EXAMINING THE EFFECTS OF INTEROCEPTIVE AWARENESS AND SELF-FOCUS ON EMOTION PERCEPTION FROM POINT-LIGHT DANCE MOVEMENTS: AN EYE TRACKING STUDY

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PLAGIARISM

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ABSTRACT

Emotional expressions are vital in human social interactions and effective communication. This study explored the influence of interoceptive awareness and self-focused attention on emotion perception from dynamic point-light dance movements along with the underlying eye behaviour. Eighty adult participants underwent random assignment into either the self-focus or control group, while considering age, gender, and interoceptive awareness. To assess interoceptive awareness, data were collected through both a heartbeat counting task and the implementation of the MAIA-2 Questionnaire. Self-focus group was supraminally primed with their self-face photograph with a neutral expression, prior to emotion recognition task. Consistent with prior research, the results revealed that participants with higher interoceptive awareness exhibited greater emotion recognition accuracy, alongside longer fixation durations, indicating increased attention to emotional stimuli. On the other hand, participants in the self-focus group demonstrated improved recognition of neutral stimuli. We interpret this finding that self-focus can enhance attention to the emotional expressions related to the self. Additionally, results revealed that females outperformed males in recognizing anger. Interestingly, females also displayed shorter fixation durations and higher fixation counts compared to males. While we found a similar fixation duration pattern in participants with low interoceptive awareness, females' shorter looking times at sad and neutral stimuli might suggest a potential higher experience or sensitivity to emotional cues. These findings were further discussed pointing to the roles of interoceptive awareness and self-focus in inferring the emotions of others as well as the underlying eye behaviour.

Keywords: biological motion, emotion perception, eye tracking, interoception, self-focus

ÖZET

Duygusal ifadeler, insanların sosyal etkileşimleri ve etkili iletişimleri açısından büyük öneme sahiptir. Bu çalışma, iç duyum (interosepsiyon) ve öz-odaklı dikkatin, dinamik nokta-ışık dans hareketlerinden duygu algılama üzerindeki etkisini araştırdı. Aynı zamanda bu faktörlerin göz hareketlerini etkileyip etkilemediğini de inceledi. Yaş, cinsiyet ve temel interoseptif farkındalık dikkate alınarak, seksen yetişkin katılımcı rastgele olarak öz-odaklanma grubu veya kontrol grubuna atandı. Interoseptif farkındalık, kalp atışı sayma görevi ve MAIA-2 Anketi kullanılarak ölçüldü. Duygu tanıma görevinin hemen öncesinde, öz-odaklanma grubundan, nötr bir ifadeyle çekilmiş olan, kendi portre fotoğraflarına kısa bir süre odaklanmaları istendi. Önceki araştırmalarla uyumlu olarak, çalışmanın sonuçları yüksek interoseptif farkındalığın, uzun süreli sabitlenme süreleriyle ve dolayısıyla duygusal uyarılara artan dikkatle bağlantılı olarak, duygu tanıma yeteneğiyle pozitif bir şekilde ilişkili olduğunu gösterdi. Diğer yandan, öz-odaklanma grubundaki katılımcıların nötr uyaranları daha iyi tanıma eğiliminde olduğu görüldü. Bu bulguyu, öz-odaklanmanın bireyin kendinde gördüğü duygusal ifadelere dikkati artırabileceği şeklinde yorumluyoruz. Ayrıca, kadınların öfkeyi daha iyi tanıma konusunda erkeklerden daha başarılı olduğu gözlemlendi. İlginç bir şekilde, kadınlar erkeklere göre daha kısa sabitlenme süreleri ve yüksek sabitlenme sayıları sergiledi. Düşük interoseptif farkındalığa sahip katılımcılarda benzer bir sabitlenme süresi deseni bulmamıza rağmen, bu bulgu kadınların duygu işlemeyle ilgili deneyim ve duygusal ipuçlarına karşı duyarlılığı işaret ediyor olabilir. Bulgular, interoseptif farkındalık ile öz-odaklanmanın, başkalarının duygularını anlama ve bu faktörlerle ilişkisi dahilinde göz davranışlarını açıklamadaki rolü kapsamında tartışılmıştır.

Anahtar kelimeler: biyolojik hareket, duygu algısı, göz izleme, interosepsiyon, öz-odaklanma

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1. INTRODUCTION

1.1. Interoception

1.1.1. Interoception as a sensory modality

Interoception is the perception of physical sensations within the body. Despite traditionally being limited to perception of visceral signals arising from the body, recent physiological and neuroanatomical studies have altered this concept and demonstrated that interoception encompasses the conscious perception of the state of the 'entire body' such as hunger, thirst, pain, itch, micturition, musculoskeletal signals (Chen et al., 2021; Craig 2003, Khalsa, 2018; Vaitl, 1996). Interoceptive processes are bidirectional (Chen et al., 2021), which occur between the nervous system and milieu interior.

Interoceptive functioning has essential implications for homeostatic processes and survival of an organism. Additionally, an internal representation as such contributes to forming a bodily self or a 'material me' (Craig, 2002; Herbert, 2012; Sherrington, 1900), thus, self-awareness and the sense of body ownership (Moseley et al., 2008; Palmer, 2018; Tsakiris et al., 2011). In a similar vein, Damasio (1996) introduced the somatic-marker hypothesis positing that the signals from somatosensation and viscera underlie an embodied self-awareness. Also according to Damasio (2010), viscerosensory processes significantly contribute to the fundamental sense of self at a profound level.

Studies investigating the neural correlates of interoception suggest that interoceptive signals do not necessarily require higher order mental processing. However, in cases when they rise to conscious awareness, it has been found that the insula shows activation and contributes to not only sensing but also integrating and regulating information both from internal and external milieu (Chen et al., 2021; Craig 2009, Critchley 2013). Neuroimaging studies show that interoceptive processing usually begins in regions beneath the cerebral cortex (parabrachial nucleus, medial nucleus tractus solitarii, ventromedial nucleus of the thalamus) prior to transmission of interoceptive afferent signals to the posterior insula where they might integrate with exteroceptive signals from primary and secondary somatosensory cortices (Chen et al., 2021; King et al.,1999). The connection of the anterior insular cortex to orbitofrontal cortex and anterior cingulate cortex has been thought to have a role in relating interoception to higher order affective and cognitive processing (Chen et al., 2021; Craig, 2009; Critchley 2013; Khalsa et al., 2009; Wang et al. 2019).

1.1.2. Assessing interoceptive awareness

Studying interoception poses challenges due to the vitality of visceral functions. The most widely used and non-invasive assessment technique is the heartbeat perception tasks (i.e. cardioception) which permit the observation of differences at an individual level. There are different methods developed to assess interoceptive awareness, which include both behavioural performance and subjective measures. Behavioural evaluation encompasses tasks such as heartbeat counting (Schandry, 1981) and heartbeat discrimination (Whitehead et al., 1977). In heartbeat counting tasks, participants are asked to count their heartbeats within a specific timeframe, while in heartbeat discrimination tasks, they aim to differentiate between cardiac congruent and incongruent tones, notes, or light flashes.

On the other hand, subjective measures rely on questionnaires such as the Multidimensional Assessment of Interoceptive Awareness (MAIA) (Mehling et al., 2012) and The Body Perception Questionnaire (Porges, 1993) to capture individuals' self-reported interoceptive awareness or sensibility. These questionnaires provide a means for individuals to subjectively report their level of interoceptive awareness.

It is noteworthy to mention that the terms used to describe these processes vary in the literature. Results obtained from heartbeat counting tasks are commonly referred to as interoceptive accuracy, while subjective measures can be referred to as interoceptive awareness or sensibility (Forkmann et al., 2016; Garfinkel et al., 2015; Murphy et al., 2019). However, for the sake of using an umbrella term, we will refer to both processes as interoceptive awareness.

It is essential to recognize that interoceptive processes are multidimensional, and the assessment tasks mentioned above may not always be strongly correlated with each other (Garfinkel et al., 2016).

1.1.3. Interoception and emotions

1.1.3.1. Emotional processing.

Peripheral theories of emotions postulate that internal signals sensed by the brain are linked to emotional experience. William James and Carl Lange independently offered similar views (James, 1884; Lange, 1885), also referred to as James-Lange theory, arguing that emotion is the feeling of the bodily changes after we perceive an arousing event. Schachter and Singer (1962) were also supporters of the theory that stipulates autonomic changes or bodily arousal in order for the emotional experience to occur. While James-Lange theory of emotion is still open to debate (Moors, 2009; Heims et al., 2004), there is evidence that shows people experience similar physiological responses to emotions (Nummenmaa et al., 2014). There are also case reports of sympathectomy patients documenting emotional deficits as a serious side effect after their procedures (Tsakiris, 2018, p. 8). In a similar vein, as the somatic-marker hypothesis (Damasio, 1996) suggests that the signals from somatosensation and viscera underlie an embodied self-awareness and emphasizes how 'body proper' is imperative for feeling. The cases with orbitofrontal cortex damage have been demonstrated to show social emotional deficits despite showing no significant difference in executive function. This conceptualization has been further expanded under the 'predictive coding framework'. The predictive coding approaches in cognitive science conceive the brain as a 'prediction machine' (Clark, 2013) which aims to minimize prediction errors or in other words surprising states. When applied in the context of interoception as interoceptive inference (Seth, 2013), it holds that a top-down inference of the causes of afferent signals produces emotional experience.

Recent studies using heartbeat measures also show evidence for the role of the representation of internal signals in the facilitation of emotion, and one's sensitivity to these sensations might be related to subjective experience of emotion (see Wiens, 2005). For example, in an EEG study by (Pollatos et al., 2005) authors showed pleasant, unpleasant and neutral affective pictures to participants to observe whether there are any links between emotional processing and interoceptive awareness. Employing a heartbeat perception task to measure interoceptive awareness, participants rated arousal and emotional valence for each picture. Findings of the study show a strong correlation between the intensity of emotional experience and perception of heartbeat, evident in the reliably higher arousal ratings and P300 amplitudes observed in participants who performed better in heartbeat perception and no significant difference in emotional valence ratings. A similar study by Dunn et al. (2010) also showed that the accuracy of heartbeat tracking related to arousal ratings to emotional pictures (e.g. happy, sad, disgusting).

There are also practical applications of interoceptive research related to emotion. Recently, a team at MIT developed a somatosensory device that imitates aesthetic chills (Schoeller et al., 2019). Their preliminary studies show improved abilities of empathy and pleasure which are emotions associated with non-thermoregulatory chills in participants wearing the device. As they proposed, emotion prosthesis and somatosensory interfaces might allow for novel methods by inducing controlled interoceptive illusion (i.e. modulation of interoception) to manipulate human emotions or identifying biomarkers of interoception.

1.1.3.2. Emotions of others.

Findings of the previous studies, mentioned in the previous section, point out a direct link between interoceptive and affective processing. While the research on the influence of interoception on understanding affective states of others has been limited, a vivid mentalization of one's own inner states, which helps to facilitate subjective emotional experience as discussed, might indicate a better processing of others' mental states as well (Arnold et al., 2019; Gao et al., 2019; Hübner et al., 2021; Ondobaka et al., 2017; Terasawa et al, 2014). Individuals with Autism Spectrum Disorders (ASD) have been suggested to exhibit impairments in both interoceptive abilities (i.e. alexithymia), and social cognition including affective mentalization. This convergence of findings further bolsters the hypothesis we are investigating (Quattrocki, 2014). Consequently, it is essential to take a closer look at studies involving ASD populations as their results hold significant value in gaining a better understanding of individuals with interoceptive deficiencies.

Over the past decade, the predictive coding framework has provided a new perspective on social cognition, with studies revealing a significant link between interoception and emotion perception—a core component of social cognition. Predictive coding framework conjectures that active inference processes are involved in the relation between interoception and social cognition (Ondobaka et al., 2017). Regarding the theory of mind, it suggests that we form hypotheses about the intentions and feelings of other agents based on our memory of past behaviours and states, and update our hypotheses in accordance with prediction errors (e.g. surprises) (Ondobaka et al., 2017; Seth, 2013; Seth, 2016). In this context, Ondobaka et al. (2017) proposes two possible explanations. First, one might rely on perceptual information about the internal state of the other to comprehend the mental states that cause the perceived behaviour. Second, a better understanding of bodily feedback that causes a certain behaviour might facilitate the prediction and understanding the state the other is in.

Empirical studies also reveal that interoceptive abilities might influence social cognition. Shah et al.'s (2017) study, which investigated emotion and theory of mind in the context of interoception, observed a link between interoceptive accuracy, quantified with a heartbeat counting task and MASC (The Movie for the Assessment of Social Cognition) score, but only for the 'emotional' questions (e.g. What is Mary feeling?). On the other hand, no such association was observed for items that were not emotional (e.g. What is John thinking?). Authors conclude that interoception might not be imperative for theory of mind, however it contributes to generating mental representations for affective states. Fukushima et al (2011), using electroencephalography (EEG) and electrocardiogram (ECG) to assess the behavioural performance of the participants in empathy tasks, found that bodily feedback might play a role in empathy, another critical component of social cognition. Another study also showed that higher interoceptive sensitivity predicted empathic traits in participants who were shown pictures of people in pain (Grynberg, 2015). Interestingly, neuroimaging studies have shown increased insular cortex activation which is considered to be the center for interoceptive processing during empathy tasks (Bernhardt, 2012; Singer et al., 2004). Moreover, there have been findings suggesting a positive association between interoceptive accuracy and emotional sensitivity (Terasawa et al., 2014), specifically for joy and sadness which are relevant emotions for intersubjective connection and social bonding.

Plausibly, social cognition might require a switch of attention from interoception to exteroception. It has been proposed that the ability to make this switch flexibly between two different signals is how interoception might promote social connection (Arnold, 2009). This is consistent with the necessities of social situations such as a social interaction where it is critical to process the intentions and emotions of others and our own responses almost in a simultaneous manner. In other words, effective detection of the emotion of others is crucial to adjust our behaviours and responses accordingly. This may also be deemed necessary for self-other connection but at the same time distinction. The processing of exteroceptive information and integrating it with interoceptive information while preventing self-other overlap is a demanding process occurring in the social brain. Thus, it has been suggested that it is necessary to diminish or inhibit self-representation for effective mentalizing (Decety, 2003). For example, Durlik (2015) found that interoceptive accuracy reduced after participants were ostracized with a cyberball paradigm due to the switch of attention from self to the others.

