prompting the need to develop efficient interventions that can address this concern. Also, individuals with AN have repeatedly been found to experience powerlessness (Woolrich, Kennedy, & Tasiemski, 2006) and no previous research has investigated whether power posing could be beneficial to improve their subjective feelings of power. As still very little is known about implicit power motives in AN, **study IV** focused on feelings of power in women with and without AN by investigating explicit feelings of power as well as implicit power motives and examining whether and how discrepancies between these dimensions relate to anxiety.

The following sections will give a more in-depth background and overview of the theoretical models and research findings regarding the chosen outcome variables. Firstly, a definition of interoception will be given (1.1) and the methods of assessing interoception will be outlined (1.2). Then, the role of interoception in emotion processing (1.3) and psychopathology (1.4) will be highlighted, to provide a rationale for improving interoception. Thereafter, previous studies that have attempted to improve interoception, as well as relevant findings that have informed the underlying design of this empirical research will be discussed (1.5). In chapter 1.6, existing research findings regarding the connection between bodily postures, emotion and cognition will be reviewed. In this context, the potential mechanisms of how power posing could influence interceptive ability will be explained (1.6.1). Furthermore, a definition of power will be given and measurements of power will be discussed (1.7) As Anorexia Nervosa was the clinical disorder under investigation in this research, theoretical models and research findings relating to it will be reviewed in chapter 1.8. Thereby, a particular focus is placed on interoceptive ability in AN and possible deficits of interoception in AN will be discussed as a possible risk factor of illness' onset and maintenance (1.8.1). Finally, the need to increase feelings of power in AN will be outlined (1.8.2) together with the importance of designing effective body-focused interventions in the treatment of AN (1.8.3).
1.1 Definition of Interoception

Interoception has been defined as the sensing, processing and representation of signals that concern the internal state of the body (Critchley & Garfinkel, 2017). In the literature, it is currently being debated whether the definition primarily refers to visceroception (i.e. the processing of signals from the inner organs such as the heart, the lungs, the gastrointestinal tract and urogenital system) or also includes proprioception (i.e. the processing of signals from the skin and muscles that relate to movement and the position of the body in space) (Berntson & Khalsa, 2021; Ceunen, Vlaeyen, & Van Diest, 2016; Craig, 2003; Garfinkel, Seth, Barrett, Suzuki, & Critchley, 2015; Ondobaka, Kilner, & Friston, 2017). A significant amount of research has focused on the investigation of visceral signals (particularly the perception of the heartbeat) when investigating interoception (Garfinkel & Critchley, 2013; Murphy, Brewer, Catmur, & Bird, 2017), however, recently, more studies including measures of both, visceroception as well as proprioception, are emerging (Horváth et al., 2020). This dissertation follows the definition of interoception as visceroception with a particular focus on signals originating from the heart.

Previous research on interceptive pathways has established a complex network of afferent signaling processes spanning sensors, pathways, systems, and circuits (Berntson & Khalsa, 2021). Broadly speaking, visceral signals, which originate from the sensory receptors in the body relay through the spinal cord and brainstem before reaching higher-order cortical areas of the cerebral cortex (Khoury, Lutz, & Schuman-Olivier, 2018). Information from interoceptive signals is represented in areas including the parabrachial nucleus, thalamus, hypothalamus, hippocampus, amygdala, insula, primary and secondary somatosensory cortex, anterior cingulate cortex and the orbitofrontal and medial prefrontal cortices (Berntson & Khalsa, 2021). The insular cortex has thereby been identified as the key structure for the monitoring and integrations of multimodal sensory signals and as a crucial area for the maintenance of bodily homeostasis (Craig, 2009; Koeppel, Ruser, Kitzler, Hummel, & Croy, 2020; Menon & Uddin, 2010; Terasawa et al., 2021). However, interoceptive circuits play an important role regarding the self, beyond the homeostatic maintenance of physiological states (Berntson & Khalsa,
The individuals' ability to sense the physiological condition of the body has been identified as essential for many areas of mental functioning, including emotion recognition and regulation (Fürstós et al., 2012; Herbert, Pollatos, & Schandry, 2007; Terasawa et al., 2021) (also see chapter 1.3), emotional intensity (Wiens et al., 2000), judgment and decision making (Dunn et al., 2010; Werner, Jung, Duschek, & Schandry, 2009) and self-awareness (Aspell et al., 2013; Tsakiris, Tajadura-Jiménez, & Costantini, 2011). The underlying idea is that the better individuals are at sensing their bodies, the better they are at responding to relevant signals to maintain a state of physiological and psychological well-being (Craig, 2003; Duquette, 2017).

1.2 Measurement of the Different Dimensions of Interoception

Over the past decades, several different dimensions of interoception have been identified and discussed. In this context, a three-dimensional model has been proposed, which includes interoceptive accuracy (IAcc), interoceptive sensibility (IS) and interoceptive awareness (IAw) (Garfinkel et al., 2015). Interoceptive accuracy refers to the performance on behavioural tests of interoception such as, for example, the heartbeat tracking task (HBTT) (Schandry, 1981) or the heartbeat discrimination task (Whitehead, Drescher, Heiman, & Blackwell, 1977). The HBTT consists of several counting trials (e.g. 25s, 35s, 45s, 60s) that are presented in random order. The participant is asked to silently count the heartbeats and to verbally report the number of counted heartbeats after every counting trial. No prior information regarding the length of the counting phase is given and participants receive no feedback on their performance. Heartbeat signals are simultaneously recorded with, either mobile heart frequency monitors, such as polar watches, or ECG monitoring (Radespiel-Troger, Rauh, Mahlke, Gottschalk, & Muck-Weymann, 2003; Schultchen et al., 2019a). IAcc is then calculated as the mean heartbeat perception score according to the following transformation:

\[
\frac{1}{4} \sum \left(1 - \frac{\text{[recorded heartbeats} - \text{counted heartbeats]}}{\text{recorded heartbeats}}\right)
\]
IAcc scores can range from 0 to 1 and higher scores indicate smaller differences between counted and recorded heartbeats and thus better interoceptive accuracy.

In the heartbeat discrimination task, participants have to determine whether or not an external signal is synchronous or asynchronous with their perceived heartbeat (Katkin, Reed, & Deroo, 1983; Whitehead et al., 1977).

Interoceptive sensibility is defined as an individual’s self-confidence relative to his or her objective performance on the heartbeat tracking task (HBTT) (Garfinkel et al., 2015). One way of assessing it is by asking individuals, after completion of the HBTT, to rate the confidence in their performance on a scale from one to ten. An alternative measure of interoceptive sensibility is a questionnaire that assesses individuals' subjective beliefs about their bodily perception. Questionnaires that are mainly used to investigate IS are the Body Perception Questionnaire (Porges, 1993) or the Multidimensional Assessment of Interoceptive Awareness (MAIA) (Mehling et al., 2012).

Interoceptive awareness refers to the concordance between interoceptive accuracy and interoceptive sensibility and is usually determined by correlational analysis or by applying receiver operating characteristics (ROC) curve analysis (Garfinkel et al., 2015). In addition to the aforementioned interoceptive dimension, a further facet of interoception has been described, namely, interoceptive emotional evaluation (Herbert et al., 2012). It refers to the interpretation of any bodily sensation that occurs or is paid attention to in a certain setting (Pollatos & Herbert, 2018). To assess it, the participants are asked to rate (on a scale from, for example, one to nine) how pleasant, aroused and anxious they felt during the performance on the heartbeat tracking task (Herbert et al., 2012; Pollatos & Herbert, 2018).

1.3 Interoception and Emotion Processing and Regulation

The assumption that interoceptive signaling represents a crucial prerequisite for emotional experience is central to many theories of emotion (Critchley, Wiens, Rotshtein, Ohman, & Dolan, 2004; James, 1884; Lange, 1887; Schachter & Singer, 1962). One of the most influential neurocognitive theories, in this context, is the somatic-marker hypothesis by Damasio (1994). Broadly speaking, it proposes that somatic changes (e.g.,
endocrine releases, changes in heart rate, smooth muscle contraction) occur as a result of so-called ‘primary inducers’ (e.g. internal or external stimuli, decisions or situations that the individual is confronted with) and are relayed to the brain (Bechara & Damasio, 2005). The pattern of the somatosensory change (i.e. an emotion) is then associated with the primary inducer and memorized in terms of a positive or negative affective response (Damasio, 1996). When a secondary inducer (i.e. a stimulus with similar characteristics as the primary inducer) occurs, the somatosensory pattern that described the appropriate emotion, termed a “somatic marker”, is re-activated, leading to a fainter experience of a somatic state belonging to the primary inducer (Bechara & Damasio, 2005). This process is referred to as a “body loop” (i.e. when the body actually changes in response to the activation and the changes are relayed to the somatosensory cortices) or an “as if body loop” (i.e. when the re-activation signals are conveyed to the somatosensory cortices which then adopt the appropriate pattern, thereby bypassing the body) (Damasio, 1996). When the neural representations of somatic patterns reach consciousness, they are experienced as feelings (Damasio, 1996).

Based on the somatic marker hypothesis, individual differences in sensing the physiological condition of their body should determine differences in emotional processing and experiences. In keeping with this assumption, there is now a growing body of experimental- and neuroimaging research highlighting a close positive relationship between interoception and emotional responses (Barrett, Quigley, Bliss-Moreau, & Aronson, 2004; Dunn et al., 2010; MacCormack, Henry, Davis, Oosterwijk, & Lindquist, 2021; Pollatos & Schandry, 2008; Salamone et al., 2021; Terasawa et al., 2021; Wiens, 2005; Wiens et al., 2000; Zaki, Davis, & Ochsner, 2012). For example, Pollatos, Gramann, and Schandry (2007) found that individuals with high interoceptive accuracy reported more intense feelings while viewing pleasant and unpleasant pictures than individuals with low interoceptive accuracy. The authors also applied high-density EEG and showed that those with high interoceptive accuracy also displayed increased activity in brain regions involved in emotional processing (as evidenced by an enhanced P300 amplitude) (Pollatos et al., 2007). Thus, high interoceptive accuracy seems to increase the intensity to which an emotion is experienced. In another study concerning
emotion regulation, Füstöss, Gramann, Herbert, and Pollatos (2012), showed that individuals with high interoceptive accuracy displayed better down-regulation of affect-related arousal than those with low IA, when using reappraisal as an emotion regulation strategy. This finding is in keeping with another study by Pollatos, Matthias and Keller (2015), which showed interoceptive accuracy to positively correlate with higher scores on an emotion regulation questionnaire. Further studies also showed that individuals with high interoceptive accuracy were also better at recalling emotional stimuli (Pollatos & Schandry, 2008) and showed higher sensitivity to the emotions of others (Terasawa, Moriguchi, Tochizawa, & Umeda, 2014). The described studies support the assumption that the awareness of ongoing bodily processes (and subsequent emotions), facilitates the experience and regulation of emotional states.

Another, highly influential theory, that complements and extends the somatic marker hypothesis, is the (interoceptive) predictive coding model (Barrett & Simmons, 2015; Seth & Friston, 2016; Seth, Suzuki, & Critchley, 2012). It assumes that neuronal representations in higher levels of cortical hierarchies generate predictions of representations in lower levels (Friston, Stephan, Montague, & Dolan, 2014). In other words, the brain, as a perceptual system, continuously builds internal models that can predict what should be observed next, if its current perceptual beliefs are correct (Smith, Badcock, & Friston, 2021). The ‘top down’ predictions are compared with incoming sensory signals from the periphery (Owens, Allen, Ondobaka, & Friston, 2018). If discrepancies between predictions and interoceptive signals occur, this produces “prediction errors” (Seth & Friston, 2016). The greater the prediction error, the greater the deviation from homeostasis (Owens et al., 2018). Therefore, the brain attempts to maximise the reliability of its predictions by minimising prediction errors (i.e., free-energy or surprise) (Owens et al., 2018). Minimizing prediction errors can be achieved by either changing the top-down predictions or by altering the sensory signals through action (e.g. autonomic reflexes) to change the sensory evidence for the percept, a process which is called ‘active inference’ (Linson, Clark, Ramamoorthy, & Friston, 2018; Owens et al., 2018). Subjective feeling states (emotional experiences) are thought to arise from active (interoceptive) inference (Seth, 2013). Thus, according to the predictive coding model,
emotional experiences encompass more than the direct representation of peripheral states as they also depend on neurally encoded predictions about bodily states that are informed by interoceptive signals across multiple hierarchical levels (Pace-Schott et al., 2019; Seth & Friston, 2016). Regarding emotional valence, Joffily and Coricelli (2013) argued that the subjective experience of emotion confounds the increasing fulfilment (pleasantness) and violation (unpleasantness) of predictions across different levels of hierarchical processing. Thus, emotional valence could depend on the rate of change of prediction error over time (Joffily & Coricelli, 2013) (e.g. with negative affect resulting from a reduction of prediction error at a rate that is lower than expected (Van de Cruys, 2017)). Emotional arousal has been argued to depend on ‘precision’ in the interoceptive systems, (i.e. the relative weight given to prior representations and prediction errors at various levels within the cortical hierarchy and between modalities (Ainley, Apps, Fotopoulou, & Tsakiris, 2016)). Therefore, interoceptive ability (and precision of the interoceptive systems) plays a crucial role as having intact interoceptive signaling fosters the generation of accurate prediction errors that will inform the internal models of the brain that shape individuals’ emotional experiences (Barrett, Quigley, & Hamilton, 2016).

In summary, this chapter highlighted that high interoceptive ability appears to facilitate emotional processing, -intensity, -regulation and recall and plays a crucial role in the generation of somatic markers, as well as in enabling the brain to build accurate predictions about the current circumstances (including bodily states), which are crucial to maintain homeostasis. These findings offer a rationale for finding pathways to improve interoceptive ability (particularly for those with low interoceptive accuracy) (see chapter 1.5). The following chapter will highlight in which areas interoceptive ability has been found to be altered and how psychiatric disorder could potentially be explained in terms of predictive coding.

1.4 Interoception and Psychopathology

There is now a growing body of research, which has highlighted altered interoceptive processing in various psychiatric-, neurological-, neurodegenerative-, developmental- and
behavioral disorders (Bonaz et al., 2021). These include depression and affective disorders (Avery et al., 2014; DeVille et al., 2018; Furman, Waugh, Bhattacharjee, Thompson, & Gotlib, 2013; Pollatos, Traut-Mattausch, & Schandry, 2009), panic and anxiety disorders (Domschke, Stevens, Pfleiderer, & Gerlach, 2010; Paulus & Stein, 2010), obsessive-compulsive disorder (Eng et al., 2020; Schultchen, Zaudig, Krauseneck, Berberich, & Pollatos, 2019b; Yoris et al., 2017), post-traumatic stress disorder (Reinhardt et al., 2020), eating- and weight disorders (Herbert & Pollatos, 2014; Martin et al., 2019; Pollatos et al., 2008) (for a detailed review on interoception and anorexia nervosa see chapter 1.8.1), substance-use disorders (Jakubczyk et al., 2019; Sönmez, Kahyacı Kılıç, Atėş Çöl, Görgülü, & Köse Çınar, 2017), deregulation/depersonalisation disorder (Sedeno et al., 2014) and autism (DuBois, Ameis, Lai, Casanova, & Desarkar, 2016; Palser, Fotopoulou, Pellicano, & Kilner, 2020). It is also noteworthy, that alterations in interoceptive processing are not only observable during the acute illness phase, but can also prevail after symptom reduction, for example, in patients remitted from anorexia nervosa (Berner et al., 2018; Fischer et al., 2016) and obsessive-compulsive disorder (Schultchen et al., 2019b).

In terms of the predictive coding model, under active inference, clinical symptoms can, for example, be viewed as the consequence of aberrant precision of top-down predictions or bottom-up prediction errors respectively. In detail, Barrett et al. (2016), argued that interoceptive predictive processing may become dysfunctional and result in psychiatric illnesses through either (a) overly precise predictions (leading to an internal model that is inefficient at managing energy regulation due to high metabolic demand) or (b) unreliable prediction errors, for example, due to imprecise (i.e. noisy) interoceptive signals from the body (leading to interoceptive signals being discounted over time, thereby hindering the output of prediction error signals) or (c) inaccurate precision of afferent interoceptive signals (e.g., due to dysfunctions in the neuromodulatory system such as low serotonin or dopamine levels) (Barrett et al., 2016). These possible dysfunctions of predictive coding processes could disrupt the adaptation of internal models that generate reliable predictions and, therefore, lead to a continuous disbalance.
in homeostasis. This, in turn, could represent a vulnerability factor to illness onset or relapse (Barrett et al., 2016; Murphy et al., 2017; Smith et al., 2021).

Providing empirical evidence for this theoretical framework, recent research by Smith and colleagues (2020) fitted a Bayesian computational model to behaviour in a transdiagnostic patient sample during an interoceptive awareness task (inspiratory breath-holding during heartbeat tapping). The authors showed that individuals with depression, anxiety, substance use, and/or eating disorders displayed lower interoceptive sensory precision than healthy individuals, but showed no difference in prior expectations (Smith et al., 2021). As high interoceptive ability has been argued to be linked to prioritizing interoception over other sensory modalities and to help to adjust the relative precision of the interoceptive priors and prediction errors where appropriate (Ainley et al., 2016), developing effective interventions that can improve interoceptive ability (e.g. interoceptive accuracy) could be highly valuable for individuals with low interoceptive precision. The following chapter will outline some of the possible pathways that could enhance interoceptive ability in clinical and non-clinical samples.

1.5 Improving Interoception

Although effective strategies to improve interoception are still limited (Quigley, Kanoski, Grill, Barrett, & Tsakiris, 2021), several attempts have been made to enhance this ability. Broadly speaking, these can be divided into body-centered interventions (Weng et al., 2021), approaches that activate self-relevant information (Ainley, Maister, Brokfeld, Farmer, & Tsakiris, 2013) and practices that use particular stimuli and context-dependent manipulations (Kunstman et al., 2016; Moeini-Jazani et al., 2017). Of course, this distinction not stringent and interventions can combine several different approaches. A further distinction can be made in terms of their training period, namely whether they are short-term or longitudinal interventions. Also, interventions can be categorized based on the chosen outcome variable, i.e. whether their application led to improvements in regards to the subjective dimension of interoception, actual performance on the HBTT or alterations in the neural networks involved in interoception (Figure 3). The following section will look at the different approaches in more detail.
Commencing with **body-centered interventions**, these include, for example, mindfulness practices, breathing monitoring, meditation, body-scanning, floating, biofeedback, body mobilizations and deep touch (Edwards, Young, Cutis, & Johnston, 2018). Regarding mindfulness-based practices, a recent review by Gibson (2019) pointed out that these can lead to improvements in interoceptive sensitivity (Bornemann, Herbert, Mehling, & Singer, 2014; de Jong et al., 2016; Parkin et al., 2014) and changes in the neuroplasticity of interoceptive networks (Casals-Gutiérrez & Abbey, 2020; Farb, Segal, & Anderson, 2013; Friedel et al., 2015; Haase et al., 2016; Young et al., 2018), however, results regarding interoceptive accuracy remain mixed, with some studies finding no beneficial effects on IAcc (Khalsa et al., 2008; Nielsen & Kaszniak, 2006; Parkin et al., 2014) and other studies finding improvements in Acc only after longer periods of practice (Bornemann & Singer, 2017; Fischer, Messner, & Pollatos, 2017). One of the mechanisms of mindfulness could be an attentional shift away from exteroceptive signals and towards interoceptive signals, as the main focus of attention often lies on an object of internal experience (e.g. sensory experience of breathing) (Hölzel et al., 2011). Completely blocking out exteroceptive signals is a mechanism used by floatation therapy, whereby individuals float supine in a pool of water saturated with magnesium salts.
This approach is body-centered and makes use of a particular context (e.g. the body being surrounded by water with the ears under the water-level). Floatation therapy appears to enhance interoceptive sensibility and attention to cardiorespiratory sensations (Feinstein et al., 2018), however, it may lack practicability in daily life for many individuals.

Considering body-centered interventions further, a recent study by Meyerholz et al. (2019) found contingent bio-feedback to significantly improve interoceptive ability. Interestingly, the contingent bio-feedback was superior to a session of mindfulness practice in the study (Meyerholz et al., 2019). However, here as well, the intervention is limited in the sense that it requires a monitor and sensory recording device to be applied.

Furthermore, another study by Edwards et al. (2018) found significant improvements in interoceptive accuracy through the application of deep touch (i.e. by putting pressure on the suboccipital muscles (rear head muscles)), by the experimenter. As the underlying mechanism of improvement, the stimulation of C-tactile (CT) afferents has been suggested (Eggart, Queri, & Muller-Oerlinghausen, 2019) which, in turn, project to the insular cortex via the lamina I spinothalamocortical pathway that relays homeostatic information to the insula (Craig, 2009). It is still not known, however, if this technique would also work if individuals would practice deep touch on themselves or used a therefore constructed portable device (Di Lernia, Cipresso, Pedroli, & Riva, 2018a).

In the context of body-centered interventions, it is also noteworthy that experienced dancers have been shown to display higher interoceptive accuracy than non-dancers (Christensen, Gaigg, & Calvo-Merino, 2018). Similarly, experienced musicians have been shown display higher interoceptive accuracy than non-musicians (Hina, Aspell, & Cardini, 2020; Schirmer-Mokwa et al., 2015). In both cases, enhanced multisensory integration, enhanced insular connectivity and the practice of self-focus have been proposed as possible underlying mechanisms (Christensen et al., 2018; Millman, Terhune, Hunter, & Orgs, 2020; Zamorano et al., 2020). However, it is still unclear whether short-term or continuous training of dance or playing an instrument could increase interoceptive ability in terms of an intervention.

Considering interventions that use the confrontation with self-relevant information in more detail, a series of studies by Ainley et al. highlighted that interoceptive accuracy
could be increased when individuals were asked to look into a mirror (Ainley, Tajadura-Jimenez, Fotopoulou, & Tsakiris, 2012), to regard a picture of themselves, or to processed self-relevant words (Ainley et al., 2013). Interestingly, another study by Maister et (2017) found that interoceptive accuracy could also be increased in those with initially low IAcc, when they looked at the face of their romantic partner. The authors argued that the romantic partners would act as a 'social mirror' and evoke the concept of a 'relational self' (Maister et al., 2017). The relational-self experience, in turn, would activate an internal, first-person awareness, that stands in contrast to an objectified, external self-representation that may be elicited when being observed (e.g. by a stranger or a video camera) (Durlik, Cardini, & Tsakiris, 2014; Maister et al., 2017). In this regards, direct eye gaze (as opposed to averted eye gaze) may also play an important role, as this has been shown to promote bodily awareness (Baltazar et al., 2014) and performance on heartbeat tracking task (Isomura & Watanabe, 2019). Thus, in sum, being confronted with self-relevant information through self-regard or partner-regard may be beneficial for some individuals to enhance IAcc. However, it is noteworthy that this form of interoceptive enhancement might not be suitable for all populations. Pollatos et al. (2016) showed that the beneficial effect on IAcc of regarding oneself in the mirror does not occur in women with AN, probably because the confrontation with the body in the mirror elicits body-related avoidance which, in turn, decreases IAcc. Therefore, alternative strategies to improve IAcc in this population need to be developed.

Regarding **stimuli- and context-dependent alteration of IAcc**, these approaches focused on the investigation of how contextual changes (e.g. a particular social context or the manipulation of sensory input) or the presentation of distinct stimuli could induce interoceptive alteration. Regarding, for example, a social context a study by Durlik and Tsakiris (2015) found that interoceptive accuracy could vary depending on whether individuals were socially in- or excluded. The authors hypothesised that social exclusion would lead to better interoceptive accuracy, as social exclusion has been found to increase activity in the anterior insular (Cacioppo et al., 2013; Eisenberger, 2012), which, in turn, has been associated with increases in interoceptive accuracy (Critchley et al., 2004). However, they found that individuals who were socially excluded in a virtual ball-tossing game displayed significant decreases in interoceptive accuracy compared to
individuals who remained socially included (Durlik & Tsakiris, 2015). One reason proposed by the authors was that the attentional resources required to feel bodily signals might have been compromised in individuals who were excluded, because of a shift of focus towards others that arose due to the perceived social threat. This made it less likely for them to focus on themselves and their body, which decreased their performance on the HBTT (Durlik & Tsakiris, 2015). In this context, an interesting study by Pollatos et al. (2015) also found that higher interoceptive accuracy was associated with lower distress following social exclusion. The two described studies regarding social exclusion raise the question of whether interventions that target loneliness could improve interoceptive ability and vice versa (i.e. whether the improvement of interoception could represent a buffer against the negative effects of social isolation or exclusion) (Arnold, Winkielman, & Dobkins, 2019). The study by Durlik and Tsakiris (2015) also highlights the importance of social connectivity as a possible mean of manipulating interoception. However, still little is known about how these observed effects could be translated into tailored interventions that make use of social dynamics and cues to improve interoception.

Considering social contextual factors further, some evidence suggests that the manipulation for social rank could play an important role in the enhancement of interoceptive ability. In this regard, a study by Moeini-Jazani (2017) highlighted that social status or dominance could benefit interoceptive accuracy. The authors manipulated social power via a role-playing task (manager versus subordinate). They found that individuals in the high-power experimental condition displayed significantly higher interoceptive accuracy than individuals in the low power condition. They explained this finding in terms of a self-focus paradigm, whereby the induction of power lead to an attentional shift towards themselves enabled by the absence of perceived social threat (Moeini-Jazani et al., 2017). These findings fit in well, with the previously described study by Durlik and Tsakiris (2015) where one could argue that the social exclusion was equivalent to a fall in social rank and thus the experience of powerlessness. The induction of power as a possible mean of improving interoception is further supported by research findings suggesting that power priming (i.e. the presentation of powerful stimuli) could also influence interoceptive ability. Kunstman et al. (2016) found that individuals with
high body dysmorphic symptomatology who were primed with power (through a power word search puzzle or a writing task about a memory where individuals felt powerful) increased in their state levels of interoceptive accuracy compared to individuals who underwent a neutral experimental condition. Thus, using stimuli that trigger the induction of power, or creating a social context of power dynamics both appear to be promising pathways of increasing interoceptive ability.

Finally, recent research has also focused on the manipulation of exteroceptive input as a possibility of enhancing bodily perception. For example, Hall et al. (2019) found that individuals who wore noise-dampening ear protectors performed significantly better on the HBTT than individuals who did not. Todd et al. (2020) could replicate these findings in a repeated measures design, they did, however, find that improvements on the HBTT were also associated with self-reported audibility of the heartbeat. The authors pointed out that the ear protectors might act as a resonant medium, amplifying the heartbeat pulse and making it more perceptible through tactile sensations caused by pressure on a blood vessel (Todd et al., 2020). Therefore, it cannot be assumed that better performance on the HBTT through the use of noise-dampening ear protectors is also associated with better interoception (Todd et al., 2020).

In summary, the described approaches have in common that many of them trigger some form of self-focus, be it on the body, the persons' identity or the self in a social context (Ainley et al., 2013; Farb et al., 2007; Moeini-Jazani et al., 2017). Thus, pathways that shift the attention of the individual towards him or herself seem promising in terms of enhancing interceptive ability. Every form of bodily posture that is deliberately adopted and held requires some form of self-focus in order to maintain it. Still, little is known regarding interventions that primarily rely on postural changes or movements of the body to influence interoceptive ability. This dissertation tries to contribute to breaching this gap in the literature by examining how powerful postures could benefit the different dimensions of interoception (study I-III). Although little is known regarding the link between bodily posture and interoception, the following chapter will review studies that have found beneficial effects of posture manipulations on other aspects of mental functioning, including emotion, cognition and behaviour.
1.6 The Connection between Bodily Postures, Emotion and Cognition

There is now a growing body of research highlighting a bi-directional relationship between bodily postures, emotions and cognition, as well as beneficial effects of integrating the body into therapeutic interventions (Fuchs & Koch, 2014; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Peper et al., 2019). Still, many mainstream psychotherapeutic approaches do not emphasise a focus on the body during clinical practice and do not actively encourage the patient to change bodily postures as a mean of enhancing therapeutic processes (Elkjaer et al., 2020; Leitan & Murray, 2014; Tschacher, Giersch, & Friston, 2017). The following paragraphs will give an overview of studies underlying the possible usefulness of bodily manipulations (e.g. through posture or movement) for therapeutic change. Thereby, a particular focus is placed on findings from non-clinical samples, research regarding different psychiatric disorders and their outcomes (e.g. symptom reduction, changes in affective states or cognition), as well as the recommendations that the authors have made regarding clinical practice (Figure 4).

FIGURE 4 | Overview the chapter content regarding body manipulations effects
In the literature concerning bodily postures, several broad distinctions have been made between different types of bodily manipulations. These include upright versus slumped bodily postures (Michalak, Mischnat, & Teismann, 2014; Nair, Sagar, Sollers, Consedine, & Broadbent, 2015), lying versus sitting or standing bodily postures (Lipnicki & Byrne, 2008; Roberts & Arefi-Afshar, 2007; Smith & Apicella, 2017) and expansive versus constricted-, neutral- or natural bodily postures (Carney et al., 2015; Körner, Petersen, & Schütz, 2019; Lee & Schnall, 2014). A further distinction has been made between postures that are adopted whilst being in motion (Hackford, Mackey, & Broadbent, 2018; Michalak, Rohde, & Troje, 2015) or whilst holding still (Wilson & Peper, 2004). Also, studies varied depending on whether they focussed on the whole body (Nair et al., 2015), the upper body (Asadi-Melerdi, Rajabi-Shamli, Sheikhhoseini, & Piri, 2020; Peper et al., 2019) or only parts of the body (Wilkes, Kydd, Sagar, & Broadbent, 2017).

Regarding non-clinical samples, there are mixed findings concerning the benefit of adopting upright/expansive bodily postures (whilst holding still) on outcomes such as behaviour or physiological changes (Körner & Schütz, 2020). For example, some studies found advantageous effects of expansive bodily postures (vs. constrictive bodily postures) on outcomes such as hormonal changes and risk-taking behaviour (Carney et al., 2010), whereas other studies were unable to replicate these particular results (Metzler & Grezes, 2019; Ranehill et al., 2015; Smith & Apicella, 2017). However, a recent review by Körner et al. (2020) highlighted that upright and expansive bodily postures seem to have advantageous effects on the actor's self-evaluations and emotional experiences. For example, studies have shown expansive bodily displays to be associated with increased state self-esteem (Körner et al., 2019), as well as subjective feelings of power (Gronau et al., 2017), compared to constrictive postures. Also, bodily postures appear to be able to increase particular emotions as well as foster recovery from negative mood. For example, in a study by Duclos and colleagues (1989) individuals were asked to adopt postures of fear, anger, disgust and sadness. Each particular posture significantly increased feelings of its associated emotion (Duclos et al., 1989). In this context, another study by Stepper and Strack (1993), showed that success at an achievement task led to greater feelings of pride if the outcome was received in an upright position rather than in
a slumped posture. Thus, the congruence between an emotion and associated bodily features appears to enhance emotional experience (Iani, 2019). In keeping with this assumption, some studies have also found that particular postures can also inhibit specific emotions. For example, research by Veenstra et al. (2017) showed that adopting a stooped body posture hindered recovery from pre-existing negative mood more than a straight posture. Also, regarding anxiety, a study by Lipnicki and Byrne (2008) manipulated individuals bodily posture before completing a demanding mental arithmetic task. The researchers found that participants only experienced anticipatory anxiety when standing up, although not when lying down (Lipnicki & Byrne, 2008).

Several further studies have highlighted the impact of posture on cognitive processes, such as memory retrieval, reasoning and information processing. For example, a study by Riskind (1983) showed that individuals found it easier to retrieve memories with positive valence when smiling and sitting upright, and memories with negative valence when frowning and holding a slumped bodily posture. In this context, a study by Arminjon and colleagues (2015) also showed that when individuals smiled whilst recalling a sad story, they rated the story as less negative than individuals who were not instructed to smile. Furthermore, Briñol, Petty, and Wagner (2009) found that upright sitting individuals (as opposed to a slouched sitting individuals) displayed significantly higher thought confidence, a meta-cognitive process that reflects individuals degree of confidence in their own thoughts. In addition, a supine bodily posture (relative to an upright bodily posture) has also been found to decrease cognitive dissonance reduction (Harmon-Jones, Price, & Harmon-Jones, 2015). Also, a recent study by Miragall et al. (2020) showed that an upright (vs. stooped) bodily posture led to more positive interpretations of ambiguous information and that the time in an upright position was associated with a change in interpretation bias. Thus, bodily postures not only seem to impact affective, but also cognitive processes.

Regarding bodily posture and movement (i.e. posture in motion/action) several studies highlighted beneficial outcomes when adopting an upright posture whilst moving the body in a particular way. For example, Hackford et al. (2018) showed that participants who walked in an upright posture (compared to a slumped walking posture) displayed significantly improved psychological states including less low arousal negative
affect, less sleepiness, less pain and marginally greater feelings of power. Differences were also recorded on a physiological level, with the upright walking posture group showing significantly lower systolic blood pressure, galvanic skin response, and marginally lower skin temperature than the slumped walking posture group (Hackford et al., 2018). Another study by Michalak and colleagues (2015) altered participants gait pattern through online gait bio-feedback and found that memory for negative words did substantially change with walking pattern. The researchers showed that individuals who were manipulated to walk in a happy manner recalled more positive words than negative words than individuals who were manipulated to walk in a depressed manner (Michalak et al., 2015). Furthermore, a study by Schneider and colleagues (2013) showed that individuals who experienced ambivalence moved more from side-to-side on a Wii Balance Board than individuals who did not experience ambivalence. At the same time, they observed that when individuals were manually made to move from side-to-side this also enhanced their experiences of ambivalence (Schneider et al., 2013). Thus, the described studies highlight that not only postures that are adopted whilst sitting-, standing- or lying still can amend emotional- and cognitive processes, but also postures that are adopted whilst shifting the body in space can have such effects.

As deficits in positive self-confidence, self-esteem, negative affect and cognitive reasoning are often prominent in psychiatric illnesses, several authors of the aforementioned studies proposed that including bodily postures in therapy might foster benefit outcomes regarding emotion and cognition (Hackford et al., 2018; Michalak et al., 2015; Veenstra et al., 2017). Nevertheless, in this regard, it is important to point out that some of the described findings may be biased, as effects may have been carried by the negative impact of contracted or slumped bodily postures, rather a true effect of upright or expansive bodily postures (Crede, 2018). Therefore, studies comparing either expansive or contracted bodily postures to neutral or natural bodily postures are of particular importance to disentangle the observed effects (Elkjaer et al., 2020). In this regard, a recent study by Körner et al. (2019) on the effects of expansive bodily displays on state self-esteem is particularly valuable, because the authors found significant positive effects of expansive bodily postures on self-worth not only compared to a
constricted condition but also to a control condition where no particular posture was adopted by the participants (i.e. when individuals adopted their usual posture).

Previous research has further focussed on the interplay between posture and emotions and cognitions in different psychiatric disorders, including depression, schizophrenia and anxiety disorders. During episodes of depression, for example, individuals have been found to display altered bodily postures, including increased head flexion, increased thoracic kyphosis and scapular protraction compared to individuals without depression (Canales, Cordas, Fiquer, Cavalcante, & Moreno, 2010; Feldman, Schreiber, Pick, & Been, 2020; Kim, Cheon, Youm, Son, & Kim, 2018; Michalak et al., 2009). Also, recurrent episodes have been associated with measures of postural misalignment (Canales, Fiquer, Campos, Soeiro-de-Souza, & Moreno, 2017). At the same time, adopting a slouched bodily posture appears to foster depressive symptomatology. For example, Michalak et al. (2014) found that patients with depression who adopted a slouched posture displayed a memory recall biased towards more negative words, compared to patients with depression who adopted an upright posture. This finding is also supported by studies of healthy subjects who reported finding it easier to generate positive thoughts in an upright position than a slumped position (Wilson & Peper, 2004).

In this regard, it is important to note that posture also appears to alter cortical activity (Spironelli, Busenello, & Angrilli, 2016; Thibault, Lifshitz, Jones, & Raz, 2014). In particular, a study by Tsai and colleagues (2016) found significant higher amplitudes of beta waves under slouched posture when recalling happy events than under erect posture when recalling happy or depressive events. Thus, recalling positive thoughts seems to be inhibited and therefore more difficult in a collapsed than erect posture (Tsai et al., 2016).

Posture also appears to impact other outcomes in individuals with depressive symptoms, such as fatigue or positive affect. A study by Wilkes et al. (2017) that compared upright and usual postures in individuals who screened positive for mild to moderate depression, found that the adaptation of an upright posture significantly increased high arousal positive affect and fatigue compared to individuals' usual posture.

In terms of therapeutic interventions that use bodily posture manipulations as a mean of symptom relief, a study by Koch et al. (2007) compared individuals with depression
participating in either a dance movement group, a group that only listened to the music of the dance (music only), and a group that moved on a home trainer bike (ergometer) up to the same level of arousal as the dance group (movement only). The results suggested that patients in the dance group profited most from the intervention, having shown significantly less depression than patients in the music group and in the ergometer group and more vitality than participants in the music group (Koch et al., 2007). The authors suggested that dance moves could be employed as rituals at the beginning or the end of a therapy session as a way of temporarily decreasing symptoms of depression and increasing vitality. These preliminary results were later supported by two meta-analyses on dance movement therapy in various clinical disorders, by highlighting a moderate effect size of dance movement therapy on reductions of depression (Koch et al., 2019).

Regarding schizophrenia, there is now a growing body of research highlighting alterations in bodily postures (including altered postural control and postural instability) in individuals with schizophrenia, compared to individuals without schizophrenia (Presta et al., 2021). For example, Christiano et al. (2017) identified the most common postural features in early and late stages of schizophrenia to be a forward-tilted head posture as well as hyperlordosis (an inward curving of the lower back). In this context, postural sway and inflexibility have also been reported as characteristic bodily features of individuals with schizophrenia (Ikai et al., 2016; Matsuura et al., 2015). As these have been associated with symptom severity (Bernard et al., 2014; Fujino & Imura, 2015), the authors of several studies have called for interventions that focus on improving bodily postures in schizophrenia (Beck & Callahan, 1980; Tschacher et al., 2017). In this context, a recent study by Biondo and colleagues (2021) compared a single-session of dance/movement therapy against verbal treatment as usual in individuals with schizophrenia in inpatient psychiatric facilities. The authors found that individuals in the dance movement group showed significantly larger symptom reduction compared to those in the treatment as usual group (i.e. in regards to self-reported psychological discomfort, as well as negative and positive symptoms) (Biondo et al., 2021). Qualitative findings also highlighted that participants in the body-centered intervention group expressed feeling in control, less angry, and motivated for treatment (Biondo et al., 2021). In keeping with this observation, a randomized control trial by Röhricht and
Priebe (2006) also showed that patients receiving body-centered psychotherapy (that involved adopting different bodily postures and moving the body in space) attended more therapy sessions and had significantly lower negative symptom scores after treatment than patients who attended supportive counselling for schizophrenia.

