Examining the Effects of Interoceptive Awareness and Self-Focus on Emotion Perception from Point-Light Dance Movements: an Eye Tracking Study

Authors

Ilkay Ari[1*], Burcu Unlutabak[2]

Affiliations

[1]Master's Program in Cognitive Sciences, Graduate School of Social Sciences Yeditepe University, Istanbul, 34755, Turkey

[2]Faculty of Arts and Sciences, Department of Psychology, Yeditepe University, Istanbul, 34755, Turkey

*To whom correspondence should be addressed; E-mail: ilkay.ari@std.yeditepe.edu.tr

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

INTRODUCTION

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.

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 also 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).

Interoception and Emotions

Recent studies assessing interoceptive awareness 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).

Findings of the previous studies 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 & Friston, 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 & Pollatos, 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.

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 (2022) 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.

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.

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, 2012; 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.

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.

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.

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?

(2) What is the impact of manipulating self-awareness, specifically inducing a self-focused state, on emotion perception?

(3) How interoception and visual perception as an exteroceptive modality interact when predicting the emotions of others?

Method

80 voluntary individuals participated in the study. Participants were paired or blocked based on age, gender and interoceptive accuracy. 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).

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) (**Figure 2**) while their eye movements were tracked with an eye tracker device. Interoceptive awareness was evaluated using the Heartbeat Counting (HBC) Task (**Figure 1**) 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.

RESULTS

Emotion Recognition Task Results

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 (**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 ps $< .001$), with the exception of anger ($p = .16$) (**Figure 3**). 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 ps for anger > 0.05) (**Figure 4**). 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 (**Figure 5**).

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 ps < .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 ps > 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**).

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 ($M_{\text{Control}} = 1.897$, $M_{\text{Self-Focus}} = 1.923$). 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 (**Figure 7**). 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).

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 ($F(1, 79) = 12.28$, $p < .001$, $\eta_p^2 = 0.146$) and condition, $F(1, 79) = 4.17$, $p = 0.045$, $\eta_p^2 = 0.055$. 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, $F(1, 79) = 10.47$, $p = 0.002$, $\eta_p^2 = 0.127$). IA, gender, and all interactions were non-significant (all *p*s > .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, $F(1, 79) = 6.51$, $p = 0.013$, $\eta_p^2 = 0.083$). Condition, IA, and all interactions were non-significant (all *p*s > .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).

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.

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 *p*s < 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) (**Table 2**). 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), (**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).

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 ps < 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 (ps > .05) and there were no significant interactions (all ps > .05).

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 (**Figure 9**). 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).

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.

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; Clarke 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. Cultural influences could potentially play a role in the differing results for anger recognition, as our participants were exclusively Turkish. 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).

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. 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). 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 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. This finding supports the notion that self-focused attention plays a crucial role in directing individuals' attention towards their own emotional expressions.

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.

CONCLUSION

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.

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Tables

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.

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.

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.