There are individual differences that might influence interoceptive processes as well. For example, developmental, anxiety and mood disorders might distort the understanding of others' affective states. Individuals with anxiety disorders can be extremely sensitive to both interoceptive stimuli and emotions of others, specifically negative ones, to the point that they might confuse sadness with anger or disgust (Terasawa et al., 2014). Autism Spectrum Disorder, on the other hand, has been shown to be associated with poor interoceptive perception and social functioning while curiously displaying higher interoceptive sensibility (Garfinkel, 2016).

Gender might also be a factor that also adds to the individual differences. A recent study suggested that female participants with higher cardioception scores were more susceptible to emotional contagion for others' negative states than male participants (Lischke et al., 2020). On another note, Prentice et al. (2022) proposed a language socialization theory and suggested that gender differences related to interoception and emotion might stem from the observation that males rely on physiological cues, while females make use of situational cues.

1.2. Self-focused attention

1.2.1. Self-concept and self-focused attention

The self construct has been a crucial topic of investigation across multiple disciplines, including psychology, sociology, neuroscience, and philosophy, for over a century. Contemporary theories of self have continued to build on similar categories of self, particularly those advanced by William James (1892). One such category is the proto-self, as proposed by Panksepp (1998) and Damasio (1999), which underlies the experience of being an organism with internal functions in a neurobiological manner. The minimal self or mental self, as proposed by Gallagher (2000) and Damasio (1999), respectively, involves the conscious subjective experience of the organism interacting with its surrounding environment, or more precisely, Umwelt (Uexküll, 2001), with a sense of agency (Gallagher, 2000; Moore, 2012 ; Haggard, 2017) and body ownership. The narrative self (Gallagher, 2000) and autobiographical self (Damasio, 1999) share similarities with James' (1892) spiritual self in that they involve a linear continuity of past, present, anticipated future memories and beliefs. The former represents a more abstract conception of self, while the latter grounds it in physical processes related to continual self-narrative. These definitions of self are not mutually exclusive; instead, they signify discrete aspects of the self-concept that are linked to self-focused attention.

Self-focused attention has been the subject of extensive theoretical and empirical investigation since the 1970s. Theoretical approaches on self-focus suggest that attention directed towards the self can have a significant impact on perception, cognition, and emotion, and can be experienced both as an object and a subject of awareness (Duval & Wicklund, 1972; Csikszentmihalyi, 1990; Macrae et al., 1998; Panayiotou & Vrana, 1998; Silvia, 2002; Silvia & Duval, 2001). Self-focused attention can be induced by various methods, such as observing oneself in a physical or abstract form, such as through self-photographs, or by focusing on self-related information, such as one's name or birth date. Theory of self-awareness (i.e. a self-focused state) (Duval & Wicklund, 1972), emphasizes the importance of self-directed attention as a fundamental aspect of self-focus. According to this theory, self-focus distinguishes between attention directed towards the external environment and attention directed inward towards the self. The act of directing attention towards oneself, by definition, constitutes self-focus.

Scheier and Carver have made significant contributions to the field of self-awareness research, particularly through their self-awareness theory (Carver & Scheier, 1978; Carver & Scheier, 2013; Scheier & Carver, 1977; Scheier & Carver, 1983; Scheier et al., 1981), which emphasizes the role of self-focused attention in clarifying emotional states and increasing the salience of emotional experiences. In one of their studies, Scheier and Carver (1977), exposed the participants to a self-focus manipulation by placing a mirror on the screen while they rated the attractiveness of nude women. The results demonstrated that participants who viewed the nude slides while simultaneously looking at themselves in the mirror rated the slides as more attractive, which suggests a heightened awareness of the emotions elicited by the images. In another study by Scheier et al. (1981), the focus was on examining the influence of self-focused attention on behavioural responses to fear. Participants with and without specific phobias were instructed to approach and hold a snake under conditions with and without the presence of a mirror. The findings revealed that directing attention towards oneself led to increased responsiveness to fear and a greater tendency to withdraw from the situation.

Current research continues to use self-focused attention as a strategic manipulation to investigate various cognitive tasks, including but not limited to emotion perception and decision-making processes. For instance, Konrath (2021) investigated the impact of self-focus manipulation on emotion recognition by employing pronouns as priming stimuli. The study discovered that self-focus improved emotion recognition abilities, irrespective of cultural orientations (individualistic or collectivistic). Similarly, Sebri and Pravettoni (2021) exposed participants to stimuli that primed either bodily (i.e. self-face photograph with a neutral expression) or narrative (i.e. self relevant words such as participant’s name, hometown, school, name of their best friend’s) self-focus during the Iowa Gambling Task. Although no significant differences were observed in advantageous decision-making, participants in the self-focus condition exhibited a preference for avoiding losses. The researchers postulated that this preference could be attributed to either distraction caused by bodily self-focus or an increased aversion to losses due to heightened bodily awareness. In a study conducted by Li and Tottenham (2011), the effects of self-face priming as well as other-face priming on facial expression processing were examined using eye tracking within a facial emotion discrimination task. Participants were presented with videos of either their own or a stranger's face expressing negative or positive emotions before performing the task. The results revealed that participants primed with their own self-face exhibited enhanced exploration of the facial stimuli, indicative of improved visual processing of facial expressions.

1.2.1.1. Saliency of self-face.

The face is extremely important and plays a crucial role in defining one's identity. It is not arbitrary that people use the term 'face-to-face' to describe physical interactions in everyday language, and it can be confidently stated that the face represents the ultimate embodiment of one's physical self. As a self-referential information related to self-focused attention, the self-face has been found to be a highly salient stimulus that captures significant attention within the human brain (Sui & Humphreys, 2013; Keyes et al., 2010). When compared with strangers, self-face is recognized faster even when presented in an unusual orientation and after repeated exposure to distracting stimuli (Keyes & Brady, 2010; Tong & Nakayama, 1999). Furthermore, attentional prioritization of self has been suggested to be automatic and not associated with familiarity, as such, evidence from comparing one's own face with that of familiar others suggests that the self-face receives greater attention (Alzueta et al., 2019), even at an unconscious level (Bola et al, 2021).

Neuroimaging studies point to the role of cortical midline structures (CMS) when processing self-referential or self-relevant information (Humphreys & Sui, 2015). Moreover, stong temporo-parietal region activation, particularly in the right hemisphere, has been noted during self-face processing. (Uddin et al., 2005; Platek et al., 2006). For example, in a study by Zeugin et al. (2020), compelling evidence was presented, linking the right temporo-parietal junction (rTPJ) to the representation of one's own face. This was demonstrated through a transcranial magnetic stimulation (TMS) study where the inhibition of participants' rTPJ was observed. The TPJ is also well-known for its involvement in social understanding (Saxe & Kanwisher, 2003). Mirror neurons have been postulated to be involved in the interplay between self and others by facilitating the understanding of actions and associated mental states through the simulation of similar actions and states experienced by oneself (Gallese, 2016). An EEG study by Alzeueta et al. (2020) suggests a presence of a top-down attentional mechanism when processing self-face which they refer to as ‘Narcissus Effect’. Authors found a more pronounced and prolonged decrease in the power of alpha-beta frequency bands in face-sensitive parts of the brain during self-face processing compared to other-face processing.

1.2.2. Interactions between self-focused attention and interoceptive awareness

As discussed in the previous sections, interoception assumes a vital role in shaping self-awareness. However, recent studies (Ainley et al., 2012; Zamariola et al., 2017) have demonstrated that it might be actually working both ways. In particular, studies have demonstrated that the processing of self-referential information and inducing self-focus through bodily or narrative/autobiographical methods can enhance an individual's interoceptive awareness (e.g. perception of heartbeat accuracy).

For example, a study conducted by Ainley et al (2012) investigated whether self-focus improves the perception of internal sensations. Participants were asked to either look at their self-face reflected in the mirror or look at a blank screen while performing a heartbeat detection task. The findings indicated a notable improvement in interoceptive awareness in the mirror condition, especially among participants with lower baseline interoceptive awareness. The findings also point to a casual relation between interoception and exteroception while processing different dimensions of self. Ainley et al. (2013) conducted another study to manipulate interoception by both bodily and autobiographical facets of the self. The participants were divided into two experimental conditions. In the first condition, participants were asked to focus on a photograph of their own face, which was intended to direct attention to the bodily self. In the second condition, participants were asked to look at self-relevant stimuli (i.e. words) to stimulate attention to the autobiographical self. Compared to baseline, the results demonstrated a significant increase in interoceptive awareness in both experiments.

In a similar vein, Zamariola et al. (2017) explored the potential of the Body Image Revealer (BIR) task to modulate interoceptive awareness. Their study aimed to examine the association between interoceptive awareness (measured using a heartbeat counting task) and body image. Researchers expected that individuals with lower interoceptive awareness would tend to objectify their bodies as measured in cognitive, affective, metacognitive, and optative domains compared to those with higher interoceptive awareness.

Furthermore, they investigated whether focusing on the bodily self (i.e. BIR task) would enhance interoceptive awareness as in previous studies. Participants underwent assessments of interoceptive awareness before and after completing the

BIR task. Results showed an increase in interoceptive awareness, but only for those in the lower interoceptive awareness group, which lend support to previous research linking self-referential processing and interoceptive awareness.

1.3. Perception of emotional expressions

1.3.1. Visual processing of emotional cues

Emotional experience encompasses a range of visual bodily and facial expressions. Given the inherently social nature of humans, the capacity to comprehend or predict other individuals' emotional states from these expressions is an essential skill for successful social interactions and even financial gains (Momm et al 2015). Emotions are highly embodied and indicators such as a gloomy face, hunched shoulders, a bowed head, and sluggish movements, for example, allow one to discern signs of sadness in an individual. Within this context, there exist differing perspectives regarding emotional expressions. Some proponents (Ekman & Friesen, 1972), assert that such expressions serve as explicit manifestations conveying information or perceivable changes reflective of emotional experiences beyond cultural influences. Conversely, another approach posits that emotional expressions primarily function as social signals, facilitating the communication of one's intentions and are not readily interpretable in isolation from contextual or linguistic background (Barrett et al., 2007; Barrett & Kensinger, 2010). On the other hand, instances may arise wherein individuals choose to conceal their happiness in situations demanding seriousness, or suppress their anger in order to avoid conflict. Or, a laughter in response to a supervisor's not-so-funny joke could be erroneously perceived as amusement, thereby serving as an attempt to establish a rapport. Ultimately, emotional expressions might serve as a means by which individuals communicate their authentic emotions or create the perception of a specific affective state. And, regardless of whether these expressive cues are deliberately projected or inadvertently revealed through facial and bodily cues, they are predominantly predicted by others through the mechanism of visual processing, even if not solely reducible (e.g. auditory information is an important cue that contributes to emotion perception).

1.3.2. Emotion perception from point-light biological motion

Effective social communication requires the ability to accurately recognize emotions in others, enabling us to respond appropriately, which has adaptive advantages. While facial expressions are frequently thought of as the primary way to convey emotional information, under certain circumstances, bodies can convey emotional information more effectively than faces, making them a sound or valid source of such information (de Gelder, 2009; Aviezer et al., 2012). Body movements of an agent can give substantial cues about their mental states, evident in their utilization in theater, film, and other performing arts. Recent research also supports this phenomenon and has shown that the motion of the body or its individual parts, such as recognizing emotion from arm movement (Pollick et al., 2001) – or biological motion – plays a significant role in nonverbal communication. The term "biological motion" describes the motion of living things, including people and animals. The study of biological motion and its implications for emotion perception has attracted interest from multiple disciplines, including psychology, neuroscience, computer science, and robotics.

Johansson (1973), a leading researcher in this field, observed that biological motion is characterized by a pendulum-like movement occurring in each joint node, and the combination of various joint movements is highly typical for different types of motion, such as running, talking, walking, arguing, and dancing. His work demonstrated the power of point light figures in distinguishing biological motion from minimal displays of moving lights attached to a person's primary joints against a black background. This way, the observer perceives a cluster of illuminated dots that are attached to a mobile subject in a manner that renders solely the dots visible, while the remainder of the picture remains black. It appears that the fundamental shape of the human form is discernible but exclusively when viewed in a moving presentation.

With technological advancements, point-light displays are now created with motion capture techniques and used as stimuli in various experimental settings. Regardless, the study of emotion detection from biological motion has benefited greatly from the use of point-light figures because focusing on kinematics helps to eliminate the influence of competing cues. In other words, it separates the motion cues from other irrelevant visual data. The human visual system exhibits remarkable sensitivity to motion, making it receptive to a wealth of visual information. Many studies that have been undertaken to investigate the viability of perceiving emotions through point-light figures suggest that point-light figures provide sufficient visual information to enable accurate judgment and classification of various basic emotions (Atkinson et al., 2004; Brownlow et al., 1997; Clarke et al., 2005; Dittrich et al., 1996; Smith & Cross, 2023). In addition to their role in emotion perception, point-light figures also hold significance in shedding light on other attributes. Researchers have demonstrated that they provide valuable insights into attributes such as gender (Alaerts et al., 2011; Pollick et al., 2005) and identity (Mitchell & Curry, 2016; Troje et al., 2005) of the figures. Furthermore, these figures have been utilized to study even complex phenomena like vulnerability to victimization such as identification of ease-of attack depending on gait kinematics. Overall, based on these studies we can conclude that, people's ability to recognize emotions from patterns of movement depicted with point-light figures suggests that they can perceive emotions without the need to first analyze a detailed shape, even in different motion types such as dance (Dittrich et al., 1996; Smith & Cross, 2023), posture and gestures (Atkinson et al., 2004; Pollick et al., 2005), or interpersonal dialogue (Clarke et al., 2005).