Regarding postures that might help individuals with anxiety disorders, the evidence remains very scarce (Feldman et al., 2020). There is only one study by Davis et al. (2017) which investigated the effect of one session of practising either an expansive-, or constrictive- or sitting posture before a public speaking task in a student and community sample with diagnosed social anxiety. No significant differences were found between the three postures in regards to reductions in social anxiety, which was measured after exposure to the social speaking task (Davis et al., 2017). However, the authors pointed out, that the stress induced by the knowledge of the public speaking task in the untreated sample with social anxiety may have diminished any possible effects (Davis et al., 2017). Considering effects in clinical samples further, the aforementioned study by Wilkes et al. (2017) also found that an upright shoulder angle was associated with lower anxiety in a sample of individuals who screened positive with mild to moderate depression. Further inferences regarding the link between anxiety and posture could be drawn from non-clinical research, where a small number of studies have investigated a possible relationship. However, the results in this regard are mixed. On the one hand, there is some evidence suggesting that adopting upright postures could protect the individual from the experience of fear. For example, Nair and colleagues (2015) investigated the influence of posture on word use during a stressful speech task. The study found that individuals who adopted a slumped posture during the task, reported significantly higher fear of social threat situations, than individuals in the upright posture. Additionally, Peper et al. (2019) found that when individuals adopted an upright bodily posture, took a breath, and then reframed their negative thoughts, they were significantly more successful in reducing their anxiety compared to individuals who reframed their negative thoughts without adopting an upright bodily posture. On the other hand, other studies which investigated the influence of upright bodily posture (vs. constricted bodily posture) on self-reported anxiety found no beneficial effects (Rossberg-Gempton & Poole, 1993). For example, Harmon-Jones and Peterson (2009) manipulated participants to feel
frustrated and found a difference in neural activity between those that were sitting upright or reclined at the level of brain activation. However, no differences were found in regards to individuals' self-reported anger, happiness, and fear (Harmon-Jones & Peterson, 2009). A possible reason for the mixed findings could be that the bodily postures chosen and the applied outcome measurements varied greatly between several studies. Firstly, they differed regarding their focus on either particular bodily parts (Wilkes et al., 2017), the upper body (Nair et al., 2015; Peper et al., 2019) or the entire body (Harmon-Jones & Peterson, 2009; Lipnicki & Byrne, 2008). Furthermore, they investigated either a specific type of anxiety, such as social anxiety (Davis et al., 2017) and anticipatory anxiety (Lipnicki & Byrne, 2008) or measured anxiety in general (Peper et al., 2019). Finally, the assessment of anxiety was either applied whilst the posture was adopted (Wilkes et al., 2017) or after a performance task in which the posture was no longer held (Davis et al., 2017).

In summary, on the one hand, the described findings in this chapter underline the potential benefit of posture adjustments to break pathological vicious circles between bodily and emotional processes that may maintain negative affect (Michalak et al., 2014; Michalak et al., 2015; Veenstra et al., 2017), and disadvantageous cognitive processes (Briñol et al., 2009; Harmon-Jones et al., 2015; Riskind, 1983). On the other hand, they also highlight that more research is needed that focuses on the practice of bodily postures in a therapeutic setting and with clinical populations, especially, in regards to anxiety disorders (Feldman et al., 2020; Veenstra et al., 2017). To the best of knowledge, to this day, no previous study assessed the impact of altered bodily posture on interoception in individuals with or without psychiatric disorders. This is an important issue to address, in light of the proposed link between bodily posture and emotion (Niedenthal, 2007) and the crucial role interoception plays in emotion processing and regulation (Critchley & Garfinkel, 2017; Dunn et al., 2010; Füstös et al., 2012; Georgiou, Mai, Fernandez, & Pollatos, 2018). The following chapter will focus on how bodily postures (in particular powerful bodily displays) could benefit improvements in interoception in more detail.
1.6.1 Power Posing and its Potential Usefulness to Improve Interoception

Several bodily manipulations described in the previous chapter made use of expansive displays of bodily features during the interventions. A bodily posture that comprises a combination of expansive bodily elements is the so-called *power pose*. It entails bodily features that observers would associate with social power, including tilting the head upward, leaning forward, placing the hands onto the waist, displaying an erect posture and adopting an overall open bodily pose (Carney, Hall, & LeBeau, 2005) (Figure 1). The adoption of such a posture is called *power posing*. This term has firstly been coined in a study by Carney, Cuddy and Yap (2010) which investigated the effects of high power poses and found that when individuals held two power poses for one minute each, they subsequently experienced elevated levels of testosterone, decreases in cortisol as well as increased feelings of power and risk tolerance (compared to individuals who held a constricted bodily posture). The study was followed by a TED talk by Amy Cuddy which yielded over 60 million views to date, rendering it one of the most successful talks on the platform (Cuddy, 2012). Thereafter, the findings of the Carney et al. (2010) study came under scrutiny, as subsequent research was unable to replicate the effects of power posing on hormonal levels and risk-taking (Ranehill et al., 2015). In this regard, the authors of the original study and other researchers pointed out that the diverging effects could possibly be explained by differences in research designs (e.g. length of time in which the postures were held, varying instructions, cover stories, filler tasks (Carney et al., 2015) and contextual factors (Cesario & McDonald, 2013)). At the same time, further studies were conducted, investigating the effects of power posing on a wide range of outcomes (see Cuddy et al. (2018) for a review of 55 studies on power posing).

To get a better understanding of the robustness of the observed effect as well as the use of power posing for particular outcomes, several reviews and meta-analyses were subsequently published. Firstly, based on 33 published studies on power posing, Carney and colleagues (2015) concluded that expansive bodily postures are associated with changes in affective states, behavioural effects and hormonal changes. However, Simmons and Simonsohn (2017) highlighted that a possible publication and selection bias could have confounded their conclusions and they, therefore, conducted a p-curve
analysis (i.e. a method aimed at detecting p-hacking) based on the studies cited in the aforementioned review by Carney and colleagues (2015). The authors concluded that empirical support was lacking for the *behavioural and physiological effects* of expansive versus contractive (Simmons & Simonsohn, 2017). They did, however, find evidence for effects of power posing on subjective feelings of power, but regarded this relationship as a demand effect occurring in the context of a manipulation check, rather than a true outcome (Simmons & Simonsohn, 2017). A further p-curving analysis by Cuddy, Schulz and Fosse (2018), which included 55 studies, found supporting evidence of power posing for so-called EASE variables (i.e. emotions, affect, and self-evaluations), but no supporting evidence for non-EASE variables (e.g., pain threshold, gambling).

In an attempt to decrease the possible confounding factor of selective reporting in systematic reviews, a special issue including six novel pre-registered studies on power posing found no evidence for behavioural or hormonal measures (Jonas et al., 2017). However, a subsequent meta-analysis of the pre-registered studies on power posing by Gronau and colleagues (2017) revealed a reliable effect of power posing on **subjective feelings of power**. This finding was also supported by the study of Cuddy at al. (2018), which included 11 further studies which could replicate this effect on felt power.

Thus, taking all the reviews together, several authors concluded that there is weak evidence supporting the effect of power posing on hormonal and behavioural outcomes, however, power posing seems to reliably increase felt power (Cesario et al., 2017; Körner & Schütz, 2020). Importantly, the effect of increased felt power also appears to be present when power poses are compared to neutral poses, as opposed to restricted poses only (Brown, Waite, Rovira, & Freeman, 2020a).

As aforementioned in the general introduction of this dissertation, the induction of subjective feelings of power has previously been linked to increases in **self-focus** (Moeini-Jazani et al., 2017). In this context, the *situated focus theory of power* also proposes that powerful individuals are less dependent on others for their personal outcomes and are, therefore, more likely to engage in private self-focus (Guinote, 2007). Support for this theory comes from research showing that individuals holding high power, are more likely to shift their attention towards themselves, rather than to others or
their surrounding (Pitesa & Thau, 2013). For example, Galinsky and colleagues (2006) conducted four experimental studies and one correlational study exploring the relationship between power and perspective-taking. Across all studies, being in a high-power condition was associated with a reduced tendency and ability to change perspectives, compared to a low-power- or control condition (Galinsky et al., 2006). Regarding emotion processing, it has also been found that individuals in high-power conditions are less likely to notice and consider their opponents' emotions (compared to individuals in low-power conditions) (van Kleef, De Dreu, Pietroni, & Manstead, 2006). In this context, a recent review by Van Kleef and Lange (2020) found that high-power individuals responded to the emotional expressions of others only when they were self-relevant. Furthermore, several studies highlighted that individuals in high power positions (e.g. CEOs and directors) report relying on bodily information (e.g. their 'gut feeling') or their intuition when making decisions (Bird & Swabey, 2014; Liebowitz et al., 2019; Pitesa & Thau, 2013), rather than on external, analytical information. Considering the focus on bodily aspects of the self, a series of studies by Guinote (2010) examined how feelings of hunger guided the eating behaviour of powerful and powerless individuals. She investigated the relationship between hunger and the amount of food eaten by individuals primed with high or low power, as well as the extent to which individuals assigned to a powerful or a powerless role ate appetizing and non-appetizing food (Guinote, 2010). The results suggested that individuals in the high power conditions ate depending on their bodily feelings, whereas no relationship between eating behaviour and bodily feelings was found for individuals in the low-power conditions (Guinote, 2010).

Based on the described evidence, it could be hypothesised that the induction of power through power posing could lead to increases in self-focus, which in turn, would benefit interoceptive ability through an attentional shift towards the self (including the body). Preliminary evidence for this idea comes from a study by Moeini-Jazani and colleagues (2017). The researchers manipulated feeling of power by priming individuals with either taking on a manager role (high power condition), a subordinate role (low power condition) or the role of a colleague (control/neutral condition) in an anticipated role play (Moeini-Jazani et al., 2017). The researchers found that individuals in the high-power
condition subsequently displayed higher interoceptive accuracy after the manipulation than those in the low-power and control condition (Moeini-Jazani et al., 2017). This effect was not explained by participants’ physiological arousal, affective state, or general intention for accuracy (Moeini-Jazani et al., 2017). The study further revealed that participants' dispositional feelings of power predicted their interoceptive accuracy similar to, and independent of, how their situationally induced feelings of power did (Moeini-Jazani et al., 2017). Another study by Kunstman et al. (2016), investigated the link between body dysmorphic symptomatology and interoception and the impact of power priming on the relationship. Individuals were either primed with power or not via a word search puzzle (powerful words/neutral words) and the recall of a memory (domination over others/recall of the past day) (Kunstman et al., 2016). The study found an overall inverse relationship between BDD symptomatology and IAcc (Kunstman et al., 2016). However, in the power condition, no relationship between BDD symptoms and IAcc was observed, suggesting that power may have attenuated the negative relationship (Kunstman et al., 2016). This observation was further supported by the findings that power priming increased state levels of interoceptive accuracy among those with the highest levels of BDD symptomatology (Kunstman et al., 2016).

The two described studies offer support for a possible link between power and sensitivity to bodily signals. However, both of the studies used power priming as a method of power manipulation. In light of the reported effects of powerful postures on subjective feelings of power (Gronau et al., 2017; Huang, Galinsky, Gruenfeld, & Guillory, 2011), it seems worthwhile to investigate their potential impact on facets of interoceptive ability. Also, regarding the high prevalence of body dysmorphic symptomatology among individuals with anorexia nervosa, and its link to illness severity (Beilharz et al., 2019; Grant, Kim, & Eckert, 2002), it seems important to explore, whether power posing could also be beneficial in this particular population. Before considering the construct of power, interoception and posture in regards to anorexia nervosa further (chapter 1.8.1-1.8.3), the following chapter will offer more information on how power can be defined and measured.
1.7 Definition and Measurements of Power

The conceptualisation of power has been challenging and many definitions of power have emerged. As Bierstedt (1950) (p.720) put it, "In the entire lexicon of sociological concepts none is more troublesome than the concept of power. We may say about it in general only what St Augustine said about time, that we all know perfectly well what it is - until someone asks us".

The word power derives from the Latin word 'podere', which translates to 'being able to' or having the ability to act (Patton, 1989). Based on this definition, power can be regarded as something that inheres in an individual or group (Patton, 1989). However, several definitions of power have highlighted the dynamically changing and relational aspect of power. For example, many definitions regard power as the experience of some form of control over others. For example, Dahl (1957) stated that "A has power over B to the extent that A can get B to do something that B would not otherwise do". From this point of view, power is being defined in terms of its influence (Fiske & Berdahl, 2007). However, other researchers have argued that this approach is problematic, as power can also be held and experienced when no action is executed (or observable) (Anderson, John, & Keltner, 2012; Fiske & Berdahl, 2007; Keltner et al., 2003). In this regard, several definitions have defined power as a potential influence (Fiske & Berdahl, 2007), for example, as "the probability that one actor within a social relationship will be in a position to carry out his own will despite resistance" (Weber, Roth, & Wittich, 1978) or an "individual’s relative capacity to modify others’ states by providing or withholding resources or administering punishments" (Keltner et al., 2003). Another perspective de-emphasized the focus on influence in regards to power, but highlighted the importance of power as outcome control, defining it as relative control over valued outcomes (e.g. materialistic or relational) (Fiske & Berdahl, 2007; Fiske & Dépret, 1996; Smith & Galinsky, 2010).

An individual’s sense- or feeling of power has been regarded as a psychological or emotional state respectively, that accompanies the perception of power (Anderson et al., 2012). Anderson et al. (2012) argued that an individuals' subjective sense of personal power can exist in a specific momentary social setting (e.g., a single interaction with one
other person), in a long-term dyadic relationship (e.g., with a friend), in a long-term group (e.g., in a family), and in a more generalized (abstract) form, across an individual’s relationships and group memberships. In keeping with this assumption, research has shown that feeling powerful can fluctuate (Anicich, Schaeer, Gale, & Foulk, 2021), depending on the situational context, but, at the same time, individuals can also display a trait-like sense of power, that is stable across relational interactions (Anderson et al., 2012). This observation provides a rationale for assessing state- as well as trait dimensions of power.

Previous studies that have investigated individuals’ subjective sense or feelings of power have used either only a single item (e.g. in form of a question such as ‘how powerful do you feel?’ (Powers & Reiser, 2005) or a pictorial scale such the Self-Assessment Manikin (SAM) by Bradley and Lang (1994) (Li, Ye, & Yang, 2017)) or several items relating to power, presented either in the form of a Likert scale (Cuddy, Wilmuth, & Carney, 2012; Gronau et al., 2017) or a visual analogous scale (VAS) (Brown et al., 2020a). By choosing any of these options, the researchers have relied on the participants' intuitive definition of power. A vast amount of other studies have integrated the validated Personal Sense of Power Scale by Anderson and colleagues (2012) (Lee & Schnall, 2014; Moeini-Jazani et al., 2017). It consists of eight items (e.g. "I think I have a great deal of power" or "I can get him/her/them to do what I want.") and individuals can indicate their answers on a 7-point scale (Anderson et al., 2012). The scale is often used to reflect an individuals' dispositional power.

The aforementioned assessment tools all target explicit feelings of power, meaning that they can be consciously and verbally expressed by individuals, and, therefore, assessed via self-report. However, several researchers also noticed the importance of considering implicit power motives when assessing individuals' power. This is important, as explicit and implicit power motives can diverge from one another (Kollner & Schultheiss, 2014). In this context, several assessment tools that aim to capture individuals' implicit power predispositions have emerged. These include for example the Multi Motive Grid by Sokolowski and colleagues (2000), the Picture Story Exercise (PSE) (McClelland, Koestner, & Weinberger, 1989), the Operant Motive Test (OMT) (Kuhl & Scheffer, 1999) or the Pictorial Attitude Implicit Association Test (PA-IAT)
(Slabbinck, De Houwer, & Van Kenhove, 2011). Although experimental research on changing power motives remains very scarce (Denzinger & Brandstätter, 2018), assuming that power posing could change implicit power seems reasonable as changes in self-evaluation and affective experiences (“I feel powerful”) might also change the underlying motivation and, consequently, the power motive (Denzinger & Brandstätter, 2018; Heckhausen & Krug, 1982). In this regard, previous research has indicated that implicit motives could be aroused by confronting individuals with motive-specific cues (such as motive relevant behaviour or imagination) (Rawolle, Schultheiss, Strasser, & Kehr, 2017; Schultheiss, Wirth, & Stanton, 2004). The perception of the motive specific cue, in turn, could result in an improved accessibility and possible malleability of the implicit motive network (Denzinger & Brandstätter, 2018).

As power is rarely investigated as a distinct outcome variable in power posing research but often only assessed as a manipulation check (Jonas et al., 2017), and most previous studies only applied one tool of investigating power, this dissertation integrated state- and trait measurements of subjective feeling of power, as well as implicit- and explicit assessment techniques. It focussed on applying these power measurements to non-clinical populations, but also to individuals with anorexia nervosa (AN). The reason for this is that quantitative assessment techniques of power have rarely been applied in this cohort. The following chapters will give an overview of psychopathology and clinical presentation of AN (chapter 1.8), as well as offer a rational for investigating subjective feelings of power in AN (chapter 1.8.2).

1.8 Anorexia Nervosa

The following chapter will give an overview regarding the definition, onset, prevalence, risk factors, psychopathology, clinical presentation, illness burden and treatment efficacy of Anorexia Nervosa (AN).

Anorexia Nervosa is an eating disorder, that is characterized by pathological weight loss behaviours causing persistent underweight (Body Mass Index (BMI) < 18.5 kg/m²),
an intense fear of gaining weight as well as distorted body-image (APA, 2013). Its onset is often in adolescence, with an early onset having been associated with more severe outcomes and a higher chronicity (Dobrescu et al., 2020; Herpertz-Dahlmann et al., 2018; Jenkins, Chait, Cistullo, & Castle, 2020). A recent systematic review estimated a lifetime prevalence of 1.4% for women and 0.2% for men (Galmiche, Dechelotte, Lambert, & Tavolacci, 2019). Several studies highlighted a higher proportion of women than men with AN (Hoek & van Hoeken, 2003; Muise, Stein, & Arbess, 2003). However, in this context, it is important to note that, men have largely been underrepresented in eating disorder research (Kinnaird, Norton, Pimblett, Stewart, & Tchanturia, 2019; Strother, Lemberg, Stanford, & Turberville, 2012), due to an inadequacy of measures that detect AN in men, the lack of coherent norms and clinical cut-off points for men, the difficulty for men to overcome stigma, the possible insensitivity of current diagnostic criteria to the male pathology, challenges in diagnosing the illness in men, as well as barriers in accessing treatment for males with AN (Limbers, Cohen, & Gray, 2018). Thus, although more recent reviews still consistently find a higher female-to-male ratio, they also indicate that there is a higher proportion of men with AN than previously assumed (Hudson, Hiripi, Pope, & Kessler, 2007). Whereas evidence regarding the risk factors that contribute towards or correlate with the development of AN in men remain sparse (Weissman, 2019), several systematic reviews and meta-analysis identified many risk factors in women (Jacobi, Hayward, de Zwaan, Kraemer, & Agras, 2004; Keel & Forney, 2013; Stice, 2002; Striegel-Moore & Bulik, 2007). These range from genetic-, to biological- to psychosocial factors, including a family history of eating disorders (Pike et al., 2021), neural circuit dysfunction, which may be enhanced in puberty (Kaye, Fudge, & Paulus, 2009), abnormal eating and gastrointestinal problems in childhood, sexual and physical abuse, negative self-evaluation, heightened weight- and shape concerns, body dissatisfaction, dieting behaviour (Jacobi et al., 2004), low self-esteem (Colmsee, Hank, & Bošnjak, 2021), perfectionism (Dahlenburg, Gleaves, & Hutchinson, 2019), negative affectivity (Pike et al., 2008), difficulties in social interactions (Westwood, Lawrence, Fleming, & Tchanturia, 2016), family relationship issues (Pike et al., 2021; Tozzi, Sullivan, Fear, McKenzie, & Bulik, 2003) and deficits in emotion processing (Oldershaw, Startup, & Lavender, 2019). Importantly, however, average univariate effects for the risk
factors are generally small (Stice, 2002), underlining the complex, multi-factorial nature of the disorder. Regarding the development and maintenance of AN, several models have been proposed that underline the interplay between biological factors, dieting behaviours, cognitive- and physical effects of starvation, as well as intra-personal dynamics that reinforce pro-anorectic belief (Oldershaw et al., 2019; Schmidt & Treasure, 2006). However, experimental investigation of causal factors is still lacking (Glashouwer et al., 2020; Kaye et al., 2009).

The severe burden of anorexia nervosa practically encompasses every area of life, being reflected on the physiological, psychological and social level. Physiologically, AN has been associated with a wide range of short- and long term consequences for the reproductive, cardiovascular, gastrointestinal and skeletal systems (Meczekalski, Podfigurna-Stopa, & Katulska, 2013). Prominent medical complications due to starvation include a reduced bone mineral- and mass density leading to osteopenia and osteoporosis, as well as an increased risk of spontaneous fractures (DiVasta & Gordon, 2019; Katzman, 2005). The majority of individuals with AN display cardiac abnormalities (Spaulding-Barclay, Stern, & Mehler, 2016), with the most common being sinus bradycardia, arrhythmias and hypotension (Portilla, 2011). Underweight has also been associated with the disruptions of hormonal levels, leading to sexual dysfunction, infertility and miscarriages (Boutari et al., 2020). Whereas several physiological damages caused by AN can improve through weight gain and nutritional rehabilitation (Mehler, Krantz, & Sachs, 2015), not all of them may be completely reversible and may affect the individuals later in life (Katzman, 2005). Regarding mortality, AN has been shown to have the highest mortality rate among all psychiatric disorders (Arcelus, Mitchell, Wales, & Nielsen, 2011), with a large proportion of deaths being attributable to suicide and medical complications relating to AN (Bulik et al., 2008; Zipfel, Lowe, Reas, Deter, & Herzog, 2000). Regarding life expectancy it has been estimated that a woman who has had AN since 15 years of age is likely to live 25 years less than predicted for the normal population (Harbottle, Birmingham, & Sayani, 2008).
Regarding the **psychological consequences of the illness**, individuals with AN show a high preoccupation with thoughts around food and weight loss, as well as frequent calorie counting, weighing, and excessive exercising (Brockmeyer et al., 2014). The time consuming-nature of their weight-loss compulsion limits their ability to focus on other areas of interest and has detrimental effects on their social and occupational lives, as evident from qualitative interviews (Godier & Park, 2015). Furthermore, comorbid psychiatric disorders are common among individuals with AN (Buhren et al., 2014) (especially anxiety disorders (Blinder, Cumella, & Sanathara, 2006)) and are associated with more negative long-term outcomes (Kask et al., 2016). As the illness prolongs, feelings of hopelessness can become overwhelming, as well as feeling of 'being stuck' in an effortful bleak life (Hannon, Eunson, & Munro, 2017). Individuals often feel torn between wanting to change and not wanting to give up the comfort, safety, predictability and feelings of identity that are connected to AN, which in turn, can fuel inner conflicts as well as feelings of self-criticism and self-hatred (Hannon et al., 2017).

Regarding the **social consequences of AN**, individuals in the acute illness stage often report feeling socially isolated and lonely (Levine, 2012), having less contact and connections with friends (Westwood et al., 2016). Also, a large proportion of individuals with AN report that the eating disorder affected their social relationships in a negative way (Cardi et al., 2018), with social difficulties perpetuating the acute illness stage (Westwood et al., 2016).

AN often takes a **chronic course**, affecting individuals over long periods of their life (Eddy et al., 2017). Longitudinal studies which have followed AN patients over several decades have shown that approximately 30 (Dobrescu et al., 2020; Theander, 1985) to 50 percent (Steinhausen, 2009; Zipfel et al., 2000) of individuals do not make a full recovery, with one in five individuals still holding an eating disorder diagnosis after 20 (Steinhausen, 2009) and 30 years (Dobrescu et al., 2020).

The described findings highlight how severe, long-lasting and deliberating the consequences of AN are. Despite the detrimental illness outcomes and the great need to offer beneficial interventions to patients, effective treatments are still very limited (Oldershaw et al., 2019). There is some low-quality evidence that family-therapy is
effective for adolescents in the short-term (Fisher, Skocic, Rutherford, & Hetrick, 2019), but no gold-standard therapy can currently be recommended for adults (Resmark, Herpertz, Herpertz-Dahlmann, & Zeeck, 2019; Zeeck et al., 2018). For example, a recent meta-analysis on the efficacy of psychological treatments for AN by van den Berg and colleagues (2019) found no significant differences between psychological treatment for AN and control conditions on weight gain, eating disorder pathology or and quality of life. This finding has been supported by another systematic review and meta-analysis by Solmi et al. (2021), which also found no psychotherapeutic interventions currently recommended for AN to outperformed treatment as usual in regards to BMI and clinical symptoms. Furthermore, pharmacotherapy for AN has little or no effect and has shown low acceptability among patients (Attia et al., 2019; Davis & Attia, 2017; Lebow, Sim, Erwin, & Murad, 2013). Moreover, regarding the treatments that do exist, treatment drop-out rates are high (Dejong, Broadbent, & Schmidt, 2012; Linardon, Hindle, & Brennan, 2018) and recurring relapse is common (Berends, Boonstra, & van Elburg, 2018).

The poor treatment outcomes of existing therapies highlight the need to develop novel, evidence-based treatments that are effective and efficient (Wonderlich, Bulik, Schmidt, Steiger, & Hoek, 2020; Zhu, Yang, Touyz, Park, & Hay, 2020). As the etiology of the disorder remains poorly understood, it has been argued that there are underlying vulnerability- and maintenance factors that have been overlooked and under-researched (Stice, 2002). These, have therefore not yet been adequately addressed in mainstream therapy for AN (Oldershaw et al., 2019). Also, experimental investigation of factors contributing to the illness is lacking (Glashouwer et al., 2020) and evidence of the impact of interventions upon proposed maintenance factors is scarce (Oldershaw et al., 2019).

This doctoral dissertation focussed on the investigation of three potential (overlooked) factors that may contribute to illness recovery, namely, the improvement of interoceptive ability, as well as individuals' feelings of power, and the use of body-centered interventions (i.e. interventions using bottom-up processing) for individuals with AN. The following three chapters will consider each of them in more detail and provide a rationale for including them in research regarding the development, maintenance and treatment of AN.
1.8.1 Interoception in Anorexia Nervosa

The theoretical approach by Bruch in 1962, proposing that interoceptive deficits are prevalent in individuals with AN, has recently been evidenced by two recent systematic reviews (Malighetti, Gaudio, Di Lernia, Gomez, & Riva, 2020; Martin et al., 2019) and one narrative review (Jacquemot & Park, 2020). However, outcomes have varied regarding the different facets of interoception. The evidence regarding interoceptive accuracy (IAcc) (as measured with the heartbeat detection task), remains mixed, with several studies findings reduced IAcc during the acute illness phase (Demartini et al., 2020; Di Lernia et al., 2018b; Pollatos et al., 2016) and after a course of treatment (CBT) (Fischer et al., 2016; Pollatos et al., 2016; Pollatos et al., 2008), compared to individuals without AN. Other studies found no differences between individuals with and without AN in regards to IAcc (Ambrosecchia et al., 2017; Demartini et al., 2017; Kinnaird, Stewart, & Tchanturia, 2020; Lutz et al., 2019; Richard et al., 2019). Inconsistencies in the findings have been attributed to the variability of the samples (in- or outpatients, recovered patients), differences in sample sizes, differentiation between AN subtypes, duration of AN, comorbidities, as well as heterogeneity in weight and treatment progress (Richard et al., 2019). However, in regards to interoceptive sensitivity (IS) there seem to be more consistent results with several studies showing lower IS in individuals with AN during the acute illness phase, compared to controls, measures by confidence in performance on the HBTT (Di Lernia et al., 2018a; Kinnaird et al., 2020) and self-reported questionnaires (Fischer et al., 2016; Jenkinson, Taylor, & Laws, 2018). Although, one study by Lutz et al. (2019) found no differences in IS between individuals with and without AN. The observation of low IS in AN is in keeping with the often reported failure to distinguish hunger and satiety, as well as an overall mistrust in their body (Brown et al., 2020b). Regarding the aforementioned studies, it is noteworthy, that most of the research has been carried out on women and evidence regarding IAcc and IS in men is scarce (Martin et al., 2019), with no study having assessed IAcc/IS in men only.

It is further important to note, that studies that focussed on the perception of other than cardiac signals, such as gastric signals and pain sensitivity, also supported a reduced IAcc
in AN (see Malighetti et al. (2020) and Martin et al. (2019) for reviews). Altered interoceptive processing in AN has further been highlighted by neuroimaging studies, especially regarding altered activation of the insular cortex (see Nunn et al. (2011) and Curzio et al. (2020) for a more updated review). In this context, altered neural and physiological responses to hunger signals (Monteleone & Maj, 2013) and heartbeat- and stomach attention (Kerr et al., 2016) have been reported. Importantly, a study by Curzio and colleagues (2020) showed a significant reduction of gray matter volume in the insular of adolescent patients with AN compared to non-AN controls. This study is important, as patients did not have a long illness duration, reducing the possibility of volume reduction as consequence of starvation, thereby underlining that anatomical brain alteration of the insular could contribute towards illness onset (Curzio et al., 2020).

Considering deficits in interoception and AN further, a novel approach linking the development and maintenance of AN to deficits in interoceptive processing has been proposed by Barca and Pezzulo (2020). They assume that starvation serves as a function of reducing interoceptive uncertainty (Barca & Pezzulo, 2020). Interoceptive uncertainty arises from interoceptive streams which are abnormally 'noisy' (i.e. of low precision due to low signal-to-noise ratio), which lead to a poorer perception of bodily states and hinder the development of well-differentiated internal models that correctly distinguish bodily signals (e.g. between low versus high hunger) (as outlined in the context of disruptions in predictive coding processes in chapter 1.4). As interoception has been identified as crucial for an individual’s sense of self (Seth, 2013), the authors argue that abnormal interoceptive processing (i.e. noisy interoceptive streams) may lead to a diminished central coherence and a blurred perception of the self (Barca & Pezzulo, 2020). Thus, according to their theory, individuals with AN limit their food intake until starvation to maximize (i.e. amplify) the gain of their autonomic signals of hunger, thus, thereby reducing their interoceptive uncertainty, experiencing bodily signals more clearly and possibly gaining a sense of self-coherence and self-control (Barca & Pezzulo, 2020). Support for this hypothesis comes from non-clinical samples, where fasting has been found to lead to better IAcc (Herbert et al., 2012). Although the model by Barca and

Pezzulo (2020) remains to be tested, it could explain why individuals with AN find it so challenging to give up persistent dieting and food restriction.

In the context of AN and interoception, a great concern is that although low interoception has been suggested as one of the three core psychopathological features of patients with eating disorders by Bruch in 1962, and systematic reviews, that are now over 15 years old identified it as a risk factor (Jacobi et al., 2004) and there is increasing evidence of disturbed interoceptive processing in AN (Malighetti et al., 2020; Martin et al., 2019) - to date - no effective intervention exists that can enhance interoceptive ability in AN. As Jacquemot and Park (2020), that conducted a narrative review on interoception in AN, pointed out "despite recent attention towards interoceptive awareness and sensitivity in the eating disorders literature, the application of these principles in treatment has received minimal attention". Until today, only two studies tried to manipulate interoceptive ability in AN. Based on a study by Ainley et al., (2012) that showed improvements of baseline IAcc after a self-focus induction in a non-clinical sample, Pollatos et al. (2016) conducted a similar study in women with AN. They investigated whether individuals' IAcc would increase during a self-focus condition, as opposed to an other-focus condition, in individuals with AN, in comparison to a non-clinical sample (Pollatos et al., 2016). IAcc was lower in the self-focus condition than in the other-focus condition in individuals with AN, whereas the opposite effect was observed in the non-clinical sample (Pollatos et al., 2016). As aforementioned in chapter 1.5, the authors explained this finding with body confrontation diminishing any beneficial effect through the induction of body-related avoidance. It is, however, not clear whether IAcc improved or decreased compared to baseline directly after the invention, as this comparison was not the focus of the study (Lucci & Patrikelis, 2017). Another study by Demartini et al. (2020) investigated whether a single yoga session could improve IAcc in individuals with AN through inductions of body-focus. Improvements were observed in the non-clinical group, but not in the AN group (Demartini et al., 2020). This dissertation tries to contribute to breaching the gap in the literature further, by investigating whether individuals with AN could benefit from power posing in regards to interoceptive ability (based on the pathways outline in chapter 1.6.1 and figure 2) (study III). The rationale for this particular approach will be described in more detail in the following two chapter.
1.8.2 Power and Anorexia Nervosa

"I started to become aware that the anorexia wasn’t a choice - it was a reaction. As a teenage girl, the only thing I could control was my body because I had no power."

- Woman recovered from chronic AN, in Dawson, Rhodes, & Touyz (2014, p. 500)

"Betty explained that losing weight was giving her power, that each pound lost was like a treasure that added to her power. This accumulation of power was giving her another kind of 'weight', the right to be recognized as an individual"

- In 'The golden cage: The enigma of anorexia nervosa.' Hilde Bruch (1978)

There are several sources of evidence suggesting that subjective feelings of power(lessness) may play a crucial role in regards to the development and maintenance of AN. These include theoretical models established by clinicians and researchers that have integrated feelings of powerlessness as an important factor regarding AN, qualitative findings from interviews and reports of patients, as well as quantitative data (from experimental and prospective research) that showed that the presence or absence of felt power appears to be highly relevant regarding eating disorder symptomatology.

Considering theoretical models of AN first, several of them have suggested that feelings of powerlessness are central to illness onset and maintenance. For example, in one of the early models of the illness, Bruch (1979, p. 59), described that individuals with AN experience an "all pervasive sense of having no control over their life or their relations to others". As a consequence, AN serves as a way of defeating feelings of powerlessness, as their body "becomes the only area of exercising control" (Bruch, 1979, p. 59). Furthermore, in the cognitive model of AN by Wolff and Serpell (1998), ‘I am powerless’ is regarded as one of three core dysfunctional assumptions. Other models of AN, such as the cognitive-interpersonal maintenance model of AN by Schmidt and Treasure (2006) (also see Treasure and Schmidt (2013) and Treasure et al. (2020) for revised and extended versions of the model), include interpersonal difficulties as a risk factor for illness onset and maintenance. The authors describe AN 'a manoeuvre with complex defensive functions, which has the effect of reducing social threat' (Schmid &
Thus, the majority of theoretical models that attempt to explain the development and maintenance of AN acknowledge that the avoidance of social threat, difficulties in social relationships and social anxiety play an important role in the onset and course of AN.

The described theoretical assumptions are supported by qualitative research. As outlined in chapter 1.7 power has a relational nature and is primarily defined as the potential influence over others (Keltner et al., 2003), or the asymmetrical control over valued resources (Fiske & Berdahl, 2007). In this regard, several studies have found that individuals with AN often experience themselves as inferior to others and of a lower social rank (Bellew, Gilbert, Mills, McEwan, & Gale, 2006; Connan, Troop, Landau, Campbell, & Treasure, 2007). They also score higher on measures of submissive behaviour and unfavourable social comparison than individuals without AN (Oldershaw, Lavender, Sallis, Stahl, & Schmidt, 2015; Troop, Allan, Treasure, & Katzman, 2003). For example, a study by Cardi and colleagues (2014) showed that compared to controls without eating disorders, individuals with AN and Bulimia Nervosa displayed a higher vigilance to social rank cues, higher levels of submissive behaviours, more negative expectations regarding others' views of themselves and more unfavorable social comparisons. Another study by Cardi et al. (2017) also found that, compared to individuals without AN, individuals with AN display a negative interpretation bias towards ambiguous social scenarios and report higher levels of rejection sensitivity. The described findings are supported by a systematic review and meta-analysis regarding social processing in AN that identified that individuals with AN experience a reduced sense of agency ($d = .38$), as well as a high sensitivity to social dominance ($d = 1.08$) (Caglar-Nazali et al., 2014).

Semi-structured interviews conducted with individuals with AN further revealed that the majority of them experience feelings of **powerlessness during the acute illness phase** (Woolrich et al., 2006). In this context, they often experience power struggles with their family members, parents and in intimate relationships (Cardi et al., 2018; Schwitzer, Rodriguez, Thomas, & Salimi, 2001) as well as with their therapists in inpatient care (Offord, Turner, & Cooper, 2006). Some forms of therapeutic interventions are perceived as over-controlling, leaving them feeling powerless and defeated (Offord et al., 2006).
Furthermore, there are also three studies that highlighted the potential impact of perceived **powerlessness before the onset of AN**. A study by Copeland et al. (2015) found that victims of bullying (i.e. a form of social control) were at increased risk for symptoms of anorexia nervosa and associated features. This association persisted after accounting for prior eating disorder symptom status, pre-existing psychiatric status and family adversities (Copeland et al., 2015). Thus, being under the social control of someone else can be considered a risk factor of AN symptomatology. Another qualitative study by Westwood and colleagues (2016) regarding patients' views of illness etiology identified the experience of social concern (including fear of social exclusion, judgment and not fitting in) before the onset of AN, as the strongest theme emerging. In this regard, all participants described difficulties with friendship prior to the onset of their ED (Westwood et al., 2016), with a particular fear of rejection by others. Finally, a study by Cardi et al. (2018) highlighted that a large majority of individuals with AN recall early social difficulties (especially involuntary submissiveness) before illness onset and recognized that these had played a role in the development of the illness.

An emotion that is highly associated with low social rank (i.e. low subjective feelings of power) is **shame** (Gilbert, 2000). Shame often result from some form of social rejection or put-down (Gilbert, 2000). A recent systematic review by Blythin (2020) showed that shame is common in those with AN and is positively associated with the severity of symptoms, and the onset of eating disorder-related difficulties. In this regard, a study by Matos et al. (2015) also showed that traumatic shame memories significantly correlated with unfavourable social rank perceptions and with increased eating psychopathology severity. In this context, Goss and Gilbert (2002) proposed that weight-loss behaviours in AN could provide a temporary sense of increased rank. In line with this proposition, Ma and Kelly (2020) recently found that in the anticipation and immediate aftermath of exercise, individuals with AN experience higher feelings of pride and lower feeling of shame (i.e. an emotional state associated with a higher social rank (Gilbert, 2000)) but, after time passes, feelings of pride reduce again and feelings of shame increase. The described findings are in keeping with the aforementioned subjective reports of patients highlighting that the experience of a low social rank (characterized by
fear of rejection, social exclusion and judgment) played an important role in the onset of the disorder.

In support of the assumption that AN serves as a way of defeating inferiority and low social rank, there are further quantitative studies underlining that low subjective feelings of power are relevant regarding food consumption, disordered eating and other AN psychopathology. For example, the aforementioned study by Cardi et al. (2018) also found that that involuntary submissiveness and fear of negative evaluation predicted eating disorder symptoms. In keeping with this observation, another study by Troop and colleagues (2003) found that submissive behaviour and unfavourable social comparison in AN were significantly related to the severity of eating disorder symptoms, even after controlling for depressive symptoms and other psychopathology. In a follow-up study, Troop et al. (2014), confirmed their initial findings by showing that low social rank predicted an increase in anorexic (but not bulimic symptoms) over 6 months. In particular, those who were low in self-reported rank were also more likely to increase their anorexic symptoms than those with high self-reported rank (Troop et al., 2014).

A similar link between low power and eating disorder symptoms has been shown in non-clinical populations. For example, Fitzsimmons-Craft, Ciao and Accurso, (2016) found that social comparisons were associated with later disordered eating thoughts and behaviours (e.g., thoughts about restriction and exercise) in college students. In this context, the need to strive to avoid inferiority has also been found to be positively associated with eating attitudes and appearance anxiety in students (Bellew et al., 2006), as well as with higher disordered eating in women in the general population (Ferreira & Mendes, 2020).

Regarding body dissatisfaction, which has also been identified as a key precipitating and maintaining factor of AN (Stice & Shaw, 2002), a study by Pinto-Gouveia, Ferreira and Duarte (2014) (that also included AN patients), found that 51 percent of body dissatisfaction could be explained by social ranking. Thus, the aforementioned studies highlight the importance of social rank mentality on eating disorder symptomatology.

