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Relationship Between Interoception and Emotion Regulation: New Evidence from Mixed Methods

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Abstract

Background: Interoception is the ability to perceive one's inner bodily feelings and is thought to be associated with the capacity of recognising and experiencing emotions. Previous research on interoception and emotion regulation has presented limitations arising from the low reliability of the interoceptive measurement and provided inconsistent results. The current study used a mixed method approach to investigate this relationship from the individuals' perspective. *Methods:* In the first phase (quantitative), questionnaires assessing interoceptive sensibility, the subjective, self-reported ability to perceive internal states, were administered to 100 healthy participants. In the second phase (qualitative), individual semi-structured interviews were conducted with nine participants. The interviews were analysed using the Interpretative Phenomenological Analysis. Three main dimensions were explored with open questions: 1) Perception of internal bodily states; 2) Emotion regulation; 3) Potential relationship between bodily states perception and emotion recognition and regulation. *Results:* Findings revealed that people with low interoceptive abilities show more difficulties in verbalizing their feelings and in decreasing the impact of emotions generated by negative experiences in daily life. *Limitations:* The generalization of the results is limited by the specific age and gender of the recruited sample. *Conclusions:* Responses of the participants supported recent evidence regarding the lack of reliability of the heartbeat counting task as a measure of interoceptive accuracy, however interviews sustained the importance of recognising the bodily states in order to be able to understand and regulate emotions.

Keywords: Interoception; Emotion Regulation; Alexithymia; Mixed method design; Interpretative Phenomenological Analysis.

Introduction

The capacity to identify sensations arising from the body - i.e., interoception - has been associated with the ability to recognise and understand emotions (Damasio, 1994; James, 1884). In addition, research suggests that better interoceptive abilities relate to better emotion regulation (Kever, Pollatos, Vermeulen, & Grynberg, 2015; Pollatos, Matthias, & Keller, 2015; Werner, Peres, Duschek, & Schandry, 2010). However, growing concerns have been recently raised about the construct validity of the most common task used to measure interoceptive abilities, the heartbeat counting task (e.g., Desmedt, Luminet, & Corneille, 2018; Murphy, Brewer, Hobson, Catmur, & Bird, 2018; Ring, Brener, Knapp, & Mailloux, 2015; Zamariola, Maurage, Luminet, & Corneille, 2018). Additionally, the predictive validity of scores on this task have also been questioned. For instance, a recent high-powered study (Zamariola, Luminet, Mierop, & Corneille, 2018) failed to replicate evidence for the coping effect of interoceptive abilities on negative affect previously found by Pollatos et al. (2015). In the present research, a new (i.e., mixed-methods) approach is adopted to examine the relationship between interoception and emotion regulation from the individuals' perspective. Below, we first present definitions of interoception and emotion regulation and review empirical studies on this relationship. Then, we report and discuss study we conducted where we adopted a mixed-methods design for exploring this link.

Interoception

Interoception is defined as the ability to perceive internal bodily sensations. Higher scores are supposed to be related to better emotional processing (James-Lange, 1884). This is highlighted by the "somatic marker" hypothesis, which posits that signals arising from the body are essential in order to understand one's feelings and guide decision-making (Damasio, 1994). These conceptualizations underline that physiological changes are crucial to understanding and recognizing emotions. They contribute to the ability to react physiologically in response to these emotions and to regulate them. Even though research on

interoception has been extensive, it was only in 2015 that Garfinkel and colleagues proposed a typological model of interoception. These authors proposed three dimensions of interoception. The first, interoceptive accuracy (IAcc), is the objective ability to perceive one's bodily states, such as heartbeats, gastric functions, and respiration. Cardiac IAcc is usually assessed using the heartbeat counting task (Dale & Anderson, 1978; Schandry, 1981) in which participants are asked to silently count their heartbeats for different time intervals, only resting upon their internal bodily signals. The second, interoceptive sensibility (IS), is defined as the subjective measure of interoception, assessed via questionnaires that ask individuals to report their ability in perceiving their bodily states. The third, interoceptive awareness (IA), is the relationship between IAcc and IS; that is, the extent to which the latter two measures are correlated (or not) within-participants.