Numerous studies have established that the way emotions are conveyed through body movements (i.e., embodiment) plays a significant role in the perception of emotions (for a review, see Kleinsmith, 2013; Wallbott, 1998). There is substantial evidence that emotions have unique motion patterns and characteristics that allow them to be perceived as different from one another, particularly from point-light stimuli. For example, Paterson et al. (2001) and Sawada et al. (2003) found that speed, acceleration, and displacement were three factors in arm movements that contribute to the identification of joy, anger, or sadness. Pollick et al.'s (2001) study suggested that anger and happiness were mostly characterized by fast movements while sadness was more linked with slow and sluggish movements. However, on the pleasantness level, such as distinguishing between anger and happiness, coordination of certain limbs or segments of the body is more likely to predict accurate judgment. Atkinson et al. (2004) also examined the impact of exaggerated expressions (i.e. bigger and more animated degree of movements) of emotions on the correct identification of emotions and emotional ratings. The results of their study indicated that the emotions expressed under exaggerated conditions were recognized more accurately, with the exception of sadness, which is primarily characterized by slower and smoother movements. Interestingly, the intensity ratings given by participants were higher for all emotions, including sadness, under exaggerated conditions. Moreover, disgust was the least detected (Atkinson et al., 2004; Diettrich et al., 1996), whereas sadness was the most accurately identified emotion in Dietrich et al.’s (1996) and Smith and Cross' (2023) studies where emotion expressions were presented with dance movements. On the other hand, Atkinson et al.'s (2004) study showed happiness was most accurately recognized. However, it is worth mentioning that there are no significant differences between happiness and sadness accuracy across these studies.

Research investigating gait patterns has also demonstrated that there are differences in movement characteristics between sad and happy emotional states. Specifically, sadness and depression have been found to be associated with a decrease in walking speed and a reduction in the vigor of arm swings, both in clinical and non-clinical populations (Michalak et al., 2009; Omlor, 2007). On the other hand, coordination of certain limbs or body segments is more likely to predict correct judgments based on pleasantness level, such as distinguishing between anger and happiness.

Notably, the alarm hypothesis proposed by Walk and Homan (1984) suggests that anger and fear are better recognized due to their evolutionary role in survival. Although the studies mentioned did not find a specific superiority of anger or fear in accurately classifying emotions, there are studies (Ikeda, 2009; Alaerts et al., 2011) which provided evidence supporting the importance of detecting anger in relation to gait detection performance. Researchers in both studies found a significant correlation between the detection of anger, but not happiness, and gait detection, suggesting that recognizing anger in others may have particular significance in terms of identifying potential threats or alarming situations which also aligns with Walk's alarm hypothesis.

Recently, studies have focused more on the individual differences observed in emotion perception from biological motion, specifically in the context of comparing typically developing individuals to those with ASD. The research conducted by Atkinson (2009), Hubert et al. (2006), and Nackaerts et al. (2012) revealed that the ASD group exhibited lower accuracy in emotion classification for each emotion. Furthermore, Lorey et al. (2012) undertook a study to examine the impact of individual factors on emotion recognition accuracy and confidence. The study controlled for one's perception of their own emotions, as quantified by the Toronto Alexithymia Scale. Authors found no significant differences in emotion perception between participants with low and high alexithymia scores. However, confidence ratings in classification were significantly lower for individuals with higher alexithymia scores.

Research has revealed that perception of emotions from biological motion involves various neural mechanisms (for a review, see Bachmann et al., 2018). Even though they provide minimal visual information, point-light display stimuli are processed by the action observation network, as reported by Saygin et al. (2004). The superior temporal sulcus (STS) has also been found essential in accurately understanding and interpreting human motion (Allison et al., 2000; Grosmann et al., 2000; Grosmann & Blake, 2002; Herrington et al., 2011). The research conducted by Centelles et al. (2011) and Alaerts et al. (2014) revealed that observing emotional point-light stimuli triggers activation in fronto-parietal regions, encompassing the premotor cortex, inferior parietal lobule and frontal gyrus. An fMRI study by Heberlein (2005) showed that the temporoparietal junction, which is typically activated in theory of mind tasks, is also responsive to emotionally expressive point-light display stimuli, along with other mentalizing stimuli such as inferring personality traits. Additionally, Atkinson et al. (2012) found that areas associated with form and movement perception, including posterior STS, extrastriate body area, and fusiform body area, exhibit responses to emotional point-light displays but not to non-emotional point-light displays.

1.4. Eye behaviour in visual attention

The way we move our eyes can reveal a lot about our cognitive states and what we pay attention to. Eye tracking, a method that studies eye movements, is increasingly being used in vision research to explore visual processing patterns. Eye movements can be unobtrusively monitored and measured in real-time with eye tracker devices. While specific eye behaviours that can discriminate among visual, cognitive, and emotional processes are not identified in the literature, various eye movement metrics can be broadly classified. However, metrics such as fixation patterns, saccades, pupil size provide a better understanding for visual attention, cognitive workload and emotional arousal (for a review, see Skaramagkas et al., 2021).

Fixation is when the eye gaze is fixated on a specific object or region of interest, aligning it with the fovea of the retina (Pritchard et al., 1960; Skaramagkas et al., 2021). The period of time that the gaze remains stationary on the same point is defined as fixation duration whereas fixation count is the number of fixations detected during that duration. Fixation duration might range between 30 – 300 ms long in general and longer fixations indicate additional effort to process the information thoroughly (Rayner, 1978). Saccades, on the other hand, are rapid movements of the eyes between different fixations. Velocity and amplitude of a saccade might differ depending on task requirements and visual stimulus (Skaramagkas et al., 2021, Kowler, 2011). Pupil size, regulated by the autonomic nervous system, might display changes in size due to light conditions, arousal (e.g. sexual, emotional) and cognitive load (Beatty, 1982; Bradley et al., 2008).

1.4.1. Fixation patterns

Fixation pattern is the predominant eye movement metric utilized to uncover information about visual attention, cognitive load, and arousal. Fixation patterns can vary depending on the modality being visually attended to, as sudden changes in stimuli are often perceived as more attention-demanding. A study by Dorr et al. (2010) demonstrated that participants exhibited longer fixation duration when watching stop-motion movies and movie trailers compared to natural movies. In contrast, the shortest fixations were observed when participants were observing static images. Organisation and functional grouping of objects also have an impact on fixation. For example, a study examining computer interfaces revealed that well-organized interfaces resulted in a lower number of fixations compared to poorly organized interfaces (Goldberg & Kotval, 1999).

Studies demonstrate that fixation duration is inversely related to cognitive load, while fixation count is positively associated with cognitive load in various working tasks like video gaming (Mallick et al., 2016), chess playing (Sheridan, 2017), flight simulation (He et al., 2012) and surgical procedure (Dalveren & Cagiltay, 2018). This implies that the number of fixations increases while fixation duration decreases during these tasks. Moreover, research suggests that prior experience or expertise is closely linked to fixation patterns. Less experienced individuals have been shown to have longer fixations during chess playing (Sheridan, 2017) and surgical procedure (Dalveren & Cagiltay, 2018). However, in situations of high cognitive load such as a training platform, expert users exhibit longer fixation duration compared to novice users (İşbilir et al., 2019).

Individual differences also alter fixation patterns. For example, a study examining fixation patterns in social anxiety suggested that socially anxious individuals fixated longer than non-anxious group when viewing angry faces (Liang et al., 2017). In a web search task, millennials demonstrated shorter fixation durations compared to older participants which indicated a lower cognitive effort (Espigares-Jurado et al., 2020). He et al. (2019) found that preschoolers with ASD displayed atypical fixation patterns when engaged in a facial emotion expression task, as compared to individuals without ASD. Children with ASD exhibited reduced fixation count and shorter fixation duration when presented with both happy and sad faces. Authors of the study also found an association between difficulties in facial emotion perception in individuals with ASD and their social interaction and developmental norms.

1.4.2. Fixation patterns and biological motion

Understanding how individuals process biological motion stimuli and its connection to eye movements is crucial for gaining insights into the cognitive processes involved. While numerous studies have investigated eye movements during various visual tasks, there are no studies that investigate the fixation patterns during biological motion perception in typically developed (TD) individuals, to the best of our knowledge. However, the studies focusing on neurodivergent populations in comparison to TD controls might provide valuable insights as altered eye movements in these populations can shed light on the complex relationship between fixation patterns, biological motion perception, emotion perception and social cognition.

Notably, two significant studies provide insights into this particular context. One of these studies, conducted by Matsumoto et al. (2015), investigated the association between altered eye movements, deficits in the perception of biological motion, and social cognition, specifically empathy, in individuals with schizophrenia, using point-light walkers as stimuli. To assess cognitive and affective empathic abilities, the researchers employed the Interpersonal Reactivity Index (IRI) (Davis, 1983). Participants underwent biological motion detection and perception tasks while their eye movements were tracked using an eye tracker. The results revealed that during the biological motion detection task, the patients with schizophrenia exhibited fewer fixations but longer fixation durations as the task difficulty increased, compared to the control group. Moreover, the fixation count positively correlated with accuracy in biological motion detection for the control group, while the patient group exhibited a negative correlation. Additionally, the control group demonstrated shorter fixation durations during accurate trials, whereas longer fixation durations were associated with higher accuracy in schizophrenic patients.

The authors also discovered a significant association between affective empathy and higher accuracy in biological motion detection, consistent with previous studies (Miller & Saygin, 2013). Furthermore, an increase in fixation count predicted a decrease in Empathic Concern scores on the IRI Index. These findings led the authors to interpret that altered fixation patterns may indicate deficits in the perception of biological motion and social cognition. Specifically, the typically developed control group's shorter but more frequent fixations may have facilitated the discrimination of different stimuli and consequently achieved higher accuracy, while individuals with schizophrenia had to compensate using a top-down processing strategy.

Another remarkable study regarding fixation patterns and biological motion was conducted by Nackaerts et al. (2012) which aimed to examine emotion and biological motion recognition from point-light displays (PLDs) in individuals with ASD compared to TD individuals. Eye movements of the participants were tracked during both tasks as an exploratory way to observe the differences between the groups. The results revealed that ASD participants exhibited a higher number of saccades and shorter looking times compared to TD participants in both tasks. Importantly, the researchers observed a strong correlation between eye movements and task performance, particularly in the emotion recognition task. This finding emphasizes the role of the emotional aspect of PLD stimuli and its impact on social cognitive abilities, suggesting that deficits in ASD may not be solely attributed to impaired biological motion perception in the context of eye behaviour.

1.5. Aim of the study

The aim of this study is to examine the effects of interoceptive awareness and self-focused attention on emotion perception while exploring their interaction with visual perception. Previous studies have already delineated links between interoceptive awareness – perception of bodily signals - and the ability to infer the emotional states of others. In a similar vein, self-focus has been shown to increase self-awareness, enhance the perception of internal signals, and improve processing of one's own emotions and perception of others' emotions.

In this context, the study will aim to answer three main research questions:

(1) Does interoceptive awareness facilitate emotion perception even when provided with a minimal visual cue? This is an important question because research demonstrating the link between interoception and affective mentalization often resort to emotion detection in facial expressions. However people are capable of detecting emotion even with minimal cues such as in kinematics of bodily movements (Frith, 2010). We expect that individuals with high interoceptive awareness will exhibit superior emotion recognition compared to those with low interoceptive awareness, even when presented with minimal visual cues (e.g., point-light display figures).

(2) What is the impact of manipulating self-awareness, specifically inducing a self-focused state, on emotion perception? By examining the effects of self-focus on emotional processing, the study aims to provide insights into how altering self-awareness influences the perception of emotions and potential interactions with interoceptive awareness. Based on prior research, we expect that manipulating self-awareness through self-focus will enhance emotion perception, given the association between self-focus and increased interoceptive awareness in previous studies

(3) How interoception and visual perception as an exteroceptive modality interact when predicting the emotions of others? While social cognition has been theorized with mostly visual, auditory, and motor perception, the emerging evidence that show the influence of interoception stipulates the inclusion of interoceptive processing to emotional theory of mind, as well as the interaction between interoceptive and exteroceptive processing. For example, previous studies suggest shorter fixation durations related to visual processing of participants with low interoceptive accuracy such as individuals with ASD (Nackaerts et al., 2012). However, as far as we are aware, no previous study has investigated the integration of interoception with visual perception in neurotypical populations. In this context, we expect to observe significant eye behaviour differences among participants with high and low interoceptive awareness, such as shorter fixation durations in individuals with lower interoceptive awareness as observed in individuals with ASD.

2. METHOD

2.1. Participants

To determine the sample size for testing our hypotheses with 80% power and a medium effect size, we conducted a priori power analysis using G*Power Version 3.1 (Faul et al., 2007). As a result, we recruited 80 participants for the study. The participants consisted entirely of voluntary individuals who were either students or staff members from Yeditepe University. Participants provided informed consent before participating in the study. We assigned the participants into two independent groups using a combination of matched pairs and block random assignment. Specifically, participants were paired or blocked based on age, gender and interoceptive accuracy, in order to minimize the differences between the two groups as these characteristics could potentially affect the results. Forty participants were assigned to the self-focus condition (20 female, mean age= 24.55, *SD*= 4.71) and forty to the control condition (20 female, mean age= 23.4, *SD*= 4.71).

The study excluded professional or semi-professional dancers, individuals with ASD, neurologic and cardiac-related problems. Participants were required to have normal or corrected-to-normal vision. The study procedures, including recruitment and experimentation, were conducted in compliance with the Declaration of Helsinki and were approved by the Science-Ethics Committee of Yeditepe University.

2.2. Design

To address the research questions, an experimental research design was developed. We used a 2 (condition: *self-focus*, *control*) x 2 (interoceptive awareness: high, low) x 4 (emotion: *happy*, *sad*, *angry*, *neutral*) factorial design with condition and interoceptive awareness as between subjects factor and emotion as within subject factor. Participants judged the emotional states of point light dance figures depicting anger, happiness, sadness, and neutral (i.e. no emotion) while their eye movements were tracked with an eye tracker device. We chose to use dance to convey emotions as the abstract nature of dance makes the emotion depiction more exempt from the diverse cultural gestures and make the universal features of emotion expression more prominent.