Further evidence for this link comes from studies that have manipulated subjective feelings of power and examined effects on food intake. For example, a study by Guinote
(2010), that was previously mentioned in chapter 1.6.1, manipulated power through priming and found that hunger predicted food intake in powerful but not in powerless individuals and powerful individuals consumed more appetizing and less non-appetizing food compared to powerless individuals. Although no previous study replicated these results in a sample of individuals with diagnosed AN, Kunstman, Smith, and Maner (2014) conducted a similar study including participants with AN symptoms. They found that experiencing power could increase caloric intake in individuals with high self-oriented perfectionism (Kunstman et al., 2014). The authors concluded that the induction of power may be a protective factor against the development of maladaptive eating patterns (Kunstman et al., 2014). This conclusion is in keeping with a meta-synthesis by Duncan, Sebar and Lee (2015) that explored the process of recovering from AN based on qualitative data. They found that the 'repossession of personal control and power' emerged as central to illness recovery (Duncan et al., 2015).

Despite theoretical models highlighting the importance of powerlessness in regards to illness onset and maintenance, as well as a growing body of research supporting the theoretical assumptions by underlining the presence of low subjective feeling of power in AN, concrete treatment interventions that are effective in improving feelings of powerlessness, are very limited. In this regard, although there has been a call to design treatments that target AN symptoms through the lens of social rank theory (Ma & Kelly, 2020; Troop et al., 2014), subjective feelings of power (i.e. in terms of low social rank) are rarely addressed in mainstream therapy. Rather, the focus of therapy is often set on reducing individuals obsession with the control of their weight and shape (Stanghellini, Daga, & Ricca, 2020). As Woolrich, Cooper and Turner (2006, p. 737) pointed out "In general, while different terms are used (powerlessness, personal ineffectiveness, lack of personal control, lack of agency), it seems that cognitive, systemic and psychodynamic theories converge on the hypothesis that a sense of powerlessness, in particular, is present in AN. However, powerlessness has not been given a great deal of attention... In contrast, ‘control’... has usually been conceptualised as a strong “need for control,” focused predominantly on eating, and not as an experience of pervasive lack of control over one’s life in general (as it was originally conceptualised by Bruch)."
In this context, it is important to note that feelings of powerlessness are also often not an integral part of AN specific assessment tools (Woolrich et al., 2006), which can lead to them being overlooked in standardized treatment. This is concerning, as social rank related topics seem to play a much more important part regarding the catastrophic worries of individuals with AN, than eating disorder-specific worries. A study, by Sternheim and colleagues (2012) showed that individuals’ fear of rejection or abandonment and fear of being negatively judged by others accounted for 42 % of worries, compared to only 1 % of eating disorder-specific worries.

Although tailored treatments regarding subjective power in individuals with AN are limited, some treatments have aimed at reducing individuals’ feelings of social threat. These include, for example, attentional bias training (e.g. a computer-based intervention that targets implicit negative interpretations of social situations) (Cardi et al., 2015; Gober, Lazarov, & Bar-Haim, 2020; Turton, Cardi, Treasure, & Hirsch, 2018) and compassion-focused interventions (Goss & Allan, 2014). It remains to be explored at what stage during recovery and in regards to which symptomatology they are most beneficial to patients.

In this context, it further noteworthy that studies that apply a test-retest experimental design with individuals with AN remain very scarce in general (Glashouwer et al., 2020), but especially in regards to low subjective feelings of power. For example, no previous studies have tried to manipulate state subjective feelings of power with a particular intervention. Therefore, one of the aims of this dissertation was to test whether power posing could improve subjective feelings of power in AN (in the short term) (study III). This is very relevant in regards to the call to conduct more experimental research that can shed light on the causal factors maintaining AN (Glashouwer et al., 2020). Furthermore, all of the described studies in this chapter have focused on subjective, explicit power in AN, but no previous study has employed implicit power measures (e.g. the MMG by Sokolowski and colleagues (2000)) (see also chapter 1.7) in individuals with AN. It is unclear whether individuals with AN have higher or lower implicit power motives than non-AN controls and whether and how discrepancies in explicit power and implicit power motives relate to eating disorder relevant symptomatology.
### 1.8.3 Using Body-Focussed Interventions in the Treatment of Anorexia Nervosa

The recommended approaches in the treatment of AN are *talking* therapies (National Institute for Health and Care Excellence [NICE], (2017)). Body-centered interventions are often marginalized in mainstream therapy for AN (Kolnes, 2012). One reason therefore could be that not many research studies exist, that have focussed on bodily manipulations in AN (Savidaki, Demirtoka, & Rodriguez-Jimenez, 2020). However, the ones that have been conducted highlighted that body-centered interventions could be a valuable *complement* to talking therapies and behavioural interventions for AN (Artoni et al., 2020). For example, a study by Artoni et al. (2020) compared TAU to TAU and a body perception training. The body perception training combined several therapeutic techniques, such as psychoeducation, relaxation, self-perception, body-oriented exercises as well as a subsequent reflection of the experience (Artoni et al., 2020). In particular, the interoceptive, proprioceptive (e.g., movement and body position in space), and tactile systems were targeted (Artoni et al., 2020). The authors observed significantly higher improvements in the combined approach of body perception training and TAU compared to TAU for all the psychometric variables considered (including body uneasiness and general/eating disorder-specific symptomatology) (Artoni et al., 2020). Another, very small-scale pilot study including AN patients, by Savidaki, Demirtoka and Rodríguez-Jiménez (2020) compared dance movement therapy with TAU. The authors found that the dance movement group significantly improved in self-reported body satisfaction, as well as appearance evaluation- and appearance orientation compared to the TAU group. The qualitative assessments of the experience of the patients in the dance movement group also showed that they reported that the intervention had a positive effect on their mood, helping them feel more cheerful or motivated, and less anxious, confused or angry (Savidaki et al., 2020). Thus, based on these preliminary studies it seems to be promising to integrate interventions that focus on the body into therapy.

There are two further studies that have found beneficial effects of posture manipulation on eating disorder pathology outcomes in non-clinical samples. Firstly, in a study by Miragall et al. (2018) individuals with high body dissatisfaction scores were instructed to either adopt an expansive bodily posture or a restrictive bodily posture, whilst undergoing...
a mirror exposure task (i.e. a confrontational task that is often used in the treatment of AN). The group that had adopted an expansive bodily posture reported significantly more positive emotions after the task than the group that had adopted a restrictive bodily posture (Miragall et al., 2018). The positive emotions, in turn, lead to improvements in negative emotions, body image satisfaction, and appraisal of the person’s own body (Miragall et al., 2018). Another study by Allan, Gervais and Smith (2013) examined whether women's posture moderated the relationship between body shape concern and restrained eating. They found that, at high levels of body shape concern, women sitting in expansive postures restrained their eating less compared to women sitting in constrictive postures (Allen et al., 2013). Importantly, the result of the study also showed that spontaneously adopted expansive (vs. spontaneously adopted constrictive) postures were associated with less restrained eating (Allen et al., 2013).

A further reason to integrate body-centered interventions into the treatment of AN comes from a recent finding by Rossi et al. (2021), which highlighted that the outcomes of one of the main recommended therapies for AN (i.e. enhanced cognitive behavioural therapy (CBT-E) (NICE, 2017)) were mediated by individuals' variation in, what they called, ‘embodiment disorder’. They defined embodiment disorder as the result of two phenomena: a deep affection of coenaesthesia (i.e. the loss of the capacity of experiencing one’s own body “from within”) and, as a form of compensation to it, an over-reliance on the gaze of others to feel oneself as an embodied self” (Rossi et al., 2021). The authors found that higher levels of embodiment disorder predicted increased diagnostic instability and the amelioration of the embodiment disorder mediated the decrease in both ED-specific psychopathology and body uneasiness (Rossi et al., 2021). Thus, by offering individuals with AN more interventions that foster the experience of the body (including modules specifically aimed at addressing interoceptive deficits), mainstream therapy for AN could, potentially, become more efficient (Rossi et al., 2021).

Promoting the experience of the body from a first-person perspective in therapy would also be in keeping with novel neuro-scientific conceptualisations of AN. For example, the allocentric lock hypothesis (ALH) proposes that individuals’ body experience is based
on an egocentric as well as an allocentric frame (Riva, 2012; Riva & Gaudio, 2012). The egocentric frame reflects the present state of the body (i.e. body as a reference of the first-person experience) (Riva, 2012). It is constantly updated via real-time input from different sensations and perceptions (Riva, 2012). On the other hand, the allocentric frame refers to an individuals' long-term body memory (i.e. the body as an object in the physical world; third person perspective) (Riva & Gaudio, 2012). The allocentric frame includes knowledge, attitudes and stored representations of the body (Riva, 2012). Whereas the two frames influence each other in healthy individuals (e.g. real-life sensory signals update allocentric body representations), the process appears to be impaired in AN patients (Artoni et al., 2020; Riva, 2012). This leaves individuals with AN ‘locked in’ their allocentric frame, unable to update the stored representations of their body (Riva & Gaudio, 2018; Serino et al., 2015). Consequently, they also cannot correctly identify and respond to relevant interoceptive signals that predict pleasant or unpleasant consequences, which in turn, restricts their emotion regulation capacity (Riva & Dakanalis, 2018). Based on the allocentric lock hypothesis (ALH), the enhancement of interoceptive ability via body-focused interventions and first-person experiences of the body (egocentric, embodied frame) could be helpful to produce an attentional shift from an allocentric memory of oneself to an embodied, egocentric one.

When talking about body-centered intervention it is further important to distinguish between interventions where the participant is instructed to move/hold/experience the body in a particular way or interventions whereby the participant is asked to observe the own body in some form (e.g. via video recording or the mirror). Based on the aforementioned studies and theories, it can be assumed that body-centered interventions that promote the individuals' experience of the body from a first-person perspective (i.e. through feeling the body in different postures or movements in space) are more beneficial to AN patients than interventions that rely on body surveillance, as these, in turn, might promote the objectification of the body. This could also explain why some studies found no advantage of adding 'body-centered' interventions to TAU (Fernández, Turon, Siegfried, Meermann, & Vallejo, 1995), as they primarily used video-, mirror- or virtual reality body confrontation with the patient (Ziser et al., 2018), rather than focusing on the
first-person experience of the body through manipulation of bodily posture per se, or the mindful experience of the body in movement.

When making a case for the use of body-centered interventions in the treatment for AN, it is further important to point out that individuals with AN often display poor bodily posture, which is rarely addressed in mainstream therapy. In particular, they have been found to show reduced body contact, a constrained breathing pattern, extensive muscular tension, as well as a lack of postural stability (Kolnes, 2012). In detail, they also show de-alignments in the position of the trunk, including an increased extension of the lower back and an anteriorly tilted pelvis, protracted and elevated shoulders as well as a forward position of the head (Kolnes, 2017). Besides, hypothermia is common in AN patients and they often report feeling cold (Birmingham, Gutierrez, Jonat, & Beumont, 2004; Carrera et al., 2012). This, in turn, can further foster the adaptation of a more restricted bodily posture to counteract and minimize heat loss (Daanen & Van Marken Lichtenbelt, 2016). Thus, regarding their whole body, individuals with AN have been described to adopt a stooped bodily posture (Bruch, 1978; Probst et al., 2013), rather than an expansive or open bodily display. This observation is concerning, as stooped bodily postures have been associated with depressed mood (Michalak et al., 2014; Wilkes et al., 2017), difficulty in recovering from negative affect (Veenstra et al., 2017) as well as disadvantageous cognitive processes (Brriñol et al., 2009; Miragall et al., 2020) (as described in chapter 1.6). Thus, in light of the dynamic interplay and the bi-directional relationship between bodily postures, emotions and cognition (Fuchs & Koch, 2014; Niedenthal, 2007), chronically adopting a stooped bodily posture could possibly maintain sensory feedback loops that enhance or maintain negative affective states and cognitive processes in AN. In this regard, it seems worthwhile to investigate, how actively changing bodily posture (i.e. an intervention that is making use of bottom-up processing) could affect areas such as body perception, affect, arousal and feelings in AN patients.

Applying power posing, in particular, in individuals with AN could have several benefits. Firstly, it is a non-verbal and body-focussed intervention. It, therefore, encompasses problems regarding diminished concentration/attention that can occur as a
result of starvation, and interfere with the therapeutic process as well as classic CBT techniques (e.g. cognitive restructuring). Furthermore, the intervention does not require individuals to think differently, but simply to stand or hold their body differently, which may make it more acceptable to patients. This point may be particularly relevant in regards to the egosyntonic nature of the disorder, that often promoted resistance to change (Vitousek, Watson, & Wilson, 1998). The postures are also easy to learn and can practically be applied everywhere. Using power posing in therapy also takes away the focus from talking to the therapist about the body (objectification of the body) to experiencing the body and its functionality through posture and movement (subjective perspective). It also is a novel intervention, that many individuals with AN have probably not tried out yet. This can be helpful in regards to the felt hopelessness that can occur after having undergone many hospital admissions and mainstream therapy without (lasting) success.

In conclusion of this chapter, there are four key reasons why body-centered interventions in general (and the practice of power posing in particular), could potentially be beneficial for individuals with AN. Firstly, novel theoretical models highlight the importance of the integration of the body for therapeutic change. Secondly, the findings that the degree of disruption in embodiment hinder efficacy of CBT-E underline the need to address body-focused treatments that promote the experience of the body 'from within'. Thirdly, preliminary studies have shown benefits of body-based interventions for AN. Finally, the application of body-centered interventions (including power posing) is an easily-applicable and low-cost method that could offer a novel treatment experience for individuals with a long history of AN.
2. Summary of the Research Studies

For an overview of the four published research studies that were conducted for this dissertation please see table 1 (p. 72). The following paragraphs will summarize each research article in turn, including its background and research rationale, hypotheses, method, results and discussion. For the full-length articles please refer to appendix A. The discussions of the results will be held brief in this chapter, as they will be discussed in more detail in the general discussion (chapter 3).

2.1 Study I: Improving interoceptive ability through the practice of power posing


**Background:** Based on the assumption that higher subjective feelings of power could increase interoception through increases in self-focus (Moeini-Jazani et al., 2017), this pilot study aimed at testing whether power posing would lead to improvements in the different facets of interoception. It was hypothesised that one session of power posing would increase interoceptive accuracy (IAcc), interoceptive sensitivity (IS) and interoceptive awareness (IAw). It was further hypothesised that one session and one week of power posing would increase individuals’ subjective feelings of power.

**Method:** The study was conducted in the laboratories of Ulm University. It included 41 female students that were recruited via advertisements at the campus. Interoceptive accuracy (measured with the heartbeat tracking task), interoceptive sensibility (measured with the BPQ and confidence ratings), interoceptive awareness (measured using the Pearson correlation $r$ between IAcc and IS, as well as a novel approach using the POMP scoring method (Cohen, Cohen, Aiken, & West, 1999)) and subjective feelings of power were assessed, before and after a single session of power posing. Then, participants were randomly assigned to two conditions (daily power posing practice vs. no practice). The conditions alternated after one week. After the training week, the outcome variables were assessed again to investigate a possible practice effect.
**Results:** Regarding the short-term effects, it was found that a single power posing session significantly increased individuals’ interoceptive accuracy ($t(40) = -3.26, p = .002, d = .26$) (Figure 5) and subjective feelings of power (on the visual analogue scale) ($t(40) = -4.754; p < .001; d = 0.42$). However, no improvements regarding interoceptive sensitivity (confidence ratings and BPQ) were found (Figure 6 and 7). After one week of daily training, individuals displayed significantly reduced BPQ scores ($t(40) = 2.71; p = .010; d = 0.14$) (Figure 7), as well as significantly increased subjective power (Sense of Power Scale-6) scores, $t(40) = -3.62; p = .001; d = 0.36$. However, no effects on IAcc were observed after one week of training (Figure 5).

**FIGURE 5** | Interoceptive accuracy mean scores visualized by time point. Note. Error Bars represent SE.
FIGURE 6 | IS mean scores visualized by time point. Note. Error Bars represent SE.

FIGURE 7 | BPQ mean scores visualized by time point. Note. Error Bars represent SE.
Discussion: The findings of this initial study supported the theory that the induction of power via a powerful posture could foster the noticing of bodily signals – at least in the short-term. However, the effect of the power posing in regards to interoceptive accuracy may only be temporary and decrease when the posture is no longer held, as no training effect was observed after one week of practice. The lower BPQ scores could indicate, that regular power posing could reduce sensibility to unpleasant bodily sensations, as the BPQ primarily focusses on sensations that seem to be bothersome to the individual. The finding that power posing increased subjective feelings of power in the short-term and after training is in keeping with previous research. The results of this study will be discussed in more detail in the general discussion (chapter 3).

2.2 Study II: Effects of embodiment interventions on interoception and anxiety


Background: A large majority of research on power posing has focused on the comparison between powerful and slumped bodily postures. However, this is problematic, as the it makes it difficult to identify the true positive effect of the powerful postures and to disentangle it from the negative effect of the constricted postures (Crede, 2018). Therefore, recent reviews have highlighted the need to conduct more studies that compare powerful and neutral bodily postures (Elkjaer et al., 2020). Also, evidence regarding the effect of different bodily postures on anxiety remains scarce (Feldman et al., 2020). Therefore, the second study of this dissertation compared powerful and neutral bodily postures in regards to the different dimensions of interoception, as well as state- and trait anxiety. It was hypothesised that one power posing session would increase individuals’ interoceptive abilities and decrease their state anxiety compared to neutral posing. Also, two weeks of daily power posing were expected to increase individuals’ interoceptive abilities and to decrease trait anxiety scores compared to neutral posing.
**Method:** 57 individuals (12 males) were recruited at Ulm University and the local community. After participants had signed the informed consent form and before the testing in the laboratory began, participants filled out an online questionnaire collecting demographic and health-related data. At the day of testing, they were assigned to either a neutral- (n = 28) or a power posing condition (n = 29) (Figure 8 (Weineck et al., 2020)) via block randomization. Participants were tested one-by-one. The specific poses were firstly shown on a picture and then presented by the experimenter in person. Individuals were subsequently asked to adopt the poses themselves. After a short training session, that endured for as long as each participant needed to understand the correct adoption of the postures, an audiotape was played that guided the participants through the poses. The order in which the postures were adopted was fixed, and each pose was held for 45 seconds. Interoceptive accuracy, interoceptive sensibility (confidence ratings and BPQ), interoceptive awareness and anxiety levels were measured at baseline, after a single posing session and after one week- and after two weeks of training the neutral- or powerful poses (twice daily).

**FIGURE 8** | Comparison between powerful- and neutral postures
**Results:** Regarding the effect of power posing or neutral posing on interoceptive ability, mixed ANOVAs were calculated with the factors condition (neutral posing, power posing) and time (baseline; T1, T2, T3). Results showed a significant effect of time on IAcc, $F(2.68, 128.78) = 6.62, p = .001$, with a medium effect size (part.$\eta^2 = .121$) (Figure 9). No significant effect of condition ($F(1.48) = 0.12; p = .734$), and no significant interaction effect between time and condition were found, $F(2.68, 128.78) = 0.13, p = .927$. Post hoc tests with Bonferroni correction revealed a significant increase in IAcc from baseline to T1 ($p = .038$), to T2 ($p = .031$) and T3 ($p = .001$) for posing in general. Regarding the individual conditions, one reviewer requested the conduction of one-sided post hoc tests with Bonferroni correction. These revealed that there was a significant effect of time on IAcc for power posing from baseline to T1 ($t(26) = -3.076, p = .010; d = 0.26$) and from baseline to T3 ($t(26) = 3.77, p = .002; d = 0.42$). Regarding neutral posing, there was no significant effect of time from baseline to T1 ($t(25) = 1.95, p = .126$), but there was a significant effect of time from baseline to T3 ($t(23) = -2.51, p = .038; d = 0.37$). Nevertheless, power posing was not superior to neutral posing after a single session in regards to IAcc. Furthermore, no effects on interoceptive sensibility or interoceptive awareness were observed after one session, at T2 or at T3.

**FIGURE 9** | Interoceptive accuracy mean scores sorted by measurement point for powerful and neutral postures. Note. Error bars represent SE; * indicate significant effects for posing in general ($p < .050$).
Regarding anxiety, mixed ANOVAs were calculated with the factors condition (neutral posing, power posing) and time (baseline; after a single session of posing or baseline; after two weeks of training). Results showed a significant effect of time on state anxiety, \(F(1, 55) = 9.07, p = .004\), with a large effect (part.\(\eta^2 = .142\)). No significant effect of condition \((F(1,55) = 0.42; p = .520)\), and no significant interaction effect between time and condition were found, \(F(1, 55) = 0.13, p = .723\). Based on further request of a reviewer, one-sided post hoc tests with Bonferroni correction were conducted and revealed a significant decrease in state anxiety from baseline to T1 for power posing \((t(28) = 2.12, p = .043; d = 0.27)\), as well as for neutral posing \((t(27) = 2.22, p = .035; d = 0.20)\). No effects of posing on trait anxiety were found.

**Discussion:** Contrary to the hypothesis, power posing was not superior to holding a neutral posture in regards to the primary outcome variables. However, overall, posing in general helped to improve interoceptive accuracy and reduce state anxiety in students. When looking at the groups separately, power posing significantly increased IAcc in the short-term, whereas neutral posing only did so after two weeks of training. This finding warrants further exploration as it could indicate that power posing might have a stronger effect on IAcc than neutral posing after one session – even though it is not superior to neutral posing. One reason why the practice of the body-centered interventions yielded a significant effect on IAcc over time could be that both entailed open- or expansive bodily features that may have been novel to the participants (in comparison to their usual bodily posture) which could have fostered self-focus. Also, to adopt and maintain the postures correctly, individuals may have had to pay more attention to their body than they usually would. The study offers a rationale for designing body-based interventions for students as a pathway of reducing state anxiety. This is particularly important in light of the rising number of students with anxiety symptoms. This observation is confirmed by study II, as evidenced by the high baseline trait anxiety scores of the sample. The results of this study will be discussed in more detail and contrasted with study I and III in the general discussion (chapter 3).
2.3 Study III: Using bodily postures in the treatment of anorexia nervosa


**Background:** Effective treatments for adults with AN remain very limited (Wonderlich et al., 2020). At the same time, emerging theories and research suggest that it is highly important to improve interoceptive deficits in individuals with AN (Rossi et al., 2021) and to integrate body-centered intervention into treatment (Artoni et al., 2020). Also, subjective feelings of power are often low during the acute illness phase (Woolrich, Cooper, & Turner, 2008) and no effective and tailored interventions are available that can directly address this concern. Therefore, the study investigated whether power posing could be beneficial to individuals with AN and a control group without AN, in regard to interoception and affective states (including subjective power). It was hypothesised that one session of power posing would significantly increase interoceptive accuracy, interoceptive sensibility, feelings of power, and feelings of pleasantness as well as reduce self-reported feelings of arousal in both groups. Furthermore, it was expected that daily power posing practice (for one week) would increase interoceptive accuracy and interoceptive sensibility in both groups.

**Method:** The study included a total of 101 female participants. 50 inpatients and outpatients with AN were recruitment from treatment centers and clinics in- and nearby Munich. 51 normal-weight women were recruited at the campuses of Ulm University and Ludwig Maximilian University in Munich. The procedure of the study was closely related to study I. Firstly, interoceptive accuracy (measured with the heartbeat tracking task), interoceptive sensibility (measured with confidence ratings), as well as subjective feelings of power, arousal and pleasantness (measures with the SAM (Bradley & Lang, 1994)), were assessed at baseline and after a single power posing. Then, participants were randomly assigned to two conditions (daily power posing practice vs. no practice). The conditions alternated after one week. After the training week, IAcc and IS were assessed again to investigate a possible practice effect.
Results: Regarding the outcomes on interoception, there was a significant main effect of time \((F(1,97) = 7.51, p = .007, \text{part.}\eta^2 = .072)\) on interoceptive accuracy from baseline to T1, no main effect of group \((F(1,97) = 0.57; p = .453)\) and no interaction between time and group \((F(1,97) = 2.12, p = .148)\) (Figure 10). Thus, interoceptive accuracy improved after one power posing session in both groups. However, no effects were found regarding IAcc after one week of practice. Also, no significant main effects of time on interoceptive sensibility (regarding a single session and one week of training) were shown. Regarding affective states, significant main effects of time on individuals' feelings of dominance \((F(1,94) = 7.43, p = .008, \text{part.}\eta^2 = .073)\) and pleasantness \((F(1,94) = 7.49, p = .007, \text{part.}\eta^2 = .074)\) were found, with power posing increasing the two outcome variables after one session of practice. Importantly, compared to women without AN, women with AN displayed significantly lower interoceptive sensibility \((F(1,98) = 7.68; p = .007, \text{part.}\eta^2 = .073)\), pleasantness \((F(1,94) = 30.95; p < .001, \text{part.}\eta^2 = .248)\) and dominance \((F(1,94) = 29.39; p < .001, \text{part.}\eta^2 = .238)\), as well as higher self-reported arousal \((F(1,94) = 12.18; p = .001, \text{part.}\eta^2 = .115)\) (Figure 11). The dropout rate of the study was very low (3%).

FIGURE 10 | Interaction plot regarding interoceptive accuracy
**Discussion:** The results showed that power posing could potentially be beneficial for women with AN regarding IAcc, subjective feelings of power and pleasantness – in the short-term. It remains to be investigated whether, for example, longer periods of practice could improve the efficacy of the intervention. The finding of lower IS, subjective feelings of power and pleasantness, as well as higher self-reported arousal in AN is in keeping with previous research and warrants further attention, as these aspects could possibly represent maintenance factors of the illness. The low drop-out rate and positive feedback of the patients during the study point towards a potentially good acceptability of this body-centered intervention in AN patients. The results of this study will be discussed in more detail and contrasted with study I and II in the general discussion (chapter 3).
2.4 Study IV: Discrepancies between explicit power and implicit power motives


**Background:** Evidence regarding low subjective feelings of power in anorexia nervosa (AN) derived from interviews with patients (Woolrich et al., 2008) and questionnaires regarding submissiveness and social rank (Bellew et al., 2006; Connan et al., 2007). However, explicit power in individuals with AN has not yet been assessed with the validated Personal Sense of Power Scale by Anderson et al. (2012). Also, no previous study has applied *implicit* measures of power motives in this particular clinical population. Thus, it is unclear whether individuals with AN have similar implicit power motives as individuals without AN, or whether they display differences in this regard. Furthermore, discrepancies between explicit- and implicit motives have been linked to negative mental health outcomes (including stress, burnout and psychosomatic symptoms) (Kehr, 2004; Rawolle, Wallis, Badham, & Kehr, 2016). Therefore, it could be that discrepancies between explicit feelings of power and implicit power motives relate to symptomatology in AN and may represent a possible maintenance factor of the illness. As anxiety is highly prevalent among individuals with AN (Blinder et al., 2006), it seems worthwhile to investigate whether discrepancies between implicit power motives and explicit feelings of power could relate to this area. It was hypothesised that women with AN would display significantly lower explicit feelings of power (on the state- as well as the trait level) than women without AN (hypothesis I), that women with AN would have similar implicit power motives as women without AN (hypothesis II), that women with AN would show a higher discrepancy between explicit feelings of power and implicit power motives than women without AN (hypothesis III) and, finally, that discrepancies between implicit power motives and explicit feelings of power would be positively correlated with anxiety in individuals with AN (hypothesis IV).
**Method:** 53 female inpatients and outpatients with AN and 48 women without AN were included in the study. They were compared regarding their explicit feelings of power, implicit power motives and anxiety. Regarding explicit power, the aforementioned Personal Sense of Power Scale (trait focus) (Anderson et al., 2012) and a visual analog scale (state focus) was applied. Implicit power motives were investigated with the Multi-Motive Grid (MMG) (Sokolowski et al., 2000), which contains two dimensions of power (‘fear of losing power’ and ‘hope for power’). In addition, trait anxiety was measured with the State-Trait Anxiety Inventory (STAI) (Laux, Glanzmann, Schaffner, & Spielberger, 1981).

**Results:** As expected, explicit feelings of power were significantly lower in individuals with AN compared to non-AN participants, as evidenced by their VAS scores ($t(97) = 4.79, p < 0.001, d = .97$) (Figure 12) and Sense of Power Scale scores ($t(88.888) = 8.14, p < 0.001, d = 1.73$) (Figure 13). Also, in keeping with our hypothesis, no differences in implicit power motives were found when comparing the groups against each other, (MMG hope for power dimension: $t(99) = -0.29, p = .773$; MMG fear of losing power dimension: $t(99) = -1.47, p = .144$) (Figure 14). However, importantly, women with AN displayed similar levels of implicit fear of losing power and hope for power ($t(52) = 0.53, p = .595$), whereas woman without AN had significantly lower fear of losing power than hope for power ($t(47) = 2.17, p = .035$) (Figure 15). Hypothesis III was partially supported, as only a significant discrepancy between explicit power and the fear of losing power subscale of the MMG was found in individuals with AN ($t(99) = -2.16, p = .033, d = .43$). Lastly, supporting hypothesis IV, discrepancies between implicit power motives and explicit feelings of power were positively correlated with trait anxiety in AN patients (MMG FP/SOPS discrepancy and trait anxiety: $r = 0.271, p = 0.05$; MMG HP/SOPS discrepancy and trait anxiety: $r = 0.307, p = .025$) (Figure 16 and 17). An exploratory analysis further revealed a significant positive correlation between the implicit fear of losing power variable and the EDI-2 (a measure of eating disorder pathology) (Thiel & Paul, 2006).
FIGURE 12 | Means of the VAS power scale of women with and without AN

FIGURE 13 | Means of the Sense of Power Scale of women with and without AN
**FIGURE 14** | Means of the MMG power dimensions of women with and without AN.

**FIGURE 15** | Means of the MMG power dimensions separated by group.
FIGURE 16 | Scatterplot of the correlation between the Hope for Power (MMG)/Personal Sense of Power Scale discrepancy and trait anxiety in women with AN.

FIGURE 17 | Scatterplot of the correlation between the Fear of Losing Power (MMG)/Personal Sense of Power Scale discrepancy and trait anxiety in women with AN.
Discussion: In keeping with previous research findings, the study showed that individuals with AN display significantly lower explicit feelings of power (on the state and trait level) than individuals without AN. In this regard, the Personal Sense of Power Scale could be a valuable tool in therapy, to identify individuals’ subjective feelings of power in AN. Regarding implicit power motives, individuals with AN showed similar implicit power motives compared to individuals without AN. In this context, it is, however, important to note that women with AN displayed a similarly high fear of losing power as hope for power, whereas the fear of losing power was lower than the hope for power in the control group. In this regard, having similarly high fear of losing power and hope for power has been identified as a possible vulnerability factor for an approach-avoidance conflict (Schmalt, Sokolowski, & Langens, 2010). Therefore, it seems worthwhile to design interventions that can reduce the implicit fear of losing power in individuals with AN. This is particularly important, as the implicit fear of losing power was positively related to eating pathology in this study. The finding that the discrepancy between explicit feelings of power and implicit power motives was related to anxiety in AN further underlined the need to develop strategies that can successfully increase subjective, explicit feeling of power in AN to reduce this incongruence. Thus, in summary, the study highlighted that increasing explicit feelings of power and reducing the implicit fear of losing power in AN could represent a valuable treatment goal.
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<td>Using bodily postures to reduce anxiety and improve interoception: A comparison between powerful and neutral poses</td>
<td>Using bodily postures in the treatment of anorexia nervosa: Effects of power posing on interoception and affective states</td>
<td>Discrepancies between explicit feelings of power and implicit power motives are related to anxiety in women with anorexia nervosa</td>
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<tr>
<td><strong>Authors</strong></td>
<td>Weineck, Messner, Hauke &amp; Pollatos</td>
<td>Weineck, Schultchen, Hauke, Messner &amp; Pollatos</td>
<td>Weineck, Hauke, Lindemann, Lachenmeir, Schnebel, Karačić, Meule, Voderholzer &amp; Pollatos</td>
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<td>n = 57 (Students of Ulm University)</td>
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<td>n = 53 patients with AN</td>
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<td>Women with AN feel less powerful than women without AN, but show similar power motives. This discrepancy is related to anxiety in AN.</td>
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**TABLE 1 | Overview of the published research studies for this dissertation**
3. Discussion

The central aim of this dissertation was to investigate whether power posing could improve interoception and subjective feelings of power in participants with and without anorexia nervosa. Study I examined whether power posing could improve individuals’ baseline-score of IAcc, IS, IAw and self-reported power after one session and one week of training. Study II explored the robustness of the effects of power posing, by comparing powerful with neutral postures. Also, anxiety was chosen as an outcome variable, as it has rarely been studied in the context of power posing. Study III investigated whether the previously identified effects in regards to power posing could also be observed in individuals with AN. Finally, study IV assessed implicit feelings of power in individuals with AN and whether discrepancies between implicit and explicit power would relate to anxiety in this clinical cohort.

The following section will look at the primary outcome variables (IAcc, IS, IAw and feelings of power) in turn and compare and contrast the findings of the four different studies accordingly. Also, the results regarding anxiety and positive affect will be discussed in regards to study II and IV. Alongside the discussion of the studies, ideas for future research will be given. Then, the strengths and limitations of this dissertation will be outlined. Finally, an outlook will be given, including pathways of how the findings of this research, and power posing research in general, could be further expanded.

3.1. Interoception

Interoceptive accuracy

Regarding interceptive accuracy, study I-III supported the assumption that power posing could improve interoceptive accuracy in the short-term. In study I, individuals improved their baseline IAcc scores after a single power posing session. However, no improvements were found after one week of daily training. One the one hand, this finding supports the previous notion that power posing has an immediate, transient effect that decreases after the posture is no longer held (Jackson, Nault, Smart Richman, LaBelle, &
This explanation would be in keeping with the observation that bodily states change dynamically as a result of physical and context-dependent alterations (Critchley, Mathias, & Dolan, 2001; Maister et al., 2017). Alternatively, it could also be that lasting changes on the interoceptive level require longer periods of training. In this regard, a study by Borneman and Singer (2017) investigated whether contemplative practice could improve IAcc. The researchers found that effects on IAcc reached significance after 6 months of training and increased in effect size up to month 9 (Bornemann & Singer, 2017). Also, Fischer, Messner and Pollatos (2017) found no effects on IAcc after practicing a body-scan intervention for 4 weeks, they did, however, find a significant improvement after 8 weeks of training. In support of the idea that longer periods of power posing could be required to alter IAcc, study II found a significant effect of time of the embodiment interventions (power posing and neutral posing) after one session as well as two weeks of training. Whereas in study III, no significant effect of time on IAcc was found after one week of training. Thus, training power posing daily for two weeks could be advantageous to individuals in regards to IAcc.

On the other hand, however, improving IAcc in the long-term could also require interventions that use multisensory integration to improve IAcc (Schirmer-Mokwa et al., 2015). Considering this idea in more detail, it is assumed that the representation and experience of bodily states are influenced by different somatosensory signals (e.g., from interoceptive, exteroceptive, proprioceptive and vestibular modalities), as well as predictions that are based on stored information about the body (Blanke, Slater, & Serino, 2015; Riva, 2016; Seth et al., 2012). Persistent alterations in IAcc may therefore require the integration of signals from the inner organs with metacognitive perceptions of the body (Malighetti et al., 2020), as well as a reflection of the bodily experience in a social context (Riva, 2018). In other words, a modification of multiple layers of body memory could be required to alter IAcc in the long-term (Riva, 2018). Thus, following the intervention-model by Artoni et al. (2020) that incorporated self-perception, body-oriented exercises as well as a subsequent reflection of the experience, it could be beneficial to practice power posing regularly, alone or in a group, as well as in different contexts and to reflect the experience through dialogue and non-verbal interventions (e.g., by painting the bodily experience (Christensen et al., 2018)).
Considering the results regarding IAcc further, **study II** expanded the initial results of **study I** by showing that power posing was not superior to neutral posing, as a significant effect of time for posing in general (i.e., in the short-term and after two weeks of training) and no significant group effect or interaction effect was found. In this regard, it is important to note that the neutral postures were neutral in the sense that they lacked the previously identified bodily features of power (Carney et al., 2005). However, as the study design did not control for the way individuals were usually standing or sitting, the neutral postures may have included elements of openness and expansiveness that were novel to the participants. For example, in hindsight, it was discovered that the second neutral pose (see Fig 6), which has previously been used as a neutral comparison posture in other studies (Smith & Apicella, 2017) is closely related to a foundational yoga posture called *tadasana*. Tadasana, in turn, has been found to alter heart rate variability (Sarang & Telles, 2006). Thus, the neutral postures may have also had effects, as they allowed the individuals to experience their bodies in a way that diverged from their habitual posture. Moreover, adopting the neutral postures may have fostered a form of self-focus, through the monitoring of the correct adaptation of the poses that led to improvements in IAcc. Therefore, in future research, it would be beneficial to include a third condition, that required individuals to adopt their *usual* bodily posture.

Although power posing was not superior to neutral posing, based on the request of one peer-reviewer, a post hoc test regarding changes in IAcc sorted by group from baseline to t1 was conducted. The test showed that changes from baseline scores in IAcc were only significant in the power posing condition, but not in the neutral posing condition – thus, effects of improvements may be stronger for the power posing condition. Nevertheless, as no differences between the groups at t1 were shown, it might be sufficient to adopt an open, non-restricted bodily posture as opposed to a very expansive bodily posture in order to improve IAcc.

**Study III** further supported the previous findings from **study I** and **study II**. It showed that individuals with AN could also benefit from power posing in regards to IAcc in the short-term, as an overall significant main effect of time, no significant main effect of group and no significant interaction effect was found. This finding is important, as, to date, it is not clear how IAcc could be improved in individuals with AN. Power posing...
may be particularly beneficial in terms of increasing body-focus, as previous studies, that have tried to alter IAcc through yoga exercises, have not found beneficial effects on IAcc for individuals with AN (Demartini et al., 2020). The study further revealed no significant difference in IAcc between individuals without AN and individuals with AN at baseline. It, therefore, supports research that has found similar performance on the HBTT in individuals with AN and controls (Ambrosecchia et al., 2017; Demartini et al., 2017; Kinnaird et al., 2020; Lutz et al., 2019; Richard et al., 2019) as opposed to research that has found lower IAcc in individuals with AN (Demartini et al., 2020; Di Lernia et al., 2018b; Pollatos et al., 2016; Pollatos et al., 2008).

The results of study III, (as well as study I and II) also support theoretical frameworks on AN, such as the allocentric lock hypothesis (Riva, 2012, 2014) (chapter 1.8.3). The underlying assumptions of the ALH predict that body-focused interventions and first-person experiences of the body (egocentric, embodied frame) would help to produce an attentional shift from an allocentric memory of oneself to an embodied, egocentric one, thereby enhancing interoceptive ability. By showing that power posing can lead to better IAcc in individuals with and without AN in the short term, the findings of study III are in line with this theory. However, in hindsight, it would have been useful to have applied a measure that also investigated individual’s subjective sense of embodiment. For example, the Identity and Eating Disorders questionnaire (Stanghellini, Castellini, Brogna, Faravelli, & Ricca, 2012), which evaluates identity and embodiment in eating disorder patient could have been integrated. In particular, administering the subscale ‘feeling extraneous from one's own body’ before and after the intervention, could have shown whether the power poses led to a more pronounced experience of the body from a first-person perspective (egocentric frame) rather than a third-person perceptive (allocentric frame). In this regard, it would have also been interesting to explore whether and how the subjective experience of embodiment would relate to changes in IAcc. Also, it would be important to replicate and expand study III by adding power posing interventions (or body-focussed interventions in general, based on study II) to TAU and comparing it to TAU in individuals with AN. Based on the results of Artoni et al. (2020), which underlined the advantage of incorporating the body into
therapy by showing superiority to TAU on eating disorder-specific outcomes, as well as the findings by Fischer et al. (2016) that showed that IAcc does not seem to improve through standard CBT for AN, integrating power posing as an add-on in mainstream therapy could show whether it would be beneficial for individuals with low IAcc throughout the course of treatment.