Emotion regulation (ER)

According to Gross (2014), emotion regulation involves three core features. The *first* core feature is the activation of a goal to alter the emotion-generative process. Goals of down-regulation of negative emotions and up-regulation of positive ones are the most common, however one person might also try to down-regulate positive emotions or up-regulate negative emotions depending on the context. Different Emotion Regulation (ER) strategies, lead to various consequences based on the context and moment at which they are implemented. ER goals can be applied to the intensity or the duration of the emotion and can be either intrinsic (in oneself) or extrinsic (in others). The *second* core feature is the engagement of ER strategies to modify the emotion trajectory, either explicitly or implicitly. John and Gross (2007) developed the Process model of ER, which comprises a five-point emotion-generative process, namely situation selection, situation modification, attention deployment, cognitive change, and response modulation. At each point, a particular ER strategy can be implemented to decrease negative emotions, such as anxiety, fear, sadness, and anger. The *third* core aspect

is the ER outcome, i.e., the effect of ER on dimensions of latency, rise time, magnitude, duration and offset of emotional responses. Most studies have focused on two ER strategies: expressive suppression and cognitive reappraisal. During suppression, a person tries to down-regulate emotion-expressive behaviours and to change their behavioural response to the eliciting event (John & Gross, 2007). Suppression has been shown to decrease positive, but not negative emotion experience (Gross & John, 2003). For this reason, it has been considered a more "maladaptive" strategy. Reappraisal is a more cognitively oriented strategy, in which one attempts to think about a situation in order to modify the emotional response (Webb, Miles, & Sheeran, 2012). Reappraisal has been linked to a decrease in negative emotions and to an increase in positive ones, and is related to better interpersonal functioning and well-being. It is thus considered a more "adaptive" strategy (Cutuli, 2014). Therefore, it might be hypothesized that individuals with higher interoceptive abilities would implement more adaptive strategies, such as reappraisal, rather than maladaptive ones like suppression.

Interoception and ER

The link between interoception and ER represents a crucial issue on both theoretical and practical levels. Trainings on interoception, such as auto-focusing and mindfulness are now being implemented as ways to better deal with emotions and achieve better health outcomes (Remmers, Topolinski, & Koole, 2016). Furthermore, it has been suggested that the ability to deal with negative emotions may be central to preventing eating disorders, such as binge eating, and emotional eating behaviour, the tendency to eat high-calorie food in response to negative emotions (Evers, Marijn Stok, & de Ridder, 2010).

Empirical studies using the heartbeat counting task suggest that higher IAcc is linked to increased memory for positive and negative emotional words (Werner et al., 2010) and better ER (Kever et al., 2015; Pollatos et al., 2015). Specifically, a study by Kever et al. (2015) showed that IAcc positively correlated with cognitive reappraisal and expressive

suppression (r = .17, p = .001), as assessed via the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). Kever and colleagues' interpretation of the findings (2015) underline that high IAcc individuals are able to recognize which strategy is more useful according to the specific context they experience. A second study by Pollatos et al. (2015) showed that, after being socially excluded, people with higher IAcc, compared to the ones with lower IAcc, reported experiencing less negative mood. These results have been interpreted in light of high IAcc individuals being more able to regulate their negative emotions to feel less hurt about being excluded. A more recent study on a larger sample (Zamariola, Luminet, et al., 2018), however, failed to replicate Pollatos and colleagues' findings (2015). This failed replication might be due to issues related to the measure of IAcc. Indeed, as mentioned above, studies on interoception and ER have only used the heartbeat counting task, whose validity has been recently questioned. More specifically, some authors (Desmedt et al., 2018; Murphy et al., 2018; Ring et al., 2015) have argued that people rely upon beliefs about number of beats per minute or simply estimate the heartbeats without actually feeling them. Additionally, Zamariola, Maurage, et al. (2018) questioned the construct validity of the IAcc scores. In particular, these authors found that IAcc scores mainly represent under-reporting of heartbeats and that correlation between actual and reported heartbeats are higher for individuals with moderate than high IAcc scores.