Figures

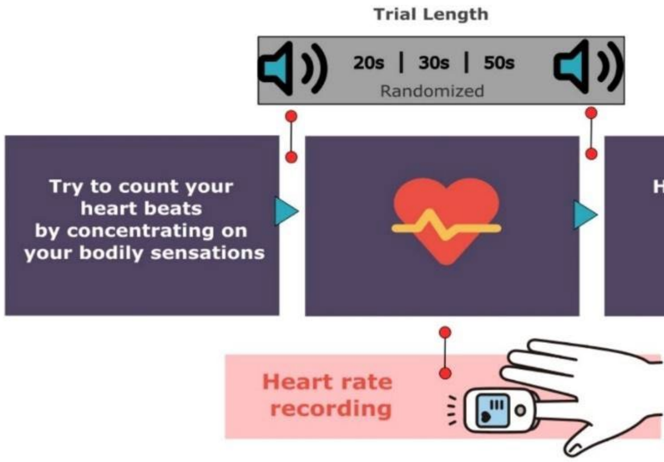

Figure 1. Experimental set up for the heartbeat counting task

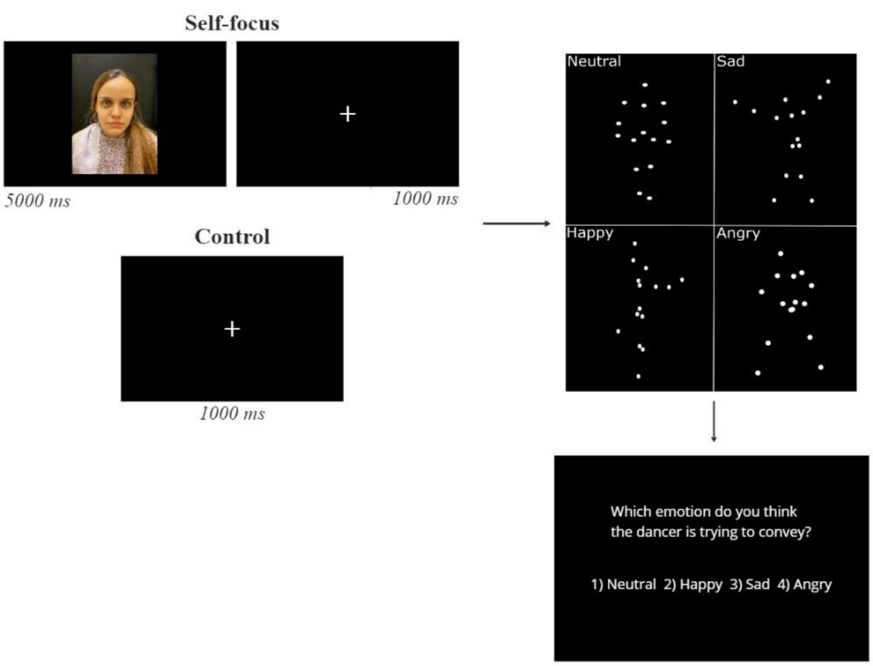

Figure 2. Experimental paradigm for the emotion recognition task

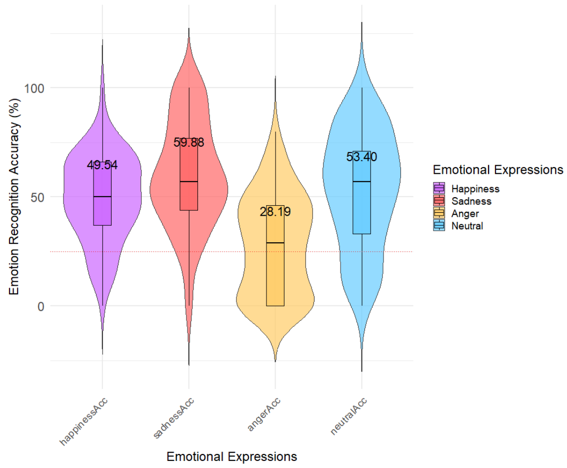

Figure 3. Mean emotion recognition accuracy among all participants

Figure 4. Mean emotion recognition accuracy among females

Figure 5. Conveyed and recognized emotional expressions by participants in a confusion matrix