*Interoceptive sensibility*

Regarding interoceptive sensibility study I-III offered little support for the assumption that power posing could improve IS. For example, none of the studies found an improvement in individuals’ confidence in their performance on the HBTT after a single session, one week- and two-weeks of power posing training. This finding goes against the hypothesis that power posing would increase IS. From a theoretical point of view, the initial hypothesis seemed reasonable, as confidence in one’s performance has been associated with the induction of power (Brinol, Petty, Valle, Rucker, & Becerra, 2007; Fast, Sivanathan, Mayer, & Galinsky, 2012). At the same time, however, performance confidence has also been shown to be a trait-like construct, that seems to remain stable across different tasks (Blais, Thompson, & Baranski, 2005; Pallier et al., 2002). Thus, it may be difficult to alter IS with a single intervention over a short time period. In keeping with this possibility, Fischer and colleagues (2017) found no significant increase in confidence scores after four weeks of body scan training, they did, however, report significant improvements after eight weeks of practice. Similarly, Parkin et al. (2014) found no changes in IS after one week of mindfulness practice, they did, however, report a significant increase in confidence rating scores after eight weeks of training. Based on the findings from study I-III as well as the aforementioned research, it would be important to replicate the studies to investigate whether confidence in performance on the HBTT would increase after several weeks of power posing practice.

Regarding the self-report measures of IS, there was only one significant finding, namely a reduction in individuals’ BPQ scores after one week of training the powerful postures in study I (compared to baseline). At first glance, this is finding contradicted our hypothesis that power posing would improve interoceptive sensibility, as the scores
decreased, rather than increased. However, taking a closer look at the questionnaire, it becomes apparent that most items reflect subjective sensations that seem to be bothersome to the individual (Mehling, 2016). Thus, one the one hand, they could be interpreted in the way that power posing may buffer against unpleasant bodily signals. However, this possible mechanism may have also been promoted by the shifting of focus between several anchor point of the body to maintain the postures correctly. Thus, individuals may have simultaneously trained a holistic body view, rather than attending to distinct aspects (i.e. unpleasant sensations) of the body. Therefore, the findings from study I should be interpreted with caution, especially because they were also not supported by study II, which found no changes in BPQ measures after two weeks of training power posing and neutral posing. To get a better understanding of the malleability of self-reported IS, future research could integrate other questionnaires, such as the Multidimensional Assessment of Interoceptive Awareness (MAIA) (Mehling, 2016), which makes a distinction between adaptive and maladaptive bodily awareness.

Considering the findings regarding IS in a clinical context, study III found that individuals with AN display significantly lower IS (measured by confidence on performance on the HBTT) than individuals without AN. This finding is congruent with a recent study by Kinnaird, (2020) which also found IS to be lower in individuals with AN, whilst displaying similar IAcc to controls. On the one hand, this finding could reflect low overall self-confidence of individuals with AN (Kastner, Lowe, & Gumz, 2019) (Kastner, Lowe, & Gumz, 2019), which may also lead to uncertainty regarding their performance on the HBTT. On the other hand, it could also reflect an AN specific interoceptive deficit, that represents a risk or maintenance factor of the illness (Jenkinson et al., 2018). Either way, the finding of lower IS in individuals with AN is concerning, as lower confidence ratings have also been found to correlate with higher eating disorder symptomatology in individuals with AN (Kinnaird et al., 2020). Thus, it would be important to investigate, whether improvements in IS in individuals with AN could be achieved through longer periods of practicing body-centered interventions, as reported by Parkin et al. (2014) and Fischer et al. (2016) in non-clinical samples.
Interoceptive awareness

The findings of diverging outcomes regarding IAcc and IS in study I-III (i.e. that power posing did not affect confidence scores, but did affect interoceptive accuracy in the short-term) is in keeping with the assumption that the different dimension of interoception are independent from one another (Forkmann et al., 2016; Garfinkel et al., 2015; Meessen et al., 2016). This is also supported by the finding that IAcc and IS did not correlate with each other at baseline, after one session of power posing and one week of training in study I, as well after two weeks of training in study II.

In regards to study III, the IAcc scores in individuals with AN were comparable to controls, but the IS scores were significantly lower. Also, as IAcc improved but confidence scores remained stable, the concordance between the two different dimensions was reduced. This pattern could also be observed in individuals without AN in study I (from baseline to T1), meaning that individuals did not integrate their increase in objective performance into their subjective belief about their performance. This discrepancy between IAcc and IS can be considered an ‘interoceptive prediction error’ (Garfinkel et al., 2016). What is still remains unclear, however, is how discrepancies between IS and IAcc may be related to other psychological outcomes. In this regard, in study I and study II a new way of expressing IAw has been introduced, using the pomp scoring method by Cohen (1999) (please see article II, p. 5 in Appendix A for a full description). By using this approach, a particular score that combines individuals’ results of IAcc and IS can be generated, allowing to record and track changes in IAw over time for each individual. This could be particularly helpful regarding future research that aims to relate IAw to other outcome variables or for single case studies in therapeutic settings (see e.g. Di Lernia et al. (2018b)), where a correlational analysis (between IAcc and IS) is not possible. Thus, it would be interesting to replicate study I-III over longer periods of power posing practice to see how IAw scores would change over time and also to explore whether and how changes in IAw scores would relate to other symptomatology that is prevalent in AN, such as embodiment disorder, hunger and satiety as well as anxiety.
3.2 Subjective Feelings of Power

Explicit and implicit power in the non-clinical samples

One of the most consistent findings of the power posing literature is that this intervention seems to increase subjective feelings of power (Cuddy et al., 2018; Gronau et al., 2017) (chapter 1.6.1). This dissertation included different measurements of individuals’ subjective power, namely a questionnaire (the Personal Sense of Power Scale), a semi-projective/implicit test (MMG) as well as visual analogue- and a pictorial assessment scale (SAM). Regarding explicit feeling of power, consistent with previous research, power posing significantly increase subjective feeling of power after a single power posing session (measured with the VAS) as well as the Personal Sense of Power Scale (short version) after one week of practicing the power poses (study I). Similarly, study III showed that a single session of power posing could significantly increase subjective power, assessed with pictorial assessment (SAM) in individuals with and without AN. Thus, these findings support that the manipulation of bodily postures can impact affective states through bottom-up processing.

Regarding implicit power measures, in study I, one week of power posing did not significantly affect individuals implicit power motives. On the one hand, it was seemed reasonable to assume that power posing could affect implicit power motives, as previous research has indicated that implicit motives could be aroused by confronting individuals with motive-specific cues (Rawolle et al., 2017; Schultheiss et al., 2004). The perception of the motive specific cue, in turn, could result in improved accessibility and possible malleability of the implicit motive network (Denzinger & Brandstätter, 2018). On the other hand, however, implicit motives have also been reported to be a stable part of individuals’ personality, thus, it may require longer periods of training for an implicit motive to change (Denzinger & Brandstätter, 2018). What can be concluded from study I, is that one week of power posing training is not long enough to affect individuals’ implicit power motives.

However, in this regard, it may be important to reconsider the way changes in implicit motives were defined. As study I was the first study that tried to experimentally
manipulate the MMG dimensions (fear of losing power and hope for power), it was exploratory in nature and therefore simply regarded changes in terms of changes in the mean scores of each dimension. However, changes could also be defined as the fear of losing power being reduced in comparison to the hope for power (FP < HP; net power = HP-FP) thus, implying a direction of change (Rheinberg & Engeser, 2010). Based on this, it seems worthwhile to continue to investigate how implicit power motives could be altered as a result of power posing practice by applying a different definition of change.

In hindsight, it would have also been valuable to have administered the MMG right after the first session of power posing practice to see whether the psychological arousal of the power postures would have also elicited changes on the state level of implicit power. Moreover, investigating changes after several weeks or months of power posing could also be important to understand whether longitudinal training programs of power posing could alter implicit motives. Thereby, it would be particularly interesting to investigate how short-term changes would relate to long-term changes, as Denzinger and Brandstätter (2018) recently argued that the situational susceptibility of implicit motives might be a precondition for long-term influences on implicit motives.

Explicit and implicit power in individuals with AN

Investigating stability and change in implicit motives also seems particularly relevant in light of the findings of study IV. At first, study IV revealed that individuals with AN display similar implicit levels of fear of losing power and hope for power. However, when looking at each group separately, individuals with AN displayed a similarly high fear of losing power as hope for power, whereas in individuals without AN, their hope for power was significantly higher than their fear of losing power. This finding is alarming, as having similarly high levels of fear of losing power and hope for power has been described as a vulnerability factor for an approach-avoidance conflict (Schmalt et al., 2010), which could be a potential stressor for individuals with AN. In this context, study IV also showed that individuals fear of losing power was significantly positively correlated with eating pathology.
It remains to be tested, whether the fear of losing power is a consequence of AN or a predisposing or maintenance factor, whereby AN serves as a way of defeating the fear of being overpowered. The latter possibility would be in keeping with the previously described observation that drive for thinness can be an attempt to reduce feelings of inferiority (Pinto-Gouveia et al., 2014) (chapter 1.8.2).

Either way, it is important to identify effective strategies that can reduce individuals fear of losing power. In this regard, it would be interesting to investigate if the repeated practice of power posing over the course of treatment could alter self-perceptions and affective states that foster the development of a ‘powerful’ self-concept. Improving subjective power is not only relevant in regards to implicit power, but also to explicit power, as study IV further revealed that individuals with AN also showed significantly lower subjective power than individuals without AN, as expected. This finding is in keeping with previous research on powerlessness in AN (Bellew et al., 2006; Connan et al., 2007) and further underlines the need to address this concern. In this regard, the Personal Sense of Power questionnaire, which was for the first time applied in an AN sample, showed good internal consistency ($\alpha = .831$) and could represent a valuable tool in therapy and research to assess subjective, explicit power. As study III indicated that power posing could also be beneficial to AN patients in terms of increasing state power, it should be further explored whether regularly training power posing could impact individuals dispositional subjective power. In this regard, a future study could compare a group of individuals with AN that receives power posing to a group of individuals that either receives TAU, or another body-centered intervention (e.g. yoga) over different periods of time. Also, it would be valuable to investigate, if power postures could help individuals with AN in situations, where they felt particularly powerless. For example, a study could examine subjective, state feelings of power at different times of the day (e.g. before or after meals, before or after exercise, in a social context) and subsequently investigate if power posing could be beneficial when feelings of powerlessness are prevalent. Importantly, as a next step, it would be important to explore whether power posing would also lead to less eating pathology (i.e. restrained eating) and more caloric intake, as previously reported in a non-clinical study by Allen et al. (2013).
Overall, the potential pathways of decreasing felt inferiority and increasing subjective feelings of power in AN still remain very limited. However, as aforementioned in chapter 1.8.2, computer-based training of cognitive bias modification has been suggested as one possible intervention (Cardi et al., 2015; Gober et al., 2020). As previous research has shown that cognitive processes are influenced by individuals’ bodily posture (Briñol et al., 2009; Harmon-Jones et al., 2015) (chapter 1.6), it would also be valuable to test whether the novel cognitive technique could be enhanced through the simultaneous adoption of a power pose. From a theoretical point of view, top-down processes (i.e. changing individuals’ social appraisal via a cognitive task) and bottom-up processes (i.e. feeling more powerful through power posing) could yield better effects than a purely top-down intervention, based on previous research in non-clinical samples (Peper et al., 2019). In this regard, Miragall et al. (2020) also found that upright (vs. stooped) posture led to more positive interpretations of ambiguous information. Thus, it would be interesting to replicate the studies regarding the training of cognitive bias modification with the added element of manipulating bodily posture in individuals with AN, to see whether it would promote a more neutral interpretation of ambiguous faces and social scenarios – and, subsequently, improve individual’s submissiveness and powerlessness.

3.3 Anxiety and Positive Affect

Reducing anxiety through bodily postures in individuals without AN

Aside from improving interoceptive ability, study III also aimed at reducing anxiety through bodily postures in individuals without AN. Firstly, it is important to note that the study supported previous research showing high levels of anxiety in student populations (Bayram & Bilgel, 2008). As aforementioned in article III (Appendix A), there is a growing body of evidence documenting the high burden of anxiety disorders and syndromes in university students, with some studies having shown a state anxiety prevalence of up to 81.7% and a trait anxiety prevalence of up to 85.6% (Brenneisen Mayer et al., 2016). In study III, the mean trait anxiety score was 40.04, which was just
above the cut-off score (of > 40) on the STAI that previous studies have chosen to identify minor and major anxiety symptomatology (Dennis, Coghlan, & Vigod, 2013). Similarly, in study IV, the mean trait anxiety score was 40.69 in the non-clinical control group. These findings further underline the need to develop effective interventions with anxiolytic effect in student populations.

Regarding the effects of bodily postures on anxiety, study III could show that neutral posing and power posing lead to a significant decrease in individuals’ state anxiety. Although, importantly, power posing was not superior to neutral posing in this regard. One explanation therefore could be that both posture sequences entailed elements of openness, as opposed to non-restrictiveness or slumped bodily features, which may have promoted reductions in state anxiety. As an underlying mechanism, the open and/or expansive postures may have activated the individuals’ behavioural approach system, which has been associated with positive affect, instead of the behavioural inhibition system, which has been associated with avoidance-related affect (e.g., anxiety) (Keltner et al., 2003). In this regard, a study by Hackford, Mackey and Broadbent (2018) showed that individuals who walked in an upright posture had significantly lower systolic blood pressure and galvanic skin response, but improved psychological states such as less low arousal negative affect, less sleepiness and less pain, than those who walked in a slumped walking posture. As an initial pilot study of power posing on anxiety, study III did not collect any physiological parameters that could explain the decreases in state anxiety on a biological level. It would, therefore, be valuable to replicate the study and to measure individuals’ heart rate, skin conductance response or EGG data whilst the different postures are adopted. Another explanation for the observed decrease in state anxiety could be that the adoption of powerful or neutral bodily postures also generated positive emotions, that had an anxiolytic effect. Some support for this observation is offered by study IV, where power posing increased self-reported pleasant affect in individuals with and without AN. Thus, when replicating study III it would be important to also assess the impact of the postures on positive emotions (e.g. pride), that may, subsequently, counteract anxiety.
Furthermore, it is important to note that the three postures were each adopted one after the other, entailing a form of movement in-between each new adaptation. This pattern could be similar to a form of meditative movement, which is characterized by a focus of awareness on the body and some form of prescribed or spontaneous movement (Larkey, Jahnke, Etnier, & Gonzalez, 2009; Payne & Crane-Godreau, 2013). Thus, as moving the body in space whilst maintaining self-focus can help to ameliorate anxiety (Payne & Crane-Godreau, 2013), it could be that the reductions in state anxiety in study III were due to the mindfulness movement of the body, rather than the postures per se. In this regard, it would be important to replicate the study with a group that simply adopted their natural or usual bodily posture whilst standing or sitting.

Regarding trait anxiety, study III did not find that two weeks of powerful- or neutral posing significantly increased individuals trait anxiety. On the one hand, it could be that changes in trait anxiety would require longer periods of practice to change. In this regard, a study by Ascì (2003) found a physical fitness programme to be effective in reducing trait anxiety in female university students after ten weeks of practice. Notably, the postures in study III were only adapted twice a day, once in the morning and once in the evening. Thus, it may not only require longer periods of practice but also more frequent training, in different social situations to evoke lasting anxiolytic changes. Another explanation for no effect on trait anxiety could be that the students were in their exam period at the time of the study. As test anxiety has previously been suggested as a form of situation-specific trait anxiety (Spielberger, 1972; Spielberger, Anton, & Bedell, 2015), it could also be that higher levels of test anxiety may have confounded individuals’ trait anxiety scores. Thus, to get a better understanding of the effects of the postures on trait anxiety, it could be beneficial to replicate the study in an exam-free period.

In summary, study III showed that embodiment interventions that include elements of adopting an open or expansive bodily posture whilst maintaining a self-focus can help to reduce state anxiety but not trait anxiety (after two weeks of practice) in student populations. As a next step, it would be valuable to investigate whether the regular, routine or spontaneous adaptation of an open or expansive bodily posture could help students in particular anxiety evoking situations.
Improving self-reported positive affect through power posing in individuals with and without AN

As aforementioned, individuals with and without AN in study IV showed improvements in their self-reported pleasant affect (on the non-verbal, pictorial SAM scale) after one session of power posing. This finding is in keeping previous research that showed that upright and expansible bodily displays are associated with and can lead to the reporting of more positive emotions in adults (Kozak, Roberts, & Patterson, 2014; Nair et al., 2015) and children (Körner, Köhler, & Schütz, 2020).

Looking at the descriptive, the improvement of positive affect in study III seems to have been primarily carried by the AN group. This finding is important, as previous studies have highlighted reduced feelings of pleasantness (Crucianelli, Cardi, Treasure, Jenkinson, & Fotopoulou, 2016; Tchanturia et al., 2012) as well as the presence of negative affect (Pila, Murray, Le Grange, Sawyer, & Hughes, 2019) in individuals with AN. In study III as well, women with AN showed significantly less self-reported pleasant affect than individuals without AN at baseline. As recent theoretical models of AN suggest that a dysregulation in positive affect contributes to illness maintenance, there has been a call to develop novel interventions that can increase positive affect in individuals with AN (Coniglio, Christensen, Haynos, Rienecke, & Selby, 2019). In this regard, study III is valuable as it indicates that power posing could be a helpful strategy to increase subjective feelings of pleasantness in individuals with AN.

The relationship between the discrepancy between implicit power motive and explicit feelings of power and anxiety in individuals with AN

Discrepancies between implicit and explicit motives have been described as a “hidden stressor” (Baumann, Kaschel, & Kuhl, 2005) and previous research has shown that they are associated with negative health outcomes such as stress, reduced life satisfaction, job burn-out, negative affect and unhealthy eating behaviour (Hofer, Chasiotis, & Campos, 2006; Job, Oertig, Brandstatter, & Allemand, 2010; Rawolle et al., 2016). Therefore, in
study IV, it was hypothesised that discrepancies in explicit feelings of power and implicit power motives would correlate with anxiety in women with AN. Anxiety was chosen as an outcome variable as it represents one of the key comorbidities in AN, with studies reporting rates as high as 56% (Blinder et al., 2006) (chapter 1.8). The findings of study III were in keeping with the proposed hypothesis, showing that trait anxiety significantly positively correlated with discrepancies between the fear of losing control dimensions and explicit feelings of power, as well as the hope for power dimension and explicit feelings of power. Therefore, decreasing the discrepancy between implicit power motives and explicit feelings of power could represent an important treatment goal. However, little is known about how this can be achieved. It can be hypothesised, that increasing subjective feelings of power would decrease the discrepancy between explicit and implicit subjective power and, thus, positively impact anxiety. To test this assumption, experimental research is needed. As study III revealed that power posing has a positive impact on individuals’ state feelings of power, it would be interesting to examine whether regular practice could increase individuals’ trait feelings of power, thereby, decreasing the discrepancy between explicit and implicit feelings of power. It could also be that by feeling more powerful on a state level (on a regular basis), individuals would decrease their implicit fear of losing power or increase their hope for power (i.e. the approach tendency of power). Either way, the approach of increasing subjective feelings of power would be congruent with the previously described systematic review meta-synthesis of qualitative research by Duncan et al. (2015) (chapter 1.8.2) that identified regaining subjective feelings of power as crucial for illness recovery.

3.4 The Experience of Practising Power Posing for Individuals with AN

In light of the notion that anecdotal information from clinicians can help to generate research new ideas (Enkin & Jadad, 1998), I allow myself to describe some of the situations that occurred and responses that I have received from patients in the context of study III. Firstly, it is important to note that patients showed a general interest in taking part in an intervention study that involved bodily postures. Also, the drop-out rate from
the study was very low (3%), which could indicate good acceptability. Those who dropped out of the study, did so because they were discharged by hospital staff, as they did not adhere to the clinic’s treatment protocol. Several of these patients sent me emails, saying how sad they felt that they could no longer take part in the study. In keeping with the ethical protocol, after the study was finished and patients were debriefed, I offered that participants could contact me, in case further questions arose or if the study impacted them in a way that required another conversation. Many patients then approached me, to request the results of the study (once the data was published) and asked me whether it would be possible to give them personal feedback because they wanted to know how well they could "feel" their bodies. One patient also said that practising the postures was very helpful to her and that she was wondering why the body has never been integrated like this in therapy before and whether I could recommend therapists that applied a body-centered approach. Another patient told me that she was very glad to have discovered power posing for herself and that she would continue to practice in her own time. Because patients often approached me when they saw me in the corridors of the clinic in-between sessions of data inputting (and there was little time and privacy for talking), the idea arose to do a spontaneous post-study workshop, where there were room and space to discuss their experiences with the body-focuses practices. Many of the patients signed up to the workshop, which took place on a Sunday at the clinic, several weeks after the end of the study. There was a lot of spontaneous talk regarding the relationship between individuals’ body and affective states. Some patients described how they notice their bodily postures changing depending on a situational context throughout the day. For example, that they always slept in a fetal bodily position, or that they had to stand with the back to the wall in group therapy sessions, because it made them ‘safer’. Another patient said that family members had commented that her body posture was more erect every time after being discharged from the hospital. Other patient described that she, at first, felt shame when practising the poses, because an inner voice told her that she does not deserve to feel ‘this way’. However, she noticed that the feelings of shame subsided with repeated practice and were replaced by positive affect after one week of training. Another patient said that “this is how I know I should feel. I am not there yet, but that’s where I want get to. I only feel this way when I do horse riding or dancing”. Other
patients said that the bodily postures felt “unusual”, but upon further exploration said that the unusual feeling did not have a negative valence. One patient also suggested that it could be valuable to train the power poses together with others in a group program. The workshop was well received and highlighted that it would be beneficial to apply a multi-modal model, that integrates the experience of body-centered interventions with a subsequent reflection upon it, as applied in the previously described studies by Artoni et al. (2020) and Savidaki et al. (2020) (chapter 1.8.3). After the workshop, one newly admitted patient that had heard about the study from other patients approached me to ask whether I could send her the audiotape (that was used to guide the participants through the movements during the study) so that she could try out the postures, even if she could no longer take part in the study. As a last anecdote, months after the study was completed, a colleague of mine (who worked at the inpatient clinic as a group therapist at the time) told me that when the patients of a group therapy session searched for solutions regarding a difficult interpersonal interaction, one solution recommended by the patients was to train standing up for oneself by practising power posing before entering the difficult confrontation with someone and they showed a new patient how power posing works.

Based on the described anecdotes and interactions with the patients, in hindsight, it would have been very valuable to have had conducted semi-structured interviews or to have collected other qualitative data, as this would have enriched the findings of study III. As there is, to date, no qualitative study in regards to power posing in general, future research should also consider this form of data to enhance the debate regarding the benefit of power posing for health and clinical outcomes. Considering the aforementioned feedback of the patients, for future research, it would be valuable to put more emphasis on the impact of shame during power posing, as well as the training of power posing in different social contexts, the integration of body-centered therapy in general as well as the application of body-centered interventions in a group format.
3.5 Strengths and Limitations

The following paragraphs will look at the strengths and limitations of this dissertation. Firstly, the strengths of studies I-III regarding existing research on interoception will be reviewed. Then, it will be outlined how studies I-IV enriched the existing literature on power posing and subjective power. Thereafter, general limitations will be discussed with suggestions of how these could be addressed in future research.

Strengths of the studies I-III in the context of existing research on interoception

Firstly, interventions that can effectively improve interoceptive abilities are still limited in general, but especially in regards to individuals with psychiatric disorders (Khoury et al., 2018). Therefore, one of the main strengths of this research is that it comprised several experimental, intervention studies aiming at increasing interoceptive ability in non-clinical samples, as well as a group of patients with anorexia nervosa.

Furthermore, studies I-II were the first to investigate whether a body-centered induction of power could impact interoception, thus, they thereby expanded previous research that manipulated IAcc through power priming (Kunstman et al., 2016; Moeini-Jazani et al., 2017).

Notably, study I-III included four measurement points, investigating changes in outcome variables in the short-term, as well as after one week of training (study I) or two weeks of practice (study II), which is advantageous in comparison to studies that only investigated effects after a single intervention session (Demartini et al., 2020; Feinstein et al., 2018; Meyerholz et al., 2019; Rominger, Graßmann, Weber, & Schwerdtfeger, 2021).

The research further assessed interoceptive accuracy and interoceptive sensibility (study I-III), as well as interoceptive awareness (study I-II) at once, which stands in contrast to other studies, which only investigates a single dimension of interoception (Bornemann et al., 2014; Bornemann & Singer, 2017; Demartini et al., 2020; Feinstein et al., 2018; Schultchen et al., 2019a; Schultchen et al., 2019b). In this context, IS was investigated through confidence ratings as well as questionnaire measures (study I & II).
Also, study I and study II made use of a new way of assessing IAω via the POMP scoring method, that could prove beneficial for future research studies wanting to relate the discrepancy between IAcc and IS to other outcome variables, or single case studies/diagnostics in a therapeutic setting.

Furthermore, study III comprised a multi-center trial, and, to date, is the study with the largest sample size regarding IAcc in individuals with AN (n\text{Total} = 101; n_{\text{Anorexia}} = 51). Thus, it can be assumed that the results regarding IAcc were possibly not underpowered, as described as a limitation in previous other studies (Demartini et al., 2020). Also, it is one of two studies (see Demartini et al., 2020) that has tried to manipulate interoceptive ability through an intervention in general, and a body-centered intervention in particular, in individuals with AN. This point is particularly important in light of the observation that body-manipulations that can support treatment outcomes in individuals with eating disorders remain scarce (Cascino et al., 2019; Folk et al., 2016; Stinson, 2019), despite several theories underlining the importance of designing interventions that allow individuals to experience their body from a first-person, egocentric perceptive (Riva & Gaudio, 2018).

Study III further addressed several limitations of the study by Demartini et al. (2020), namely by including IS as an outcome variable, increasing the sample size and practising the intervention over several days. Study III is also particularly valuable in regards to the recent call to conduct more experimental research regarding the impact of interventions upon proposed risk and maintaining factors of AN (Glashouwer et al., 2020; Oldershaw et al., 2019).

Finally, the intervention under investigation (i.e. power posing) is very easy to learn and to apply in everyday life, thus, it encompasses some of the practical constraints of previous interventions that were used to manipulate IAcc such as floating therapy, bio-feedback or deep touch (Edwards et al., 2018; Feinstein et al., 2018; Meyerholz et al., 2019). As the participants were also asked to train the postures at home, and not just in the laboratory, it could be argued that study I-III had high ecological validity.
Strengths of study I-IV in the context of existing research on power posing and subjective power

As subjective power has rarely been studied as a primary outcome variable in power posing research, but mostly as a short manipulation check (Jonas et al., 2017), study I-III applied four different methods of assessing subjective power, including state- and trait measurements of subjective feeling of power, as well as explicit- and implicit power measures. Implicit power motives, in particular, have previously not been investigated in the context of power posing research.

Furthermore, a large majority of research has compared power poses with slumped or constricted bodily postures (Körner & Schütz, 2020). This is problematic, as it makes it difficult to disentangle a possible positive effect of the powerful postures from a possible negative effect of the constricted postures (Crede, 2018). Therefore, recent reviews have highlighted the need to conduct more studies that compare powerful and neutral bodily postures (Elkjaer et al., 2020). This is one of the strengths of study II as it compared powerful with neutral postures, as opposed to slumped bodily postures. Considering the strengths of study II further, it is also the first study that has investigated the impact of power posing (and neutral posing) on individuals state- and trait anxiety using the STAI.

Overall, study I-III were the first to assess a possible training effect of power poses, as most other power posing studies only investigated effects after a single session of practice (see Cuddy et al. (2018) for a review).

Study III is also the first study that applied power posing in an eating disorder population. In this context, although there is a growing body of research highlighting low subjective feelings of power and social rank as well as a tendency towards submissiveness in individuals with AN, pathways of reducing felt powerlessness and increasing subjective explicit feelings of power in AN are still very limited. Study III contributed towards breaching this gap in the literature, by showing that power posing could possibly be helpful for individuals with AN in terms of increasing state subjective feelings of power.
Furthermore, Study IV applied the Sense of Power Scale and the MMG power dimension for the first time in a sample of AN. In this regard, due to the good internal consistency shown in study IV, the Sense of Power Scale could be a useful tool for assessing subjective power in AN, which could be beneficial to apply in future research and a therapeutic setting. Study IV further enriched research on subjective power in anorexia nervosa, by showing that individuals with AN have comparable levels of implicit power motives, albeit showing significantly lower levels of explicit power than controls. Study IV was also the first study to show similar implicit levels of fear of losing power as hope for power in individuals with AN, highlighting the need to address this possible approach-avoidance conflict in treatment. Thus, it is one of the strengths of study IV to have identified individuals implicit fear of losing power, in addition to the already known explicit feeling of having a low social rank from previous research studies.

Limitations

Firstly, although study II included male and female participants, study I, II and IV are limited by the fact that they only included female participants. This was, however, not based on an intentional decision. In study I the females only sample occurred as only women signed up to the study, which could have been caused by a recruitment bias in the psychology building. In study III and IV, two men with anorexia nervosa signed up to the study and completed the demographics questionnaire, however, they were discharged a few days before the beginning of baseline testing, as they had reached the end of their treatment. Nevertheless, it is important to be aware that the results of study I, II and IV are not generalizable to men. Future research should therefore replicate the studies with a male-only or mixed-gender sample. This would be particularly important, as no previous study assessed the different interoceptive dimension in men with anorexia nervosa.

Moreover, it is important to note that study I and III did not include a comparison group that adopted a non-powerful posture. This limitation was, however, addressed in study II (at least for the non-clinical sample) through the inclusion of a neutral posing
condition. In this regard, as aforementioned, it would be beneficial to also include an additional comparison group where individuals would be asked to adopt their natural bodily posture, to disentangle the possible effects of upright/open bodily postures and powerful postures on interoception and subjective feelings of power.

The crossover-design used in study I and III had the benefit that every individual taking part in the study also received an intervention. This was particularly relevant in regards to the AN group, due to the critical clinical condition of the patients in inpatient care and the high need to meet clinical needs. However, this design did not allow a comparison with a TAU group. Also, the outcomes variables after the week of pausing the intervention could not be compared to the ones after the week of training the intervention, due to possible contamination. Thus, in future research, it would be beneficial to include a TAU, waiting list control group or alternative treatment group (e.g. a cognitive-psychoeducative treatment such as BodyWise (Mountford et al., 2015)).

Furthermore, study III included individuals with AN regardless of their length of illness, illness severity, length of treatment or treatment setting. Thus, the sample was heterogeneous in regards to the individuals' stage of recovery and it is unclear during which therapy phase power posing could be most beneficial to individuals with AN. However, in this context, a recent study has shown that greater levels of illness severity and duration were not related to treatment outcome (Raykos, Erceg-Hurn, McEvoy, Fursland, & Waller, 2018). Also, regarding illness severity, in particular, the subcategorization into the different DSM-5 severity specifiers, has not been found to be meaningful regarding outcome variables such as eating pathology or physical and emotional functioning (Gianini et al., 2017; Machado, Grilo, & Crosby, 2017). Therefore, it could be speculated that illness duration and severity may have negligible effects on the outcomes of power posing. Nevertheless, future research could test this experimentally, for example, by including a group of individuals at high risk of developing AN, as well groups of individuals with AN and an illness duration under 3 years and over 7 years (Ambwani et al., 2020). Also, individuals could be divided based on their treatment setting (inpatient vs. outpatients). Based on the modest support of the DSM-5 severity
specifiers (Gianini et al., 2017), it may also be worth subcategorizing the AN sample based on measurements other than on BMI, such as eating pathology or quality of life, submissive behaviour or personal sense of power.

Considering limitations regarding the AN sample in study III further, there was an unequal distribution of AN subtypes (restrictive type vs. binge/purging type and atypical AN), which did not allow the performance of a well-powered group analysis. Therefore, the study could not indicate whether power posing yielded different effects in the subgroups and it should be replicated with an equal distribution of AN subtypes in the main sample.

Regarding study IV, the analysis regarding implicit and explicit power discrepancies and anxiety, was limited by its correlational design, which does not allow conclusions to be drawn in regards to causation. Thus, it would be valuable to manipulate state- and trait explicit- and implicit power in an experiment in individuals with AN, and to investigate whether it would affect their state- and/or trait anxiety levels.

A further limitation does concern the measurement of interoceptive accuracy in study I-III. Firstly, IAcc was investigated through cardiac awareness only and other methods of assessing IAcc (e.g. gastric or respiratory signals and pain sensitivity) were not applied. Thus, it could be beneficial to replicate the study with a different interoceptive measurement. Secondly, the heartbeat tracking task has been criticized for being susceptible to non-interoceptive influences such as knowing or guessing ones’ heart rate, prior knowledge about heart rate, time estimations or practice effects (Desmedt, Luminet, & Corneille, 2018; Ring, Brener, Knapp, & Mailloux, 2015), which were not directly controlled for in study I-III. However, possible time estimations were tried to be minimized by giving clear, standardized instructions and asking participants not to engage in any other strategy than sensing their heartbeats when completing the task. In this regard, recent studies did also not find a positive relationship between time estimates and interoceptive ability, and controlling for time estimates did not change the relationship between IAcc and other outcomes (Santangelo et al., 2018; Shah, Hall, Catmur, & Bird, 2016). It is therefore unlikely that time estimates confounded the results.
Regarding practice effects, the post hoc tests in study II did also not show a significant improvement in the neutral power posing group in the short term. Also, no improvement of IAcc in study I and III was found after one week of training. If practice effects had impacted the results, this should have resulted in an increase in IAcc in the neutral posing group at T1 (study II), or increases after training (study I and III). In this regard, other studies that used the HBTT either did not find significant improvements over several time points (Fischer et al., 2016; Parkin et al., 2014) or found variations in IAcc depending on the manipulation used (Ainley et al., 2012; Fischer et al., 2017) or between different groups in a repeated measures design (Demartini et al., 2020). These observations further speak against the influence of practice effects. Nevertheless, the results of study I-III should be interpreted bearing the possible psychometric limitations of the heartbeat tracking task in mind and it would be beneficial to replicate the studies and to control for the described variables to confidently exclude them as confounding factors.

Furthermore, in study I-III there no direct control of whether individuals practised the postures regularly in their own time, as instructed. However, to enhance treatment compliance, they were given a daily diary chart as well as the audiotape, that aimed at ensuring the postures were correctly adapted. Individuals were also asked how many times they had practised the postures per day. Only the data of those that had filled out the entire battery of self-report diaries and had indicated having practised the postures twice daily were included in the analyses. Delivering power posing in a group format (e.g. as sessions in the morning or evening at the clinic) could be helpful to address this possible limitation.

Considering the limitations further, in study III it was also not controlled for whether or not individuals had eaten before the intervention, or before the assessment after the week of power posing practice. The participants were, however, retested at the same time of day, to keep the contextual factors as constant as possible. However, if the theory of Barca and Pezzulo (2020) (that has previously been described in chapter 1.8.1) is substantiated (i.e. that individuals with AN limit their food intake to amplify their autonomic signals of hunger, thereby reducing interoceptive uncertainty and increasing
the experience of bodily signals), then they should perform better on the HBTT in a state of hunger, as previously shown in non-clinical samples (Herbert et al., 2012). Therefore, in future research, it would be important to test the effect of power posing on IAcc before or after meal consumption, as effects as hunger or satiety could have impacted the result on IAcc in study III.

### 3.4 Outlook

Based on the outcomes of studies I-IV of this dissertation, previous studies on power, the experience of having conducted the experiments, as well as the aforementioned strengths and limitations, the following section will give an outlook of how the findings of this research, power posing research in general, and research in regards to AN, could be further expanded.

*Expanding and refining the methods in power posing research*

One of the biggest challenges in power posing research is to apply measurements that can successfully capture the subjective experience as well as psychological and physiological effects that occur whilst holding the postures. As being embodied means always, at any time, holding a particular posture – it is likely that the posture that individuals adapt whilst undergoing research also has an impact on their self-evaluations. For example, questionnaires are usually filled out whilst sitting down, thereby directing the gaze and head downwards. In regards to this dissertation, although the measurements were filled out shortly after the intervention, it should not be underestimated that the sitting posture, that was adopted whilst self-reporting, may have had an impact on the results. In this context, Durlik and Tsakiris (2015) also pointed out that a short delay between the intervention and the administration of the questionnaires can lead to the self-reports being *reflective* rather than *reflexive*. Therefore, in hindsight, in regards to study I-III, it would have been advantageous to have somehow captured feelings of power, anxiety and positive affect, whilst the postures were still adopted. Future studies could
therefore place a small response device (e.g., one that has been designed for the use in fMRI research) into the participant’s hand and project the self-report measures with a beamer in front of the participants, so that they could answer with less delay and whilst still being in the affective state of the posture. Also, qualitative data could be collected before, after or whilst the participants are adopting the posture (or after a training period). Moreover, physiological measures could be applied that could collect data simultaneously to adopting different bodily postures.

Assessing how changes in the interoception affect symptomatology

In regards to generating evidence for the theoretical assumptions of the predictive coding model (described in chapter 1.3 and 1.4), one crucial question for future research in this context is whether ‘normalising’ interoceptive precision through interventions that target interoceptive ability, can improve affective symptomatology (Owens et al., 2018). As aforementioned, standard talking therapy on its own does not appear to lead to changes in interoceptive accuracy in patients with anorexia nervosa (Fischer et al., 2016) or OCD (Schultchen et al., 2019b), although, theoretically, it may help in terms of generating accurate top-down predictions (e.g. through the development of more precise emotion concept knowledge) (Smith et al., 2021). Therefore, it would be crucial to give individuals with low interoceptive ability the opportunity to practice interventions that target interoceptive ability (as described in chapter 1.4 and 1.5) for longer periods and to assess whether, how and when changes in symptomatology would occur. This would offer clinicians novel strategies of treatment, which would be in keeping with theory and evidence from computational neuroscience.

Increasing the emphasis on implicit and explicit power in AN research

Based on the findings of this dissertation (study III and IV), it can further be suggested that low subjective feelings of power and implicit power motives (in particular the implicit fear of losing power) in individuals with AN should receive more research interest. Thereby, based on the findings of study VI and previous research on
powerlessness in AN, the central question should be: how can women and men with anorexia nervosa be empowered? (Duncan et al., 2015). As previously pointed out in chapter 1.8.2, in the majority of clinical practice and research, the focus is often placed on individuals’ strong need for control, focussing predominantly on individual’s obsession with the control of their weight and shape (Stanghellini et al., 2020), but not on the need to seek power in one’s life (Woolrich, Cooper and Turner, 2006, p. 737). Attending more carefully to individuals power needs and developing strategies that could support individuals with AN in regaining power in functional, non-maladaptive ways could refine treatment approaches and offer more tailored interventions.