The present study

The present study investigated how participants who report having low, average and high interoceptive abilities 1) report performing the heartbeat counting task; and 2) report perceiving their emotions, bodily sensations, and regulating their emotional states in everyday life situations. We adopted a mixed-methods approach in order to gain qualitative insights into the assumed relationship between interoception and emotion regulation. The advantage of

using mixed methods lies in the explanations that qualitative data are able to bring to the quantitative measures.

In the present study, the quantitative phase recruited individuals scoring high, average, and low in interoceptive sensibility. The qualitative phase investigated if and how these individuals perceived their bodily awareness and if and how this influences their emotional awareness. Importantly, the quantitative phase included a measure of interoceptive accuracy, namely the heartbeat counting task, in order to investigate in the qualitative phase the strategies people report using when performing this task. The mixed-methods approach also allowed us investigating perceived abilities to regulate emotions. As previously stated, past research has focused mainly on questionnaires or mood induction techniques. These are limited by the restricted range of responses that are permitted, and lab restrictions on the ability to induce emotions that are able to effectively affect participants.

Method

(See Supplementary material for details)

Design

An explanatory sequential design was employed.

Participants

All participants (N = 100) were students at one Belgian French-speaking University. A subset of nine participants (3 with high, 3 with average, and 3 with low interoceptive awareness) were selected for the qualitative phase. The details of the final sample are in displayed in Table 1.

Materials and measures

Measures of Interoceptive Sensibility (IS)

1) Body Awareness Questionnaire (Shields, Mallory, & Simon, 1989).

2) Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling et al., 2012).

Measure of Interoceptive Accuracy (IAcc)

Heartbeat counting task.

Semi-structured interviews using guide open questions and probes and a funnelling technique to elicit accounts of individual perceptions of internal bodily states, and emotion recognition and regulation, with the aim of exploring the assumed relationship between the two.

Diary-keeping in which participants included in the qualitative phase were asked to keep a diary for one week and record daily at least one positive and one negative emotional experience.

[Table 1 around here]

Results

Questionnaires (See Supplementary material for more details)

Using the total score for the two scales, the 25^{th}, the 50^{th}, and the 75^{th} percentiles were calculated in order to divide the sample in three groups (low, average, high). Hence, three groups were created for the BAQ and three groups for the MAIA. After this step, the assigned groups for the BAQ and the MAIA were compared and only participants showing coherence between the two questionnaires were retained, i.e., participants assigned to the same group for both BAQ and MAIA. In order to have a homogenous sample and since studies showed an effect of gender on interoception (Cameron, 2001), males were excluded, resulting in 10 women in the low group, 22 in the average, and 9 in the high. Lastly, on the basis of the BMI, under- (BMI < 18) and over-weight people (BMI > 30) were excluded in order to focus on a sample of healthy participants, resulting in 9 people in the low group, 13 in the average, and 9

in the high, for a total of 31 people. Table 2 displays the mean scores of BAQ and MAIA for each subgroup.

Emails were sent to these 31 people to invite them to the lab to perform the heartbeat-counting task to assess IAcc. Only 12 out of 31 answered and 11 came to the lab (one did not show up). On the basis of the coherence between their scores at the questionnaires and the performance at the heartbeat-counting task, 2 were excluded and 9 were selected for the interviews.

[Table 2 around here]

Semi-structured Interviews Data Analysis

The interview data were analysed using Interpretative Phenomenological Analysis (IPA), (Smith, 1996) with the aim of understanding more of participants' lived experience of interoception and emotion regulation. IPA allows insight to linguistic, affective, and cognitive meanings and processes through analysis of participants' talk (Shinebourne, 2011). It is an idiographic approach that seeks commonalities across data sets. IPA employs a double hermeneutic so that participants' accounts are regarded as an interpretation of their experience which is then interpreted by the researcher. The researcher's interpretation is informed by their pre-existing knowledge and experiences. In order to bracket off as far as possible the imposition of these onto the meanings intended by the participants in this study, the first author and an additional researcher (A.V.O) independently read and coded the interviews, subsequently discussing and reaching a consensus on their analysis and the identification of superordinate themes. Three themes were constructed (Interoception Ability, Emotional Regulation Ability and Influences on Interoception Abilities and Emotional Regulation Abilities (see Table 3). The Themes are presented in detail below and the Discussion considers how these inform our understanding of the assumed relationship between them.