Interoceptive awareness was evaluated using the Heartbeat Counting (HBC) Task prior to emotion recognition task, to determine whether it modulates emotion recognition. Multidimensional Assessment of Interoceptive Awareness 2 Scale (MAIA-2) (Mehling et al., 2018) was also given to participants to assess their subjective interoceptive awareness. To investigate the effects of self-focus, participants were supraliminally primed in the form of a portrait photograph of the participant prior to emotion recognition task. Control group was not exposed to any priming. The independent variables were the condition (self-focus or control) and the emotion (happy, sad, angry, or neutral) depicted by the point-light dance figures. The dependent variables were emotion recognition accuracy, reaction times, eye movements (i.e. fixation count and fixation duration) for each emotion during the emotion recognition task.

2.3. Materials, apparatus and stimuli

2.3.1. Assessment of interoceptive awareness

For the behavioural evaluation of interoceptive awareness, we employed Shandry’s (1981) Heartbeat Counting Task, a non-invasive technique that entails counting the number of perceived heartbeats during a predetermined interval. This method has been widely validated by numerous studies (Ainley et al., 2012; Ainley et al., 2013; Calì et al., 2015; Pollatos et al., 2005; Pollatos et al., 2007; Pollatos et al., 2009). The task was created using MATLAB in Psychtoolbox (Brainard, 1997).

In addition, for the subjective assessment of interoception, we utilized the Multidimensional Assessment of Interoceptive Awareness 2 Scale (MAIA-2; Mehling et al., 2018), comprising a total of 37 items, along eight distinct subscales, including 1. *Noticing* (the recognition of bodily signals that are either unpleasant, pleasant, or neutral), 2. *Not-distracting* (tendency not to divert one's attention from uncomfortable or painful sensations), 3. *Not-worrying* (tendency to not feel anxious or distressed when experiencing uncomfortable or painfulsensations), 4. *Attention regulation* (ability to maintain and regulate focus on bodily signals), 5. *Emotional awareness* (recognition of the relationship between physical sensations and emotional conditions), 6. *Self-regulation* (ability to manage distress by directing attention towards bodily signals), 7. *Body listening* (paying attention to bodily feelings to gain insight) 8. *Trusting* (perception of one's body as secure and dependable). 8-factor model of the MAIA-2 scale was confirmed with *RMSEA*= 0.055 and *SRMR*= 0.064 fit indices. The main purpose of the scale is to measure multiple dimensions of interoception in a conscious level and is available to be used in research on interoception and mental health interventions. We used the Turkish version of the scale as all participants were Turkish and it also has been validated (Özpınar et al., 2021) as a reliable scale for interoceptive awareness with acceptable Cronbach alpha (α > 0.60) and Kaiser-Meyer-Olkin (*KMO*= 0.910) values.

2.3.2. Emotion recognition task

To investigate how participants perceive emotions conveyed through point-light dance figures, we used a set of 16 videos that were obtained from the Motion Capture Norming Library which is a collection of emotionally expressive and non-expressive point-light dance movements that was created by Smith and Cross (2022). Videos were created by using contemporary dance and ballet figures performed by a professional female dancer. 15 sequences of neutral, happy, sad, and 14 sequences of angry and fearful movements were captured to create point-light displays. The authors conducted two validation experiments for the videos, with the second experiment involving the use of the four clips from each emotion category with the highest recognition accuracy rates in the first experiment. This resulted in a total of 20 clips, all of which demonstrated accuracy rates that exceeded the chance level of 20% and ranged up to 60%. We chose four different emotions - happiness, sadness, neutral, and angry - with four videos for each emotion from the library.

Participants assigned to the self-focus condition were photographed in a portrait orientation using the back camera of an iPhone 11 after the assessment of interoceptive awareness. The photographs, which included the participant's head and shoulders, were captured against a black background. Resulting images were mirror-reversed and added to the experiment as a supraliminal priming stimulus before the emotion recognition task.

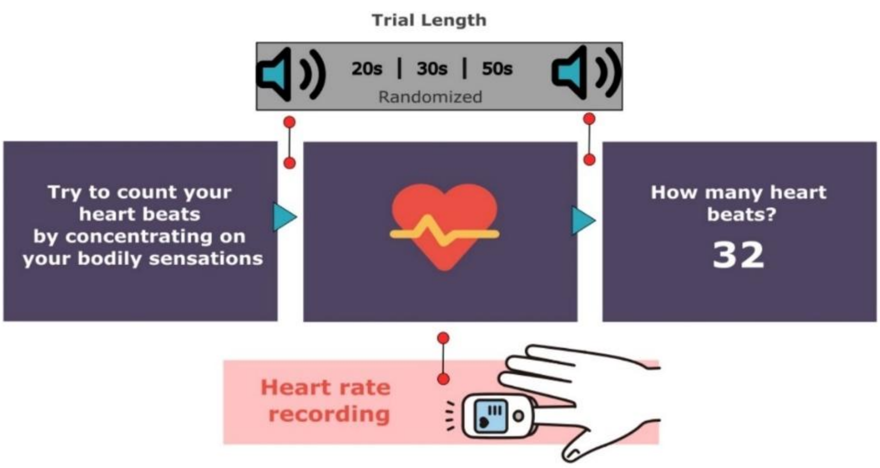
The experiment was created using MATLAB along with the Psychtoolbox library (Brainard, 1997). Eye behaviour of the participants was measured with Gazepoint GP3 eyetracker (Vancouver, Canada) during emotion recognition task.

2.4. Procedure

The study was undertaken in the VR Lab of Yeditepe University. Prior to the experiment, participants were provided with a brief introduction of the study. After reading and signing the informed consent form, they were asked to complete the Multidimensional Assessment of Interoceptive Awareness 2 (MAIA-2) questionnaire first. The questionnaire comprised of 37 items, rated on a 6-point Likert scale (ranging from 0 to 5) to assess how well the items corresponded with their subjective experiences, with 0 representing "never" and 5 indicating "always". Following this, the lights were turned off, and a heartbeat counting task was performed, whereby participants were instructed to attend to their own bodies and, specifically, their hearts while a pulse oximeter was placed on their left hand. They were asked to mentally count the number of their heartbeats in three different intervals (25, 30, and 50 seconds) in random order without touching any part of their bodies while their actual heartbeat being recorded for each interval with a pulse oximeter. We, then, assigned the participants to either the self-focus or control group based on their gender, age, and interoceptive accuracy information. Participants in the self-focus group were photographed and their photographs were added to the experiment before starting the emotion recognition task.

Figure 1

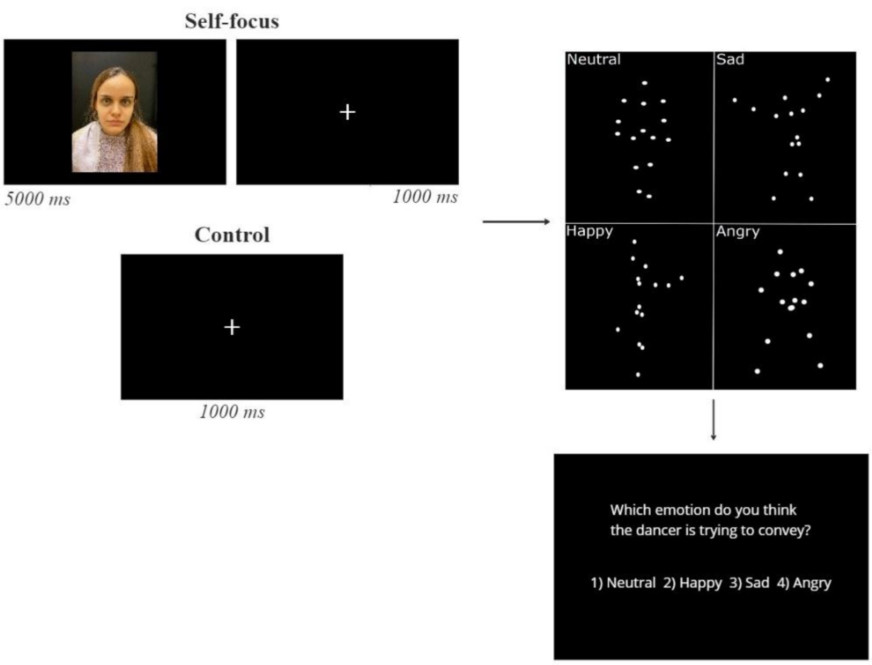
Experimental set up for the heartbeat counting task



For the emotion recognition task, the lights were turned off again, and The participants were positioned before a computer, with their forehead and chin resting on a chinrest positioned at an approximate distance of 70 cm from the monitor. The chinrest was sanitized before each use. Participants' eye movements were calibrated using the eye tracker immediately before the start of the experiment. Calibration involved a five-point calibration and validation process. Gazepoint GP3 eye tracker recorded each session from the start to the finish. The emotion recognition task began with an introduction to the experiment, followed by a trial task to familiarize the participants with the experiment, using a neutral dance video. Self-focus group participants were informed that they would see their own photo for 5 seconds and were asked to focus on the photo during that time. After that, a cross appeared for 1000 ms, and participants were presented with point-light dance figures one by one. After the presentation of each video, participants were prompted to indicate which emotion the dancer was trying to convey using a multiple-choice question, with the possible answers always presented in the same order: 1. neutral, 2. happy, 3. sad, 4. angry. Participants responded by pressing the corresponding key dedicated to each emotion with their left hand, which was placed on the keyboard's 1, 2, 3, and 4 keys before starting the experiment.

Figure 2

Experimental paradigm for the emotion recognition task



The stimuli were presented using a random permutation sequence across 32 trials without an intertrial interval. Each video duration ranged between 7-37 seconds and participants completed the task in a self-paced fashion. After the task was completed, participants were debriefed and interviewed regarding their overall emotional identification strategies and their approach to recognizing specific emotions, as well as the most distinctive feature they took into account. Whole procedure took approximately 25-30 minutes.

2.5. Data Preparation, Preprocessing and Analysis

2.5.1. Emotion Recognition Task and Interoceptive Awareness Scores

Participants' performance was evaluated based on their ability to accurately identify point light videos corresponding to happy, sad, angry, and neutral emotional expression categories, in the context of emotion recognition task. Correct identifications were assigned a score of 1, while incorrect responses received a score of 0. Scores were then averaged to determine the accuracy percentage within each emotion category for each participant.

Interoceptive Awareness (IA) was assessed as a measure of participants' ability to accurately count their heartbeats. The calculation of IA followed the formula developed by Shandry (1981):

$$IAcc = 1 - 1/3 * \Sigma\ ((|\text{recorded heartbeats} - \text{counted heartbeats}|) / \text{recorded heartbeats})$$

The formula computes the mean absolute difference between the monitored and counted heartbeats, divided by the recorded heartbeats. The resulting IA score falls within the range of 0 to 1. Values closer to 1 indicates a higher interoceptive accuracy. Participants were categorized as high or low in interoceptive awareness based on a median split analysis of their accuracy scores in the HBC task (median = 0.70). This approach involved dividing the participants into two groups, (1) high interoceptive awareness with scores above the median and (2) low interoceptive awareness with scores below the median.

MAIA-2 scores were computed for each participant, representing their responses to the Multidimensional Assessment of Interoceptive Awareness questionnaire. For each subscale, the participant's score was derived by averaging their ratings, except for the "not-distracting" and "not-worrying" scales, which were reverse-scored as specified in the questionnaire.

2.5.2. Eye tracking data preprocessing

For the calculation of fixation patterns, a fixation radius of 58 pixels and a minimum duration of 120 milliseconds were defined to identify a fixation. To analyze fixation patterns, we utilized a custom MATLAB script that we developed to calculate fixation duration and fixation count for each trial completed by the participants. The processing of the eye tracking data involved several steps. Firstly, relevant data such as gaze coordinates and timestamps were extracted. Next, fixations were identified by monitoring changes in gaze position within the defined fixation radius and minimum duration. Then, the fixation count and duration were updated based on the identified fixations.

To calculate the fixation count, the eye tracking data was iterated through for each trial. Using Euclidean distance calculations, changes in gaze position were monitored to identify transitions between fixations. Whenever the distance between the current and previous gaze positions exceeded the predefined fixation radius, a new fixation was detected. The total number of fixations were tracked by incrementing a counter variable. In addition to the fixation count, fixation duration was also calculated for each fixation per trial. By analyzing the timestamps associated with gaze positions, the start and end times of each fixation were determined. Then, the duration of each fixation was computed as the time difference between the end time of the previous fixation and the start time of the current fixation.

During the parameter calculation process, only the eye movement data points that corresponded to trial data were considered. Additionally, any fixation points of gaze data flagged as invalid, as indicated by the FPOGV parameter, were excluded from the calculations. Moreover, participants' data files with an overall percentage of valid flagged data less than 70%, were removed completely. Consequently, out of the initial 80 participant data, only 69 were used in the fixation pattern calculations.

2.5.2. Analysis

JASP 0.16.0.0 was used for all statistical tests. While gender differences were not included in the hypotheses, as previous research has reported gender-related variations in the literature, gender was incorporated as an exploratory factor in the analyses.

A Wilcoxon signed-rank test was employed, as the score percentages deviated from a normal distribution, to conduct an analysis of emotion recognition abilities across the participants. Mixed-design repeated measures and factorial ANOVAs (Analysis of Variance) were conducted to examine the effects of condition, interoceptive awareness, and gender on emotion recognition accuracy and fixation patterns (fixation duration and fixation count). The assumption of normality was not considered as Levene's test for equality of variances did not indicate any violations. A Pearson's correlation was carried out to reveal the associations between implicit (heartbeat counting task) and explicit (MAIA-2 Questionnaire) measures of interoceptive awareness. Analysis regarding fixation patterns initially included all trials, while a subsequent analysis focused solely on accurate trials.

In cases where the assumption of sphericity was violated, the Greenhouse-Geisser correction was employed, and the p-values were adjusted using the Bonferroni correction method. The statistical significance was determined at an alpha level of $p < .05$.

