Dissociation between the cognitive and interoceptive components of mindfulness in the treatment of chronic worry

Luis Carlos Delgado-Pastor [a,*], Luis F. Ciria [b], Beatriz Blanca [b], José L. Mata [b], María N. Vera [b], Jaime Vila [b]

[a] University of Zaragoza, C/ Pedro Cerbuna, 12, 50009 Zaragoza, Spain
[b] University of Granada, Avda del Hospicio s/n, 18071 Granada, Spain

ABSTRACT

Objetives: Despite the increasing interest in mindfulness, the basic components and action mechanisms of mindfulness remain controversial. The present study aims at testing the specific contribution of two components of mindfulness -attention to cognitive experience (*metacognition*) and awareness of inter-oceptive sensations (*metainteroception*)- in the treatment of chronic worry.
Method: Forty five female university students with high scores in the Penn State Worry Questionnaire were split into three groups: a mindfulness cognitive training group, a mindfulness interoceptive training group, and a non-intervention control group. Participants were assessed before and after the interven-tion using physiological indices of autonomic regulation (skin conductance, heart rate, heart rate vari-ability, and respiratory sinus arrhythmia) and self-report indices of mindfulness and clinical symptoms (chronic worry, depression, positive and negative affect, and perceived stress).
Results: Both mindfulness training groups showed significant improvement after the intervention in self-report indices of mindfulness and clinical symptoms. However, the interoceptive training group was superior in also showing significant improvement in the physiological indices of autonomic regulation. *Limitations:* The relatively small sample size may have increased the probabilities of type I and II errors. Our Intervention program was relatively short. The participants were all female.
Conclusions: These results support the hypothesis that, in the context of treating chronic worry, the interoceptive and cognitive components can be somewhat dissociated and that, when both components are applied separately, compared to a non-intervention condition, the interoceptive component is more effective.

1. Introduction

In recent years, reports of the beneficial effects of mindfulness applications in a variety of contexts, including the treatment of psychological and stress-related disorders, have proliferated (Allen et al., 2006; Baer, 2003; Grossman, Niemann, Schmidt, & Walach, 2004). There are also several outcome studies that have combined mindfulness skills and cognitive behaviour therapy (CBT) and reported positive results in the treatment of anxiety disorders (Roemer, Williston, Eustis, & Orsillo, 2013), depression (Kuyken et al., 2008), addiction (Zgierska et al., 2009), and personality disorders (Linehan, 1993), among others. However, for some critics, the integration of mindfulness into CBT lacks the support of sufficient scientific evidence (Carmody, 2009). Few studies have specifically sought to identify which action mechanisms underlying the practice of mindfulness are truly effective in producing the reported outcomes. Moreover, despite the increasing interest in mindfulness, there is still little consensus among researchers about the basic components and action mechanisms of mindfulness.

Bishop et al. (2004) distinguished two fundamental components of mindfulness: the regulation of attention to focus it on the present experience; and an attitude of curiosity, openness, and acceptance of that experience. Baer (2003) proposed five components of mindfulness: exposure, cognitive change, self-management, relaxation, and acceptance. Shapiro, Carlson, Astin, and Freedman (2006) suggested that mindfulness has three key components:

* Corresponding author. Facultad de Ciencias Humanas y de la Educación, University of Zaragoza, 22003 Huesca, Spain. Tel.: +34 974239341; fax: +34 974237384.
E-mail address: siulcar@hotmail.com (L.C. Delgado-Pastor).

attention, intention, and attitude. Brown, Ryan, and Creswell (2007) also proposed five components of mindfulness: insight, exposure, non-attachment, enhanced mind-body functioning, and integrated functioning. More recently, Hölzel et al. (2011) considered the following four components: attention regulation, body awareness, emotion regulation (including re-appraisal and exposure, extinction, and reconsolidation), and change in perspective of the self. Additionally, some researchers have proposed that a variety of action mechanisms underlie the practice of mindfulness, such as reperceiving (Shapiro et al., 2006), decentering (Segal, Williams, & Teasdale, 2002), and self-compassion (Kuyken et al., 2010). Undoubtedly, this conceptual diversity, sometimes confounding components and effects of mindfulness, makes the investigation of mindfulness complex and hinders the consistency of the construct.