[Table 3 around here]

Interoceptive Abilities

The first theme represents the participants' experience in perceiving bodily sensations during specific interoceptive tasks such as the heartbeat-counting task, or in daily life. In general, the heartbeat-counting task was considered challenging to perform due to the difficulty in perceiving one's own heartbeat.

I was not aware, I think I have underestimated my heartbeats. I did it randomly. (Participant 1, low)

I know that there were times when I was fine because I really felt my beats and then there were times when it was a little more random. (Participant 4, average)

Interestingly, two participants suggested that the task is easier if physical effort is involved.

I should have run to feel more [the heartbeats]. (Participant 3, low)

Two participants with high interoception were more confident about their answers, stating that they thought that they provided the exact number of heartbeats for each time interval.

I felt like I had more or less the right number except once, but I don't know if it was correct or not. (Participant 7, high)

Make an introspection of oneself, it's really...it's not easy. Trying to take away all the, uh, thoughts and, uh... ***And did you manage? (Question asked by the experimenter)*** *I think so, yes. Yes yes yes yes yes I think I did. (Participant 9, high)*

These participants express less confidence in performing the task but more in subjective awareness of their bodily sensations. The dissociation between the objective and subjective aspects of interoception may suggest a Gettier-type problem in which the justified true belief of ability to perceive bodily sensations accurately is challenged by the difficulty of the task.

In contrast, other participants (with low interoception) reported not focussing on their bodily sensations at all and not using them to better recognise their emotions.

Uh, I think I don't pay attention to them [bodily sensations]. I think I'm not good at that, often I don't dwell on what I feel physically, but rather on what's going on in my head. (Participant 2, low)

Interestingly, the three with average and one with high interoception explicitly mentioned the presence of a link between perceiving bodily sensations, recognising emotions and being able to regulate them.

Well, yes, because when I really know how I feel, I can manage better afterwards. (Participant 4, average)

I have the impression that if we know ourselves well physically, we could also be better in knowing ourselves intellectually and mentally. (Participant 5, average)

I really think that people who are good in their body, who do more sports, sleep better, do yoga... Well, people who are more attentive to their bodily sensations and take care of them etc. and who know their body well, I think that they can better manage their emotions and also breathing and also self-control. (Participant 8, high)

This theme illustrates that many participants perceive connections between bodily sensation awareness and emotion regulation. Some explicitly link the process to cognitive awareness. Those that did not have confidence in recognising their bodily signals said they were not convinced that knowing body feelings well would help with identification of emotions. The findings suggest that varying degrees of reassurance from the ability to read personal bodily signals are gained. It seems that those who are confident in recognising their own signals ascribe greater ability to recognise not only their emotions but also in knowing other aspects of themselves as well. The greater emphasis put on the link between bodily signals and other aspects of knowing the self is one that suggests a greater confidence in being

able to make informed decisions about actions and behaviours. Those with less body awareness seem to be more dismissive of a link between the body and emotions, perhaps protecting themselves from further discomfort from experiencing negative emotions.

Emotional Regulation Abilities

The second theme focuses on the ability to identify, label and regulate emotions. Importantly, the analysis of the interviews revealed the presence of alexithymic traits: the three participants in the low group and one with average interoception reported having issues with labelling and describing their feelings, suggesting a possible relationship between low interoception and alexithymia. Alexithymia (Sifneos, 1973; Taylor, Bagby, & Parker, 1999) is a deficit characterised by difficulty in identifying feelings and externally oriented thinking, in addition to difficulty in verbalizing feelings. Participants reported struggling with defining how they feel, and also being challenged in expressing and identifying their feelings, verbally or in writing.

I feel my emotions, but it is not easy to express them or to say if it's the right emotion I feel. (Participant 1, low)

I'm going to say, having to codify the situation I was reporting [in the diary] was hard, especially to put it in words wasn't always easy. (Participant 2, low)

Understanding emotions is crucial for emotion regulation and in particular in implementing strategies to deal with negative emotions. The three participants in the low group and one with average interoception described feeling confused when facing negative emotions, especially in the context of discussions with significant others.