3. RESULTS

3.1. Emotion recognition task results

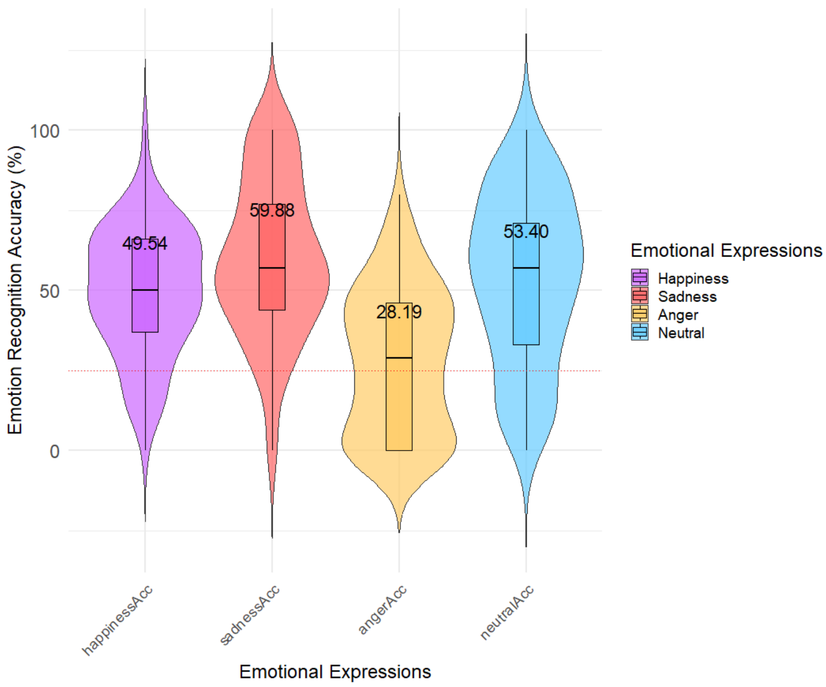
3.1.1. Emotion perception

On average, participants exhibited an mean accuracy of 47.75% (*SD* = 13.72) in recognizing emotional expressions. Individually, the recognition rates varied across different emotional expressions, independent of condition, IA, and gender (see Table 1). A Wilcoxon signed-rank test was carried out to determine whether performance of participants exceeded chance levels (with a 25% chance due to the presence of four response options) for identifying presented emotional expressions (happy, sad, anger, neutral) based on interoceptive awareness levels, condition and gender, as well as all participants.

Results showed that participants consistently recognized emotional expressions significantly above chance level for all emotions (all *p*s < .001), with the exception of anger ($p = .16$). However, further analysis revealed females were able to detect anger above chance levels ($p = 0.008$), whereas no significant effects were found for interoceptive levels or condition (all *p*s for anger > 0.05).

Figure 3

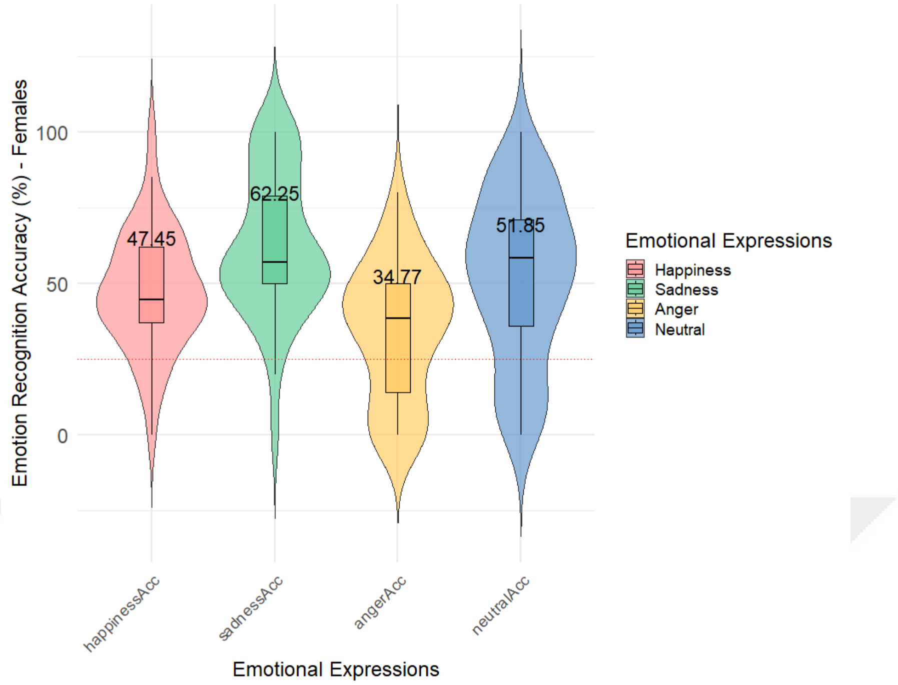
Mean emotion recognition accuracy among all participants



Note. Dotted red line indicates the chance level of 25%.

Figure 4

Mean emotion recognition accuracy among females



Additionally, error distribution analysis revealed a notable pattern of confusion between Anger and Happiness, with a high rate of misidentification at 50%, and there were some instances of confusion between sadness and neutral expressions, as well as between sadness and happiness (see Figure 5).

Figure 5

Conveyed and recognized emotional expressions by participants in a confusion matrix

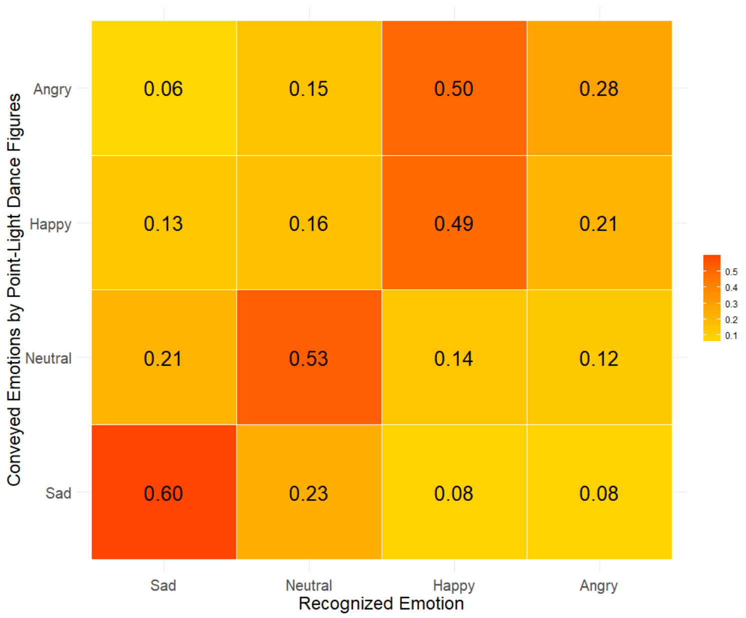


Table 1

Mean emotion recognition accuracy values based on interoceptive awareness levels, conditions, and gender.

	High IA		Low IA	
	Male	Female	Male	Female
Self-focus				
sad	0.62 (0.16)	0.64 (0.24)	0.45 (0.23)	0.45 (0.23)
neutral	0.69 (0.25)	0.58 (0.26)	0.69 (0.13)	0.55 (0.27)
happy	0.53 (0.19)	0.45 (0.17)	0.48 (0.21)	0.43 (0.22)
angry	0.25 (0.24)	0.35 (0.26)	0.21 (0.17)	0.23 (0.20)
Control				
sad	0.76 (0.23)	0.71 (0.20)	0.46 (0.27)	0.65 (0.25)
neutral	0.40 (0.30)	0.51 (0.31)	0.43 (0.21)	0.43 (0.27)
happy	0.53 (0.21)	0.51 (0.16)	0.53 (0.23)	0.51 (0.26)
angry	0.20 (0.24)	0.40 (0.25)	0.19 (0.21)	0.40 (0.16)
All participants				
sad	0.69 (0.21)	0.67 (0.22)	0.45 (0.25)	0.56 (0.26)
neutral	0.55 (0.30)	0.55 (0.28)	0.55 (0.22)	0.48 (0.27)
happy	0.53 (0.19)	0.47 (0.16)	0.51 (0.22)	0.47 (0.24)
angry	0.23 (0.23)	0.36 (0.25)	0.20 (0.19)	0.32 (0.20)

Note. Standard deviation values are provided in parentheses.

3.1.2. Effects of interoceptive awareness, condition, and gender on emotion perception

A mixed-design repeated measures ANOVA was conducted to examine the effects of condition, interoceptive awareness, and gender on emotion recognition accuracy. The within-subject factor included emotion categories (sad, neutral, happy, angry), while the between-subject factors comprised condition (self, control), interoceptive awareness (high, low), and gender (female, male). The results of the analysis revealed a significant main effect of emotion, $F(3, 237) = 29.089$, $p < .001$, $\eta_p^2 = 0.288$, suggesting that depiction of emotions significantly influenced the participants' recognition performance. Anger ($M = .28$) was significantly different than all other emotional expressions (all *p*s < .001) as the least recognized as pairwise comparisons revealed. Accuracy for happiness ($M = 0.50$) was also significantly lower than sadness ($p = .041$). No significant difference was observed between sadness and neutral, as well as neutral and happy (all *p*s > 0.05). A significant main effect of interoceptive awareness was identified, $F(1, 79) = 5.917$, $p < .017$, $\eta_p^2 = 0.076$, indicating that higher levels of interoceptive awareness were related with better emotion recognition accuracy ($M = 2.02$).

Figure 6

Mean emotion recognition accuracy based on interoceptive awareness

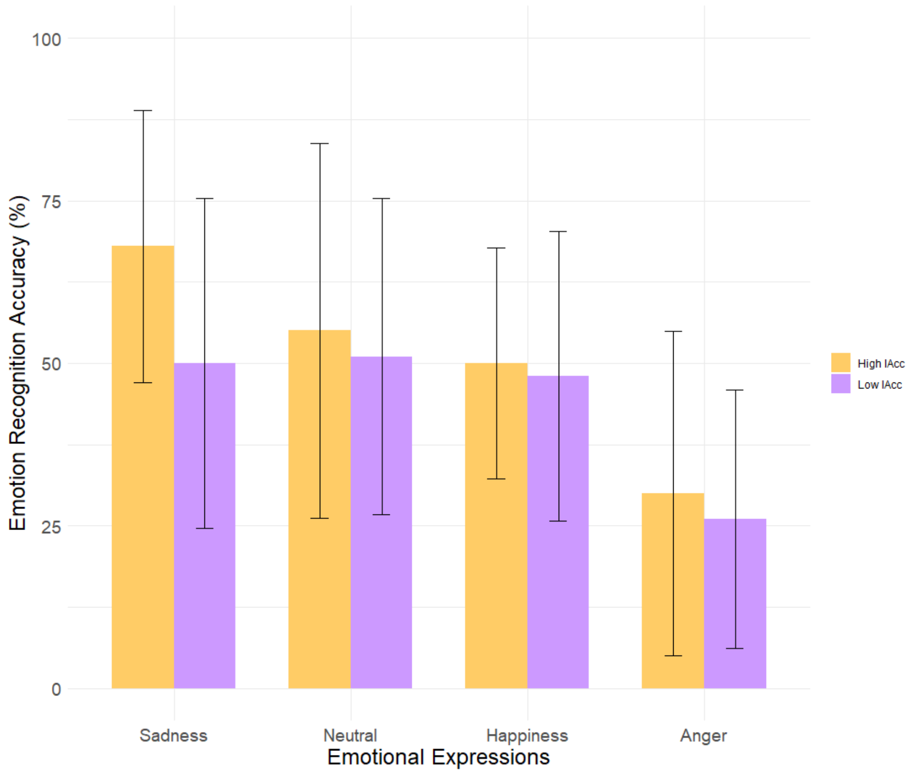
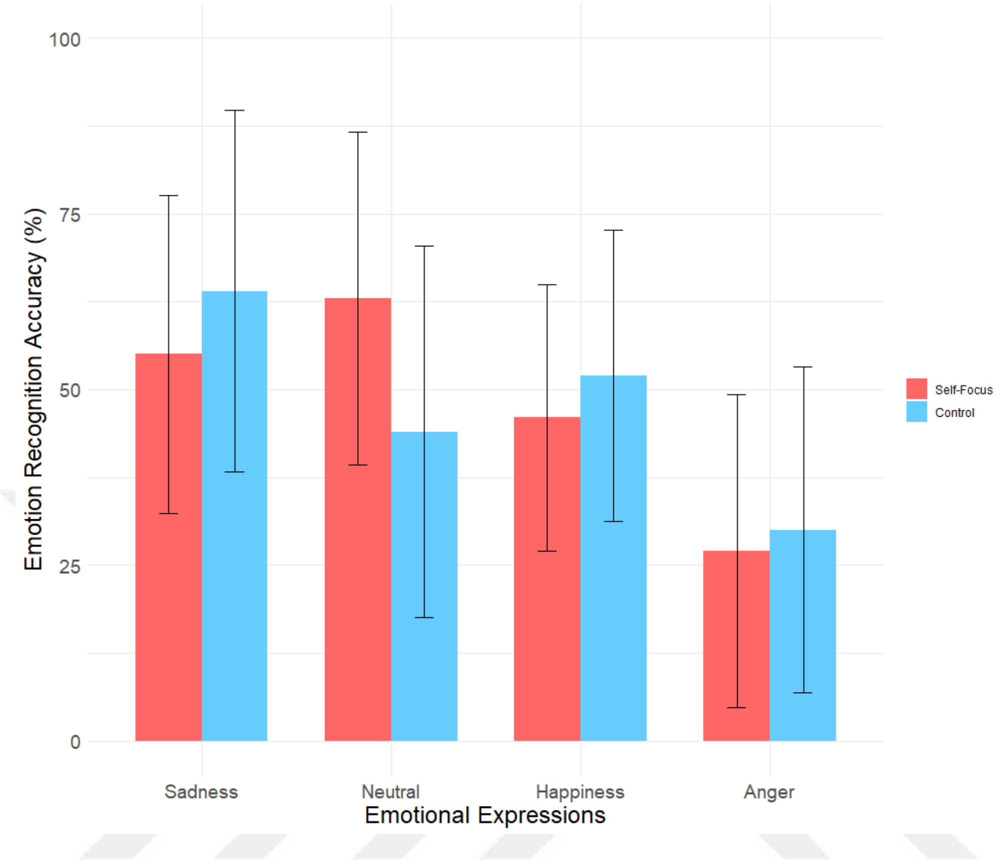


Figure 7

Mean emotion recognition accuracy based on condition



The condition alone did not have a significant effect on the participants' overall performance (p = .98). Participants in both conditions yielded a similar mean accuracy in recognizing emotions (M_{Control} = 1.897, $M_{\text{Self-Focus}}$ = 1.923). Gender also did not demonstrate a statistically significant impact on emotion recognition performance (p = .37). However, we observed an interaction between emotion and condition, $F(3, 237) = 6.36$, $p < .001$, $\eta_p^{\,2} = 0.081$, indicating that the relationship between emotion and recognition performance differed depending on the condition. Pairwise comparisons showed that accuracy for neutral stimuli was significantly lower in the control condition compared to the self-focus condition (Mean Difference = -0.186, SE = 0.051, t = -3.628, p = 0.009, 95% CI [-0.348, -0.024]), (see Figure 7). Although we observed a significant interaction between condition and gender, $F(1, 79) = 4.017$, $p = .049$, $\eta_p^{\,2} = 0.053$, follow-up pairwise comparisons did not yield any significant results. No other interactions were significant (all ps > 0.5).