As a first step, it would be important to include state- and trait measurements of subjective power (e.g. the sense of power scale or other scales that measure submissiveness or feelings of inferiority) more often in the assessment of individuals with AN in treatment and research. This could help to gain a better understanding, of which role these may play in individuals’ lives, how they might fluctuate throughout the course of a day or in the context of particular life events and whether they change throughout the course of treatment.

Furthermore, it would also be important to identify if, where and how the need to feel powerful can impact behaviours in AN. In other words, it would be interesting to explore whether low subjective feeling of power or an implicit fear of losing power could be underlying factors that influence and promote some of the phenomena that occur and symptoms that are prevalent in AN. As an example, many research articles support a high striving towards academic achievements in individuals with AN (Dura & Bornstein, 1989; Schilder, Sternheim, Aarts, van Elburg, & Danner, 2021). However, it is rarely questioned what the underlying motive for this drive for academic excellence could be. At first glance, a high achievement motive would seem plausible. However, in this context, it is noteworthy that individuals often misidentify their implicit motives. For example, in a study by Kuhn & Krug (2005) (as cited in Rheinberg & Engeser, (2010)) only 32 % of participants were able to correctly identify their power motive. Most of them ascribed themselves a dominant achievement motive, when, in fact, they had a dominant power motive, based on implicit motive tests (Kuhn & Krug, 2005, as cited in
Rheinberg & Engeser (2010)). Thus, in regards to AN, it could be hypothesised that striving towards achievement may represent a pathway to experiencing power (defined as having influence in one’s life) as opposed to feeling inferior to others. This idea would be congruent with the belief “If I don’t strive to achieve, I’ll be seen as inferior to other people”, which is included in the striving to avoid inferiority scale by Gilbert et al. (2007). Thus, increasing subjective power through tailored interventions could potentially reduce maladaptive striving to avoid feelings of inferiority in individuals with AN.

Another area where an implicit power motive or low feelings of power could influence individual’s behaviour in AN could be perfectionism, which has been reported to be highly prevalent in individuals with AN (Dahlenburg et al., 2019; Lloyd, Yiend, Schmidt, & Tchanturia, 2014). Taking a closer look at the underlying function of perfectionism, Dunkley and colleagues (2006) argued that it either serves to fulfil personal standards, or, importantly, it can reflect the striving to avoid rejection/criticism from others. The latter has been associated with eating pathology and drive for thinness (Bellew et al., 2006; Ferreira, Pinto-Gouveia, & Duarte, 2013; Ferreira, Trindade, & Ornelas, 2015) (as described in chapter 1.8.2). If perfectionism is linked to restricted eating, as well as avoiding inferiority, then it would seem worthwhile to investigate whether the induction of power could positively impact perfectionistic striving or restricted eating in AN. In this context, a study by Kunstman et al. (2014) could show that among individuals high in self-oriented perfectionism, the induction of situational power (through priming) could increase caloric consumption. Therefore, it would be important to investigate whether similar effects could be observed in individuals with AN by regularly inducing subjective feeling power through power posing (as in study III) and investigating if this would impact outcomes such as perfectionism or restricted eating over time.

Although the link between implicit power motives, low subjective feelings of power and symptomatic behaviour in AN would still have to be systematically investigated, thinking of a possible connection between these areas would be in keeping with early models of AN and individuals’ self-reports that regard AN as a way of temporarily gaining power and control (as outlined in chapter 1.8.2).
In summary, it would be important to investigate the influence of the power motive on other aspects highly relevant in AN (e.g., such as striving towards achievement, perfectionism or restrictive eating) to get a better understanding of whether and how individuals’ behaviour may be driven by low subjective feelings of power and/or an implicit fear of losing power. Of course, in this context, it would also be important to expand study IV by investigating other implicit motives in AN (such as the achievement- or affiliation motive) to define the role of the power motive, compared to other motives. This could help to tailor interventions better and to reduce dysfunctional behaviour that may aim at compensating an unmet personal need, based on an implicit motive.

*Investigating how increasing subjective feeling of power could positively impact psychopathology*

As a next step, it would be valuable to manipulate individuals subjective feeling power (e.g. through power posing) in AN and to investigate whether and how this could impact other symptoms and areas of psychopathology. In this regard, it would firstly be valuable to replicate the studies that have shown positive effects of power posing on aspects relevant to AN in non-clinical samples, such as restrictive eating (Allen et al., 2013), self-esteem (Körner et al., 2019), as well as body image satisfaction (Miragall et al., 2018). Then, it would also be important to investigate whether the induction of power through power posing could achieve similar effects as shown through power priming, such as, increased in abstract thinking (Smith & Trope, 2006), which has also been found to be impaired in AN (Tokley & Kemps, 2007). Importantly, it would be valuable to identify the underlying mechanisms of power posing in regards to AN. It could be that a shift in focus towards the self and the experience of the body “from within” would be one of the key beneficial mechanism, as individuals with AN may often shift their attention outwards, to attend towards social threat (Cardi et al., 2015) and regard their body from a third-person perspective (i.e. allocentric lock) (Serino et al., 2015).
Identifying potentially overlooked and untreated maintenance factors of AN

In two very recent review articles, the term “crisis” was used when describing the current clinical reality and paucity of effective treatments for individuals with severe and enduring anorexia nervosa (Kaye & Bulik, 2021; Wonderlich et al., 2020). On the one hand, the low treatment effectiveness challenges the underlying theoretical assumptions of the disorder – or, at least, underlines that there may be overlooked maintenance factors of the illness that have not yet been adequately addressed in mainstream therapy. On the other hand, it highlights the great need to develop novel, innovative and evidence-based treatments for AN. This dissertation highlighted several factors that should receive more research attention in regards to the development of effective treatments. These include low interoceptive sensitivity (study III), low positive affect and anxiety (study IV) as well as implicit and explicit power, as aforementioned. A further factor concerns the inclusion of the body in treatment (study III), which will be discussed in more detail in the following paragraph. Attending to these factors by understanding their cause, maintenance and consequences could offer more avenues for treatment and possibly enhance treatment effectiveness.

Enhancing the investigation of body-centered interventions in AN to improve interoception and other outcomes

Theoretical models based on neuroscientific evidence (e.g. the allocentric lock hypothesis (see Riva et al. (2012), described in chapter 1.8.3), recent treatment studies (Artoni et al., 2020; Savidaki et al., 2020), as well as a large body of research on the interaction between bodily postures and cognitive processes and affective states in non-clinical samples (chapter 1.6) support the potential benefit of integrating the body into therapy.

Despite this, body-based approaches are still largely neglected as novel treatment pathways in recent articles (e.g. Wonderlich et al (2020)). Therefore, another important future pathway is to conduct more interventions that promote the experience of the body from a first-person perspective in AN, thereby putting more emphasis on the perceptual
experience of the body (as opposed to only a cognitive and affective evaluation of the body). This could potentially help to increase interoceptive accuracy (study III), reduce embodiment disturbances in AN, foster the trust into bodily signals as well as generate a shift from regarding the body as an object to a subjective bodily experience, thereby allowing the individual to feel less estranged from the body (Rossi et al., 2021). These aspects are unlikely to be promoted by purely cognitive interventions. In this regard, it would be important to assess whether standard treatment could be enhanced by adding embodiment interventions (such as power posing, a focus on open/upright bodily postures (study II), dance movement therapy, yoga, the use of different body postures in therapy sessions to express felt emotions, or a combination of interventions which focus on the perceptual experience of the body).

Based on the workshop conducted after study III (as described in chapter 3.4), reflection groups with patients could promote an understanding of the acceptability and experience of the body-centered interventions and help to refine them to their needs. Also, they would foster autonomy in patients and allow them to take an active part in their treatment. This could be a valuable strategy to avoid feelings of being overpowered by stringed treatment protocols, which have previously been described by patients in hospital settings (Offord et al., 2006).

Offering patients different forms of embodiment interventions in treatment would also give them novel impulses. This is particularly important regarding the hopelessness that can arise in patients and carers after lengthy, ineffective treatments (Zhu et al., 2020). In the context of AN, words such as “severe and enduring” “chronic,” “persistent,” and “treatment-resistant” are often used to describe those who have been ill for a longer period of time (Broomfield, Stedal, Touyz, & Rhodes, 2017). However, as Zhu and colleagues pointed out (2020), illness should not be seen as intractable merely because of a lengthy duration. “Treatment-resistant” does not and should never mean that the person is untreatable, it simply means, that the right treatment has not been found yet. Body-centered interventions (including power posing) that emerge from evidence-based theoretical models of the illness, could offer novel, well-accepted treatment options that may enrich and extend standard care.
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Appendix A: Original Research Articles


5.1 Article I: Improving interoceptive ability through the practice of power posing.
A pilot study.


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Improving interoceptive ability through the practice of power posing: A pilot study

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Abstract

Interoception refers to the detection and perception of signals from the inner body. Deficits in this domain have been linked to psychopathologies, prompting the search for strategies to improve this ability. Preliminary studies have shown that interoception could be enhanced through the manipulation of subjective feelings of power. We tested the effects of adopting powerful postures on different facets of interoception. Firstly, we measured the impact of a single power posing session on interoceptive ability in 41 healthy females. Then, the same participants were randomly assigned to two conditions (daily power posing practice vs. no practice). After one week the conditions alternated. Interoceptive accuracy, measured by the heartbeat tracking task, interoceptive sensibility, measured by the Body Perception Questionnaire (BPQ) and confidence ratings, as well as subjective feelings of power were assessed at baseline, after a single power posing session and after one week of training. A single power posing session significantly increased individuals' interoceptive accuracy. Also, power posing reduced individuals' scores on the BPQ after one week of daily practice and increased subjective feelings of power after one session and one week of daily practice. These findings suggest that adopting powerful postures has the potential to increase interoceptive accuracy, as well as subjective feelings of power, and to reduce interoceptive sensibility, measured by questionnaire.

Introduction

Interoception refers to the perception of internal bodily sensations [1]. There is growing evidence supporting its crucial role in domains such as body ownership and selfhood [2, 3], intuitive judgment and decision-making [4, 5], emotional experience [6–8], emotional processing [9–11], behavioral self-regulation [12] and body image [13, 14]. Also, several studies targeting clinical populations have shown that deficits in the different interoceptive dimensions seem to be related to various psychopathologies [15]. Low interoceptive accuracy (IAcc) has, for example, been linked to major depression [16–18] and anorexia nervosa [19–21], whereas heightened IAcc appears to be prominent in anxiety disorders [22–24]. Considering the role of interoception in mental health further, a study by Füstös et al. [25] found that when using cognitive reappraisal as an emotion-regulation strategy, interoceptive accuracy facilitated the down-regulation of negative affect. In keeping with this observation, Kever et al. [26] also
showed that individuals with higher accuracy made more use of reappraisal and suppression strategies, when regulating their emotions, compared to individuals with lower interoceptive accuracy. These findings imply that the awareness of ongoing bodily processes fosters the response to affect-related arousal.

Despite advances in our understanding of the different dimensions and effects of interoception, as well as research highlighting interoceptive deficits in clinical populations, little is known about effective strategies of improving this ability [27]. Evidence for possible interventions that could enhance interoceptive skills comes from studies showing that particular populations display increased interoceptive abilities. For example, a recent study by Christensen et al. [28] found experienced ballet dancers to have better interoceptive accuracy than nondancers. The authors explained their findings with a dual action model, which highlights the interplay of eliciting and attending to emotional states and expressing these immediately through the body (via dance). Another study by Schirmer-Mokwa et al. [29] found that professional musicians displayed better interoceptive accuracy than non-musicians. The researchers highlighted the role of enhanced multisensory integration, which is especially trained in professional musicians, as a possible mechanism of enhancing interoceptive skills. Evidence for increased interoceptive ability due to meditation practice remains mixed. On the one hand, there is a line of studies that could not find better interoceptive accuracy in experienced meditators [30, 31]. On the other hand, there is evidence that meditators indicate higher confidence in their interoceptive ability than non-meditators [32]. Moreover, it seems that training non-meditators in a body scan intervention for eight weeks can enhance their interoceptive accuracy [33].

Furthermore, there is preliminary evidence suggesting that interoceptive deficits can be targeted through the enhancement of self-focus [34]. Ainley et al. [35, 36], for example, found that interoceptive accuracy could be increased when individuals looked at themselves in a mirror or processed self-narrative information. However, this strategy does not appear to be effective for every population. Pollatos et al. [37], for example, highlighted that individuals suffering from anorexia nervosa do not seem to benefit from this method of interoceptive enhancement, as they might find it difficult to engage in self-confrontation. This prompts the question whether there are other pathways of inducing self-focus.

One alternative strategy of enhancing self-focus could be through the manipulation of a person’s subjective feelings of power [34]. From an evolutionary perspective, powerful individuals are less dependent upon others for personal resources and are therefore less likely to divert their attention outwards towards those less dominant [38, 39]. Less powerful individuals, on the other hand, must pay careful attention to their environment to avoid threat and therefore have less capacity to divert their attention inwards [40, 41]. Thus, power appears to serve as a stress buffer that allows individuals to engage in self-focus [39]. In support of this theory, research has shown that individuals who are primed with high power take on a more self-oriented view and find it more difficult to engage in other-oriented perspectives than individuals who are primed with low power [42]. In comparison to powerless individuals, the powerful also appear to be less distracted by external information and report trusting their ‘gut feeling’ when it comes to decision making [43].

There are, to date, two studies, which looked at the effects of power manipulation on interoception per se. Kunstman and colleagues [44] investigated the effects of power priming on interoceptive accuracy and found that power priming increased IAcc in those with high levels of body dysmorphic symptomatology. In their study, power was manipulated via a word search puzzle containing high power words, as well as an experiential writing prime, where individuals were asked to remember a time when they had influence over others. In another recent study, Moeini-Jazani et al. [34] showed that inducing power through a powerful role
(i.e. impersonating a manager in a manager-subordinate role playing task) positively impacted upon individuals’ interoceptive accuracy.

The present study will extend the previous findings by using physical postures reflecting power (i.e. power-posing [45]) as a method of power manipulation, instead of solely relying on semantic or associative priming. This approach has several advantages. Firstly, power posing has repeatedly been found to increase subjective feelings of power (see [46] for a review). Furthermore, inducing power via an embodiment intervention is beneficial, as powerful postures have been shown to have stronger effects on the activation of implicit power than powerful roles [47]. Also, the application of powerful postures is a non-verbal, time-effective method, which can easily be applied without having to activate autobiographical memory or having to engage in prior role-play.

The present study aims to explore the effects of a single session of power posing, as well as one week of daily practice, on the different dimensions of interoception, namely, interoceptive accuracy, sensibility, and awareness [24, 48]. Interoceptive accuracy reflects performance on behavioural tests of interoception, such as the heart beat tracking task (HBTT) [49]. Interoceptive sensibility, on the other hand, describes individuals’ subjective beliefs about their interoceptive accuracy and is assessed with self-report measures, such as the Body Perception Questionnaire (BPQ) [50] or individuals’ confidence ratings about their performance on the heart beat tracking task [1]. Interoceptive awareness refers to the concordance between interoceptive sensibility and accuracy [27]. By investigating effects on all three dimensions, one hopes to gain a more differentiated understanding of the potential benefits of power posing on interoceptive ability. In particular, we aim to explore which dimension is most likely to be affected by power posing. This is important, as patients with psychiatric disorders vary in regards to their interoceptive abilities. For example, Pollatos and Georgiou [51] found that women with bulimia nervosa showed no differences in interoceptive accuracy compared to healthy controls. They did, however, differ in terms of their interoceptive sensibility, measured by questionnaire. Exploring the effects on each dimension can potentially help to offer patients more tailored treatments in the future.

To address the research questions, participants underwent a single power posing session, as well as one week of daily power posing. Primary outcomes were measures of interoceptive ability, and secondary outcomes were measures of subjective feelings of power. Results were compared to baseline. It was hypothesised that (I) One session of power posing will have a significant impact on individuals’ interoceptive accuracy, sensibility (confidence; BPQ) and awareness scores; (II) Daily power posing will have a significant practice effect on individuals’ interoceptive accuracy, sensibility (confidence, BPQ) and awareness scores. (III) Power posing will have a significant effect on individuals’ subjective feelings of power.

**Materials and methods**

**Design**

The first part of the study measured the effect of a single-session of power posing on interoceptive ability and subjective feelings of power. It had the form of a single group repeated-measures design. 42 healthy females were recruited at Ulm University. One participant was excluded from the study due to the diagnosis of major depression, leaving a total of 41 participants. The heartbeat tracking task (HBTT) (Schandry, 1981), a question on individuals’ confidence on the task, as well as a fixed-format questionnaire, were administered before and after a single power posing intervention.

The second part of the study measured the effect of one week of daily power posing practice on interoceptive ability and subjective feelings of power. It had the form of a 2x2 crossover
design. After the testing of the short-term effects in the laboratory, all 41 healthy females were randomly assigned to two groups by a lottery system. Group A underwent daily power posing practice for one week (one session in the morning and one in the evening), whilst Group B paused with the practice. After one week, Group A paused the power posing practice, and Group B practiced daily.

In addition to this study, we intended to investigate the effects of power posing in patients with eating disorders and planned to compare the data to the healthy sample. This was the reason for choosing a crossover design in the study reported here. In clinical trials, it ensures that every patient receives a form of treatment, and is not only part of a control group [52, 53]. It also offers higher power with a smaller sample size, which is particularly relevant as clinical participants can be difficult to recruit. Please note that the data of the clinical sample is not reported here.

Participants

42 healthy Caucasian females were recruited from students at Ulm University. In return for their participation, they received course credit. They were informed that the study aimed to investigate the effects of physical postures on muscular strength. Participants had a mean age of 20.85 (SD = 1.84) and a mean BMI of 20.65 (SD = 2.29). Exclusion criteria were previous or present psychiatric or somatic disorders, age under 18 and specific experience with power posing. One participant was excluded from both parts of the study, as she was taking SSRIs and indicated suffering from depression, leaving a total of 41 participants. None of the remaining participants were taking medication (except contraceptives) or had a past or present psychiatric or severe somatic illness, as assessed by anamnestic questionnaire.

Group A and Group B did not differ significantly regarding their age (Group A: M = 20.81 (SD = 1.75); Group B: M = 20.90 (SD = 1.97); t(39) = -0.156, p = .877) or level of fitness (Group A: M = 60.95 (SD = 11.03); Group B: M = 58.05 (SD = 21.90); t(28) = 0.532, p = 0.599).

Materials

Questionnaires. An online questionnaire was used to collect health status and personal data one week before testing (including age, educational background, level of fitness, previous experience with body centred interventions). Level of fitness reflected the extent to which individuals felt physically fit. Participants could give an answer ranging from not at all (0) to very much (100). Questions on the experience with body-centred interventions asked individuals to indicate whether they practiced yoga, pilates, mindfulness, meditation or back training, to identify potential confounding variables. Participants could indicate their answer on a three-point scale (‘never practiced’; ‘practiced before, but not at the moment’; ‘practising on a regular basis’). Also, different standardized psychological questionnaires were administered. The German version of the Patient Health Questionnaire (PHQ-D) was developed as a screening measure for mental disorders in primary care, based on the diagnostic criteria of DSM-IV [54]. In this study the long version of the questionnaire was used, that includes subscales screening for e.g. depression, somatoform symptoms, anxiety and psychosocial stress. All questions refer to the occurrence of symptoms over the past two to four weeks. Furthermore, the awareness subscale of the Body Perception Questionnaire [50] was administered. This measure has been previously used as a measure of interoceptive sensibility [1, 55]. The BPQ awareness subscale consists of 45 items reflecting bodily sensations. Examples of the items are ‘I am aware of my eye movements’ or ‘I am aware of my mouth being dry’. Participants can indicate their awareness of each sensation on a five-point scale ranging from ‘never’ to ‘always’. Also, the trait subscale of the state-trait anxiety inventory (STAI) was applied [56]. It is a validated measure that
contains 20 items assessing individuals’ trait anxiety on a four-point scale ranging from ‘almost never’ to ‘almost’ always (score range 20–80). At the end of the weekly power posing practice, participants were given an evaluative questionnaire constructed by the authors. They were asked how many times they practiced daily and could indicate their answers on a 4-point scale (‘less than once per day’; ‘once per day’; ‘two times per day’; ‘more than two times per day’). They were also asked whether they could fill in the diary as instructed. They could indicate their answers by choosing one of the following items ‘yes, as instructed’; ‘no, I had to make minor changes’; ‘no, I had to make major changes’; ‘no not at all’.

Measurements of interoceptive ability. **Interoceptive Accuracy (IAcc)**. Interoceptive accuracy was assessed using the heart beat tracking task (HBTT) [49]. The task included four heartbeat counting trials using the mental tracking method. After a short training interval of 15s, four intervals of 35s, 45s, 25s and 60s followed. The four intervals were presented in a fixed order across participants. Participants were instructed to count their own heartbeats silently and to verbally report the number of counted heartbeats at the end of each counting phase. The beginning and the end of the counting intervals were indicated by a start and stop cue given by the experimenter. Participants were instructed not to take their own pulse or attempt to use any other form of manipulation to support the counting of their heartbeats. No prior information regarding the length of the counting phase was given. Participants received no feedback on the quality of their performance at the end of each trial. Heartbeat signal was recorded with the mobile heart frequency monitor RS800CX (Polar Electro Oy, Kempele, Finland). The RS800CX, records the inter-beat-interval, is non-invasive and can compete with other ECG measures regarding its validity and reliability [57, 58]. IAcc was calculated as the mean heartbeat perception score according to the following transformation:

\[
\frac{1}{4} \sum (1 - \frac{|\text{recorded heartbeats} - \text{counted heartbeats}|}{\text{recorded heartbeats}})
\]

IAcc scores could range from 0 to 1. Higher scores indicated smaller differences between the counted and recorded heartbeat and thus better IAcc.

**Interoceptive Sensibility (IS)**. Interoceptive sensibility is defined as an individual’s self-confidence relative to his or her objective performance on the heartbeat tracking task (HBTT) [1]. After completion of the HBTT, participants were asked to rate their confidence in their performance on a scale from one to ten (1 = not confident at all; 10 = fully confident) and to verbally report their rating to the experimenter. As a secondary measure of interoceptive sensibility, the Body Perception Questionnaire [50] was applied.

**Interoceptive Awareness (IAw)**. Interoceptive awareness refers to the concordance between interoceptive sensibility- and accuracy measures [27]. To operationalise interoceptive awareness, we applied the ‘percent of maximum possible’ or POMP scoring method described by Cohen et al. [59]. A POMP score is the result of a linear transformation of any raw metric into a 0 to 100 scale. For this study, interoceptive accuracy and confidence scores were converted into POMP scores to make them comparable. The absolute difference between POMP scores was then calculated as a variable representing IAw. For the scaling of the awareness score to be intuitive, i.e. for higher scores to represent higher awareness, the calculated absolute difference between POMP scores was again subtracted from 100. This resulted in an awareness score between 0 and 100. This approach has the benefit, that an individual awareness score, reflecting the correspondence between interoceptive accuracy and confidence, could be generated for each participant. In addition to this approach, the Pearson correlation \( r \), between accuracy and confidence was used as an index of interoceptive awareness [60]. A stronger correlation, after power posing, would suggest that interoceptive awareness has
improved relative to baseline. For this calculation, the data was collapsed after training or after pause respectively.

**Measurements of subjective feelings of power.** Several power measures were included as a manipulation check. We thereby assessed subjective feelings of power, as well as *explicit*, and *implicit* power motives. Explicit motives reflect aspects of the self-concept that the individual is consciously aware of [61]. Implicit motives, on the other hand, are not consciously represented but still guide and select spontaneous behaviour [62]. Previous research has highlighted that explicit and implicit motives often diverge from one another [63–65]. This observation prompted us to choose a multi-dimensional approach to determine subjective sense of power.

To assess individuals’ *explicit* feelings of personal power, we created a 6-item Likert scale in German, that was based on the Personal Sense of Power Scale by Anderson et al. [66] (item one to six). We refer to it as the Sense of Power Scale 6 German Version (SOPS 6 GV). The Cronbach’s alpha of our scale was .815. Participants could indicate their agreement or disagreement on a six-point scale. The response options ranged from 1 = ‘strongly disagree’ to 6 = ‘definitely agree’. An example of a statement was ‘I think I have a great deal of power’. Some of the statements were reverse scored to prevent response bias. Please refer to the supporting information section (S1 File and S2 File) for a full version of the scale.

Also, a visual analogue scale (VAS) was used, asking participants to indicate how powerful they felt, by marking their answer with a pen on the line. One end of the line was labelled with 0, indicating no power at all, whereas the other end was labelled with 100, indicating high power. To avoid participant’s suspicion regarding the true nature of the study, the VAS of subjective feelings of power was embedded between two other visual analogue scales labelled ‘energetic’ and ‘strong’. For the analysis, only the VAS power scale was used.

As a third measure of explicit power, the Self-Assessment Manekin Scale (SAM) was applied [67]. SAM measures felt pleasure, arousal and dominance through pictorial assessment. Participants are asked to circle one of five manekins that best reflected their current state on three scales. For the manipulation check, only the dominance subscale was used.

As an *implicit* measure of power, we used the Multi Motive Grid (MMG) by Sokolowski et al. [61]. The MMG is a semi-projective measure, assessing individuals’ implicit motivation for affiliation, achievement and power. The measure contains a series of 14 drawings, depicting ambivalent social situations. Below every picture, a number of statements are given, and individuals are asked to judge whether each statement fits the given situation or not, by circling ‘yes’ or ‘no’. The MMG distinguishes between hope and fear components of affiliation, achievement and power. In the case of power, the two components are ‘hope for power’ and ‘fear of losing’ power. Examples of power statements are ‘anticipating to lose standing’ or ‘hoping to acquire a good standing’. The single motive scores for each picture are summarised to obtain a global score for each of the six motive components. Scores range from one to twelve. Previous studies have indicated good internal consistency and reliability of the measure [61, 68].

**Power postures.** The bodily postures relevant for the training program were selected from previous research studies on non-verbal displays of power [45, 69, 70]. A total of three different power poses were applied. Each posture contained several elements associated with power such as, e.g. tilting the head up, leaning forward, placing the hands into the waist or adopting an open bodily position [71]. Please refer to Fig 1 for a full display of the power poses. The order in which the postures were adopted was fixed. Each pose was held for 45 seconds. This duration was chosen, based on previous studies showing beneficial effects after 60 to 120 seconds of power posing [46]. As we included three different poses, we reduced the previously used duration by 15 seconds per pose, as it has been proposed that holding the postures for too long might cause discomfort in the individuals (especially the feet-on-the-desk posture)
and might lead to disadvantageous effects [46]. Thus, one session lasted for approximately six minutes, including short breaks between each posture to adjust the body. An audiotape, guiding individuals through each pose, was played during each session. The tape was recorded by a female experimenter and ensured that the poses were adopted correctly and homogeneously. While adopting the poses, individuals were asked to fixate on a cross on the wall, placed one hand length above their individual height, at a 1.5 meter distance. Participants were also specifically instructed to engage in self-focus by continually shifting their attention between three anchor points (feet; sternum; chin), and to feel the space they were taking up. This self-focus component was added as we wanted to ensure that participants adopted the poses correctly when practising at home. Based on previous pilot testing, we realised that if attention is not paid to the three anchor points, it is likely that individuals will, for example, not push the sternum area outwards and quickly fall back into a slumped posture (especially in the feet-on-the-desk-posture). Due to a similar reason, the fixation cross was added. While developing the practice sequence of the power poses, we observed that the chin easily drops after a few seconds of holding the powerful posture, as holding the chin slightly upwards is not very natural and the body automatically falls back into its initial posture. Fixating a cross that directs the gaze of the participant upwards has the potential to control this aspect.

Procedure

The study was conducted in accordance with the Declaration of Helsinki, and ethical approval was obtained from the Institutional Review Board (IRB) of Ulm University. Before testing, informed consent was collected from the participants according to IRB requirements. Individuals were tested at the laboratories of the Clinical- and Health Psychology Department of Ulm University. They were informed that the study aimed to investigate the effects of physical postures on muscular strength to avoid power priming and response bias. To increase believability in the cover story, individuals were asked to count how many times they could push in a hand grip (HG). They were given 60 seconds to execute as many pushes with their dominant hand, as possible. Both sides of the HG clicking together counted as one push. The experimenter noted the number of final pushes on a separate sheet of paper. Furthermore, they completed the battery of questionnaires. Individuals’ heartbeat perception was then tested at baseline (T0) and after a single power posing session (T1). The power poses were shown on a picture and subsequently presented in person by the experimenter. Individuals were then asked to adopt the pose themselves. After a short training session, that endured for as long as each participant needed to understand and apply the postures correctly (approximately one to two minutes), the audio instruction tape was played. During this procedure, the experimenter left the room to avoid reducing self-focussed attention due to social presence [72, 73]. After the testing of

![Fig 1. Power postures in the order of practice. Note. Postures were adopted in the presented order.](https://doi.org/10.1371/journal.pone.0211453.g001)
the one-session effects of power posing in the laboratory, participants were randomly assigned to two groups (A and B) via a lottery system. To avoid order effects, the training and the pause condition were counter-balanced between groups. Firstly, Group A was asked to practice the learnt postures daily (once in the morning and once in the evening) and Group B was explicitly told not to apply the poses again. To ensure that the poses were adopted correctly at home, participants were given the fixation cross, a printed picture of each pose, as well as the audio recording with the instructions. Heartbeat perception was tested after one week of power posing training or pause respectively (T2) and again after switching the experimental condition (T3). Participants filled in the questionnaires before and after the testing sessions. To increase compliance, individuals filled out a daily diary, noting the date and time of the power posing, as well as the poses they adopted. Please refer to Fig 2 for a flow chart outlining the procedure of the study and participants’ experimental exposure over time. A diagram of all measures and intervention used is given in the supporting information section (S1 Table).

Data analysis

All data were analysed using IBM SPSS Statistics 22 software (SPSS, Chicago, IL). Normality of the data was assessed using Shapiro Wilk test, Q-Q plot and histogram. The assumption of normality was upheld for all variables except BPQ and SOPS 6 GV due to outliers. A priori contrast analysis was performed using paired samples t-tests to investigate mean differences in interoceptive accuracy, interoceptive sensibility measured by confidence rating and the body perception questionnaire (BPQ), interoceptive awareness and subjective feelings of power (VAS; SAM), before and after a single power posing session (Baseline vs. T1). P value significance level cut-off was adjusted for multiple comparisons using the Holm-Bonferroni correction method. Interoceptive awareness was calculated by transferring interoceptive accuracy and confidence scores into POMP (percentage of maximum possible) scores, according to the method described by Cohen et al. [59]. Thereby the following formula was used: POMP = [(observed—minimum) / (maximum—minimum)] / 100. 'Observed' represented the observed score for a single case, 'minimum' reflected the minimum possible score on the scale, and 'maximum' reflected the maximum possible score on the scale. Then, the absolute difference between interoceptive accuracy- and sensibility POMP scores was calculated. At this stage, higher scores reflected higher discrepancies between interoceptive accuracy and confidence and thus, lower interceptive awareness. For the scaling of the awareness score to be intuitive, i.e. for higher scores to represent higher awareness, the calculated absolute difference between POMP scores was subtracted from 100, which resulted in an awareness score between 0 and 100. To investigate the effect of power posing after one week of training, data of the same outcome measures, collected after each power posing training period, was collapsed. It was ensured that there were no significant differences between the outcomes of power posing conditions before the data was collapsed. Missing data varied slightly between measures, and the numbers of cases are reported for each analysis.

Results

Demographics and questionnaire data

For a full list of demographic information, please refer to Table 1. Regarding compliance, all participants (N = 41) indicated that they had practiced power posing twice a day. All but one participant (97.6%) (N = 40), indicated that they had filled out the diary as instructed. Also, all participants, except one, (97.6%) (N = 40) stated that they had used the audiotape as instructed.
Recruitment of 42 female participants

Online questionnaires one week prior to testing, collecting demographic and health information

Exclusion of one participant due to psychiatric diagnosis (leaving N = 41)

Questionnaires on subjective feelings of power, BPQ, Hand Grip Task, Heartbeat Detection Task and Confidence Rating (T0)

Power Posing Intervention (single session) in the laboratory

Questionnaires on subjective feelings of power, BPQ, Hand Grip Task, Heartbeat Detection Task and Confidence Rating (T1)

Randomisation of participants (N = 42) into two groups

Group A (N = 21) practised power posing daily

Group B (N = 20) was instructed not to practice at all

After one week: Questionnaires on subjective feelings of power, BPQ, Hand Grip Task, Heartbeat Detection Task and Confidence Rating (T2)

Group A (N = 21) was instructed not to practice at all

Group B (N = 20) was instructed to practice power posing daily

After one week: Questionnaires on subjective feelings of power, BPQ, Hand Grip Task, Heartbeat Detection Task and Confidence Rating (T3)
Effects of a single session of power posing on interoceptive ability

Regarding the single session effect of power posing (please also see Table 2), participants displayed higher interoceptive accuracy after a single power posing session ($M = 0.70; SD = 0.19$), than before ($M = 0.65; SD = 0.19$). This difference, $-0.04$, BCa 95% CI $[-0.26, -0.01]$, was significant $t(40) = -3.26$, $p = .002$, and represented a small effect size, $d = 0.23$ (Cohen, 1988). Regarding interoceptive sensibility scores, the confidence rating of participants was not significantly higher after a single power posing session ($M = 4.62; SD = 1.90$), than before ($M = 4.58; SD = 1.81$); $t(40) = -0.23$, $p = .819$. Also, no significant difference was found in BPQ scores between baseline ($M = 1.90; SD = 0.70$) and T1 ($M = 1.80; SD = 0.65$); $t(40) = 1.95$, $p = .059$. BPQ scores did not significantly correlate with interoceptive accuracy at baseline ($r = -.134; p = .405$) or T1 ($r = -.036; p = .821$). Participants’ interoceptive awareness score, was significantly lower after a single power posing session ($M = 72.91; SD = 20.75$) than before ($M = 78.02; SD = 19.58$); $t(40) = 3.01$, $p = .005$, indicating a higher discrepancy between interoceptive accuracy and confidence, after power posing, thus lower interoceptive awareness.

The correlation between interoceptive accuracy and confidence was not significant at baseline ($r = .304, p = .053$) or at T1 ($r = .305, p = .052$).

Interoceptive accuracy mean scores sorted by time points (baseline; after a single, after one week of training) are visualised in Fig 3.

Effects of one week of power posing on interoceptive ability

Regarding the effect of one week of power posing, (please also see Table 2 and Figs 3–5), participants did not display higher interoceptive accuracy after one week of training ($M = 0.68; SD = 0.18$) compared to baseline ($M = 0.65; SD = 0.19$). $t(40) = -1.670$, $p = .103$. Regarding interoceptive sensibility scores, the confidence rating of participants was also not significantly higher after one week of training ($M = 4.77; SD = 2.07$) compared to baseline ($M = 4.58; SD = 1.81$); $t(40) = -0.898$, $p = .375$. When looking at interoceptive sensibility with the BPQ measure, BPQ scores were significantly lower after one week of power posing training ($M = 1.73; SD = 0.65$) than at baseline ($M = 1.90; SD = 0.70$); $t(40) = 2.71; p = 0.010$. BPQ scores did not significantly correlate with interoceptive accuracy after training ($r = .073; p = .652$). Participants’ interoceptive awareness score, was lower after one week of power posing ($M = 71.93; SD = 18.38$) than before ($M = 77.40; SD = 18.19$); $t(40) = 2.76$, $p = .034$, indicating a higher discrepancy between interoceptive accuracy and confidence after one week of power posing training.

Table 1. Demographic information at baseline.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>($SD$)</td>
<td>$[n]$</td>
</tr>
<tr>
<td>Age</td>
<td>20.85</td>
<td>(1.84)</td>
<td>[41]</td>
</tr>
<tr>
<td>Highest Education</td>
<td>5.00</td>
<td>(0.00)</td>
<td>[41]</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>20.65</td>
<td>(2.29)</td>
<td>[41]</td>
</tr>
<tr>
<td>Level of Fitness</td>
<td>59.54</td>
<td>(17.05)</td>
<td>[41]</td>
</tr>
<tr>
<td>STAI</td>
<td>47.68</td>
<td>(4.74)</td>
<td>[41]</td>
</tr>
</tbody>
</table>

Note. $M =$ Mean; $SD =$ Standard Deviation; $n =$ Number of Participants.

Score Ranges. Level of Fitness (0–100); STAI (20–80)

https://doi.org/10.1371/journal.pone.0211453.t001
posing. However, this difference was no longer significant after Holm-Bonferroni correction was applied.

Interoceptive accuracy did not significantly correlate with confidence after one week of power posing practice ($r = .045, p = .780$) or practice pause ($r = .220, p = .167$).

Subjective feelings of power
The internal consistency of the German 6-item sense of power scale (SOPS 6 GV) was assessed by Cronbach’s alpha after the data was collected. Reverse scored items were recoded before the reliability analysis. Cronbach’s alpha was .815.

Paired samples t-tests were run to determine whether there was a statistically significant mean difference in VAS and SAM scores before and after a single power posing session. As can be seen from Table 3, power posing led to a significant increase in VAS scores, from Baseline ($M = 39.78; SD = 19.15$) to T1 ($M = 47.80; SD = 20.09$), $t(40) = -4.754; p < .001$. Participants did not show significantly higher SAM scores at T1 ($M = 2.90; SD = 0.87$) than at baseline ($M = 2.65; SD = 0.74$), $t(40) = -2.508; p = .016$.

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Table 2. Results of interoceptive measures.