Uh, when I'm like that [in a negative mood], I don't really know what to do, it happens to me now and then. (Participant 1, low)

Events provoking negative emotions could also lead to frustration.

If I'm having a fight with my boyfriend, I can't deal with my emotions at all. I'm crying, I'm screaming, it's the end of the world. (Participant 2, low)

Two participants with low, one with average, and one with high interoception mentioned using less adaptive emotion regulation strategies, such as procrastination, suppression, rumination, or denial.

I say to myself, go and put this thing in a small box and put the little box in the back of your head and think about it in 6 months and in 6 months, it won't hurt me, well...I'll have the impression to be less affected by it. (Participant 3, low)

Because I kept turning the discussion upside down in my head. (Participant 6, average)

It's when I'm facing the wall that I do it. Otherwise, I deny the situation as quickly as I can. (Participant 9, high)

It is worth noting that the participant with high interoception knew that these were not efficient strategies, while none of the participants with low or average interoception mentioned any awareness related to the efficiency of the strategies they used.

Two participants with low interoception told of events that suggested they do not actively implement an emotion regulation strategy, but instead that external circumstances solved the issues.

Since my dad called me back to apologize [after a discussion], well, that's all settled. (Participant 2, low)

These responses suggest that those participants might have a more passive attitude towards negative emotions, which in turn may explain why they use maladaptive emotion regulation strategies, such as expressive suppression, which are likely to be effective only in the short-term to deal with traumatic experiences.

One participant with average and one with high interoception declared using food as comfort in stressful situations. They both knew that they tend to eat in response to negative feelings and not because of real hunger.

*[Talking about when she is nervous] Eat everything that falls to my hand *laughs nervously*. (…)*

I think it's more when I'm in a negative mood than in a positive one. (Participant 6, average)

When I eat in cases like this, it's to run away from something, I'm clearly not hungry, it's just to fill a gap in fact. (Participant 9, high)

In contrast to the difficulties in emotion regulation, two participants with average and the three participants with high interoception showed awareness of possible strategies they can implement when facing negative emotions.

So I took a bath, watched a movie. I adapted to the situation. (Participant 9, high)

Interestingly, they are aware of the fact that some strategies are more effective than others or some work only in the short-term.

If I try to implement a strategy, it doesn't automatically mean that it works, and I still feel this feeling after, but I understood it, I know it's there. (Participant 5, average)

Turning to external activities or other people appears to offer relief or a solution to the feelings of discomfort brought about by experiencing negative emotions. Despite sometimes knowing that the relief may be short-term or the strategy not a guaranteed solution, it seems important to have access to external resources in order to better deal with negative emotions.

For some participants, this approach is extended by searching for improved understanding of themselves as a pathway to expressing awareness of their needs and improving emotion regulation. Two participants with average and all participants with high

interoception are very self-aware and are involved in activities aimed at increasing their self-focus, such as psychotherapy, yoga, or sport.

Well, I see a psychologist every week and so I really learn to refocus on myself and listen to myself. (…) I like yoga because you learn to really focus on yourself. (Participant 4, average)

Sport really takes a special place in my week and in the organization of my mood and my life. (Participant 8, high)

Some participants described using inner speech, to give themselves motivation, and strength, or simply to reflect on their own or someone else's behaviour. Two participants with average and all participants with high interoception talked to themselves.

I'm saying to myself "No [her name], you're not going to hurt the others, you wait until it's over and it's going to get better". (Participant 7, high)

This theme shows a range of actions and activities that these participants employ to confront or minimise their awareness of negative emotions, some external, such as physical activities and talking to people, others internal such as talking to oneself. These strategies may be creating opportunities for reflection that enable the participants to identify and accept negative emotions, which for some may further enable development of ways to manage them.

Influences on interoceptive and emotional abilities

The third theme describes the features that participants recounted as influencing their interoceptive and emotional abilities, including having a positive attitude, keeping a diary, and having support from significant others. One participant with average and the three participants with high interoception showed an active and positive attitude when facing difficult situations. For example, a participant with average interoception still travels by car even after a very traumatic car accident. Among the participants with high interoception, one is living a difficult situation with an aggressive boyfriend, but she has the strength to call the call centre

for domestic violence to ask for advice and is trying to figure out how to move away from the apartment she is sharing with the partner. Another participant with high interoception also showed a positive attitude and flexibility, being able to face challenges, and looking for different solutions to overcome the difficulties that she encounters.