Figure 8

Interaction between emotion and condition

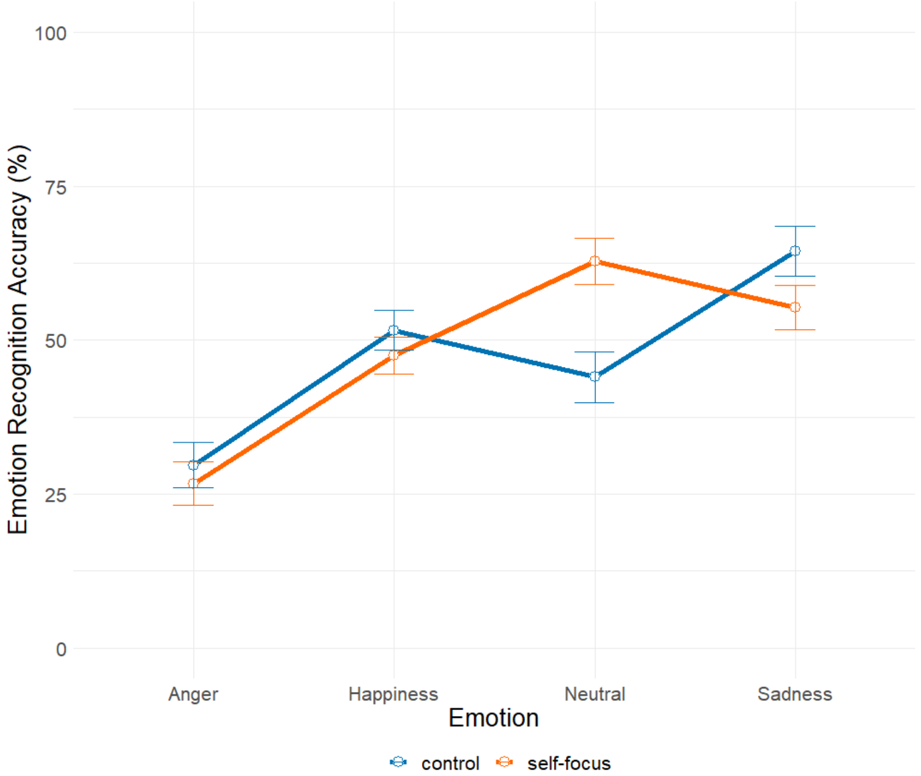
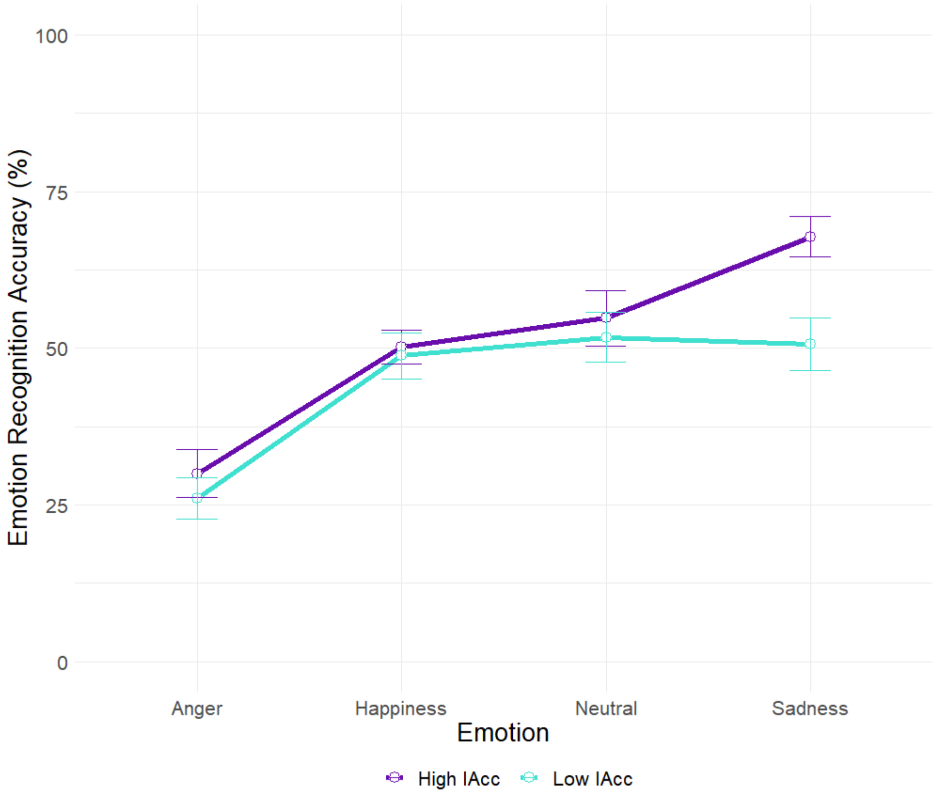


Figure 9

Mean emotion recognition accuracy based on interoceptive awareness



Additionally, given the significant main effect of emotion, we zeroed in on examining each specific emotion level by conducting factorial ANOVAs. Sadness demonstrated a significant main effect for IA (F(1, 79) = 12.28, p < .001, η_p^2= 0.146) and condition, F(1, 79) = 4.17, p = 0.045, η_p^2= 0.055. Gender did not exhibit a significant main effect (p = .41). None of the interactions reached significance (all ps > .05).

Post hoc tests revealed that participants with higher IA performed better in identifying sad emotional expressions compared to those with low IA (Mean Difference = 0.180, SE = 0.051, t = 3.505, 95% CI [0.078, 0.282], p < .001). Moreover, the control group outperformed the self-focus group in this regard (Mean Difference = 0.105, SE = 0.051, t = 2.043, 95% CI [0.003, 0.207], p = .045).

For neutral expressions, only the condition exhibited a significant main effect, F(1, 79) = 10.47, p = 0.002, η_p^2 = 0.127). IA, gender, and all interactions were non-significant (all ps > .05). After conducting post hoc comparisons, we observed that the control group performed worse in identifying neutral stimuli (Mean Difference = -0.186, SE = 0.058, t = -3.237, 95% CI [-0.301, -0.072], p = .002), which aligns with the findings from the repeated measures ANOVA test.

Regarding anger, only gender demonstrated a significant main effect, F(1, 79) = 6.51, p = 0.013, η_p^2 = 0.083). Condition, IA, and all interactions were non-significant (all ps > .05). Post hoc analysis indicated that females exhibited better recognition of anger compared to males (Mean Difference = 0.127, SE = 0.050, t = 2.553, 95% CI [0.028, 0.226], p = .013).

Lastly, for happiness, no significant main effects or interactions were found for any factors (all ps > .05).

3.2. Eye-tracking results

To analyze the participants' eye movements during the task, the fixation count and fixation duration data, calculated for each emotion, were subjected to separate mixed-design repeated measures ANOVAs. The ANOVA models included the same within- and between-subject factors as mentioned previously in the emotion recognition accuracy analysis.

3.2.1. Fixation duration

Analysis revealed a significant main effect of emotion, $F(2.516, 204) = 15.99$, $p < 0.001$, $\eta_p^2 = 0.208$. Although all emotions had different fixation durations (all ps < 0.05), neutral fixation duration was not significantly different from happy and angry emotions ($p = 1$). Gender revealed a significant main effect, $F(1, 68) = 8.33$, $p = 0.005$, $\eta_p^2 = 0.120$, indicating that females exhibited shorter fixation durations compared to males (Mean Difference = -0.107). Additionally, we observed a main effect of IA, $F(1, 68) = 4.59$, $p = 0.036$, $\eta_p^2 = 0.070$ indicating that individuals with better perception of their heartbeat (i.e. high IA) displayed greater fixation durations compared to those with low IA (Mean Difference = 0.080), (refer to Figure 8). No significant main effect for condition was found ($p = .70$).

An interaction between emotion and gender was observed, $F(2.516, 68) = 3.41$, $p = 0.026$, $\eta_p^2 = 0.053$. Post-hoc tests showed that females exhibited shorter fixation durations compared to males for sad (Mean Difference: -0.150, t =-3.445, p = 0.023, 95% CI [-0.289, -0.011], p = .0.23) and neutral emotional expressions (Mean Difference = -0.148, t =-3.395, p = 0.027, 95% CI [-0.287, -0.008], p = .0.27), while we found no significant differences for the emotions of happiness and anger. Other interactions were non-significant (all ps > .05).

Regarding accurate trials, we found a significant main effect of emotion, $F(2.228, 204) = 4.04$, $p = .017$, $\eta_p^2 = 0.094$). Post-hoc tests revealed that participants fixated longer on sad expressions compared to happy expressions (Mean Difference = 0.131). Also, a significant main effect of gender was observed, $F(1, 68) = 4.27$, $p = .045$, $\eta_p^2 = 0.099$). Specifically, females had shorter fixation durations compared to males (Mean Difference = -0.132). No other main effects or interactions were significant (all ps > .05).

Table 2

Mean fixation duration (ms) based on interoceptive awareness levels and gender

	Fixation duration	
Interoceptive awareness	High	Low
sad	570.37 (249.30)	462.61 (224.58)
neutral	483.64 (218.88)	392.40 (198.30)
happy	413.83 (124.81)	359.83 (112.29)
angry	471.14 (130.70)	408.54 (139.42)
Gender	Female	Male
sad	436.87 (175.56)	588.54 (269.28)
neutral	360.30 (147.09)	507.44 (236.41)
happy	355.96 (113.98)	415.56 (122.06)
angry	402.13 (127.80)	474.72 (138.03)

Note. Standard deviation values are provided in parentheses.

Figure 10

Mean fixation durations by interoceptive awareness levels across expressions

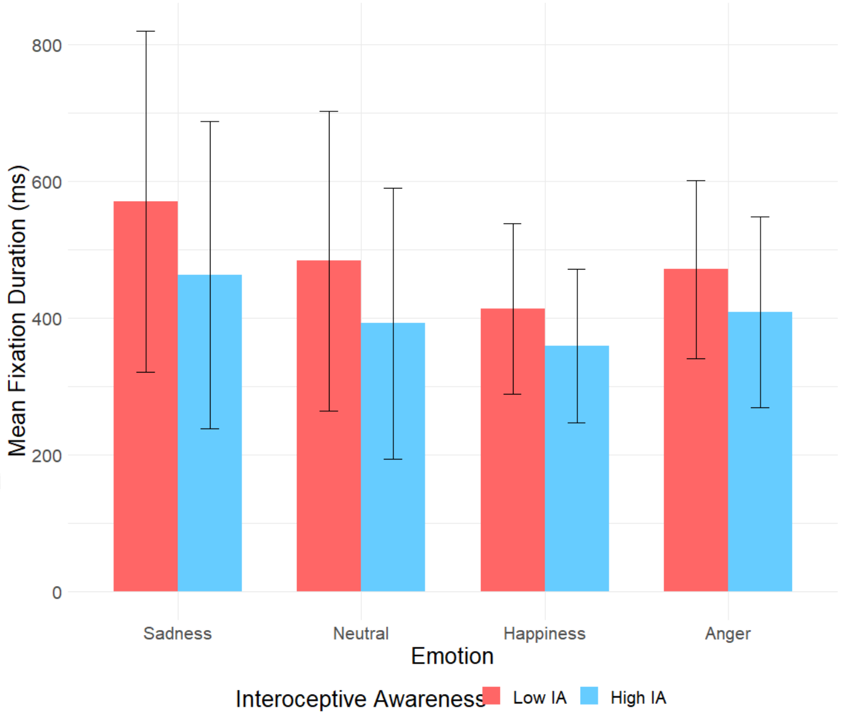
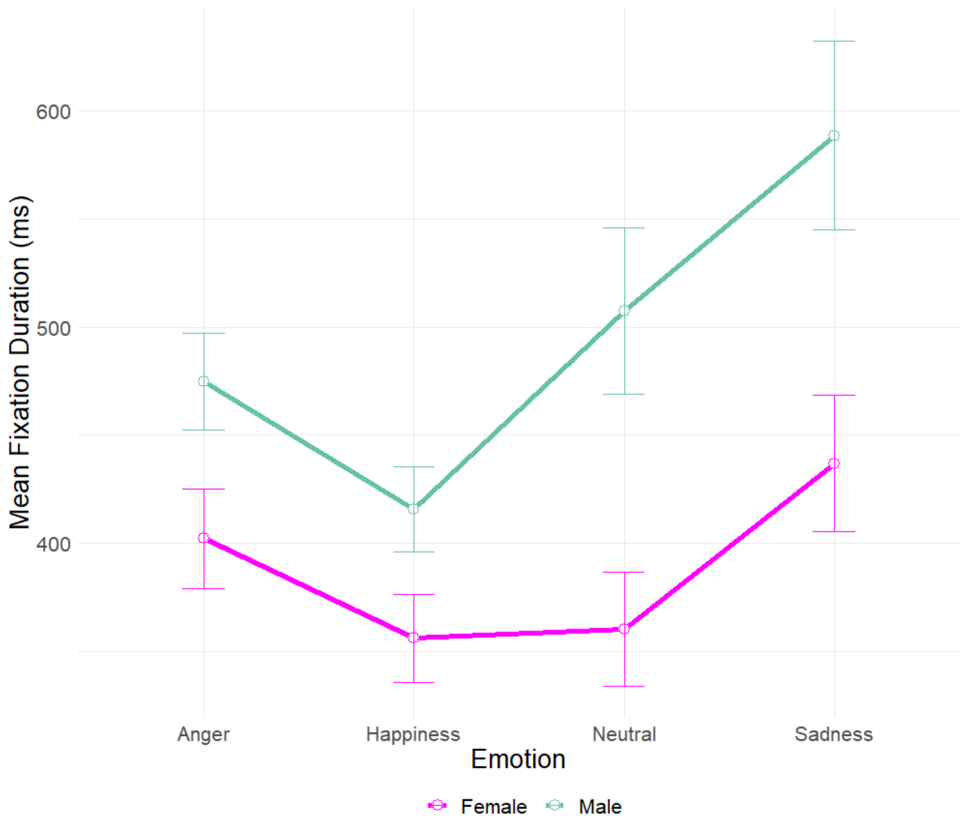