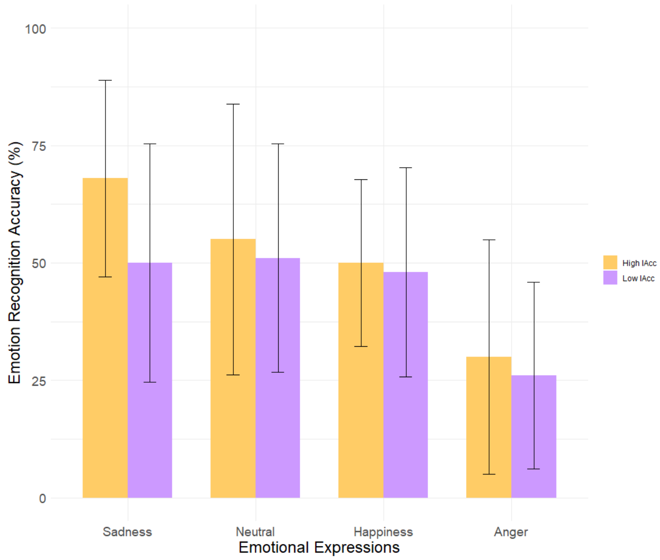

Figure 6. Mean emotion recognition accuracy based on interoceptive awareness

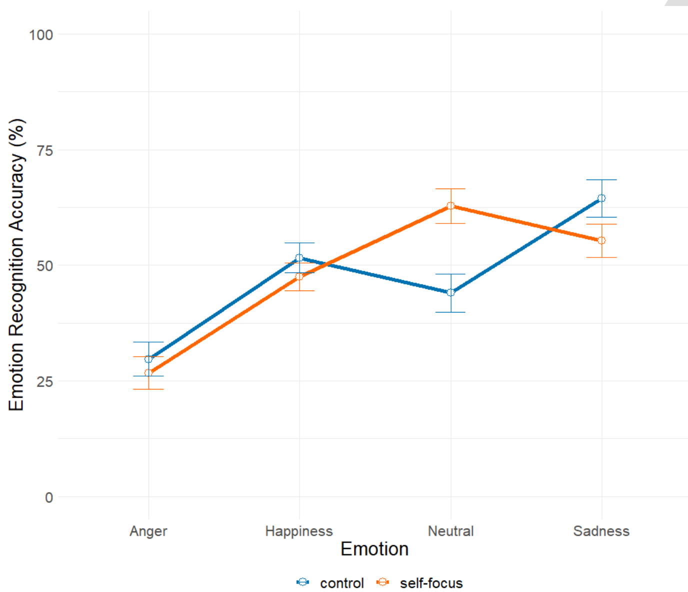

Figure 7. Interaction between emotion and condition

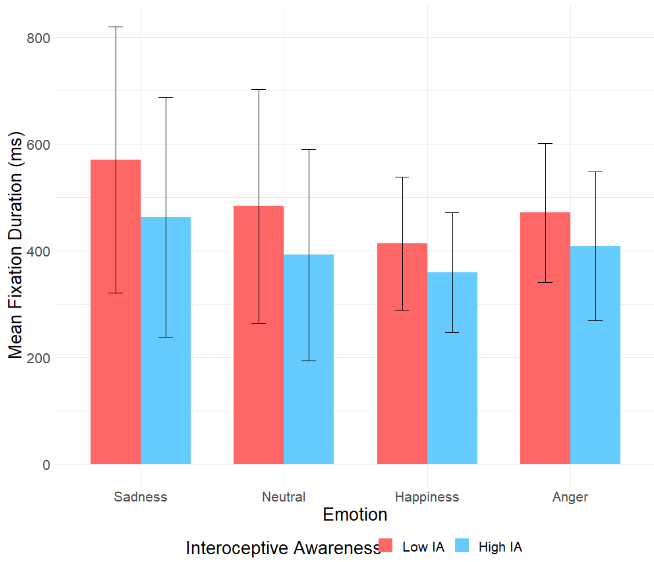

Figure 8. Mean fixation durations by interoceptive awareness levels across expressions

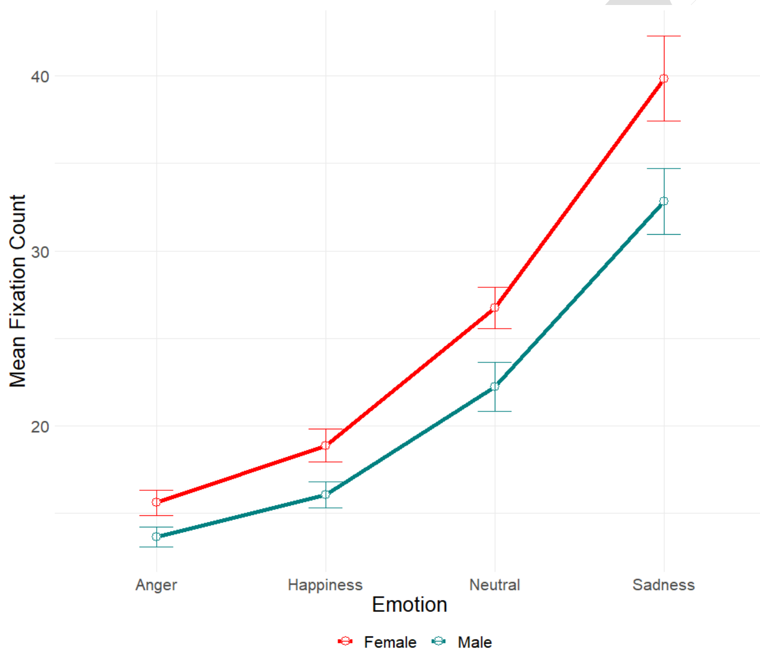

Figure 9. Mean fixation count by gender across expressions