The [car] accident that happened, well, it's still been two years in the end, it left traces, so I got into the car and then we started and then I saw that there was no head rest, but still I thought about it for 20 minutes, I went back to the fact that there was no head rest, as if it were going on in a loop, but I've managed to reassure myself in the end by relativizing and positioning myself differently. (Participant 5, average)

The task of keeping a diary helped the participants to understand and regulate their emotions, representing a tool that might be used in clinical practice. Interestingly, one person with low, two with average, and the three with high interoception reported how the diary helped them to realise which different strategies they could have implemented to deal with negative emotions and experiences.

Yes, because every time I've had an emotion in my day, it's like I was going through all the moments [of that event] again. (Participant 9, high)

Another aid in emotion regulation is the support that people can seek from significant others, such as family, friends, and partners. One person with low and one with average interoception importantly stated that talking with significant others about difficult issues helped them to reconsider the situation and see it from another perspective. This strategy is useful in helping them to better deal with negative feelings and overcome the challenging moment.

It did me good to explain to her [the mother] because she moderates things well, she listens to me, she understands my feelings. (Participant 2, low)

Related to this, some participants reported the important role that family background and education play in the ability to identify and regulating emotions. One participant with low interoception reported encountering trouble in talking about herself and her feelings because in her family people are not used to such expressive behaviours. In contrast, two participants with high interoception stated the importance of being surrounded by significant others who are experts in psychology or pedagogy or having received an education in non-violent communication. This feature may highlight a "nature or nurture" issue, indicating that high interoceptive and emotional abilities might be the result of both individual and social differences throughout personality development.

We're like that in my family and, uh, I think it still had a big impact, so that's it. (Participant 3, low)

Many of the features identified by these participants as helpful to them suggest their need for understanding what has led to the negative emotion, and reassurance that it can be expressed. Armed with this knowledge, participants are better able to overcome the discomfort it causes and regulate the negative emotion.

Discussion

This study aimed to investigate the relationship between interoception and emotion regulation using a mixed-methods approach to gather personal accounts of experiences of interoception and emotions from people with different levels of interoception.

The Interoception Abilities theme describes how all participants found the heartbeat counting task difficult to perform and provided responses either randomly or on the basis of external cues. Further, that all had difficulties in perceiving their heartbeats, and had low awareness of cardiac signals, those categorised with low interoception having greater difficulty. This is consistent with studies suggesting that performance on this task relies on

non-interoceptive processes, including reliance on general beliefs about heartbeat rates (Desmedt et al., 2018; Ring et al., 2015; Zamariola, Maurage, et al., 2018).

Descriptions and explanations of emotional experiences that constructed the Emotions Abilities themes show the complexity of recognising and verbalising emotions. Some participants were challenged by identifying negative emotions, whilst others recognised them but struggled to know how to regulate them. As experimental research on the negative relationship between interoception and alexithymia has led to mixed results, either showing a negative correlation between IAcc and alexithymia, or only detecting a weak link to IS (e.g., Herbert, Herbert, & Pollatos, 2011; Murphy et al., 2018; Zamariola, Vlemincx, Corneille, & Luminet, 2018), the findings of this study suggests further research is needed to further explore a negative association between these constructs at the subjective level, as well as at the objective level.

The present study found that a range of strategies were used by participants to calm down or be motivated to initiate a helpful activity. These included talking to oneself, using food as comfort, and engaging in physical activity. Not always successful in dismissing the discomfort of negative emotional experience, these strategies provide varying degrees of relief. This may be because they create opportunities for reflection on the experiences. We can also speculate that being physically active can compensate for the maladaptive strategy of occasional unhealthy eating (Rabia, Knäuper, & Miquelon, 2006).