Figure 11

Mean fixation duration (ms) by gender across expressions



3.2.1. Fixation count

In regards to fixation count, analysis demonstrated a significant main effect of emotion $F(1.635, 204) = 239.22$, $p < 0.001$, $\eta_p^2 = 0.797$. Pairwise comparisons indicated that all emotions had varying fixation counts (all *p*s < 0.05). A significant main effect of gender was also found ($F(1, 68) = 6.06$, $p = 0.017$, $\eta_p^2 = 0.090$), with females demonstrating more fixation counts compared to males (Mean Difference = 3.979). Main effect of IA and gender was not significant (*p*s > .05) and there were no significant interactions (all *p*s > .05).

Table 3

Mean fixation count based on interoceptive awareness levels and gender

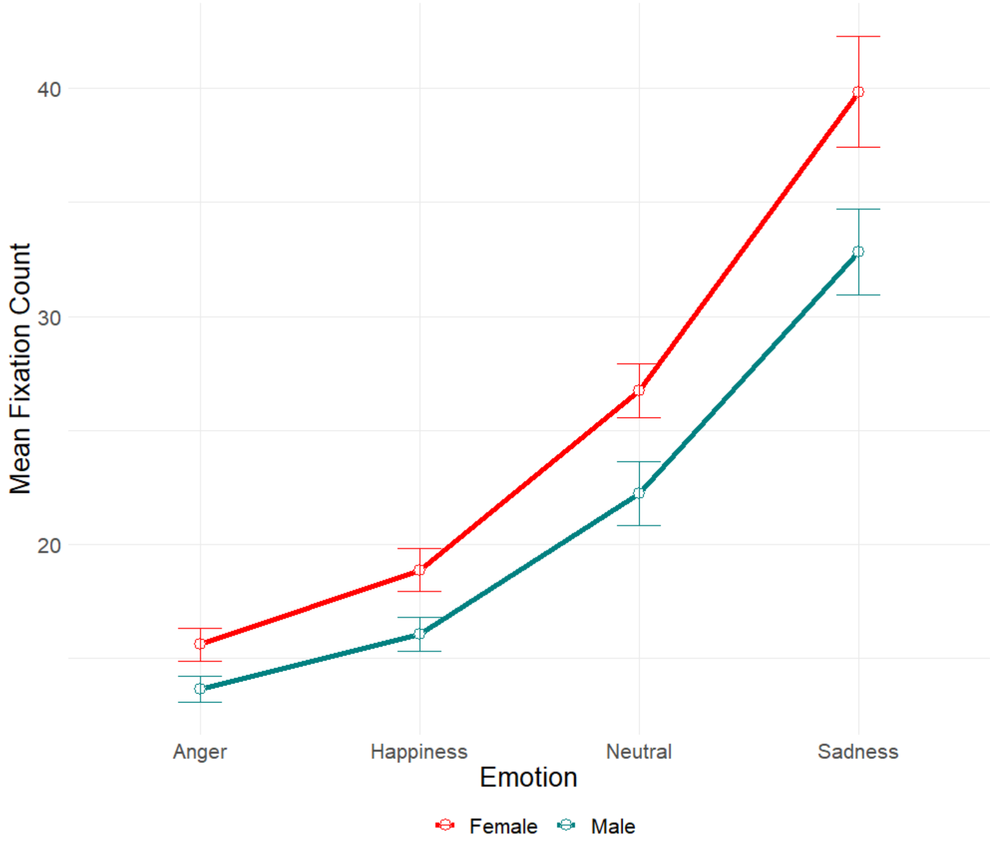
	Fixation count	
Interoceptive awareness	High	Low
sad	34.06 (13.20)	38.21 (12.37)
neutral	22.76 (6.34)	25.98 (9.46)
happy	16.74 (4.87)	17.96 (5.32)
angry	13.63 (3.47)	15.55 (4.09)
Gender	Female	Male
sad	39.86 (13.52)	32.81 (11.61)
neutral	26.75 (6.53)	22.21 (8.65)
happy	18.87 (5.25)	16.04 (4.63)
angry	15.59 (4.02)	13.65 (3.55)

Note. Standard deviation values are provided in parentheses.

Regarding accurate trials, a significant main effect of emotion $F(2.285, 204) = 91.29$, $p < 0.001$, $\eta_p^2 = 0.701$ was observed. Main effect of gender also reached significance, $F(2.285, 68) = 4.58$, $p = 0.039$, $\eta_p^2 = 0.105$ (Mean Difference = 4.819). No main effect of IA and condition was observed. No interactions were found except for an interaction between emotion and gender (F(2.285, 68) = 3.545, p = 0.028, $\eta_p^2 = 0.083$) was revealed. Post-hoc tests showed that all emotions differed significantly in terms of the number of fixations (all ps < .001), except for Happiness and Anger, which showed no significant difference ($p = 1$) which is consistent with the high confusion rate between both emotional expressions. Regarding emotion and gender interaction, female participants displayed a higher number of fixations on stimuli conveying sadness compared to males (Mean Difference = 10.381, $SE = 2.878$, $t = 3.607$, $p = .014$, 95% CI [1.121, 19.640], p = 0.014).

Figure 12

Mean fixation count by gender across expressions



4. DISCUSSION

The aim of the current study was twofold: firstly, to examine the effects of interoceptive awareness and self-focused attention on emotion perception, and their potential interaction; and secondly, to examine whether these effects manifest in the participants' eye movements, specifically their fixation patterns. Notably, to our knowledge, this study is the first exploration of the interaction between interoception and fixation patterns in non-clinical populations. Based on previous research, we hypothesized three main outcomes: interoceptive awareness would facilitate emotion recognition, manipulating self-awareness through self-focus would enhance emotion recognition, and also an interaction between interoception and fixation patterns was expected in the context of emotion perception. To test these hypotheses, we devised a novel paradigm in which participants were presented with point-light dance figures depicting anger, happiness, sadness, and neutral expressions, while their eye movements were tracked. The study employed a between-subjects design, with two conditions (self-focus and control) assigned to independent groups of participants, controlled for age, interoceptive awareness and gender .

Interoceptive awareness was evaluated utilizing the Heartbeat Counting Task before the emotion recognition task to observe its potential influence on emotion perception. Additionally, participants completed the Multidimensional Assessment of Interoceptive Awareness 2 Scale (MAIA-2) to assess their subjective interoceptive awareness. To examine the effects of self-focus, participants in the self-focus condition were supraliminally primed with a portrait photograph of themselves with a neutral expression, while the control group was not exposed any priming. The dependent variables measured in the study included emotion recognition accuracy and eye movements, specifically fixation count and fixation duration, during the emotion recognition task.

Regarding emotion perception, evaluated through the emotion recognition task, it was observed that participants exhibited higher accuracy in recognizing sadness compared to other emotions, while recognizing anger was more challenging. However, gender played a significant role in the recognition of anger, with females displaying the ability to identify anger depicted by point-light dance movements above chance levels. Additionally, as hypothesized, interoceptive awareness significantly influenced emotion recognition accuracy, with individuals having higher interoceptive awareness performing better, particularly in recognizing sadness. Furthermore, the experimental condition also had an impact on emotion recognition, with participants in the self-focus condition showing improved recognition of neutral stimuli compared to those in the control group. Notably, the control group exhibited better recognition of sadness.

Regarding fixation patterns, a significant gender effect was observed, with females displaying shorter fixation durations and higher fixation counts for both all trials and accurate trials. Specifically, females showed shorter fixation durations when presented with sad and neutral emotional expressions compared to males. Additionally, females exhibited higher fixation counts, particularly for sadness, during accurate trials. This finding is noteworthy, considering that for all trials, interoceptive awareness had a significant effect on fixation duration, aligning with recent studies suggesting that participants with high interoceptive awareness have a tendency to exhibit longer looking times at emotional stimuli overall.

4.1. Emotion perception

In terms of emotion recognition accuracy, participants in both the self-focus and control conditions demonstrated a moderate level of performance. Consistent with previous studies that have shown the ability to recognize emotions from biological motion alone, such as point-light gestures (Atkinson et al, 2004; Clark et al, 2005) or point-light dance figures (Walk & Homan, 1984; Dittrich et al, 1996; Smith & Cross, 2023), participants in our study were able to reliably recognize emotional expressions significantly above chance level for all emotions, except for anger. However, the confusion between anger and happiness was particularly notable, as both groups exhibited a high rate of misidentification for these emotions. This finding contradicts the results of Ikeda & Watanabe's (2009) study and Walk’s (1984) alarm hypothesis, which suggested an association between anger and gait detection, emphasizing the significance of detecting anger for survival.

The unexpected result of lower accuracy in recognizing anger compared to the validation study on the stimuli used raises interesting questions. The validation study conducted by Smith and Cross (2023) reported above-chance levels of anger recognition, despite noting a tendency for anger to be frequently confused with happiness as well. This discrepancy suggests that there might be factors specific to our study that contributed to the difficulty in accurately recognizing anger.

Cultural influences could potentially play a role in the differing results for anger recognition, as our participants were exclusively Turkish. Our post-experiment interviews with participants revealed some interesting insights as well. Some participants reported that they did not perceive any stimuli conveying anger, while some expressed the belief that dance cannot effectively convey anger and that is why they never selected the option during the task. These observations suggest that cultural interpretations and expectations regarding the expression of anger through dance might have influenced participants' ability to accurately identify anger in our study.

On the other hand, when analyzing the data by gender we observed that females in the study were able to identify all expressions, including anger, above chance levels and outperformed males in the identification of anger. This finding might have implications for the perception of threat specifically in females, and previous studies have provided evidence for this heightened susceptibility to anger (Abbruzzese et al., 2019; He et al., 2018).

4.2. Effects of interoceptive awareness

In line with our hypothesis, the levels of interoceptive awareness significantly influenced the accuracy of emotion recognition, even when participants were provided with minimal visual cues in the form of point-light displays. Participants with high interoceptive awareness demonstrated significantly better recognition of sadness, which aligns with findings from previous studies that utilized dance movements as stimuli (Dittrich et al., 1996; Smith & Cross, 2023). Furthermore, individuals with higher interoceptive accuracy exhibited higher overall accuracy in recognizing emotions when all emotion recognition scores were combined. This finding suggests that individuals who are more attuned to their own internal states might have an advantage in accurately perceiving and recognizing emotional expressions. In other words, the ability to perceive and accurately interpret one's own internal states might enhance the prediction and understanding of emotions displayed by others. These results are consistent with previous studies highlighting the connection between interoceptive awareness and emotional understanding (Arnold et al., 2019; Decety & Sommerville, 2003; Fukushima et al., 2011; Garfinkel et al., 2016; Grynberg & Pollatos, 2015; Hübner et al., 2021; Ondobaka et al, 2017; Pollatos et al., 2005; Shah et al., 2017; Terasawa et al., 2014).

Notably, the recognition of anger was consistently challenging for all participants, regardless of their interoceptive awareness levels. Even participants with higher interoceptive awareness did not reliably recognize anger above chance level. This exception might be attributed to various factors, including the specific stimuli used in the study and potential cultural differences in emotional understanding derived from dance movements.

Moreover, no correlations were found between MAIA-2 questionnaire's subscales and interoceptive awareness assessed by heartbeat counting task, providing evidence for the multi-dimensionality of interoceptive processes. The observed weak associations between subjective reports and implicit measures (i.e. assessment of the capacity to perceive bodily signals) suggest that these two dimensions of interoceptive awareness might tap into different aspects of the modality, highlighting the importance of considering both measures to gain a comprehensive understanding of interoceptive processes.

4.3. Effects of self-focus

The condition (self-focus vs. control) did not show an effect on overall performance on emotion recognition accuracy. However, the relationship between emotion and recognition performance differed depending on the condition. Specifically, the self-focus condition exhibited significantly superior recognition of neutral expressions compared to the control condition. Post-experiment interviews also support the neutral expression's easier recognition. Some participants in the self-focus condition explicitly reported that it seemed to them that most of the dance figures were depicting neutral expressions.

This finding supports the notion that self-focused attention plays a crucial role in directing individuals' attention towards their own emotional expressions. These findings also align with embodied simulation accounts, emphasizing the significance of our own facial gestures in perceiving and understanding the emotions, as well as mental states of others (Gallese, 2007; Niedenthal, 2007). For instance, studies involving individuals who received botox injections, which paralyze facial muscles temporarily, have shown difficulties in emotion recognition (Lewis, 2018) or altered emotional processing (Davis et al., 2010, Stark et al, 2023), highlighting the importance of one's own facial expressions in emotional processing. Additionally, other studies have also found correlations between emotion recognition and muscle movements detected by electromyography (EMG) (Wallbott, 1991; Dimberg & Petterson, 2000).