<table>
<thead>
<tr>
<th>Measurement-Poinds</th>
<th>Baseline</th>
<th>After one session</th>
<th>After one week of training</th>
<th>Test statistics</th>
<th>Baseline to after one session</th>
<th>Baseline to after one week of training</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPQ</td>
<td>1.90 (0.70) [41]</td>
<td>1.80 (0.65) [41]</td>
<td>1.73 (0.65) [41]</td>
<td>t (40) = 1.95</td>
<td>.059</td>
<td>t (40) = 2.71</td>
</tr>
<tr>
<td>Interoceptive Accuracy</td>
<td>0.65 (0.19) [41]</td>
<td>0.70 (0.19) [41]</td>
<td>0.68 (0.18) [41]</td>
<td>t (40) = -3.26</td>
<td>.002*</td>
<td>t (40) = -1.67</td>
</tr>
<tr>
<td>Interoceptive Sensibility</td>
<td>4.58 (1.81) [41]</td>
<td>4.62 (1.90) [41]</td>
<td>4.77 (2.07) [41]</td>
<td>t (40) = -0.23</td>
<td>.819</td>
<td>t (40) = -0.90</td>
</tr>
<tr>
<td>Interoceptive Awareness</td>
<td>72.91 (20.75) [41]</td>
<td>78.02 (19.58) [41]</td>
<td>67.75 (21.40) [41]</td>
<td>t (40) = 3.01</td>
<td>.005*</td>
<td>t (40) = 2.20</td>
</tr>
</tbody>
</table>

Note. M = Mean. SD = Standard Deviation. T = T-Test-Statistic. p = Significance Level.
* = Statistically significant difference after Holm-Bonferroni adjustment
For the analysis a two-tailed test was applied.
BPQ = Body Perception Questionnaire
Interoceptive Sensibility = Confidence in performance on HBTT task
Score Ranges. BPQ (1–5); IAc (0–1); IS (1–10); IAw (0–100)

https://doi.org/10.1371/journal.pone.0211453.t002

Fig 3. Interoceptive accuracy mean scores visualized by time point. Note. Error Bars represent SE.
https://doi.org/10.1371/journal.pone.0211453.g003
Regarding the effect of one week of power posing on individuals’ sense of personal power, results showed that there was a significant difference between baseline and a one-week power posing training on the German Sense of Power Scale (SOPS 6 GV) \( (t(40) = -3.622; p = .001) \), with participants displaying higher scores after the training \( (M = 26.51; SD = 3.70) \) than before \( (M = 25.20; SD = 3.68) \). Regarding the implicit power measure MMG, scores on the 'hope for control' dimension (MMG-HK) were lower after one week of power posing training \( (M = 7.15; SD = 3.25) \) than at baseline \( (M = 7.54; SD = 2.71) \). However, this difference was not significant \( (t(40) = 0.942; p = .352) \). On the MMG 'fear of losing control' dimension (MMG-FK), scores were higher after one week of power posing training \( (M = 6.93; SD = 3.17) \) than at baseline \( (M = 6.15; SD = 2.31) \), though, this difference was also not significant \( (t(40) = -1.920; p = .062) \). For a full list of mean scores and standard deviations for the power measures, please refer to Table 3.
Discussion

The central aim of the study was to investigate whether power posing had an effect on individuals’ interoceptive ability. Firstly, we measured the impact of a single power posing session on interoceptive ability in 41 healthy females. Then, the same participants were randomly assigned to two conditions (daily power posing practice vs. no practice). After one week the conditions alternated. Interoceptive accuracy, measured by the heartbeat tracking task and interoceptive sensibility, measured by the Body Perception Questionnaire (BPQ) as well as confidence ratings, were assessed at baseline, after a single power posing session and after one week of training. The main finding was that power posing significantly increased individuals’ interoceptive accuracy after one session of power posing. Power posing reduced interoceptive sensibility, measured by the Body Perception Questionnaire, only after one week of daily practice. In the following paragraphs, the results regarding each interoceptive dimension will be discussed in more depth, together with their clinical implications and future directions.

As expected we found that a single power posing session significantly increased individuals’ interoceptive accuracy. This finding is in keeping with previous research, showing that the induction of power appears to foster individuals’ perception of bodily signals [34, 43, 44, 74]. Unlike previous studies that used cognitive priming (i.e. a top-down approach) as a mechanism to activate subjective feelings of power [34, 44], we focused on the adoption of powerful physical postures (i.e. a bottom-up approach). The induction of power through an embodiment intervention is in line with theories of grounded cognition, which postulate that the adoption of bodily postures elicits affective states and related cognitions [75]. A possible mechanism behind increases in interoceptive accuracy through power posing could be that the strengthening of subjective feelings of power due to the adoption of a physical pose made it likely for individuals to shift their attention inwards, which offered them more capacity to notice their bodily signals [34, 74]. Additionally, it might be that the adoption of a powerful posture lead to a bodily state associated with relaxation and non-threat (e.g. via a reduction in

Table 3. Results of power measures.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measurement-Points</th>
<th>Test statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>After on session</td>
</tr>
<tr>
<td></td>
<td>M (SD) [N]</td>
<td>M (SD)</td>
</tr>
<tr>
<td>MMG_HK</td>
<td>7.54 (2.71) [41]</td>
<td>-</td>
</tr>
<tr>
<td>MMG_FK</td>
<td>6.15 (2.31) [41]</td>
<td>-</td>
</tr>
<tr>
<td>Power (Questionnaire)</td>
<td>25.20 (3.68) [41]</td>
<td>25.78 (2.94) [27]</td>
</tr>
<tr>
<td>VAS_Power</td>
<td>39.78 (19.15) [41]</td>
<td>47.80 (20.09) [41]</td>
</tr>
<tr>
<td>SAM_Dominance</td>
<td>2.65 (0.74) [40]</td>
<td>2.90 (0.87) [40]</td>
</tr>
</tbody>
</table>

Note. M = Mean. SD = Standard Deviation. T = T-Test-Statistic. p = Significance Level. Abbreviations and Score Ranges.

* = Statistically significant difference after Holm-Bonferroni adjustment.

For the analysis a two-tailed test was applied.

MMG_HK = Multi Motive Grid (Hope for Control) (0–12)
MMG_FK = Fear of Losing Control (0–12)
Power (Questionnaire) = SOPS 6 GV (Sense of Power Scale 6 German Version) (6–36)
VAS_Power = Visual Analog Scale—Power (0–100)
SAM_Dominance = Self Assessment Manekin Dominance Item (1–5)

https://doi.org/10.1371/journal.pone.0211453.t003
respiratory rate or physiological arousal) [76–78], which might have fostered sensitivity to heartbeat perception through the absence of stress-related physiological responses. A recent study by Hackford et al. [79], for example, found that the adoption of an upright walking posture was associated with a significantly lower galvanic skin response, lower systolic blood pressure response, and marginally lower skin temperature compared to the adoption of a slumped walking posture. Also, Schmid and colleagues [77] showed that individuals who were primed with power showed significantly lower physiological arousal (i.e. lower heart rate increase) after a social stress test compared to controls. On the other hand, there is also research suggesting that powerful postures can lead to increases in physiological arousal [80], reflecting the activation of the behavioural approach system [81]. In this regard, Scheepers and colleagues [82] showed that priming individuals with high power was associated with an efficient cardiovascular pattern ('challenge'), reflected in high cardiac performance (cardiac output), coupled with low total peripheral resistance. As high cardiac outflow, in turn, has been associated with increased interoceptive accuracy [83, 84], it could be that the cardiovascular pattern induced by the power posing might have fostered performance on the HBTT. Of course, these possible explanations are hypothetical and warrant further investigation.

Using powerful postures as a way to induce power might be particularly beneficial as Huang and colleagues [47] showed that bodily postures had a higher impact on outcomes associated with power, than associative priming. However, it is important to note that we did not find evidence that one week of power posing training maintained the initial increase in interoceptive accuracy. There are several reasons that could explain this unexpected finding. Firstly, it could be that the adoption of a powerful posture has an immediate, temporary effect that decreases when the posture is no longer held. This idea would be in keeping with dynamically changing bodily states as a consequence of physical and context-dependent alterations [85–87]. Alternatively, it may also be that one week of training is simply not enough time to lead to a maintained increased effect. Some studies on the malleability of interoceptive accuracy have shown that longer periods of sustained practice are required to achieve lasting change. Bourne-man and Singer [88], for example, found that significant improvements in interoceptive accuracy could only be reached after six months of contemplative practice. It would, therefore, be beneficial to investigate whether effects can be found when power posing is practiced for several weeks.

Regarding interoceptive sensibility, unlike expected, power posing did not significantly improve individuals' confidence in their performance on the HBTT task after a single session or one week of power posing. From a theoretical point of view, power posing could potentially increase individuals' confidence in subjective performance, as confidence in one's performance has been associated with the induction of power [89–91]. However, performance confidence has also been shown to represent a trait-like construct, which appears to remain stable across different tasks [92, 93]. Thus, here as well, one week of power posing might not be a sufficient amount of time to alter confidence in performance. In line with this assumption, Parkin and colleagues [94] found no changes in interoceptive confidence after one week of mindfulness practice. They did, however, report a significant increase in confidence rating scores after eight weeks of training. Similarly, Fischer et al. [33] reported no significant increase in confidence scores after four weeks of body scan training, they did, however, find significant improvements, after eight weeks of practice. It is further important to note, that power posing targeted the manipulation of individuals' self-focus and heightened self-focus might not directly relate to increases in performance confidence [95, 96]. Finally, the finding that the power manipulation did not affect confidence, but did affect interoceptive accuracy in the short-term, provides support for the previously proposed independence between interoceptive accuracy and sensibility (measured by confidence) [1, 60, 97]. This assumption is also
supported by the finding that no significant correlations between interoceptive accuracy and confidence were found at baseline, after one session of power posing, after one week of daily practice or after one week of practice pause.

When assessing interoceptive sensibility using the BPQ awareness subscale, a significant reduction in BPQ scores was observed after one week of daily power posing practice. As a significant increase was not observed for interoceptive accuracy or confidence at this time point, this observation further underlines the assumption that the different dimensions of interoception appear to diverge from one another. As there is still very little evidence regarding the association between interoceptive sensibility (measured by BPQ) and other cognitive- and emotional constructs, the implications that can be drawn from our observation remain limited. However, one aspect that could be important to consider in regards to this finding is that although the BPQ is commonly applied as a measure assessing interoceptive sensibility, it does not distinguish between adaptive and maladaptive bodily awareness [98]. The majority of the items appear to reflect subjective sensations that seem to be bothersome to the individual [98]. Based on this observation, it can be speculated that the power manipulation might have affected a dimension of interoceptive sensibility that reflects subjective sensitivity to unpleasant bodily signals. To clarify this issue, it would be valuable to integrate other self-report questionnaires assessing interoceptive sensibility, such as the Multidimensional Assessment of Interoceptive Awareness (MAIA) [98], in the future. The MAIA has the advantage that it not only assesses the ‘noticing’ dimension of interoceptive sensibility, but several others, such as the ability to sustain attention to bodily sensations or the tendency not to react with emotional stress to bodily sensation [98]. Also, it investigates responses to pleasant, unpleasant and neutral bodily sensations, thus, discriminates between adaptive and maladaptive aspects of interoceptive sensitivity [99]. Using this additional measure in future research could help to get a better understanding of the specific facets of interoceptive sensibility power posing could potentially influence.

Considering the findings on interoceptive awareness, we found a significant short-term effect of power posing on interoceptive awareness, with a decline in interoceptive awareness appearing after a single power posing session. This finding is logical because interoceptive awareness reflects the concordance between interoceptive accuracy and interoceptive sensibility measures [1]. As interoceptive accuracy improved and confidence rating remained stable, the concordance between the two different dimensions was reduced, meaning that individuals did not integrate their increase in objective performance into their subjective belief about their performance. This failure to optimally incorporate ‘bottom-up’ interoceptive signals when updating ‘top-down’ subjective beliefs is considered an interoceptive prediction error [100]. The question is, what impact this observed divergence (i.e. a state change in interoceptive awareness) has on other domains of functioning such as, for example, emotional experience. To this date, no previous studies looking at the effects of improved interoceptive accuracy have addressed the potential modulating role of interoceptive sensibility [101]. On the one hand, as interoceptive accuracy and sensibility are considered independent of one another [1], effects that may emerge as a result of enhanced interoceptive accuracy in domains (such as the experience or regulation of emotions), are likely to occur even when individuals do not subjectively believe themselves to have better interoceptive ability. However, on the other hand, previous research has found that trait interoceptive prediction errors correlated with lower emotional sensitivity, the occurrence of anxiety symptoms [100], abnormal skin sensations [102] and emotional eating [103]. Thus, a large discrepancy between the two dimensions may be disadvantageous for the individual. In this pilot study we focused on the effects of power posing on state interoceptive awareness and did not relate the observed changes to secondary outcomes. It would, therefore, be interesting to investigate in the future how the awareness dimension of
interoception relates to other aspects such as e.g. anxiety and stress, when power posing is practiced over a longer time period. [101].

Regarding the results of the power measures, individuals showed increased VAS scores after a single power posing session and a heightened sense of personal power after one week of training, measured by questionnaire. Both findings support our third hypothesis, by indicating that individuals experienced themselves as more powerful after power posing than before. This observation converges with the literature on power posing, with the majority of studies reporting a heightened subjective sense of power after power posing [46, 104]. These findings are important as 'felt power' has been associated with an increase in positive- [80, 105] and a reduction in negative affect [106]. It might, therefore, be beneficial to test the long-term application of power posing in clinical samples, which display particular deficits in this domain.

Regarding practical implications, the current study supports that power posing seems to have an immediate, temporary effect on interoceptive accuracy, as well as a one-session and a training effect on subjective feelings of power. As power posing seems to 'boost' the perception of bodily signals, it could be particularly beneficial to apply in situations where sensitivity to self-relevant physiological information is required (e.g. intuitive judgment and decision making [4], emotional processing [8] or body image [13]). Also, it might be advantageous as a one-session intervention for individuals who display low IAcc and reduced subjective feelings of power, for example, those with anorexia nervosa [21, 107] or depression [18, 108]. The benefit of training power posing daily for one week to increase interoceptive accuracy is not supported by our findings. Also, our study did not find that it leads to improvements in individual’s confidence in their performance on the HBTT. However, one week of power posing practice seems to reduce the perception of bodily sensations that are bothersome to the individual (measured by questionnaire). Therefore, practicing power posing might also be beneficial for individuals displaying high scores on the BPQ, for example, patients with joint hypermobility [109], generalized anxiety- or panic disorder [110].

The study has several limitations. Firstly, holding a particular posture for a certain amount of time always goes hand in hand with some kind of self-focus, as it requires moment-to-moment self-monitoring to keep the body correctly adjusted. Therefore, it is very difficult to disentangle the effect of the power postures from the effect of self-focus that might have resulted from holding the poses. To clarify this question one could integrate neutral postures, as well as postures expressing low power in a future study and compare these with powerful postures. Theoretically, the powerful postures should lead to better interoceptive accuracy than the neutral or powerless postures, as high power seems to foster mechanisms that initiate and maintain self-focus more than low power. Regarding the limitations of the study further, the Schandry task has been criticised for being susceptible to non-interoceptive influences, such as prior knowledge about heart rate, guessing one’s heart rate, time estimations and practice effects (for further information, please see [111–114]) and we did not control for these possible confounding factors. One reason for this was that assessing beliefs about their heart rate prior to task completion has been proposed to influence performance on the task [115]. One strategy to bypass this possibility could have been to ask individuals about it after the task had been completed for the first time. However, as we tested the subjects again at other time points, the question about their heart rate knowledge might have influenced their subsequent responses. Regarding the influence of time estimates, several recent studies that included a time estimation task, did not find a positive relationship between time estimates and interoceptive accuracy, and controlling for time estimates did not change the relationship between interoceptive accuracy and other outcomes [116, 117]. It is therefore unlikely that time estimates confounded the results, especially as interoceptive accuracy did not significantly increase after one week of training in our study. However, it would be beneficial to replicate the study and
control for these factors to confidently exclude them as confounding variables. Furthermore, we do not know whether the participants engaged in any form of uncontrolled practice of interoceptive enhancement during the week of practice or pause, such as counting their own heartbeats. However, we did inquire whether they practiced any other body-centered intervention during the week of practice or pause (e.g. yoga), which none of the participants confirmed. Finally, we used a female sample only, thus the results are not generalizable to men.

Regarding future directions, it would be valuable to investigate the effect of power posing on interoceptive ability in clinical populations, for example, individuals with anorexia nervosa, who have been shown to display deficits in interoceptive accuracy throughout the course of therapy [118] and have been reported to perceive themselves as powerless [107, 119]. Also, it would be important to explore how changes that can be observed in the different interoceptive dimensions due to specific interventions relate to improvements in other domains of functioning such as emotional experience, behavioural self-regulation and quality of life, to get a better understanding of the areas that could be targeted with practices that have been found to improve interoceptive abilities.

**Conclusion**

Our study was the first to investigate the effects of adopting powerful postures on the different dimensions of interoceptive ability. We conclude that power posing has the potential to improve interoceptive accuracy in the short-term and reduce scores on the BPQ awareness subscale after one week of practicing. Further research should investigate whether the same effect can be found in clinical populations, which display particular deficits in interoceptive ability.

**Supporting information**

**S1 File. Sense of power scale—6—English version.**
(PDF)

**S2 File. Sense of power scale—6—German version (SOPS 6 GV).**
(PDF)

**S1 Table. Overview measures.**
(PDF)

**Acknowledgments**

We would like to thank Selina Rothenfusser (B.Sc.), Maria Sassmannshausen (B.Sc.) and Markus Fischer (M.Sc.) for their great support with participant recruitment and data collection. We are grateful to Dipl.-Psych. Evelyn Beverly Jahn and Dr Christina Lohr for their valuable ideas regarding the practice of the power poses. We also thank Eric Rost for his helpful advice concerning data analysis.

**Author Contributions**

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**Data curation:** Felicitas Weineck.

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References


5.2 Article II: Using bodily postures to reduce anxiety and improve interoception: a comparison between powerful and neutral poses.


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Using bodily postures to reduce anxiety and improve interoception: A comparison between powerful and neutral poses

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Abstract

Background
Previous research has shown that anxiety syndromes are highly prevalent among university students. Effective treatments are needed to reduce the burden of anxiety in this population. Powerful postures have been found to impact affective states, as well as interoception (i.e. the ability to perceive inner bodily signals). However, no previous study has compared the effects of powerful- and neutral postures in regards to anxiety and interoceptive ability.

Methods
The first part of the study measured the single-session effect of adopting powerful- vs. neutral postures on students’ (n = 57) interoceptive ability and state anxiety. The second part of the study measured the effect of adopting powerful or neutral postures twice daily for two weeks, on individuals’ interoceptive ability and trait anxiety.

Results
State anxiety decreased in both conditions whereas interoceptive accuracy only increased in the power posing condition after a single session. Interceptive accuracy increased in both groups after two weeks of training.

Limitations
The study included no comparison to a condition where individuals adopted their natural (i.e. usual) bodily posture.

Conclusions
Embodiment interventions that include elements of adopting an open or expansive bodily posture whilst maintaining a self-focus, can help to reduce state anxiety and improve interoceptive accuracy in student populations. Power posing does not seem to be superior to holding a neutral posture to improve interoceptive accuracy or anxiety. One reason therefore
could be that both conditions include the manipulation of self-focus and a postural change that diverges from individuals’ normal posture.

Introduction

Regarding university students, there is now a large body of evidence documenting the high burden of anxiety disorders and syndromes [1–3], with some studies showing a state anxiety prevalence of up to 81.7% and a trait anxiety prevalence of up to 85.6% [4]. Preliminary findings from a longitudinal study also highlight that self-reported anxiety disorders among students have doubled since 2008 [5]. Moreover, anxiety has been shown to correlate with lower perceived performance [6], lower self-esteem [7], procrastination [8], higher levels of stress and depression [9], lower psychosocial functioning and quality of life [10], as well as sleep disturbances [11]. Therefore, effective and efficient interventions are urgently needed to reduce anxiety symptoms and to improve the mental health in student populations [12, 13].

In this context, the use of embodiment interventions may be helpful. The embodiment approach to emotion generation proclaims that affective states can occur and be modified as a result of alterations in bodily postures, facial expression or the individual’s voice [14–16]. Evidence for this assumption comes from studies highlighting the close connection between emotions and bodily movements [17–19]. Regarding anxiety, research by Lipnicki and Byrne [16] found that participants only experienced anticipatory anxiety when standing up, although not when lying down, before completing a demanding mental arithmetic task. In another study, Nair et al. [20] analysed word use during a stressful speech task. Individuals in an upright posture reported fewer words relating to fear than individuals in a slumped posture. Furthermore, research by Peper et al. [21] showed that individuals who adopted an upright bodily position, took a breath, and then reframed their negative thoughts were significantly more successful in reducing their anxiety compared to individuals who reframed their negative thoughts without adopting an upright bodily posture. However, the evidence regarding anxiety and posture remains mixed. Others studies that have investigated the influence of upright bodily posture compared to reclined bodily posture on self-reported anxiety found no beneficial effects [22–24]. One reason therefore could be that the design of the experiments and the chosen outcome variables varied greatly between the studies. For example, they focused either on a specific type of anxiety, such as social anxiety [24], anticipatory anxiety [16] or anxiety in general [21], or measured anxiety whilst the posture was adopted [25] or after a performance task in which the posture was no longer held [24]. Also, the manipulations of the postures differed in regards to their focus on the whole body [16, 22], the upper body [20, 21, 26] or only parts of the body [25].

To our knowledge, no previous study specifically investigated the effect of power posing [27], on individuals’ state- and trait anxiety using the validated State-Trait Anxiety Inventory [28]. Power posing refers to the adoption of an expansive and dominant bodily posture [27]. From a theoretical point of view, power posing should decrease state anxiety in the short-term, as power posing has been shown to increase state self-esteem [29], which in turn, has been found to be negatively correlated with anxiety [30]. Also, straight postures (as opposed to slumped postures) seem to foster mood recovery [14, 25]. Furthermore, expansive and open bodily postures have been associated with emotions such as pride [31], whereas slumped postures have been found to correlate with emotions such as guilt [32, 33]. Designing effective embodiment interventions that can easily be applied in everyday life might offer students novel coping strategies for reducing their anxiety levels.
Another aspect highly relevant in the context of emotion regulation is *interoceptive ability* [34]. Interoception refers to the perception and processing of internal bodily signals [35]. Previous research could show that interoceptive accuracy (IAcc) facilitated the down-regulation of affect [36]. For example, individuals with higher IAcc made more use of reappraisal and suppression strategies, when regulating their emotions, compared to individuals with lower IAcc [37]. From a theoretical point of view, the induction of power via a bodily posture should increase interoceptive ability, as power has been linked to increases in *self-focus*. From an evolutionary perspective, powerless individuals are more likely to shift their attention outwards to detect potential threat or to gain access to resources [38]. Therefore, they have less capacity to divert their attention inwards [39]. Powerful individuals, on the other hand, have a higher capacity to shift their attention inwards, as they are less dependent upon others for personal resources and are therefore less likely to divert their focus outwards towards less dominant individuals [40]. As a consequence, if someone is more focussed on him or herself, the idea is that he or she is more likely to notice bodily signals [41]. In keeping with this assumption, previous research has shown that individuals who are primed with power find it more difficult to engage in other-oriented perspectives than powerless individuals [42], are less distracted by external information [43] and report trusting their 'gut feeling' when it comes to decision making [43, 44]. Regarding IAcc in particular, Kunstman et al [45] found that power priming through words or writing up powerful memories increased IAcc in those with high levels of body dysmorphic symptomatology. Furthermore, Moeini-Jazani et al. [46] showed that IAcc could also be increased through the induction of social power via a powerful role play (manager vs. manager-subordinate). In a previous pilot study, we found that IAcc could be improved through a single power posing session [47]. This body-focused approach appears to be particularly promising as powerful postures have been shown to have stronger effects on the activation of implicit power than powerful roles [48]. However, our study did not reveal whether the effect of increased IAcc could be upheld when comparing power posing to neutral posing and we did not investigate the effects of power posing on anxiety. Therefore, the current study will expand previous research by comparing neutral- and power posing in regards to interoceptive abilities (i.e. IAcc, interoceptive sensibility and interoceptive awareness) and anxiety. This is also important, as research comparing powerful to neutral postures remains scarce [49, 50]. The majority of previous studies have used contractive postures as a comparison group [51]. This is problematic, as it makes it difficult to identify the true positive effect of powerful postures and to disentangle it from the negative effect of contractive poses [49].

To address the research questions, participants underwent a single power posing- or a single neutral posing session, as well as two weeks of daily power posing- or neutral posing practice. Primary outcomes were measures of anxiety and interoceptive ability. We hypothesised that (I) One session of power posing would increase individuals’ interoceptive abilities and decrease their state anxiety scores compared to neutral posing; (II) Two weeks of daily power posing would increase individuals’ interoceptive abilities and decrease their trait anxiety scores compared to neutral posing.

**Methods**

**Participants**

Sixty-four healthy students were recruited at Ulm University. In return for their participation, they received course credit. Exclusion criteria were a present psychiatric or physical disorder, age under 18 and specific experience or knowledge regarding power posing. Seven participants were excluded from the study due to the diagnosis of chronic physical illness (n = 1), knowledge about power posing (n = 1) or because they did not adhere to the training protocol.
This exclusion left a total of 57 (12 male) participants. Participants had a mean age of 22.70 (SD = 3.88) and a mean BMI of 21.86 (SD = 2.72). None of the participants were taking medication, except contraceptives (n = 8). The number of participants in our study was in keeping with the a priori power analysis. Based on data from a similar study by Moeini-Jazani [46] (n = 135), comparing powerful, neutral and powerless conditions, their effect size (ES) was considered to be medium using Cohen’s [52] criteria. With an alpha = .05 and power = 0.80, the projected sample size required for this effect size (G*Power 3.1.9) was n = 46 for the simplest within-group comparison.

Questionnaires

After having signed up for the study, participants received an online questionnaire via email, collecting health-related and demographic information (including age, BMI, educational background, level of fitness, hours of sport per week, smoking and previous experience with body-centred interventions). Also, the German version of the Patient Health Questionnaire (PHQ-D) [53] was administered.

Furthermore, the German version of the State-Trait Anxiety Inventory (STAI) was applied [54]. It is a validated measure, containing a total of 40 items, assessing different dimensions of anxiety on a 4-point scale, ranging from ‘almost never’ to ‘almost always’. The distinction is made between state and trait anxiety. State anxiety indicates how the participant currently feels, i.e. it reflects a fluctuating emotional state that can vary depending on the situational context. Trait anxiety, on the other hand, reflects the individuals’ proneness to anxiety in general. The subscales for the dimensions include 20 items each and scores can range from 20–80 respectively (with higher scores reflecting higher anxiety).

After two weeks of training the power- or neutral posing, participants were also given an evaluative questionnaire constructed by the authors to assess training compliance. Individuals were asked how many times they practised daily and could indicate their answers on a 4-point scale (‘less than once per day’; ‘once per day’; ‘two times per day’; ‘more than two times per day’). Please note that this study was part of a larger research project. Therefore, several other questionnaires were administered (e.g. the Multi Motive Grid by Sokolowski et al. [55] and the Personal Sense of Power Scale by Anderson et al. [56]), which will not be addressed here, as they will be published in another article with a focus on a clinical sample.

Measurements of interoceptive ability

Interoceptive Accuracy (IAcc). IAcc reflects performance on behavioural tests of interoception [57]. The heartbeat tracking task (HBTT) [58] was used to assess individuals’ IAcc. It is one of the most widely used measures of interoception [59, 60], is easy to administer and has good test-retest reliability [61–63]. It also correlates with other measures of heartbeat detection [64, 65] and neural markers of interoception, such as heart-beat evoked potential [66]. The task included four heartbeat-counting trials, which were presented in a fixed order. Participants were instructed to silently count their heartbeats during these intervals (35s, 45s, 25s and 60s). In between each interval was a 45s break, where they were asked to report the number of counted heartbeats. The experimenter gave a start and stop cue at the beginning and the end of each counting interval. Before the task began, participants were instructed not to take their pulse or to use any other form of manipulation to support the counting of their heartbeats. Also, no prior information regarding the length of the counting phase was given, and participants received no feedback on the quality of their performance. Heartbeat signal was recorded with the BioPac Model MP150, using the software AcqKnowledge 4.0 (Biopac Systems, Inc., Goleta, CA). For the recording, three electrodes were placed on the right clavicle, the lower left...
part of the ribcage and the right hip. IAcc was calculated as the mean heartbeat perception score according to the following transformation:

\[
IAcc = \frac{1}{4} \sum (1 - \frac{|\text{recorded heartbeats} - \text{counted heartbeats}|}{\text{recorded heartbeats}})
\]

IAcc scores could range from 0 to 1. Higher scores indicate smaller differences between the counted and recorded heartbeat and thus better IAcc.

**Interoceptive Sensibility (IS).** IS reflects the individuals' self-confidence relative to his or her objective performance on the HBTT [57]. After each interval of the HBTT, participants were asked to rate their confidence in their performance on a scale ranging from one to ten (1 = not confident at all; 10 = fully confident). As a secondary measure of IS, the Body Perception Questionnaire [67] was applied. This measure has previously been used to assess IS [57, 68]. The BPQ awareness subscale includes 45 items reflecting different bodily sensations. Examples of the items are 'I am aware of how fast I am breathing' or 'I am aware of muscle tension in my arms and legs'. Participants can indicate their awareness of each sensation on a 5-point scale ranging from 'never' to 'always'.

**Interoceptive Awareness (IAw).** IAw refers to the concordance between IAcc and IS measures [57]. To operationalize IAw, we applied the 'percent of maximum possible' or POMP scoring method [69]. This way of expressing IAw has been applied in a previous article by Weineck et al. [47]. A POMP score is the result of a linear transformation of any raw metric into a 0 to 100 scale. In this study, IAcc and confidence scores (= IS) were converted into POMP scores to make them comparable. Thereby the following formula was used: POMP = \([(\text{observed} - \text{minimum}) / (\text{maximum} - \text{minimum})]\) x 100. 'Observed' represented the observed score for a single case, 'minimum' reflected the minimum possible score on the scale, and 'maximum' reflected the maximum possible score on the scale. After the conversion, the absolute difference between interoceptive accuracy- and sensibility POMP scores was calculated. At this stage, higher scores reflected higher discrepancies between interoceptive accuracy and confidence and thus, lower interoceptive awareness. For the scaling of the awareness score to be intuitive, i.e. for higher scores to represent higher awareness, the calculated absolute difference between POMP scores was again subtracted from 100. This transformation results in an awareness score between 0 and 100. Representing IAw in the form of POMP scores has the benefit that an individual awareness score, reflecting the correspondence between IAcc and confidence, can be generated for each participant and, therefore, changes over time can easily be recorded.

Furthermore, the Pearson correlation \(r\), between IAcc and confidence was used as an index of interoceptive awareness [70].

**Embodiment interventions—bodily postures**

Refer to Fig 1 for a display of the powerful and neutral postures. All postures are presented in the order of their application.

**Powerful postures.** The three different powerful postures were selected from studies on bodily displays of power [27, 71, 72]. They were the same ones as those used in our previous pilot study on the effects of power-posing on interoceptive abilities [47]. Each posture contained several elements associated with power such as expansive positions of the arms and legs, the chin and gaze that were tilting upwards and the adaptation of an open bodily position [73]. The order in which the postures were adopted was fixed, and each pose was held for 45 seconds. This duration was chosen, based on previous studies showing beneficial effects after 60 to 120 seconds of power posing [51]. An audiotape (female voice), that lasted for approximately six minutes, guided individuals through each posture. To ensure that the participants
raised their chin correctly whilst practising the poses, they were asked to look at a cross on the wall, placed one hand length above their individual height, at a 1.5-meter distance. Participants were also instructed to continually shift their attention between three anchor points (feet; sternum; chin) to ensure that they did not automatically fall back into their initial or a slumped posture.

Neutral postures. The three different neutral postures were closely linked to the powerful postures in terms of bodily alignment (i.e. if the person in the powerful posture was sitting down, the person in the neutral posture was also sitting down), however, they lacked the expression of bodily power [74]. As an example, in posture number two (see Fig 1), the participant had to stand up, however, instead of expanding the arms sideward, the arms were left hanging parallel to the upper body. Also, instead of tilting the head upwards, the participants were asked to look directly ahead of them. The fixation cross on the wall was placed on their individual eye level at a 1.5-meter distance. Similar to the powerful postures, the order in which the neutral postures were adopted was fixed, and each pose was held for 45 seconds. Here as well, an audiotape (female voice) was played, that lasted for the same amount of time as for the powerful postures, guiding individuals through each posture. Participants were also asked to continually shift their attention between three anchor points (feet; sternum; chin).

Procedure

The study was conducted in accordance with the Declaration of Helsinki, and ethical approval was obtained from the Institutional Review Board (IRB) of Ulm University. Before testing, informed consent was collected from all participants according to IRB requirements. Data collection took place at the laboratories of the Clinical and Health Psychology Department of Ulm University. Participants were informed that the study aimed to investigate the effects of
cervical spine training on different aspects of health. This cover story was used to avoid potential power priming and response bias.

Before the testing in the laboratory, participants filled out an online questionnaire collecting demographic and health-related data. After the testing of individuals’ interoceptive and anxiety scores at baseline in the laboratory, all participants were randomly assigned to two groups via blocked randomization. The power posing group (n = 29) practised power posing for one session, whilst the neutral posing group (n = 28) adopted neutral postures for one session. Participants were tested one-by-one. The poses were shown on a picture and subsequently presented in person by the experimenter. Individuals were then asked to adopt the poses themselves. After a short training session, that endured for as long as each participant needed to understand and apply the postures correctly, the audiotape was played, guiding the participants through the movements. The heartbeat tracking task (HBTT) [58], a question on individuals’ confidence on the task, as well as a fixed-format questionnaire, were administered before (baseline) and after each session (T1). The second part of the study measured the effects of training either the powerful- or the neutral postures twice a day for two weeks at home. The power posing group (n = 29) underwent power posing practice twice daily for two weeks, whilst the neutral posing group (n = 28) underwent neutral posing practice twice daily for two weeks. Participants were instructed to adopt the postures once in the morning and once in the evening. To increase compliance with the training routine participants were given diary charts. Participants’ interoceptive ability was tested again after one week of training (T2), as well as two weeks of practice (T3).

Data analysis. All data were analyzed using IBM SPSS Statistics 25 software (SPSS, Chicago, IL). Mixed ANOVAs were calculated to investigate the effects of embodiment interventions (2 levels: power posing vs. neutral posing) on interoceptive ability and anxiety over time (2 levels: either baseline vs. after a single training session, or 4 levels: baseline, T1, T2, T3). Mauchly’s test of sphericity was performed for each analysis and the results were adjusted accordingly if the test was significant. P-value significance level cut-off was adjusted for multiple comparisons using the Bonferroni correction method. Missing data varied slightly between measures, and the numbers of cases are reported for each analysis. The effect size for the tests with mixed ANOVA was expressed in terms of partial eta squared (η² part) and divided into the categories small effect size (η² part < .01 to < .06), medium effect size (η² part .06 to < .14), and large effect size (η² part ≥ .14) [52].

Results

Demographics and questionnaire data

For demographic information and relevant health-related outcomes refer to Table 1.

Effects of power- or neutral posing on state and trait anxiety

State and trait anxiety mean scores sorted by condition and time points are visualized in Table 2. Regarding the single session effect of power posing or neutral posing on state anxiety, a mixed ANOVA was calculated with the factors condition (neutral posing, power posing) and time (baseline; after one session). Results showed a significant effect of time on state anxiety, $F(1, 55) = 9.07, p = .004$, with a large effect (part.η² = .142). No significant effect of condition ($F(1,55) = 0.42; p = .520$), and no significant interaction effect between time and condition were found, $F(1, 55) = 0.13, p = .723$. One-sided post hoc tests with Bonferroni correction revealed a significant decrease in state anxiety from baseline ($M = 36.10; SD = 7.76$) to T1 ($M = 34.03; SD = 8.18$) for power posing ($t(28) = 2.119, p = .043$), as well as for neutral posing (baseline: $M = 37.21; SD = 8.26$; T1: $M = 35.58; SD = 8.16$), $t(27) = 2.219, p = .035$. 

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Regarding the training effect of power posing and neutral posing on trait anxiety, a mixed ANOVA was calculated with the factors condition (neutral posing, power posing) and time (baseline; T2, T3). Results showed no significant effect of time on trait anxiety, \( F(2, 104) = 0.66, p = .520 \). No significant effect of condition \( F(1, 52) = 1.33; p = .253 \), and no significant interaction effect between trait anxiety and condition was found, \( F(2, 104) = 1.88, p = .158 \).

Table 1. Demographic information at baseline.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Neutral Posing</th>
<th>Power Posing</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>[n]</td>
<td>%</td>
</tr>
<tr>
<td>Age</td>
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<td>[28]</td>
<td>23.4 (5.00)</td>
</tr>
<tr>
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<td>[28]</td>
<td>21.7 (2.82)</td>
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<td>[28]</td>
<td>56.5 (17.42)</td>
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<td>Hours of sport per week</td>
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<td>[28]</td>
<td>2.4 (2.40)</td>
</tr>
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<td>Females</td>
<td>75</td>
<td>21</td>
<td>82.8</td>
</tr>
<tr>
<td>Individuals who smoke</td>
<td>28.6</td>
<td>8</td>
<td>24.1</td>
</tr>
<tr>
<td>Current significant burden in life</td>
<td>32.1</td>
<td>9</td>
<td>41.4</td>
</tr>
<tr>
<td>Experience with body interventions</td>
<td>42.9</td>
<td>12</td>
<td>34.5</td>
</tr>
</tbody>
</table>

Note. \( M = \) Mean; \( SD = \) Standard Deviation; \( n = \) Number of Participants.
Score Ranges. Level of Fitness (0–100)

https://doi.org/10.1371/journal.pone.0242578.t001

Table 2. Means and standard deviations of anxiety and interoceptive measures.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measurement points</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group</td>
<td>M (SD)</td>
<td>[n]</td>
<td>M (SD)</td>
</tr>
<tr>
<td>Anxiety State</td>
<td>Neutral posing</td>
<td>37.21 (8.26)</td>
<td>[28]</td>
<td>35.58 (8.16)</td>
</tr>
<tr>
<td></td>
<td>Power posing</td>
<td>36.10 (7.76)</td>
<td>[29]</td>
<td>34.03 (8.18)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>36.65 (7.96)</td>
<td>[57]</td>
<td>34.80 (8.13)</td>
</tr>
<tr>
<td>Anxiety Trait</td>
<td>Neutral posing</td>
<td>39.08 (8.62)</td>
<td>[26]</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Power posing</td>
<td>40.93 (9.36)</td>
<td>[28]</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>40.04 (8.98)</td>
<td>[54]</td>
<td>-</td>
</tr>
<tr>
<td>Interoceptive Accuracy</td>
<td>Neutral posing</td>
<td>0.66 (0.16)</td>
<td>[24]</td>
<td>0.69 (0.16)</td>
</tr>
<tr>
<td></td>
<td>Power posing</td>
<td>0.63 (0.19)</td>
<td>[26]</td>
<td>0.68 (0.18)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.64 (0.17)</td>
<td>[50]</td>
<td>0.68 (0.17)</td>
</tr>
<tr>
<td>Interoceptive Sensibility</td>
<td>Neutral posing</td>
<td>4.04 (1.66)</td>
<td>[26]</td>
<td>4.17 (1.50)</td>
</tr>
<tr>
<td></td>
<td>Power posing</td>
<td>4.83 (1.47)</td>
<td>[26]</td>
<td>5.14 (1.63)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4.43 (1.60)</td>
<td>[52]</td>
<td>4.66 (1.63)</td>
</tr>
<tr>
<td>Interoceptive Sensibility (BPQ)</td>
<td>Neutral posing</td>
<td>2.74 (0.88)</td>
<td>[26]</td>
<td>2.75 (0.89)</td>
</tr>
<tr>
<td></td>
<td>Power posing</td>
<td>2.54 (0.81)</td>
<td>[28]</td>
<td>2.62 (0.91)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2.63 (0.84)</td>
<td>[54]</td>
<td>2.68 (0.89)</td>
</tr>
<tr>
<td></td>
<td>Power posing</td>
<td>78.00 (16.21)</td>
<td>[26]</td>
<td>77.49 (16.13)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>73.42 (17.83)</td>
<td>[50]</td>
<td>72.17 (18.33)</td>
</tr>
</tbody>
</table>

Note. \( M = \) Mean; \( SD = \) Standard Deviation; \( n = \) Number of Participants.
Score Ranges. Body Perception Questionnaire (BPQ) (1–5); Interoceptive Accuracy (0–1); Interoceptive Sensibility (1–10); Interoceptive awareness (0–100); Anxiety State (STAI-S) (20–80); Anxiety Trait (STAI-T) (20–80).