Participants who thought of themselves as better able to regulate their emotions reported being more self-focused, and motivated to better understand their inner life through psychotherapy, mindfulness, and yoga. Recent meta-analyses suggest beneficial effects on mental health of psychotherapy and practicing yoga (see Hofmann, Wu, & Boettcher, 2014; Klatte, Pabst, Beelmann, & Rosendahl, 2016) and further research could investigate uptake and benefit for individuals who are more introspective and seeking a higher balance between

body and mind. In this study those who described seeking this balance were categorised as high interoception.

Having a positive and active attitude when facing negative experiences emerged as an important feature that can lead to better emotion regulation. The ability to do this varied but subjective ability to influence both interoceptive and emotional abilities with the use of the diary was additionally reported by many. Strategies that helped to clarify emotions felt seemed to enable better identification of strategies that could be beneficial to reducing negative feelings. It may be that that these participants are able to better employ metacognitive processes precisely because they have greater awareness of the emotions they feel.

This study, conducted with young adult female participants, has shown insight to how interoception and emotion regulation are understood and managed by individuals, and the different relationships between them. The in-depth analysis of interview to better understand the lived experience enriches interoception research and allows some insight to the relationship between this and emotion regulation. It challenges the reliability of the heartbeat counting task and highlights the need for future studies to develop new techniques to assess interoceptive accuracy. Such techniques may for example assess interoception using other bodily functions such as gastric processes and respiration, or by using heartbeat evoked potentials (HEPs), (e.g. Pollatos, Kirsch, & Schandry, 2005) or the heartbeat discrimination task (see Ring & Brener, 2018). The present research suggests a need for further investigation into the negative relationship between alexithymia and interoceptive abilities. Most importantly, the study indicates that interoception and emotion regulation are subjectively related. Future qualitative research should further investigate this relation, as well as the importance of accessing a range of strategies that enable flexibility of emotion regulation response according to differences in awareness of bodily signals.

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Table 1: Characteristics of the sample selected for the qualitative part of the study.

Participant	Age	Interoceptive group	BAQ score	MAIA score	IAcc score
1	19	Low	61	2.44	.67
2	22	Low	67	2.19	.49
3	21	Low	46	1.41	.34
4	21	Average	69	2.94	.51
5	23	Average	77	2.88	.50
6	18	Average	70	2.55	.48
7	20	High	105	4.06	.91
8	25	High	90	3.41	.57
9	18	High	93	4.00	.48

Note:
BAQ: Body Awareness Questionnaire
MAIA: Multidimensional Assessment of Interoceptive Awareness
IAcc: Interoceptive Accuracy

Table 2: Characteristics of the subsample (n = 31) selected for the heartbeat counting task to measure interoceptive accuracy.

Group (*n*)	**Mean (*SD*) BAQ**	**Mean (*SD*) MAIA**
Low (9)	56.66 (*8.12*)	2.16 (*0.35*)
Average (13)	77.00 (*6.93*)	2.91 (*0.17*)
High (9)	97.22 (*7.36*)	3.76 (*0.30*)

Note:
BAQ: Body Awareness Questionnaire
MAIA: Multidimensional Assessment of Interoceptive Awareness

Table 3: Themes identified using Interpretative Phenomenological Analysis.

Master theme	Subthemes	Illustrative quote
1. Interoceptive abilities	1) Performing the heartbeat counting task	*So I was counting, but I wasn't even sure that it was really the beat of my heart. (Participant 3, low interoception)*
	2) Perceiving bodily sensations	*Uh, no, actually, if I pay attention, it's because it's very present, otherwise I forget, I don't even think about it. (Participant 3, low interoception)*
2. Emotional abilities	1) Alexithymia	*I don't make too much difference between a lot of emotions, when I feel joy, I'm joyful but I can't say too much. (Participant 6, average interoception)*
	2) Emotion regulation	*The negative emotions I have a bit more trouble dealing with them. (Participant 4, average)*
3. Influences on interoceptive and emotional abilities	1) Attitude	*When there's something that's not going well, okay, we find another solution, we go, we do something else and not feel sorry for ourselves. (Participant 9, high interoception)*
	2) Keeping a diary	*I found the diary very interesting from a personal point of view. (Participant 5, average interoception)*
	3) Significant others	*Uh, and so I got her advice [a friend] and she was agreeing with me and it was a relief, yes, it's a relief to hear her say, well, it's not your fault either. (Participant 5, average interoception)*