Our findings also suggest an intriguing interplay between the simulation theory and the predictive coding framework. Simulation models propose that emotion perception involves simulating the same emotional state within oneself, rather than solely relying on the perception of facial expressions or bodily cues. This implies that observing another person's emotional state can elicit an emotional contagion or evoke a simulated emotional experience by activating representations of corresponding bodily states or motor patterns (Adolphs, 2002; Gallese et al., 2004; Heberlein, 2009) On the other hand, the predictive coding framework suggests that we predict the emotional states of others based on our memory of past feelings and states (Ondobaka, 2017).

In our study, it is plausible that participants might have displayed a strong emotional contagion when they viewed their own neutral expression photo, invoking a sense of emotional resonance through self-face perception. This, in turn, might have activated representations of bodily states and motor programs. This finding supports the principles of predictive coding, as participants can utilize their recent memory of their own emotional state to predict the emotional states of the point-light dancers. Moreover, our findings also indicate that the self-focused attention induced by priming self-face not only enhances facial emotion recognition but also facilitates the recognition of emotions related to bodily expressions. This might underlie that the attention directed towards the self-face can extend to bodily self-focused attention, leading to improved recognition of emotions expressed through the bodily kinematics (i.e. dynamic point-light display figures).

Furthermore, although the self-focus and control groups did not exhibit difference in terms of overall accuracy scores, there were variations in the distribution of accuracy rates across different emotions. While we observed enhanced recognition of neutral expressions in the self-focus condition, the accuracy rates for other emotions were comparatively lower and mean accuracy across all expressions was similar for both groups regarding emotion recognition task. In this context, the concept of capacity limitations and resource allocation in attention research can help provide insights into the underlying mechanisms. According to resource allocation models, attention has a pivotal role in regulating the allocation of processing resources (Kahneman, 1973; Wickens, 1984). These models propose that by allocating a higher amount of resources to a specific task or stimuli, performance on that task can be improved. However, the act of prioritizing one task by the means of cueing and allocating additional resources to it inevitably entails a trade-off, as it diminishes the availability of resources for other simultaneous tasks (Luck et al.,1996; Meinhardt & Pekrun, 2003).

In relation to our study, the priming of participants with their own neutral expression photo can be seen as a manipulation that directs attention to self-relevant stimuli. By allocating more attentional resources to their own face, participants might have enhanced their perception and processing of the neutral stimuli. In other words, it appears that the self-focused attention might allocate attentional resources to prioritize the perception of emotions displayed on the self-face, consistent with the findings of studies emphazing the saliency of self-face (Alzueta et al., 2019; Bola et al, 2021; Sui & Rotshtein, 2019). However, this allocation of attentional resources also implies that there is a limitation in the available attention, and when participants were primed with their own self-face, attentional resources were directed towards recognizing the recently simulated emotional expression.

Regarding the potential interaction between self-focused attention and interoceptive awareness, our study did not reveal any significant interaction between self-focus and interoception in relation to emotion perception. It is worth noting that previous studies have suggested that self-focused attention has the potential to enhance awareness of the bodily self and consequently increase interoceptive awareness . However, since we did not directly assess the participants' interoceptive awareness after the task, we cannot definitively determine whether such an effect occurred in our study.

4.4. Fixation patterns

The eye tracking data analysis provided valuable insights into participants' fixation patterns during emotion recognition. Notably, participants with higher interoceptive awareness demonstrated longer fixation durations indicating a more detailed and thorough processing of emotional stimuli. These findings align with our initial hypothesis, which was based on previous research by Nackaerts et al. (2012) that observed shorter fixation durations in individuals with ASD compared to TD participants. Although our study focused on typically developed participants, we expected to observe a similar pattern, considering that individuals with ASD often exhibit interoceptive deficiencies, not directly related to autism but as a result of the presence of alexithymia that occurs concurrently (Shah et al., 2016).

Moreover, the task in our study involved tracking the forms and motions on the screen while attempting to predict the conveyed emotion of the dancer. This task placed a high cognitive load on participants, which might also explain the observed differences between groups. Previous research has shown that expert users tend to exhibit longer fixation durations compared to novice users in situations involving high cognitive effort (İşbilir et al., 2019).

The longer fixation durations observed among expert users might indicate their ability to allocate greater attentional resources and engage in more in-depth processing of the visual stimuli. Their expertise and prior experience might allow them to efficiently extract relevant information from complex visual scenes, resulting in longer looking times and less number of fixations. In contrast, novice users might lack the necessary knowledge to effectively assess where and for how long to direct their attention in order to process the visual information and make accurate predictions. As a result, they might exhibit shorter fixation durations.

On the other hand, we found no differences between self-focus and control conditions in terms of fixation patterns. It is possible that the manipulation of self-focus did not have a direct impact on participants' visual exploration strategies during the task, but rather influenced their interpretation of emotional cues.

Gender differences were also observable in fixation patterns, with females showing lower fixation durations and a higher number of fixations across all trials compared to males. However, it's important to interpret this finding cautiously, as we also observed a similar pattern between high and low interoceptive awareness groups, whereas participants with lower interoceptive awareness performed worse in correctly identifying emotions. There are also studies suggesting that prior experience or expertise may influence fixation patterns, with findings of longer looking times observed in individuals who are less experienced during activities such as chess playing (Sheridan, 2017) or surgical procedures (Dalveren, 2018). These findings support the notion that individuals with more experience in emotional processing might exhibit different patterns of attention allocation. It is plausible that females, on average, may possess more experience or heightened sensitivity to emotional cues, contributing to their distinct fixation patterns. Their demonstrated superiority in identifying sadness and neutral emotions in all trials, and sadness in accurate trials, lends support to this interpretation, as these emotional expressions were the ones most accurately recognized among all participants.

4.6. Limitations

There are certain limitations that should be taken into consideration when interpreting the results of our study. Firstly, our experiment focused solely on self-focus priming and its impact on the perception of emotional expressions. Although we observed that self-focus enhanced the recognition of neutral expressions displayed on self-face, we did not investigate the effects of priming with other emotional expressions. Therefore, the generalizability of our findings to other emotional contexts is limited.

Secondly, the stimuli set used in our study might have had limitations in terms of confusion rates between emotions and overall accuracy rates in validation tests. Using a stimuli set with clearer differentiation between emotions and higher validation accuracy would strengthen the reliability and applicability of the results.

Furthermore, our experimental design focused exclusively on self-focus priming, and we did not include an other-focus priming condition for direct comparison. Therefore, we cannot draw conclusions about the differential effects of self-focus and other-focus priming on emotion perception.

4.7. Conclusion and future directions

Current study aimed to contribute to our understanding of the role of interoception, self-focused attention, and their potential interaction with visual perception in the mechanisms underlying emotion perception. Notably, we have shown a novel relationship between interoceptive awareness and fixation patterns, highlighting the importance of internal bodily sensations in the processing of emotions. We concluded that both interoceptive awareness and self-focus can positively influence emotion perception through distinct mechanisms. Self-focus, achieved by directing attention to the bodily self, has the potential to enhance accuracy in emotion recognition. However, it is worth mentioning that this process might also be susceptible to the influence of primed expressions, which can impact the recognition of emotions. On the other hand, interoceptive awareness can enhance emotion perception by enabling individuals to accurately perceive internal bodily sensations, rather than relying solely on the temporary direction of attention towards specific emotional valences, which allows the interpretation that interoception might render the representation of a bodily or embodied self possible. Furthermore, while interoception facilitates the separation of the self from the other, also, interestingly, makes it possible to comprehend the other better. And, the distinction between the effects of self-focus and interoceptive awareness, reflected in the participants' eye behavior during the study, further supports our findings.

Moving forward, future research should further investigate the complex interplay between self-focus and emotion perception. In this context, it is essential to explore the mechanisms underlying the differential effects of self-focus on various emotional expressions. Although our findings indicated that self-focus improved the recognition of the neutral expression displayed on the participants' own faces, we did not incorporate priming with other facial expressions. As a result, our understanding of how different priming conditions might affect the recognition of various emotional expressions is limited. Future research should consider incorporating different self-face expressions, such as happy, angry, and sad, to examine the specific impact of self-focus on each emotion.

Additionally, future studies should explore the broader implications of self-focused attention on social interactions. Understanding how self-focus influences the perception and interpretation of emotions in interpersonal contexts can provide valuable insights into communication and empathy. Examining the role of self-focus in different populations, such as individuals with social anxiety or ASD, could further expand our understanding of its influence on social functioning.

Moreover, considering the influence of factors such as prior experience, expertise, and sociocultural norms on self-awareness and emotion recognition would offer a more extensive comprehension of the underlying mechanisms involved. Incorporating neuroimaging techniques and physiological measures could further elucidate the fundamental neural and physiological mechanisms associated with self-awareness and emotion perception.

By addressing these future directions, we can gain a more comprehensive understanding of how self-awareness, either interoceptive or induced by self-focus, contribute to emotion perception and pave the way for potential applications in various domains, including social cognition, mental health, education, and interpersonal communication.

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APPENDIX A: Multidimensional Assessment of Interoceptive Awareness Version 2 (MAIA-2) (2018) - Turkish

Aşağıda belirli ifadeler göreceksiniz. Lütfen ifadelerin günlük hayatınıza ne sıklıkla uyduğunu belirtiniz

	Her bir sırada bir sayıyı yuvalak içine alınız					
	Hiçbir zaman				Her zaman	
1. Gergin olduğum zaman, gerginliğin bedenimin neresinde olduğunu fark ederim.	0	1	2	3	4	5
2. Bedenimin içinde rahat hissetmediğimde, bunu fark ederim.	0	1	2	3	4	5
3. Bedenimin hangi bölgesinde rahat hissettiğimi fark ederim.	0	1	2	3	4	5
4. Nefes alışverişimdeki değişikleri fark ederim, örneğin nefes alışverişimin yavaşlayıp veya hızlandığını.	0	1	2	3	4	5
5. Bedenimdeki fiziksel gerginliği veya rahatsızlığı daha fazla şiddetlenene kadar yok sayarım.	0	1	2	3	4	5
6. Rahatsızlık hislerinden uzaklaşmak için dikkatimi dağıtırım.	0	1	2	3	4	5
7. Acı veya rahatsızlık hissettiğimde üstesinden gelmeye çalışırım.	0	1	2	3	4	5
8. Acı hissini yok saymaya çalışırım.	0	1	2	3	4	5
9. Rahatsızlık hislerini başka şeylere odaklanarak uzaklaştırmaya çalışırım.	0	1	2	3	4	5
10. Keyif vermeyen beden duyumları hissettiğimde, kendimi başka bir şey ile meşgul ederim, böylelikle onları hissetmek zorunda kalmam.	0	1	2	3	4	5
11. Fiziksel acı hissettiğimde mutsuz olurum.	0	1	2	3	4	5
12. Rahatsızlık hissettiğimde bir şeylerin yanlış olduğunu düşünerek endişelenmeye başlarım.	0	1	2	3	4	5
13. Keyif vermeyen bir beden duyumunu endişelenmeden fark edebilirim.	0	1	2	3	4	5
14. Acı ve rahatsızlık hissettiğimde, endişelenmem ve sakin kalabilirim.	0	1	2	3	4	5
15. Rahatsızlık veya acı içinde olduğumda, bunları aklımdan çıkaramam.	0	1	2	3	4	5
16. Etrafımda olup bitenlere dikkatimi dağıtmadan nefesime odaklanabilirim.	0	1	2	3	4	5

17. Etrafımda pek çok şey olup bitiyorken bile içsel bedensel duyumlarıma olan farkındalığımı sürdürebilirim.	0	1	2	3	4	5
18. Biriyle sohbet ederken, duruşuma dikkat edebilirim.	0	1	2	3	4	5
19. Dikkatim dağıldığında, farkındalığımı bedenime döndürebilirim.	0	1	2	3	4	5
20. Dikkatimi düşüncelerimden, bedenimi hissetmeye yöneltebilirim.	0	1	2	3	4	5
21. Bir tarafım ağrılı veya rahatsız olsa bile tüm beden farkındalığımı sürdürebilirim.	0	1	2	3	4	5
22. Bedenimin tümüne bilinçli bir şekilde odaklanabilirim.	0	1	2	3	4	5
23. Kızgın olduğumda bedenimin nasıl değiştiğini fark ederim.	0	1	2	3	4	5
24. Hayatımda bir şey yolunda olmadığında, bunu bedenimde hissederim.	0	1	2	3	4	5
25. Huzurlu bir deneyimden sonra bedenimin daha farklı hissettirdiğini fark ederim.	0	1	2	3	4	5
26. Rahat hissettiğimde, nefesimin daha kolaylaştığını fark ederim.	0	1	2	3	4	5
27. Mutlu veya neşeli hissettiğimde bedenimin nasıl değiştiğini fark ederim.	0	1	2	3	4	5
28. Her şeyin üst üste geldiğini hissettiğimde, içimde huzurlu bir yer bulabilirim.	0	1	2	3	4	5
29. Farkındalığımı bedenime yönlendirdiğimde, sakinlik hissederim.	0	1	2	3	4	5
30. Nefesimi, gerginliği azaltmak için kullanırım.	0	1	2	3	4	5
31. Düşüncelerim arasında kaybolduğumda, nefesime ve bedenime odaklanarak zihnimi sakinleştirebilirim.	0	1	2	3	4	5

32. Bedenimi, duygusal durumumla ilgili bilgi almak için dinlerim.	0	1	2	3	4	5
33. Üzgün olduğumda, bedenimin nasıl hissettirdiğini keşfetmek için zaman ayırırım.	0	1	2	3	4	5
34. Bedenimi, ne yapmam gerektiği konusunda beni bilgilendirmesi için dinlerim.	0	1	2	3	4	5
35. Bedenimin içinde evdeyim.	0	1	2	3	4	5
36. Bedenimin güvenli bir alan olduğunu hissediyorum.	0	1	2	3	4	5
37. Beden duyumlarıma güvenirim.	0	1	2	3	4	5