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Effects power- or neutral posing on interoceptive ability

Regarding the training effect of power posing or neutral posing on interoceptive ability, mixed ANOVAs were calculated with the factors condition (neutral posing, power posing) and time (baseline; T1, T2, T3). Results showed a significant effect of time on IAcc, $F(2.68, 128.78) = 6.62, p = .001$, with a medium effect size ($\eta^2 = .121$). No significant effect of condition ($F(1.48) = .12; p = .734$), and no significant interaction effect between time and condition were found, $F(2.68, 128.78) = 0.13, p = .927$. Post hoc tests with Bonferroni correction revealed that there was a significant increase in IAcc from baseline to T1 ($p = .038$), to T2 ($p = .031$) and T3 ($p = .001$) for posing in general (Table 2 and Fig 2). Regarding the individual conditions, one-sided post hoc tests with Bonferroni correction revealed that there was a significant effect of time on IAcc for power posing from baseline to T1 ($t(26) = -3.076, p = .010$) and from baseline to T3 ($t(26) = 3.768, p = .002$). Regarding neutral posing, there was no significant effect of time from baseline to T1, $t(25) = 1.948, p = .126$, however, we found a significant effect of time from baseline to T3, $t(23) = -2.512, p = .038$.

Regarding IS, measured by confidence rating, no significant effect of time, $F(3, 150) = 2.03; p = .112$, no significant effect of condition ($F(1,50) = 5.72; p = .021$), and no significant interaction effect between time and condition, $F(3, 150) = .30; p = .829$ was found (Fig 3). When looking at interceptive sensibility with the BPQ measure, also, no significant effect of time, $F(1.51, 78.37) = 2.06; p = .146$, no significant effect of condition ($F(1.52) = .37; p = .544$), and no significant interaction effect between time and condition ($F(1.51, 78.37) = 0.37; p = .635$) was found. No significant effect of time ($F(2.71, 129.88) = 4.32; p = .008$), no significant effect of condition ($F(1.48) = 6.73; p = .013$), and no interaction effect between time and condition ($F(2.71, 129.88) = 0.13; p = .927$), was observed regarding interoceptive awareness. The correlation between interoceptive accuracy and confidence was not significant at T3 ($r = .118; p = .174$).

Discussion

The central aim of the study was to investigate whether power posing and neutral posing had an effect on individuals’ anxiety levels and interoceptive ability. In particular, it was assessed whether power posing was superior to neutral posing in regards to these primary outcome
measures. Fifty-seven healthy students were randomly assigned to two groups (power posing vs. neutral posing). Firstly, we measured the impact of a single power posing session and a single session of neutral posing on interoceptive ability and state anxiety. Then, we measured the effects of two weeks of daily training of the powerful or neutral postures on individuals’ interoceptive ability and trait anxiety. The main finding was that there was a significant main effect of time on IAcc, thus, IAcc improved in the short-term and after two weeks through posing. We also found a significant effect of both embodiment interventions on state anxiety after a single session of adapting the powerful or neutral poses. No effects on the other dimensions of interoception were found.

Firstly, the hypothesis that power posing was superior to neutral posing regarding state anxiety was unsupported, as there was no significant main effect of condition. One explanation therefore could be that the neutral posing condition also entailed a treatment effect. The postures were neutral in the sense that they lacked the elements of perceived dominance. We did not, however, control for how individuals were usually standing or sitting. Thus, the poses the participants adopted in the neutral condition may have included elements of openness and expansiveness that were novel to the participants. Posture two (see Fig 1), for example, has been used in previous research as a neutral comparison posture [74]. However, when conducting a literature review, we also found that it is closely related to a foundational yoga posture called *tadasana*, which has been found to alter heart rate variability [75]. In this context, it is also noteworthy, that both, the powerful and the neutral postures, contained features that were opposed to those used to induce fear in previous research [19]. Thus, adopting an open, non-restrictive bodily posture may evoke anxiolytic responses, independent of how expansive it is. Furthermore, as the neutral poses were adopted one after the other, they may have represented a form of meditative movement, which is characterized by a focus of awareness on the body and some form of prescribed or spontaneous movement [76, 77]. Research on meditative movement has shown, that moving the body in space whilst shifting attention towards the self can help to ameliorate anxiety and depression [77]. Thus, in the future, it would be valuable to include usual postures (i.e. postures that do not require the individuals to maintain an instructed position) as well, to disentangle the effects of the applied embodiment interventions.
Although power posing was not superior to neutral posing, the study revealed that power posing and neutral posing reduced individuals’ state anxiety in the short-term. Regarding the effect of power posing, this observation is in keeping with research highlighting that the induction of power seems to foster subjective feelings of power [78], which, in turn, have been found to be beneficial for the reduction of anxiety [79]. As an underlying mechanism, it could also be that the powerful postures activated the individuals’ behavioural approach system, which has been linked to positive affect, as opposed to the behavioural inhibition system, which has been associated with avoidance-related affect (e.g., anxiety, fear) [38]. Anderson et al. [80], for example, found that participants with high feelings of power experienced more emotions such as pride, and fewer emotions such as fear, compared to participants with low feelings of power. They were also more likely to perceive rewards and less likely to perceive threats. Thus it can be speculated that the features of the power poses (e.g. leaning forward) may have induced a particular physiological activity that, in turn, influenced emotional processing [81]. In this context, Hackford et al. [82], found that individuals who walked in an upright posture showed significantly lower systolic blood pressure and galvanic skin response than those who walked in a slumped walking posture. In addition, the upright walking group showed improved psychological states including less low arousal negative affect, less sleepiness and less pain. To get a better understanding of the underlying physiological mechanisms that supported the observed effects in our study, it would be beneficial to include physiological measures in future research, for example by assessing individuals’ skin conductance response whilst holding the postures [83].

Considering the results on anxiety further, no effects on trait anxiety for posing in general were found, when comparing the time points against each other. One explanation could be that two weeks of training is not long enough to achieve changes in trait anxiety through posing. Previous studies aiming at a reduction in trait anxiety have often designed interventions that took place for longer periods, e.g. ten weeks [84]. Also, it is important to note that data collection took place during the exam period, and students may have experienced greater test anxiety. As Spielberger [85] pointed out that test anxiety could be a form of situation-specific trait anxiety [86], higher levels of test anxiety may have confounded individuals’ trait anxiety scores during the time of testing.

Regarding interoceptive accuracy, we found that power posing significantly increased individuals’ IAcc in the short-term and after two weeks of training, when compared to baseline. This finding is in keeping with our previous study on embodied power [47], as well as research on power priming, highlighting that the induction of power appears to foster individuals’ IAcc [45, 46]. In this context, it is noteworthy, that neutral posing did not significantly improve IAcc from baseline to T1. However, here as well, we did not find support for the hypothesis, that power posing is superior to neutral posing in regards to IAcc, as we did not find a significant main effect of the conditions.

Regarding our hypothesis that power posing would be superior to neutral posing in regards to IAcc after two weeks of training, this hypothesis was also unsupported, as improvements occurred in both groups and there was no significant main effect of the conditions. One reason could be that through the open bodily features that are included in both postures categories, a state of non-threat and relaxation is evoked, which fosters attention to bodily signals through the absence of stress-related arousal [82, 87, 88]. An alternative explanation could be that both conditions included the element of self-focus, which is probably induced whilst ensuring that the poses are adopted correctly (i.e. the focus on the feet, the sternum and the position of the chin). Previous experiments could show that self-focus increases interoceptive accuracy [46]. For example, Ainley and colleagues found that individuals’ IAcc could be improved when individuals looked at themselves in a mirror [89], at a photograph of themselves, or processed self-
relevant words [90]. Thus, in the future, it could be useful to compare the postures used in this study to two conditions, where individuals are not instructed to hold particular postures but to simply stand or sit in their usual posture, with or without shifting their attention towards the three anchor points. This could help to gain a deeper understanding of the influence of self-focus on the observed effects. The improvements in both groups after two weeks are noteworthy, as they highlight a possible training effect of IAcc. Regularly adopting open bodily postures and moving the body in space (i.e. embodiment interventions) seem to benefit IAcc, as the mean values increased steadily over time in both conditions. This is an important finding regarding the current debate whether and how interoceptive ability can be improved through the regular practice of a particular intervention [91, 92]. In this context, Fischer et al. [93] found a significant positive effect of a body scan intervention on IAcc after eight weeks of practice. Similarly, Bornemann et al. [63] reported improvements in IAcc after six to nine months of contemplative practice. However, other research found no training effect of IAcc through mindfulness after two months [94]. To get a better understanding of the training effects of power posing or neutral posing it would be interesting to investigate, whether IAcc would continue to improve over prolonged periods of practice (e.g. eight weeks).

Looking at the current evidence-base for powerful postures in general, there have been mixed results regarding their effectiveness. Supporting evidence seems to depend on the chosen outcome variables. For example, a recent p-curve analysis, including 55 studies, by Cuddy et al. [78] found no support for so-called non-EASE variables (including e.g. hormones, pain threshold or performance in a job interview). However, they found supporting evidence for EASE variables (including emotions, affect and self-evaluations). Therefore, our findings regarding the effects of powerful postures are in keeping with this recent analysis as they highlight benefits on affective states as well as the perception of bodily signals, which are an important prerequisite for emotion processing [36].

The study has several limitations. Firstly, we did not collect any qualitative or quantitative data on the subjective experience of the postures. It could be that participants preferred one posture to the other and one group may have enjoyed practising the poses more than the other. Regarding this point, it would be beneficial to also include likability ratings in future research to understand which intervention receives higher preference ratings. Also, comparing powerful postures to individuals’ usual or natural postures, as aforementioned, might help to get a better understanding of the underlying mechanisms of the observed effects. Furthermore, there may have been demand characteristics that could have impacted the results. However, as we tried to minimize these by using a cover story, removing all headlines from the questionnaires and embedding the anxiety questionnaires in a series of other questionnaires to avoid priming the individuals with the main objective of the study. Nevertheless, demand characteristics could have played an important role, especially as recent studies have highlighted the influence of the social context on bodily posture effects (see [51, 95, 96]). Thus, the results of this study should be interpreted baring this possible confounding variable in mind. For future research, it would also be valuable to adopt the different postures once with and once without the experimenter present to get a better understanding of how experimenter presence or absence may have impacted the results. Considering limitations further, the heartbeat detection task has been criticised for being susceptible to non-interoceptive influences, such as knowing or guessing one’s heart rate, time estimations or practice effects [97, 98] and we did not control for these possible confounding factors. In this context, it is noteworthy that several recent studies that included a time estimation task, did not find a positive relationship between time estimates and interoceptive ability, and controlling for time estimates did not change the relationship between IAcc and other outcomes [99, 100]. It is therefore unlikely that time estimates confounded the results. Also, regarding practice effects, the post hoc tests revealed no
significant improvement in the neutral power posing group in the short term. If practice effects had impacted the results, this should have resulted in an increase in IAcc in the neutral posing group at T1. Also, other studies that applied the HBTT at different time points either did not find significant improvements over time [94, 101] or did find variations in IAcc depending on the manipulation used [89, 93]. These observations speak against the influence of practice effects. Finally, the study was conducted using a sample of university students and the results may not be generalizable to individuals with a diagnosed anxiety disorder. However, previous studies have chosen a cut-off score of >40 on the STAI for minor and major anxiety symptomatology [102] and it is noteworthy that our student sample displayed a baseline mean score of 40.04. Thus, based on this observation the results of this study may be generalizable to individuals with a similarly high trait anxiety score.

Regarding clinical implications, the study highlights that, although power posing is not superior to neutral posing, adopting open, mindful postures and moving the body in space seem to be beneficial for interoceptive accuracy as well as state anxiety. This observation is particularly relevant to consider when designing embodiment interventions aiming at the reduction of anxiety in students.

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Formal analysis: Felicitas Weineck, Dana Schultchen.

Funding acquisition: Felicitas Weineck, Olga Pollatos.

Investigation: Felicitas Weineck.

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Validation: Felicitas Weineck, Dana Schultchen, Gernot Hauke, Matthias Messner, Olga Pollatos.

Visualization: Felicitas Weineck.

Writing – original draft: Felicitas Weineck.

Writing – review & editing: Felicitas Weineck, Dana Schultchen, Gernot Hauke, Matthias Messner, Olga Pollatos.
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5.3 Article III: Using bodily postures in the treatment of anorexia nervosa: Effects of power posing on interoception and affective states.


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Using bodily postures in the treatment of anorexia nervosa: Effects of power posing on interoception and affective states

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Abstract
Objective: Power posing involves the adoption of an expansive bodily posture. This study examined whether power posing could benefit individuals with anorexia nervosa (AN) and women with normal weight in regards to interoceptive ability and affective states.

Method: Participants included 50 inpatients and outpatients with AN as well as 51 normal-weight women. Interoceptive accuracy (IAcc), measured by the heartbeat tracking task and interoceptive sensibility (IS), measured by confidence ratings, were assessed at baseline, after a single power posing session and after 1 week of daily training. Also, the short-term effects of power posing on subjective feelings of dominance, pleasantness, and arousal were investigated.

Results: Both groups increased in their IAcc after one power posing session. Also, there was a significant main effect of time on feelings of dominance and pleasantness in the short-term. Women with AN displayed lower levels of IS, dominance, and pleasantness as well as higher levels of arousal than women without AN.

Discussion: These findings suggest that power posing has the potential to increase IAcc, subjective feelings of power and pleasant affect in the short-term. Further research should investigate which mechanisms foster the effectiveness of this intervention to tailor it to the needs of women with AN.

Keywords
anorexia nervosa, embodiment, interoception, power posing

Abbreviations: AN, anorexia nervosa; BPT, body perception training; CBT, cognitive behavioural therapy; HBTT, heartbeat tracking task; IAcc, interoceptive accuracy; IRB, Institutional Review Board; IS, interoceptive sensibility; SAM, self-assessment manikin.

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Anorexia nervosa (AN) is an enduring and deliberating eating disorder, with severe psychological, physiological, and social consequences (Fichter, Quadflieg, Crosby, & Koch, 2017). Despite advances in identifying the risk and maintaining factors of the illness, AN remains challenging to treat (Murray, Quintana, Loeb, Griffiths, & Le Grange, 2019; Oldershaw, Startup, & Lavender, 2019), with studies reporting high rates of relapse (Berends, Boonstra, & van Elburg, 2018) and treatment drop-out (Dejong, Broadbent, & Schmidt, 2012; Linardon, Hindle, & Brennan, 2018). Although no gold-standard therapy is available for adults (Resmark, Herpertz, Herpertz-Dahlmann, & Zeeck, 2019; van den Berg et al., 2019), cognitive behavioural therapy (CBT) has been shown to be moderately effective for symptom reduction and is one of the recommended, most widely used psychotherapeutic approaches to treating AN (Zeeck et al., 2018). This form of therapy includes techniques such as creating personalized formulations, psychoeducation, cognitive restructuring, self-monitoring, recognizing dietary rules, addressing the over-evaluation of shape and weight or mirror exposure (Byrne, Fursland, Allen, & Watson, 2011). Broadly speaking, these interventions strongly rely on executive functioning, that is, top-down processing, to achieve behavioural and emotional changes (Goldapple et al., 2004; Huang et al., 2014; Jokić-Begić, 2010; Otto, Misra, Prasad, & McRae, 2014; Shou et al., 2017). Top-down processing involves the recruitment of higher-order brain regions (e.g., the prefrontal cortex) to modulate responding in emotion-generative brain areas (e.g., the amygdala) (Buhle et al., 2014; Ochsner et al., 2009). In contrast, bottom-up processing refers to the direct reactivity of emotion-generative brain regions without active recruitment of higher-order brain areas (Westbrook et al., 2013). Embodiment interventions are nonverbal, experiential techniques that use the posture and the movement of the body as a way to generate emotions, thereby strongly relying on mechanisms of bottom-up processing (Pietrzak, Lohr, Jahn, & Hauke, 2018).

It has been suggested that, in addition to improving cognitive control, it is important to examine which body manipulations could support treatment outcomes in individuals with AN (Cascino et al., 2019; Folk et al., 2016). Although studies on the effectiveness of embodiment interventions in eating disorder populations remain scarce (Stinson, 2019), there is some evidence from nonclinical samples suggesting that they could be a valuable complement to CBT for AN. For example, Miragall et al. (2018) found that women with high body dissatisfaction could benefit more from mirror exposure when they adopted an expansive, rather than a contracted bodily posture. Another study by Allen, Gervais, and Smith (2013) also showed that the adoption of expansive (vs. constrictive) postures was associated with less restrained eating among women with high body shape concerns.

The adoption of powerful bodily postures, also named power posing (Carney, Cuddy, & Yap, 2010), is an intervention that may be particularly helpful for individuals with AN for several reasons. Firstly, there is evidence supporting that women with AN tend to feel powerless and of low social rank (e.g., they often experience power struggles with family members, parents and therapists, have a high fear of losing control or perceive that they have little influence over others, their body or their eating disorder) (Kam & Lee, 1998; Mullen, Dowling, Doyle, & O’Reilly, 2020; Offord, Turner, & Cooper, 2006; Schwartz, Rodriguez, Thomas, & Salimi, 2001; Troop, Allan, Treasure, & Katzman, 2003; Wolff & Serpell, 1998; Woolrich, Cooper, & Turner, 2008). In this regard, power posing could help, as it has been shown to increase subjective feelings of power (Gronau et al., 2017), which, in turn, have been associated with increases in self-esteem (Körner, Petersen, & Schütz, 2019).

Secondly, the bodily posture of individuals with anorexia nervosa tends to be stooped (Bruch, 1979; Kolnes, 2012; Probst et al., 2013). This can be disadvantageous as stooped bodily postures have been associated with depressed mood (Shafir, Tsachor, & Welch, 2015; Wilkes, Kydd, Sagar, & Broadbent, 2017). Assuming a reciprocal flow of information between bodily states and emotions (Niedenthal, 2007), chronically adopting a slumped bodily posture could foster sensory feedback loops that promote the maintenance of negative affect (Michalak et al., 2009; Shafir et al., 2015). Through the practise of power posing individuals with AN could potentially benefit from changes in affective states via bottom-up processing (Park, Dunn, & Barnard, 2011).
such as improvements in positive affect (Shafir et al., 2015; Wilkes et al., 2017) or reductions in stress-related arousal (Peña & Chen, 2017; Schmid & Schmid Mast, 2013).

Finally, the activation of power has been associated with improvements in interoceptive ability (Kunstman et al., 2016; Moeini-Jazani, Knoeferle, de Moliere, Gatti, & Warlop, 2017; Weineck, Messner, Hauke, & Pollatos, 2019). Interoception refers to the perception and processing of internal bodily signals (Craig, 2002) and has been associated with the down-regulation of negative affect (Füstös, Gramann, Herbert, & Pollatos, 2012; Kever, Pollatos, Vermeulen, & Grynberg, 2015). For example, a study by Kever et al. (2015) showed that individuals with higher interoceptive accuracy made more use of reappraisal and suppression strategies, when regulating their emotions, compared to individuals with lower interoceptive accuracy. Also, higher interoceptive accuracy has been associated with lower levels of distress, lower behavioural affiliation tendencies following social exclusion, as well as more self-reported emotion-regulation strategies (Pollatos, Matthias, & Keller, 2015). In regards to eating disorders it is also important to note that positive changes in emotion regulation and interoceptive skills during treatment have been found to significantly predict less risk of eating disorder at discharge (Preyde, Watson, Remers, & Stuart, 2016). In general, a distinction is made between interoceptive accuracy (IAcc), which reflects performance on behavioural tests of interoception, and interoceptive sensibility (IS), which refers to an individuals' subjective belief about their interoceptive ability (Garfinkel, Seth, Barrett, Suzuki, & Critchley, 2015). A recent systematic review by Martin, Dourish, Rotshstein, Spetter, and Higgs (2019) highlighted that interoceptive deficits are prominent in patients with AN. Also, when present, these deficits do not seem to improve with CBT alone (Fischer et al., 2016). This highlights the need to design interventions that promote interoceptive processing in AN patients with low interoceptive ability.

One pathway in which power posing could increase IA in individuals with AN is through an increase in self-focus (Ainley, Tajadura-Jimenez, Fotopoulou, & Tsakiris, 2012; Moeini-Jazani, Knoeferle, de Moliere, et al., 2017). From an evolutionary perspective, individuals who are powerless are more likely to direct their attention outward to detect potential threat or to gain access to resources (Keltner, Gruenfeld, & Anderson, 2003). Consequently, they have less capacity to turn their attention inward (Fiske & Dépret, 1996). On the other hand, individuals who are powerful are more dependent upon others for personal resources, are less likely to experience threat and, therefore, have more capacity to shift their attention inward, toward themselves (Guinote, 2007). If an individual is more focussed on himself or herself, the idea is that he or she is also more likely to notice bodily signals (Guinote, 2010). In line with this assumption, a study by Kunstman et al. (2016) found that power priming through words or powerful memory recall increased IAcc in those with high levels of body dysmorphic symptomatology. Furthermore, Moeini-Jazani, Knoeferle, de Molière, Gatti, and Warlop (2017) showed that IAcc could also be increased through the induction of social power via a powerful role play. In this context, it is noteworthy that Ainley et al. (2012) found the IAcc of healthy individuals to increase via self-observation in the mirror. However, Pollatos et al. (2016) highlighted, that this effect does not occur in women with AN, probably because the confrontation with the body in the mirror elicits body-related avoidance which, in turn, decreases IAcc. Therefore, the induction of power via a powerful posture may be particularly helpful for women with AN as it does not involve a direct confrontation with the body in front of a mirror or memory retrieval of powerful events, that the person may have never experienced.

Another pathway in which power posing could benefit women with AN is by supporting multisensory integration and helping to update the individuals' body memory through concrete body-focussed exercises (Artoni et al., 2020). The allocentric lock hypothesis (ALH) assumes that body experience is based on an egocentric as well as an allocentric frame (Riva, 2012; Riva & Gaudio, 2012). The egocentric frame reflects the present state of the body (first-person perspective) which is constantly updated via real-time input from different sensations and perceptions (Riva, 2012). The allocentric frame refers to the individuals' long-term body memory (third person perspective) which includes knowledge, attitudes and stored representations of the body (Riva, 2012). In healthy individuals these two frames influence each other (e.g. real life sensory signals update allocentric body representations) (Artoni et al., 2020; Volcic & Kappers, 2008). However, in AN patients this process appears to be impaired, leaving the individuals 'locked in' their allocentric frame (Riva & Gaudio, 2018; Serino et al., 2015). As a consequence, they are unable to identify and respond to interoceptive signals that predict pleasant or unpleasant consequences and are therefore restricted in their emotion regulation capacity (Riva & Dakanalís, 2018). Recent research by Artoni et al. (2020) has highlighted that implementing a body perception training (BPT) that focuses on interoceptive, proprioceptive (e.g., self-movement and body position in space), and tactile perception into therapy leads to better therapy outcomes (e.g., reduced body image disturbance) than TAU. Based on this finding, exercising the power poses...
may produce an attentional shift from an allocentric memory of oneself to an embodied, egocentric power pose. This, may improve the processing of interoceptive signals and at the same time update the body memory with more positive content. In this context, Eich, Nelson, Leghari, and Handy (2009) also showed that the activation of an allocentric memory (third person perspective) produces a significant reduction in one's cortical representations of the physical, embodied self. Thus, implementing body-focused exercises may have the opposite effect by promoting the egocentric, first person perspective of the self.

Looking at the current evidence-base of power posing in general, there have been mixed results regarding its effectiveness. Supporting evidence seems to depend on the chosen outcome variables. For example, a recent p-curve analysis, including 55 studies, by Cuddy, Schultz, and Fosse (2018) found no support for so called non-EASE variables (including, e.g., hormones, pain threshold, or performance in a job interview). However, the authors found supporting evidence for EASE variables (including emotions, affect, and self-evaluations). In light of this observation, assessing the effects of power posing on the perception of bodily signals in AN appears to be promising, as this ability represents an important prerequisite for emotion processing (Füstös et al., 2012).

Although there is now a growing body of research that investigated the effects of power posing in normal-weight individuals (Cuddy et al., 2018), no previous study assessed possible benefits in eating disorders populations. Therefore, the central aim of this study is to investigate the effects of power posing on interoceptive and affective states in women with AN as well as non-AN controls. We hypothesized that a single power posing session would significantly increase interoceptive accuracy, interoceptive sensitivity, feelings of power, and feelings of pleasantness as well as reduce individuals’ feelings of arousal in both groups. Also, we examined the effects of 1 week of daily power posing training and expected that regular power posing practice would increase interoceptive accuracy and interoceptive sensibility in both groups.

2 METHODS

2.1 Participants

Women without AN were recruited at the campuses of Ulm University and Ludwig Maximilian University in Munich via flyers. Exclusion criteria were a present psychiatric disorder or physical disease according to ICD-10, age under 18, and specific experience with power posing. To assess the individuals' experience with power posing, the participants were asked whether or not they had previously practised or heard of power posing before after the study was completed. They were also asked to state what they thought the study was about. This approach was taken to ensure that no previous knowledge about the concept of power posing and its potential benefits could have confounded the results through cognitive priming.

Women with AN were recruited in two outpatients clinics for eating disorders in Munich, Germany (ANAD e.V. and the Treatment Centre for Eating Disorders (TCE) at Dritter Orden Hospital) as well as the inpatient ward of Schoen Clinic Rosenbeck in Rosenheim, Germany. The consecutive sampling method was applied. Inclusion criteria were age over 18 (no upper age limit), meeting the DSM-5 criteria of AN or atypical AN, as assessed by semistructured interview by a clinical psychologist, and the physical ability to adopt the power poses. Exclusion criteria were previous knowledge about power posing. In return for their participation, individuals received either course credit or monetary compensation. During the experimental phase all patients also received standardized CBT treatment for AN.

The final sample of the study consisted of 101 individuals, including 50 patients with AN and 51 non-AN controls. All of the participants were female and age did not differ between groups (t(76) = 1.594; p = 0.115). The mean BMI was 15.51 (95% CI: 14.9–16.1) in the AN group and 20.21 (95% CI: 20.2–21.4) in the non-AN group. Of the AN patients, 80% (n = 40) were diagnosed with restrictive AN, 16% (n = 8) were diagnosed with purging AN and 4% (n = 2) were diagnosed with atypical AN. About 19% (n = 18) of the AN sample had psychiatric comorbidities. About 6% (n = 6) displayed an anxiety disorder, 7% (n = 7) displayed an affective disorder, 7% (n = 7) displayed an obsessive compulsive disorder, 3% (n = 3) displayed an adjustment disorder, 1% (n = 1) displayed posttraumatic stress disorder, and 1% (n = 1) displayed an enduring personality change. In the AN sample, 38% (n = 19) of the participants were prescribed medication. About 42% (n = 8) of them took neuroleptic medication and 78% (n = 15) took antidepressant medication (SSRI, SNRI, or NDRI). Patients continued to take their medication during the experimental phase. For a full list of the demographic information please refer to Table 1.

2.2 Procedure

The study was conducted in accordance with the Declaration of Helsinki, and ethical approval was obtained from the Institutional Review Board (IRB) of Ulm University. Prior to testing, informed consent was
collected from all participants according to IRB requirements. Data collection of the non-AN sample took place at the laboratories of the Clinical and Health Psychology Department of Ulm University, as well as in Munich. Data collection of the AN sample took place in the quiet therapy rooms of the outpatient clinics ANAD e.V., and TCE in Munich, as well as Schoen Clinic Roseneck in Rosenheim. Participants were informed that the study aimed to investigate the effects of bodily postures on different aspects of health. This cover story was used to avoid potential power priming and response bias.

The design and procedure of the study were closely related to a previous pilot study by Weineck et al. (2019). Firstly, the heartbeat tracking task (HBTT) (Schandry, 1981), a question on individuals’ confidence on the task, as well as a fixed-format questionnaire assessing affective states, were administered at baseline (T0). Then, the power poses were presented in person by the experimenter and individuals were asked to adopt the poses themselves. After a short training session, an audiotape was played that guided the participants through the movements. Individuals’ interoceptive and affective scores were assessed again after this session (T1). Then, all participants were randomly assigned to two groups via blocked randomization. Individuals in Group A practiced power posing twice daily for 1 week, whilst those in Group B were asked to pause the training for 1 week. After 1 week, these conditions alternated for all participants. This cross-over design was chosen to avoid order effects. When asked to train the power poses, participants had to adopt the poses once in the morning and once in the evening. To increase compliance with the training routine participants were given diary charts. Participants’ interoceptive ability was tested again after the week of training.

After the study was completed, participants were debriefed about the purpose of the study and were invited to take part in a focus and discussion group, to ask questions and share their personal experiences with the power poses (McShane, Davey, Rouse, Usher, & Sullivan, 2015).

### 2.3 Measurements of affective states

To measure changes in affective states, the Self-Assessment Manikin (SAM) by Bradley and Lang (1994) was used. It is a pictorial assessment technique that measures a persons’ affective reaction based on three dimensions: dominance, pleasantness and arousal. The assessment includes a range of figures for each dimension and participants are asked to place a cross on the figure that represents their current emotional state. In this study, a 5-point rating scale was used for each dimension. As an example, the pleasantness figure ranged from a smiling, happy figure to a frowning, unhappy figure. Reverse-scored scales were recoded before the data analysis.

### 2.4 Measurements of interoceptive ability

#### 2.4.1 Interoceptive accuracy

IAcc reflects performance on behavioural tests of interoception (Garfinkel et al., 2015). To assess individuals’ IAcc, the heartbeat tracking task by Schandry (1981) was used. It is one of the most widely used measures of interoception (Tabor, Vollaard, Keogh, & Eccleston, 2019; Young, Gaylor, de Kerckhove, Watkins, & Benton, 2019), is easy to administer and has good test-retest reliability (Bornemann, 2017; Pollatos, Traut-Mattausch, Schroeder, & Schandry, 2007). It further correlates with other measures of heartbeat detection (Knapp-Kline & Kline, 2005; Knoll & Hodapp, 1992) and neural markers of interoception, such a heart-beat evoked potential (Mai, Wong, Georgiou, & Pollatos, 2018). The task included four heartbeat-counting intervals (35, 45, 25, and 60 s), which were presented in a fixed order. Participants were instructed to silently count their own heartbeats during these trials. In a 45 s break between each interval, participants were asked to report the number of counted

**Table 1** Sample characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>AN</th>
<th>Controls</th>
<th>t(df)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>23.88</td>
<td>22.25</td>
<td>t(76) = 1.594</td>
<td>p = 0.115</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>15.51</td>
<td>20.83</td>
<td>t(99) = 12.294</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Duration of illness (years)</td>
<td>7.78</td>
<td>6.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital admission due to ED</td>
<td>3.62</td>
<td>3.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current length of hospital stay (weeks)</td>
<td>9.11</td>
<td>11.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eating Disorder Inventory-2 (total)</td>
<td>319.14</td>
<td>59.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: AN, anorexia nervosa; ED, eating disorder; M, mean; SD, standard deviation.
heartbeats. The experimenter gave a verbal cue at the beginning and the ending of each interval. Before the task began, participants were instructed not to take their pulse or to use any other form of manipulation to support the counting of their heartbeats. Also, no prior information regarding the length of the counting phase was given, and participants received no feedback on their performance. Heartbeat signal was recorded with the mobile heart frequency monitor RS800CX (Polar Electro Oy, Kempele, Finland). This monitor offers a noninvasive method to record the interbeat-interval and can compete with other electrocardiography measures regarding its validity and reliability (Kingsley, Lewis, & Marson, 2005; Williams et al., 2017). IAcc was calculated as the mean heartbeat perception score according to the following transformation:

\[
\frac{1}{4} \sum \left(1 - \left(\frac{|\text{Recorded heartbeats} - \text{counted heartbeats}|}{\text{Recorded heartbeats}}\right)\right)
\]

IAcc scores could range from 0 to 1. Higher scores indicate smaller differences between counted and recorded heartbeats and thus a better interoceptive accuracy.

2.4.2 | Interoceptive sensibility

IS is another dimension of interoceptive ability and reflects the individuals’ self-confidence relative to his or her objective performance on the HBTT (Garfinkel et al., 2015). Thus, it expresses individuals’ subjective beliefs about their interoceptive ability. To assess IS, participants were asked to rate the confidence in their heartbeat perception performance on a scale ranging from one to ten (1 = not confident at all; 10 = fully confident), after each interval of the HBTT.

2.5 | Embodiment interventions—Powerful postures

The three different powerful postures were selected from studies on bodily displays of power (Arnette & Li, 2012; Carney et al., 2010; Hall, Coats, & LeBeau, 2005) and were the same ones as those used in our previous pilot study (Weineck et al., 2019). Each posture contained several elements associated with power such as expansive positions of the arms and legs, the chin and gaze that were tilting upward, and the adoption of an open bodily position (Carney, Hall, & LeBeau, 2005) (Figure 1). The power poses were adopted in a fixed order and each one was held for 45 s. This duration was chosen, as previous studies highlighted beneficial effects after 60–120 s of power posing (Carney, Cuddy, & Yap, 2015). Participants were guided through each posture by a 6-min-long audiotape (female voice). Whilst practicing the poses, participants were asked to look at a cross on the wall, placed one hand length above their height, at a 1.5-m distance. This instruction was given to ensure that they raised their chin correctly whilst practicing the poses. Participants were also asked to continually shift their attention between three anchor points (feet; sternum; and chin) to ensure that they did not automatically fall back into their initial or a slumped posture.

2.6 | Data analysis

All data were analysed using IBM SPSS Statistics 25 software (SPSS, Chicago, Illinois). Mixed analyses of variance were calculated to investigate the effects of power posing on interoceptive ability and affective states over time (2 levels: either baseline vs. after a single training session, or 2 levels: baseline, after 1 week of training) and on group (2 levels: AN vs. non-AN). Mauchly’s test of sphericity was performed for each analysis and the results were adjusted accordingly if the test was significant. The p-value significance level cut-off was adjusted for multiple comparisons using the Bonferroni correction method. Missing data varied slightly between measures, and the numbers of cases are reported for each analysis.

3 | RESULTS

3.1 | Effects of a single session of power posing on interoceptive ability

The main effect of time on IAcc after a single power posing session was significant, \(F(1.97) = 7.51, p = 0.007\), \(\text{part.}\eta^2 = 0.072\), indicating that the power poses had an effect in both groups after one session (Table 2).
No significant main effect of group \((F(1,97) = 0.57; p = 0.453)\), and no interaction effect between time and group were found, \(F(1,97) = 2.12, p = 0.148\).

Regarding IS, measured by confidence rating, no significant main effect of time, \(F(1,98) = 1.35; p = 0.248\) was found. However, there was a significant main effect of group \((F(1,98) = 7.68; p = 0.007, \text{part.}\eta^2 = 0.073)\,\text{with the AN-}\)group displaying lower levels of IS than the non-AN controls (Table 2). No significant interaction effect between time and group was found, \(F(1,98) = 0.321\).

### Table 2: Means and standard deviations of interoceptive and affective measures

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Measurement points</th>
<th></th>
<th>After one session</th>
<th>Baseline$^b$</th>
<th>After 1 week of training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline$^a$</td>
<td></td>
<td>Baseline$^b$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>([M \text{ (SD)} \mid n])</td>
<td>Baseline$^b$</td>
<td>([M \text{ (SD)} \mid n])</td>
<td>Baseline$^b$</td>
<td>([M \text{ (SD)} \mid n])</td>
</tr>
<tr>
<td>Interoceptive accuracy</td>
<td>Anorexia nervosa</td>
<td>0.59 (0.21) [49]</td>
<td>0.61 (0.22) [49]</td>
<td>0.61 (0.19) [44]</td>
<td>0.63 (0.19) [44]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Controls</td>
<td>0.61 (0.19) [50]</td>
<td>0.65 (0.17) [50]</td>
<td>0.60 (0.18) [51]</td>
<td>0.64 (0.17) [51]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.60 (0.20) [99]</td>
<td>0.63 (0.20) [99]</td>
<td>0.61 (0.19) [95]</td>
<td>0.63 (0.19) [95]</td>
<td></td>
</tr>
<tr>
<td>Interoceptive sensibility</td>
<td>Anorexia nervosa</td>
<td>3.70 (1.95) [49]</td>
<td>3.51 (2.05) [49]</td>
<td>3.79 (1.98) [44]</td>
<td>3.68 (2.19) [44]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Controls</td>
<td>4.64 (1.78) [51]</td>
<td>4.63 (1.88) [51]</td>
<td>4.64 (1.78) [51]</td>
<td>4.81 (2.02) [51]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4.18 (1.91) [100]</td>
<td>4.08 (2.04) [100]</td>
<td>4.25 (1.91) [95]</td>
<td>4.29 (2.17) [95]</td>
<td></td>
</tr>
<tr>
<td>Pleasantness</td>
<td>Anorexia nervosa</td>
<td>2.96 (1.07) [46]</td>
<td>3.26 (1.02) [46]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Controls</td>
<td>4.00 (0.64) [50]</td>
<td>4.04 (0.64) [50]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.50 (1.02) [96]</td>
<td>3.67 (0.93) [96]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arousal</td>
<td>Anorexia nervosa</td>
<td>2.89 (1.14) [46]</td>
<td>2.87 (1.09) [46]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Controls</td>
<td>2.30 (0.93) [50]</td>
<td>2.14 (0.86) [50]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2.58 (1.07) [96]</td>
<td>2.49 (1.04) [96]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominance</td>
<td>Anorexia nervosa</td>
<td>1.85 (0.82) [46]</td>
<td>2.02 (0.83) [46]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Controls</td>
<td>2.66 (0.72) [50]</td>
<td>2.84 (0.84) [50]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2.27 (0.86) [96]</td>
<td>2.45 (0.93) [96]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a$Baseline for test ‘Baseline to after one session’.

$^b$Baseline for test ‘Baseline to after 1 week of training’.

3.2 Effects of a single session of power posing on affective states

There was a significant main effect of time on feelings of pleasantness, \(F(1,94) = 7.49, p = 0.007, \text{part.}\eta^2 = 0.074\), indicating an increase in feelings of pleasantness from baseline to after one session across both groups (Table 2). Also, there was a significant main effect of group \((F(1,94) = 30.95; p = 0.000, \text{part.}\eta^2 = 0.248)\) with the AN group showing lower feelings of pleasantness scores across both measurements than the control group (Table 2). No significant interaction effect between time and group was found, \(F(1,94) = 4.41, p = 0.038\). Regarding arousal, results showed no significant main effect of time on arousal, \(F(1,94) = 1.29, p = 0.259\). However there was a significant main effect of group \((F(1,94) = 12.18; p = 0.001, \text{part.}\eta^2 = 0.115)\), with the AN group showing higher levels of arousal across both measurements, compared with the non-AN group (Table 2). No significant interaction effect between time and group was found, \(F(1,94) = 0.390\). Regarding feelings of dominance, results showed a significant main effect of time on feelings of dominance, \(F(1,94) = 7.43, p = 0.008, \text{part.}\eta^2 = 0.073\). As can be seen from Table 2, there was an increase in feelings of dominance from baseline (\(M = 1.85; \text{SD} = 0.82\)) to T1 (\(M = 2.02; \text{SD} = 0.83\)) in the AN group, as well as in the non-AN group (T0: \(M = 2.66; \text{SD} = 0.72\); T1: \(M = 2.84; \text{SD} = 0.84\)). Also, there was a significant main effect of group \((F(1,94) = 29.39; p = 0.000, \text{part.}\eta^2 = 0.238)\) with the AN group showing lower dominance scores across measurement points compared with the non-AN group (Table 2). No significant interaction effect between time and group was found, \(F(1,94) = 0.00, p = 0.963\).
3.3 Effects of 1 week of power posing on interoceptive ability

The main effect of time on IAcc was not significant, \( F(1.93) = 2.03, p = 0.157 \). Also, no significant main effect of group \( (F(1.93) = 0.00; p = 0.993) \), and no significant interaction effect between time and group were found, \( F(1.93) = 0.20, p = 0.653 \) (Table 3).

4 DISCUSSION

The central aim of the study was to investigate whether power posing could benefit women with and without AN in regards to interoception and affective states. Firstly, we measured the impact of a single power posing session on interoceptive ability, dominance, pleasantness, and arousal. Then, we investigated the effects of 1 week of daily power posing training on individuals' interoceptive ability. The key finding was that there was a significant main effect of time on interoceptive accuracy, thus, interoceptive accuracy improved in the short-term, in both groups. We also found a significant effect of power posing on individuals' feelings of dominance and pleasantness after a single training session. No effects on the other dimensions of interoception were shown. Women with AN displayed significantly lower interoceptive sensitivity, pleasantness and dominance, as well as higher arousal than women without AN.

The finding that interoceptive accuracy improved in both groups is in keeping with previous studies highlighting that the induction of power appears to foster bodily awareness (Guinote, 2010). One possible mechanism behind this effect could be that power increases self-focus, which, in turn, promotes sensitivity to bodily information (Moeini-Jazani, Knoeferle, de Molière, et al., 2017; Weineck et al., 2019). Furthermore, adopting particular postures and maintaining a focus on them seems to enhance multisensory integration (Artoni et al., 2020; Christensen, Gaigg, & Calvo-Merino, 2018). Multisensory integration, in turn, plays a crucial role in body representation and updating body memory (allocentric, offline) through real-time input from different sensations and perceptions (Riva & Dakanalis, 2018; Schirmer-Mokwa et al., 2015).

However, looking at the descriptive data of the current study, it seems that the effect of improved IAcc is primarily carried by the women without AN, as the women with AN displayed a less pronounced increase in IAcc over time. One possibility could be that the feelings that arose through the intervention interfered with the self-focus of the individuals, which in turn, influenced their interoceptive ability. For example, our data suggest that the adoption of the powerful postures, induced feelings of dominance in the participants. However, women with AN generally assign themselves a low social rank tend to feel powerless (Troop, Allan, Serpell, & Treasure, 2008; Troop et al., 2003). Therefore, it is possible that suddenly feeling powerful through bottom-up processing may not have matched the individuals' overall self-perception of being powerful. If there is a mismatch between felt power and perceived power, theoretical models suggest that this discrepancy may lead to feelings of shame (Dempsey, 2017; Troop & Redshaw, 2012). The secondary emotion of shame may have led to an attentional shift toward the outside (Goss & Allan, 2009). This, in turn, may have reduced the participants' sensitivity to their bodily information (Ainley, Maister, Brokfeld, Farmer, & Tsakiris, 2013; Keltner et al., 2003).

Furthermore, the women's self-focus may have been influenced by consequences of social signalling. Broadly speaking, social signalling refers to the exchange of information through bodily cues or actions in a social context (Davies, Schmidt, Stahl, & Tchanturia, 2011; Frith & Frith, 2007). When the power poses are adopted, they are likely to elicit social evaluations in observers (Rennung, Blum, & Goritz, 2016). Women with AN are probably not used to posing powerfully, as they usually tend to display stooped postures with poor postural stability and restricted breathing patterns (Kolnes, 2012). The expansiveness of their body might have trigger cognitions relating to 'being seen', by taking up more space and conveying a high social rank though posture (Arnette & II, 2012). It is likely that, at this moment, the women's attention shifted outward to scan how their environment might perceive their bodily posture of status and dominance. This may have also led a reduced probability to notice their bodily signals. From the discussion groups after the study, we gathered from the patients that they felt more and more comfortable with the postures after continuous training. If secondary feelings of shame arose during the practice, these tended to subside with repeated exposure to the postures. Therefore, we assume that individuals with AN may benefit from longer periods of practicing the powerful postures (e.g., 2 months, as seen in other body-centred intervention studies [Fischer, Messner, & Pollatos, 2017]).

It is further important to note that we did not find a significant effect of time after 1 week of training. One reason therefore could be that posing powerfully has an immediate, temporary effect that decreases when the expansive posture is no longer adopted. In other words, power posing appears to enhance mechanisms of self-focus (Guinote, 2010; Moeini-Jazani, Knoeferle,
de Molière, et al., 2017), that are not activated when the person is adopting his or her usual bodily posture. This explanation is in keeping with evidence on dynamically changing bodily states as a consequence of physical and context-dependent alterations (Critchley, Mathias, & Dolan, 2001; Maister, Hodossy, & Tsakiris, 2017). Furthermore, the representation and experience of current and dynamically changing bodily states is influenced by different somatosensory signals (e.g., from exteroceptive, proprioceptive, interoceptive, and vestibular modalities), as well as predictions based on stored information about the body (Blanke, Slater, & Serino, 2015; Riva, 2016; Seth, Suzuki, & Critchley, 2012). Long-term effects on interoceptive ability may therefore require the integration of inputs arising from within the body with metacognitive perceptions of the body (Malighetti, Gaudio, Matamala-Gomez, & Riva, 2020) and a reflection of the experience in a social context (in other words a modification of multiple layers of body memory) (Riva, 2018). In this regard, Artoni et al. (2020) highlighted the benefits of a body perception training that combined various therapeutic techniques, including psychoeducation, relaxation, self-perception, body-oriented exercises, and a reflection of the experience through drawings, written narration, and dialogues with others. Thus, in future studies and a therapeutic context, it could be beneficial to include additional components in the power posing intervention that combine the adoption of the postures with a meta-reflection on the experience. Also, it would be valuable to investigate whether a training effect could be observed after longer periods of practice.

The observation that IS does not improve with power posing is in line with previous studies reporting no short-term effect of body-centred interventions on this interoceptive dimension (Fischer et al., 2017; Parkin et al., 2014; Weineck et al., 2019). It could be that confidence in one’s performance is a trait-like construct that is unlikely to change over a short period of time (Blais, Thompson, & Baranski, 2005; Pallier et al., 2002). However, from a theoretical point of view, IS should be influenced by power posing, as the induction of power seems to foster confidence in one’s performance (Briñol, Petty, & Wagner, 2009; Fast, Sivanathan, Mayer, & Galinsky, 2012). Thus, here as well, prolonged periods of practice may be necessary to achieve such a change. In this context, Fischer et al. (2017) found no significant increase in IS after 4 weeks of body scan practice, they

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Notes: * = significant after adjusting $p$-value for multiple testing. Regarding IS, no significant main effect of time, $F(1, 93) = 0.07; p = 0.796$, no significant main effect of group ($F(1, 93) = 6.43; p = 0.013$) and no significant interaction effect between time and group, $F(1, 93) = 1.30; p = 0.258$ were found.
did, however, report significant improvements after 8 weeks of training. Similarly, Parkin et al. (2014) found significant improvements in IS only after 8 weeks of mindfulness practice. It is further noteworthy, that women with AN reported significantly lower IS compared with women without AN. This could reflect low overall self-confidence of women with AN (Kastner, Lowe, & Gumz, 2019), leading to mistrust in their performance on the HBTT. Future research should investigate, how low IS in AN relates to other aspect of eating disorders pathology (e.g., the difficulty of discriminating bodily signals relating to hunger and satiety).

Regarding the results on affective states, the finding that power posing significantly increased subjective feelings of dominance is consistent with previous power posing research (Cuddy et al., 2018). A recent meta-analysis by Gronau et al. (2017) revealed moderate to strong evidence for the effect of power posing on felt power. However, the finding of our study is novel as it highlights that the effect of increased felt power can also occur in AN populations. This result is important when it comes to designing embodiment interventions aiming at the reduction of powerlessness in women with eating disorders. In this context, it is noteworthy that theoretical models of AN often include powerlessness as a key factor in regards to illness onset and maintenance (Murray, 2003; Schwitzer et al., 2001). For example, Bruch (1979) describes the AN symptomatology as an attempt to defeat feelings of powerlessness. Similarly, the cognitive model of AN by Wolff and Serpell (1998) regards ‘I am powerless’ as a key dysfunctional assumption of individuals with AN. Furthermore, qualitative assessments of patients’ account highlight that feelings of powerlessness are central to the illness (Schwitzer et al., 2001; Woolrich et al., 2008). However, therapeutic concepts and manuals often do not describe concrete strategies that directly address how reductions in felt powerlessness can be achieved. This is disadvantageous, as the presence or absence of felt power appears to be highly relevant regarding the eating disorder symptomatology. Regarding food intake, for example, Guinote (2010) found that hunger predicted the amount of food eaten by powerful but not by powerless participants. Also, powerful individuals consumed more appetizing and less non-appetizing food in comparison to powerless individuals. Furthermore, in a study including participants with AN symptoms, Kunstman, Smith, and Maner (2014) found that experiencing power could increase caloric intake in those with high self-oriented perfectionism. Thus, the induction of power may be a protective factor against maladaptive eating patterns (Kunstman et al., 2014) and could be an important intervention to support recovery from AN (Troop et al., 2003).

Considering the results on feelings of pleasantness, our study revealed that women with AN displayed lower feelings of pleasantness than non-AN controls. This finding is in line with previous studies highlighting reduced feelings of pleasantness (Crucianelli, Cardi, Treasure, Jenkinson, & Fotopoulou, 2016; Tchanturia et al., 2012) as well as the presence of negative affect (Pila, Murray, Le Grange, Sawyer, & Hughes, 2019) in individuals with AN. We further found that power posing could increase self-reported feelings of pleasantness in both groups in the short term. This finding is important in regards to recent research proposals highlighting the need to develop interventions which increase positive affect in individuals with AN (Coniglio, Christensen, Haynos, Rienecke, & Selby, 2019). Building a bridge from this research finding to clinical practice, this could indicate that adopting a bodily posture that fosters positive emotions could benefit individuals’ affective states before, during or after a therapy session.

Regarding arousal, our data is in keeping with evidence showing that individuals with anorexia nervosa report significantly higher levels of arousal than non-AN controls (Tuschen-Caffier et al., 2015). These levels of arousal were, however, not influenced by one power posing session. On the one hand, this finding is unexpected, as power should reduce individuals’ arousal through reductions in heart and respiratory rate or skin conductance responses (Hackford, Mackey, & Broadbent, 2018; Schmid & Schmid Mast, 2013). However, it is important to point out that our measure of arousal was based on self-report and changes on the physiological level of arousal may not have been reflected in the questionnaire. In this context, a study by Zonneville-Bender (2005) reported a discordance between self-reported emotional and neurophysiological arousal in patients with AN (i.e., the self-reported emotional arousal in women with AN did not correspond with changes in their heart rate). Thus, we do not know whether and how power posing affected individuals’ physiological arousal. Furthermore, evidence from some studies also suggests that powerful postures might increase physiological arousal (Laborde, Strack, & Mosley, 2019; Nair, Sagar, Sollers, Consedine, & Broadbent, 2015; Smith & Bargh, 2008). One reason, therefore, could be that power activates the behavioural approach system, thereby inhibiting the parasympathetic system (Keltner et al., 2003; Laborde et al., 2019; Smith & Bargh, 2008). Future studies should, therefore, include objective measures of arousal to gain a better insight into the effect of power posing on physiological parameters in patients with AN.

Overall, we would like to highlight that the intervention was very well received. This could be seen by a
low drop-out rate (below 3%) and the patients’ willingness to take part in the discussion and debriefing group. It has been suggested that it is highly important to consider how patients experience therapies and to maximize treatment acceptability (Hoskins et al., 2019). Embodiment interventions such as power posing appear to receive interest from the patients and could potentially be a good pathway toward dialogue about self-perception and body-perception.

The study has several limitations. Firstly, the sample was heterogeneous in regards to the individuals’ stage of recovery. Thus, it is unclear during which therapy phase power posing could be most beneficial. Furthermore, there was an unequal distribution of AN subtypes. Therefore, we could not perform a well-powered group analysis and do not know whether the intervention yielded different effects in the subgroups. Furthermore, our sample consisted of females only and the results are not generalizable to men. Also, the heartbeat detection task has been criticised for being susceptible to non-interoceptive influences, such as knowing or guessing one’s heart rate, time estimations, or practice effects (Desmedt, Luminet, & Corneille, 2018; Ring, Brener, Knapp, & Mailloux, 2015) and we did not control for these possible confounding factors. We did, however, try to minimize them my giving clear, standardized instructions, which underlined that participants should not engage in any other strategy than sensing their heartbeats when completing the task. In this context, it is also noteworthy that several recent studies that included a time estimation task, did not find a positive relationship between time estimates and IA, and controlling for time estimates did not change the relationship between IA and other outcomes (Santangelo et al., 2018; Shah, Hall, Catmur, & Bird, 2016). It is, therefore, unlikely that time estimates confounded the results. Nevertheless, the results of the current study should be interpreted bearing the possible psychometric limitations of heartbeat tracking task in mind. In hindsight, it would have also been valuable to include a questionnaire that especially focuses on the body representation of the individual such as the ‘Identity and Eating Disorders (IDEA)’ questionnaire, that evaluates identity and embodiment in eating disorder patients (Stanghellini, Castellini, Brogna, Faravelli, & Ricca, 2012). By including the subscale ‘feeling extraneous from one’s own body’ one could have investigated whether the power poses led to a more pronounced experience of the body from a first person perspective (egocentric frame) rather than a third person perspective (allocentric frame).

Regarding future directions further, it would be interesting to investigate the effects of power posing after longer periods of practice (e.g., 8–10 weeks). Moreover, as the effects of power posing seem to depend on a social context (Cesario & McDonald, 2013), one could deliver the intervention in a group setting and investigate how this format would affect the results. To gain deeper insight into the perception and experience of power posing in women with AN, and to adapt the postures to their needs, it could also be valuable to conduct structured qualitative assessments during the training. Furthermore, our study was restricted to two main outcome variables. It would be interesting to see how power posing relates to other aspects of mental health in women with AN. For example, a recent study by Körner et al. (2019) found power posing to increase state self-esteem. It would be important to assess whether this effect also occurs in AN populations, who display low levels of self-esteem (Kastner et al., 2019).

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CONFLICT OF INTEREST
The authors declare that there is no conflict of interest.

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5.4 Article IV: Discrepancies between explicit feelings of power and implicit power motives are related to anxiety in women with anorexia nervosa.


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Discrepancies Between Explicit Feelings of Power and Implicit Power Motives Are Related to Anxiety in Women With Anorexia Nervosa

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Background: Several studies identified low subjective feelings of power in women with anorexia nervosa (AN). However, little is known about implicit power motives and the discrepancy between explicit feelings of power and implicit power motives in AN.

Aim: The study investigated the discrepancy between explicit feelings of power and implicit power motives and its relationship to anxiety in patients with AN.

Method: Fifty-three outpatients and inpatients with AN and 48 participants without AN were compared regarding subjective feelings of power and anxiety. Explicit power [investigated with the Personal Sense of Power Scale (trait focus) and a visual analog scale (state focus)], implicit power motives [investigated with the Multi-Motive Grid (MMG)] and trait anxiety [measured with the State-Trait Anxiety Inventory (STAI)], were assessed.

Results: Explicit feelings of power (state and trait level) were lower in patients with AN compared to non-AN participants. No differences in implicit power motives were found when comparing the groups against each other. However, looking at the groups separately, women with AN had similar levels of implicit fear of losing power and hope for power, whereas woman without AN had significantly lower fear of losing power than hope for power. Focusing on discrepancies between powerful feelings and power motives, results were mixed, depending on the subscale of the MMG. Lastly, discrepancies between implicit power motives and explicit feelings of power were positively correlated with trait anxiety in AN patients.

Conclusion: These findings underline that individuals with AN display significantly lower explicit feelings of power, however, they show similar implicit power motives compared to individuals without AN. The discrepancy between explicit feelings of power and implicit power motives is related to anxiety in AN and may represent a vulnerability factor to illness maintenance.

Keywords: anorexia nervosa, power, implicit motives, anxiety, powerlessness, eating disorders
INTRODUCTION

A motive has been defined as a predisposition to either approach particular incentives such as power, achievement or affiliation, or to avoid particular threats such as rejection, failure, or domination by others (Thrash et al., 2019). Previous research on human motivation has made a distinction between implicit- and explicit motives (Brunstein, 2018). Explicit motives refer to concrete self-assigned goals an individual strives for (Brunstein et al., 1998). They are consciously and verbally expressed and can, therefore, be assessed with self-reports (Kollner and Schultheiss, 2014).

In contrast, implicit motives describe spontaneously recalled and dispositional preferences for affective incentives that are assessed indirectly with picture-story exercises, such as the semi-projective Multi-Motive Grid (Sokolowski et al., 2000; Job et al., 2010). Thus, an individual’s explicit motives can be seen as consciously set goals while implicit motives refer to affect-driven motive dispositions that the individual is mostly unaware of (Schuler et al., 2019).

Implicit and explicit motives can diverge from one another (Schultheiss et al., 2009). This discrepancy between implicit- and explicit motives has been found to negatively impact an individual’s physical health and psychological wellbeing (Kehr, 2004; Schüler et al., 2008). For example, it has been linked to a decrease in volitional strength (Kehr, 2004) and life satisfaction (Hofer et al., 2006), as well as a higher rate of job burnout (Rawolle et al., 2016) and negative affect (Job et al., 2010). Baumann et al. (2005) consequently referred to the discrepancy between implicit- and explicit motives as a “hidden stressor” which affects the individuals’ health. The stressful impact of motive discrepancies can be explained as a consequence of a behavioral conflict: self-assigned goals are influenced by social demands and may not always align with unaware motives, leading to behavioral tendencies that diverge (Job et al., 2010). Consequently, motive discrepancy may represent a vulnerability factor to psychopathology (Hofer and Chasiotis, 2003; Brandstatter et al., 2016). Despite this assumption, the impact of motive incongruence has rarely been studied in clinical samples.

The few studies that have focused on this issue in a clinical context have highlighted that motive incongruence may play a crucial role in symptom generation and maintenance (Langan-Fox et al., 2009; Langan-Fox and Canty, 2010). Regarding anorexia nervosa (AN), for example, Frank et al. (2019) proposed a model linking motive discrepancy to anxiety, which in turn affects negative eating behavior. The conscious goal to restrict food intake and to lose weight in AN patients conflicts with the implicit basic instinct to gain weight for survival, causing an internal conflict and, consequently, anxiety (Frank et al., 2019). This, in turn, might reinforce food restrictive behavior in order to avoid losing control (Frank et al., 2019). A similar pattern has been observed in non-clinical samples. For example, Job et al. (2010) found that motive incongruence was associated with unhealthy eating behavior in college students, mediated by negative affect. Based on these findings, continuing the investigation of implicit motives in AN patients seems crucial to gain a deeper understanding of potential internal conflicts that may generate and maintain anxiety and disordered eating. Anxiety is a particularly important outcome variable to investigate, as it represents one of the key comorbidities in AN, with studies reporting rates as high as 56% (Blinder et al., 2006). It also represents a factor that enhances the severity, chronicity and treatment resistance of the eating disorder (Kaye et al., 2004) and can persist after recovery from AN (Federici and Kaplan, 2008).

One motive that may be particularly relevant in the context of eating disorders is the power motive. Several studies have shown that women with AN display lower subjective (i.e., explicit) feelings of power than women without AN (Wolff and Serpell, 1998; Schwartz et al., 2001; Troop et al., 2003; Woolrich et al., 2008). They also assign themselves a lower social rank and tend to feel inferior to others (Troop et al., 2003; Bellew et al., 2006). A perceived low social rank and feelings of inferiority are associated with negative affect, such as shame (Ferreira et al., 2015), self-criticism (Pinto-Gouveia et al., 2014), and anxiety (Bellew et al., 2006). These, in turn, may further contribute to feelings of perceived powerlessness (Woolrich et al., 2006).

In this context, it is important to highlight that perceived power seems to be highly relevant regarding food consumption and disordered eating. For example, Guinote (2010) found that hunger predicted food intake in powerful but not in powerless individuals and powerful individuals consumed more appetizing- and less non-appetizing food compared to powerless individuals. Furthermore, Kunstman et al. (2014) found that experiencing power could increase caloric intake in participants with AN symptoms and high self-oriented perfectionism.

Despite strong evidence for low subjective feelings of power in women with AN and its proposed link to pathology, little is known about implicit power motives in this clinical cohort. It is, for example, uncertain whether women with AN have a higher, lower, or similar implicit power motive compared to women without AN. However, it is likely that they have a similar implicit power motive to women without AN as previous research has suggested that the eating disorder serves an attempt to defeat feelings of powerlessness (Bruch, 1979; Wolff and Serpell, 1998), which could be reflected in a high implicit power motive.

Furthermore, it is noteworthy that research on powerlessness in AN has mainly relied on qualitative data (Woolrich et al., 2006; Duncan et al., 2015) and has not integrated validated quantitative measurements that focus specifically on power, such as the Personal Sense of Power Scale by Anderson et al. (2012) or the Multi Motive Grid power-subscale by Sokolowski et al. (2000). In this study, we would like to breach this gap in the literature by examining whether there is a discrepancy between implicit power motives and explicit feelings of power in AN and by investigating how a possible discrepancy between these two variables might relate to feelings of anxiety. Based on existing theoretical models and previous research, we propose four hypotheses:

1. Women with AN display significantly lower explicit feelings of power on the state and the trait level than women without AN.
2. Women with AN have similar implicit power motives as women without AN.
3. Women with AN show a higher discrepancy between explicit feelings of power (trait level) and implicit power motives than women without AN.
4. Discrepancies between implicit power motives and explicit feelings of power are positively correlated with anxiety in AN patients.

**MATERIALS AND METHODS**

**Sample Characteristics**
Fifty-three female patients with AN were recruited in two different outpatient clinics for eating disorders in Munich, Germany [ANAD e.V. and the Treatment Centre for Eating Disorders (TCE) at Dritter Orden Hospital] as well as in the inpatient ward of Schoen Clinic Rosenbeck in Rosenheim, Germany. All patients had to be diagnosed with AN as defined by the DSM-5 criteria, determined by a semi-structured interview [SKID-5 cv (Beesdo-Baum et al., 2019)] by a clinical psychologist. Another inclusion criterion was that participants had to be over 18 years old. Patients with AN had a mean age of 24.70 years (SD = 7.12) and a mean body mass index (BMI) of 15.51 kg/m² (SD = 2.09). 42 patients were diagnosed with restrictive AN, nine with binge/purging AN, and two with atypical AN.

The control sample consisted of 48 women without AN, recruited via advertisement at Ulm University. In the control group, mean age was 22.58 years (SD = 4.12), and mean BMI was 21.89 kg/m² (SD = 2.73). Inclusion criteria were (1) no present psychiatric or somatic disorder and age over 18 years. Groups did not differ in age [t(84.824) = -1.848; p = 0.068] but, expectedly, differed in BMI [t(99) = 13.089; p < 0.001]. Further demographic information such as trait anxiety scores, illness duration, number of previous hospital admissions and scores of the Eating Disorder Inventory-2 are presented in Table 1.

**Measures**

**Subjective Feelings of Power**

*Personal Sense of Power Scale (SOPS)*

To assess the explicit trait power of participants, the Personal Sense of Power Scale by Anderson et al. (2012) was used. It comprises eight items on a six-point scale, ranging from strongly disagree (=1) to definitely agree (=6). In our study, the McDonalds ω was excellent (ω = 0.909) indicating that the SOPS is as an internally reliable measurement (Hayes and Coutts, 2020). An example of a statement was “I think I have a great deal of power.” Some of the statements were reverse-scored to prevent response bias.

**Visual Analog Scale (VAS) (state level)**

To investigate participants’ explicit state power, they had to indicate how powerful they felt at the present moment on a visual analog scale. They had to mark their answer with a pen on a line, ranging from no power at all (=0) to high power (=100). The VAS for the power scales was embedded between a scale assessing current energy level and strength to avoid priming the participants with the focus of the study.

**Multi-Motive Grid (MMG)**

The MMG by Sokolowski et al. (2000) was used to assess implicit power. This semi-projective assessment aims to evaluate an individuals’ implicit motivation for affiliation, achievement, and power. Each motive has two dimensions. For example, regarding the power motive, the MMG distinguishes between hope for power (HP) and fear of losing power (FP). The HP dimension primarily represents an individuals predisposition to influence other people or to gain power and status over others (Schmalt et al., 2010). On the other hand, the FP dimension is concerned with avoiding the loss of standing and the fear of being overpowered by other people (Schmalt et al., 2010). Fourteen drawings with different ambivalent social situations were presented. Below the picture, a range of statements was shown referring to each motive and its dimension. Participants were instructed to judge whether the presented statement fitted the given situation or not, by circling “yes” or “no.” Examples of power statements were “anticipating to lose standing” or “hoping to acquire a good standing.” For each picture, a single motive score was calculated to obtain a global score for each of the six motive components. Scores ranged from zero to twelve. For our study, only the power scores were used. The MMG has demonstrated good internal consistency and reliability in previous research (Sokolowski et al., 2000; Kehr, 2004). In our study, both MMG power subscales showed acceptable reliability (MMG HP: α = 0.762; MMG FP. α = 0.712).

**Anxiety Level**

The State-Trait Anxiety Inventory (Laux et al., 1981) is a widely used and validated questionnaire for the assessment...
of anxiety symptoms. For this study, only the trait anxiety scale was used to assess individuals’ dispositional anxiety level. The reason, therefore, was that the MMG and the Personal Sense of Power Scale (that were used to calculate power motive discrepancies) both also focus on trait-like constructs rather than situational feelings of power. The trait anxiety scale consists of 20-items and a four-point scale ranging from almost never (=1) to almost always (=4). Sum scores can range from 20 to 80, with higher scores indicating higher anxiety. In our study the McDonalds $\omega$ was excellent ($\omega = 0.920$) indicating that the trait scale was as an internally reliable measurement.

Procedure
The study was conducted in accordance with the Declaration of Helsinki and ethical approval was obtained from the Institutional Review Board of Ulm University (Protocol Nr 109/15). In a first step, participants were informed about the study procedure and signed an informed consent to take part. The AN patient sample was assessed in a separate, quiet therapy room of the outpatient clinics ANAD e.V., and TCE in Munich, as well as Schoen Clinic Roseneck in Rosenheim. The non-AN sample was tested in the laboratories of the Clinical- and Health Psychology Department of Ulm University. The participants completed the different questionnaires in their own time with the experimenter present. At the end of the study, participants received either course credit or monetary compensation.

Statistical Analyses
Data analyses were performed using the program IBM SPSS Statistics 26 (SPSS, Chicago). Group differences (AN vs. non-AN) in implicit and explicit power variables (hypothesis 1–3) were investigated using independent samples AN in implicit and explicit power variables (hypothesis 1–3) were investigated using independent samples $t$-tests. Homogeneity of variance was tested using Levene’s Test. When the assumption of homogeneity was violated, Welch’s $t$-test was used. Regarding hypothesis 3, MMG scores and SOPS scores were $z$-standardized and then absolute differences between the $z$-scores were calculated (Rawolle et al., 2016). Pearson correlations were conducted for the different power measures and anxiety separated by the groups (hypothesis 4). P-values less than 0.05 defined significant results. Two-sided tests were used for all hypotheses.

RESULTS
Confirming hypothesis 1, women with AN ($M = 3.35; SD = 0.78$) showed significantly lower Personal Sense of Power (SOPS) values than women without AN ($M = 4.40; SD = 0.49$), $t(88.888) = 8.136, p < 0.001, d = 1.726$, see Figure 1. Regarding the VAS power scores, women with AN also displayed significantly lower scores ($M = 21.08, SD = 20.64$) than women without AN ($M = 41.38, SD = 21.55$), $t(97) = 4.786, p < 0.001, d = 0.972$ (see Figure 2). Thus, women with AN showed significantly lower explicit feelings or power than women without AN (on the state and the trait level).

As expected, there was no significant difference between groups regarding the MMG hope for power dimension, $t(99) = -0.289, p = 0.773, d = 0.058$, (see Table 2 and Figure 3) and no significant difference between groups regarding the MMG fear of losing power dimension, $t(99) = -1.472, p = 0.144, d = 0.296$. Thus, the implicit power motives did not differ between groups (hypothesis 2).

Regarding hypothesis 3, women with AN ($M = 1.43, SD = 0.97$) displayed significantly higher discrepancies between the MMG hope for power dimension and the SOPS than women without AN ($M = 1.05, SD = 0.78$), $t(99) = -2.157, p = 0.033, d = 0.434$. No differences between the groups regarding discrepancies between the MMG hope for power dimension and the SOPS were found, $t(99) = -1.027, p = 0.307, d = 0.206$ (please refer to Table 2 and Figure 2). Thus, this hypothesis was partially supported. Further analysis revealed that there was no significant difference between the MMG hope for power dimension and the MMG fear of losing power dimension in the AN-group (Table 3). However, in the non-AN group, the MMG fear of losing power dimension was significantly lower than the MMG hope for power dimension (Table 3).

Regarding hypothesis 4, there was a significant positive correlation between the MMG FP/SOPS discrepancy and trait anxiety ($r = 0.271, p = 0.050$) (Figure 4) as well as a significant positive correlation between the MMG HP/SOPS discrepancy and trait anxiety ($r = 0.307, p = 0.025$) for the anorexia nervosa.
group (Figure 5). No significant correlations were found for the control group regarding the MMG FP/SOPS discrepancy and trait anxiety ($r = -0.229$, $p = 0.118$) and the MMG HP/SOPS discrepancy and trait anxiety ($r = 0.044$, $p = 0.767$).

Exploratory analysis also revealed a significant positive correlation between the MMG FP/SOPS discrepancy and the EDI-2 in the AN group, ($r = 0.29$, $p = 0.035$). No significant positive correlation between the MMG HP/SOPS discrepancy and the EDI-2 was found ($r = 0.184$, $p = 0.186$). Regarding the MMG FP variable on its own, it significantly correlated with the EDI-2 in the AN group ($r = 0.372$, $p = 0.006$).

DISCUSSION

The study aimed to evaluate the discrepancy between implicit power motives and explicit feelings of power and its relationship with anxiety in women with- and without AN. As expected, the AN sample displayed significantly lower explicit power (on the trait- and state level) than the non-AN sample. In comparison, no differences between implicit power were found when comparing the groups against each other. However, looking at the groups separately, women with AN had similar levels of implicit fear of losing power and hope for power, whereas woman without AN had significantly lower fear of losing power than hope for power. Regarding the explicit- and implicit power discrepancies, results were mixed. Whereas there was a higher discrepancy between the Personal Sense of Power Scale and the MMG hope for power dimension. Lastly, higher discrepancies between implicit power motives and explicit feelings of power were associated with higher levels of anxiety in patients with AN. No correlations were found regarding the non-AN sample.

The finding that individuals with AN displayed lower explicit feelings of power is in keeping with previous research findings highlighting that women with AN report feelings of powerlessness during their illness (Schwitzer et al., 2001; Troop et al., 2003; Woolrich et al., 2006; Duncan et al., 2015). It also fits in with theoretical models that highlight the presence of powerlessness as a key factor of illness pathology (Bruch, 1979; Wolff and Serpell, 1998). To our knowledge, this is the first study that employed the Personal Sense of Power Scale (Anderson et al., 2012) in AN patients. As it showed good internal consistency, it could be valuable to integrate as a diagnostic tool during clinical treatment, to assess the individuals’ explicit power level before and after interventions.

Furthermore, our finding showed that no differences between both groups were found for the implicit power motives, indicating that women with AN have similar predisposition to approach power and fear of losing power, as women without AN. Although no previous study used the MMG in an AN sample, our finding is congruent with studies that employed the MMG in other clinical samples, such as individuals with remitted major depression- and bipolar disorder (Fuhr et al., 2014) that also found no difference between individuals with and without psychopathology.

Regarding discrepancies between implicit power motives and explicit feelings of power in AN, the results were mixed. The finding that women with AN showed a significantly higher discrepancy between their explicit feelings of power and the fear of losing power dimension of the MMG, compared to women without AN, is in keeping with our expectation. This finding is concerning, as discrepancies in implicit- and explicit motives have been linked to psychopathology and stress (Baumann et al., 2005; Job et al., 2010; Rawolle et al., 2016). As the fear of losing power dimension was also significantly positively correlated with trait anxiety and eating pathology (EDI-2) in the AN group, decreasing the fear of losing standing and being overpowered by others could represent an important therapy goal.

Considering the findings further, individuals with AN did not show a significantly higher discrepancy between explicit feelings of power and the hope for power dimension of the MMG than women without AN. In this context, we found that the hope for power was significantly higher than the fear of losing power.

### TABLE 2 | Means and standard deviations of power measurements and MMG/personal sense of power scale discrepancies.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control group</th>
<th>Anorexia nervosa</th>
<th>Test statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>SOPS</td>
<td>4.40</td>
<td>0.49</td>
<td>3.35</td>
</tr>
<tr>
<td>VAS powerful</td>
<td>41.38</td>
<td>21.55</td>
<td>21.08</td>
</tr>
<tr>
<td>MMG hope for power (HP)</td>
<td>7.71</td>
<td>2.69</td>
<td>7.87</td>
</tr>
<tr>
<td>MMG fear of losing power (FP)</td>
<td>6.81</td>
<td>2.42</td>
<td>7.58</td>
</tr>
<tr>
<td>MMG HP/SOPS discrepancy</td>
<td>0.92</td>
<td>0.74</td>
<td>1.07</td>
</tr>
<tr>
<td>MMG FP/SOPS discrepancy</td>
<td>1.05</td>
<td>0.78</td>
<td>1.43</td>
</tr>
</tbody>
</table>

**FIGURE 3** | Means of the Multi-Motive Grid (MMG) fear of losing power and hope for power dimension of women with and without AN. Error bars represent SE.
in the non-AN group. On the other hand, implicit approach tendencies toward power and the fear of losing power were similar in the AN group. Having similarly high levels of fear of losing power and hope for power has been described as a vulnerability factor for an approach-avoidance conflict (Schmalt et al., 2010). Therefore, future research should put particular emphasis on ways in which similar levels of approaching power and avoiding the loss of power can relate to eating pathology and disadvantageous behavior in individuals with AN.

In keeping with our prediction, the discrepancy between implicit power motives and explicit feelings of power was linked to trait anxiety, only in the AN group. This finding is in line with previous research highlighting that the discrepancy between implicit- and explicit motives is associated with anxiety in women with AN (Frank et al., 2019). This observation further underlines the importance of developing strategies to reduce the discrepancy between implicit- and explicit power motives in AN. However, little is known about how this can be achieved (Job, 2007). As the explicit power motive in AN is significantly reduced compared to non-AN women, it would be beneficial to firstly increase subjective feelings of power in women with AN. This idea is congruent with a systematic review meta-analysis of qualitative research by Duncan et al. (2015) that identified regaining subjective feelings of power as crucial for illness recovery. One promising approach could be to practice power posing with individuals with AN. Power posing refers to the adoption of an expansive bodily posture (Carney et al., 2010, 2015). It is a non-verbal, body-focused technique that has repetitively been found to increase individuals’ feelings of power (Cuddy et al., 2018). It may be particularly helpful as recent studies in the field of eating disorders highlighted beneficial effects integrating body-centered interventions into treatment (Artoni et al., 2020).

To our knowledge, this is the first study investigating discrepancies between explicit feelings of power and implicit power motives and their relationship with anxiety in AN patients. However, our research needs to be interpreted, considering some limitations. Firstly, our AN sample was heterogeneous. For example, the participants differed regarding the AN subtype, comorbidities (e.g., depression and anxiety), as well as stages of recovery (in- and outpatients). Therefore, the study could be replicated and refined differentiating between the subtypes of AN and comparing participants during the acute illness and after recovery. Secondly, these data are cross-sectional. They should be extended by experimental and longitudinal data such as an ecological assessment to understand how subjective feelings of power and/or power motives fluctuate (e.g., throughout the day, with food intake as well as over the course of standardized treatment).

Furthermore, the investigation of the implicit power motive was based on the Multi Motive Grid by Sokolowski et al. (2000). Other tests that investigate implicit motives include the Picture Story Exercise (PSE) (McClelland et al., 1989), the Operant Motive Test (OMT) (Kuhl and Scheffer, 1999) or the Pictorial Attitude Implicit Association Test (PA-IAT) (Slabbinck et al., 2011). Thus, it could be valuable to replicate the study using an alternative implicit motive assessment. In this context, we mainly focused on the power dimension. Consequently, it would be interesting to investigate how individuals with and without AN differed regarding their implicit achievement- or affiliation motives.

Regarding clinical implications, our study has highlighted that low explicit feelings of power (on the state- and trait level) are present in AN patients. They should be explored in

### TABLE 3 | Differences between MMG HP and MMG FP.

<table>
<thead>
<tr>
<th>Group</th>
<th>Variables</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>T</th>
<th>df</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>Control group</td>
<td>MMG hope for power</td>
<td>48</td>
<td>7.71</td>
<td>2.69</td>
<td>2.170</td>
<td>47</td>
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<td></td>
<td>MMG fear of losing</td>
<td>48</td>
<td>6.81</td>
<td>2.42</td>
<td></td>
<td>48</td>
<td></td>
</tr>
<tr>
<td></td>
<td>power (FP)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anorexia nervosa</td>
<td>MMG hope for power</td>
<td>53</td>
<td>7.87</td>
<td>2.85</td>
<td>0.534</td>
<td>52</td>
<td>0.595</td>
</tr>
<tr>
<td></td>
<td>MMG fear of losing</td>
<td>53</td>
<td>7.58</td>
<td>2.81</td>
<td></td>
<td>53</td>
<td></td>
</tr>
<tr>
<td></td>
<td>power (FP)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### FIGURE 4 | Scatterplot of the correlation between the Hope for Power (MMG)/Personal Sense of Power Scale discrepancy and trait anxiety in women with AN.

### FIGURE 5 | Scatterplot of the correlation between the Fear of Losing Power (MMG)/Personal Sense of Power Scale discrepancy and trait anxiety in women with AN.
therapy, as they could represent a vulnerability factor regarding disordered eating and illness maintenance. In a therapeutic context, one could for example track explicit feelings of power (state level) using the visual analog scale at different points during the day or during episodes of disordered eating (e.g., before food intake, after food intake, during starvation, after purging etc.). Doing this could underline the connection between the individuals’ incentive to obtain power and avoid feelings of powerlessness through disordered eating. As our exploratory analysis also revealed a significant positive correlation between the MMG FP/SOPS discrepancy and the EDI-2, future studies should put a particular focus on how motive incongruence could be linked to eating pathology. Furthermore, one could assess individuals’ discrepancies between explicit feelings of power and power motives before, during and after treatment, to get a better understanding of possible inner conflicts and whether therapy is successful in reducing this incongruence.

CONCLUSION

To sum up, our data provide evidence that explicit feelings of power are lower in women with AN than women without AN. However, there seems to be no significant difference regarding implicit power motives when comparing the groups against each other. Looking at the groups separately, women without AN display a significantly lower implicit fear of losing power than hope for power. In women with AN, the fear of losing power is similarly high as the hope for power. Moreover, the discrepancy between explicit feelings of power and implicit power motives is positively associated with anxiety in AN. It seems worthwhile to focus on the assessment of power in AN patients and to develop interventions that can address feelings of powerlessness.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, (FW), upon reasonable request.

REFERENCES


ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Institutional Review Board of Ulm University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

FW, DS, GH, KL, AS, and OP conceptualized the research idea and planned the experiments. FW carried out the experiments. FW, DS, and AM contributed to data analysis. FW, DS, GH, AM, UV, and OP contributed to the interpretation of the results. FW, DS, and FD wrote the manuscript. All authors provided critical feedback and helped shape manuscript.

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