In one of the few studies aimed at disentangling the cognitive and affective components of mindfulness, Sears and kraus (2009) developed two interventions that focused on either attention (i.e., awareness of the breath, sounds and bodily sensations and a stance of accepting whatever arises) or emotion (i.e., loving kindness that includes extending friendliness, compassion, joy, and peacefulness to the self and others). These authors compared these two interventions to a non-intervention control condition and a combination condition (attention + loving kindness). They reported greater benefits of the combination condition in the self-report measures of anxiety, negative affect, hope and irrational beliefs. However, the study failed to show the expected dissociation between the cognitive and affective components of mindfulness. No significant differences were found between the three intervention conditions. Moreover, the durations of the interventions were a confounding variable because the duration of the combination condition was longer than that of the other two interventions.

The present study sought to further investigate the specific contributions of the cognitive and emotional aspects of mindfulness by focussing on two different components: (a) attention to cognitive experience (*metacognition*) and (b) awareness of interoceptive sensations (*metainteroception*). Hözel et al. (2011) referred to these components as *cognitive control of attention* and *body awareness* and provided empirical evidence that suggests that these components are linked to different neural substrates. The *cognitive control of attention* is thought to be linked to the anterior cingulate cortex (Van Veen & Carter, 2002) and the fronto-insular cortex (Sridharan, Levitin, & Menon, 2008), whereas *body awareness* is thought to be closely related to the insula (Craig, 2003; Hözel et al., 2008) and the secondary somatosensory cortex (Gard et al., 2012). If the above interpretation is correct, then the cognitive and interoceptive components of mindfulness, i.e., attention and awareness of cognitive versus interoceptive phenomena, should be dissociable through appropriate manipulation of the training procedures. The present study aimed to test this dissociation, defined as the separation of the cognitive and the interoceptive components of mindfulness, by examining their differential effects in the treatment of chronic worry (hypothesis 1).

Chronic worry was selected for two reasons. First, there is evidence that the combination of the cognitive and interoceptive components of mindfulness in the treatment of chronic worry results in significant clinical improvements (Delgado et al., 2010). Second, there are alternative conceptual models of the psychopathology and treatment of chronic worry that separately emphasise the relevance of each of these components. For example, Borkovec's model (Borkovec, Alcaine, & Behar, 2004) considers chronic worry to be a cognitive avoidance response to perceived threats that has been learned because worry momentarily suppresses the aversive somatic experience of anxiety. From this perspective, mindfulness training based on the interoceptive component might facilitate extinction of the avoidance mechanism by calmly acknowledging and accepting the somatic experience of anxiety. Alternative models, such as the uncertainty intolerance model (Dugas, Gagnon, Ladouceur, & Freeston, 1998) and the metacognitive vulnerability model (Wells, 2005), explain chronic worry as a consequence of a cognitive deficit associated with negative thoughts and beliefs. Wells' model emphasizes the presence of meta-worries, a characteristic that has been demonstrated that applies to both clinical and non-clinical worriers (De Bruin, Rassin & Muris, 2007). From this perspective, mindfulness training based on the cognitive component might be beneficial via the attenuation of cognitive vulnerability or the breaking of the vicious circle of meta-concerns. The present study also aimed to test the hypothesis that the interoceptive training is more effective than the cognitive training in reducing chronic worry, thus supporting indirectly the prediction from Borkovec's model rather than the prediction from alternative cognitive models (hypothesis 2).

2. Method

2.1. Participants

The participants were 45 female university students with a mean age of 21.5 years (SD = 3.94) and high scores on the *Penn State Worry Questionnaire* (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990). The participants were selected from an initial pool of 531 students who completed the questionnaire. Inclusion criteria were: (a) to score above the 80th percentile in this pool (M = 67.46, SD = 4.3, range = 62−78) and (b) to be female university student, caucasian, and between 18 and 30 years old. Exclusion criteria were: (a) to suffer generalised anxiety disorder (GAD), (b) to be undergoing any psychological or pharmacological treatment, and (c) to have any cardiovascular problem. All participants were screened using the *Anxiety Disorders Interview Schedule* (ADIS-IV; Brown, Di Nardo, & Barlow, 1994) to guarantee that no participants suffered from generalised anxiety disorder (GAD) in order to increase the homogeneity of our student sample. Only 2 participants did not pass the screening procedure for this reason.

2.2. Design

The participants were randomly assigned to one of the following three groups: a mindfulness cognitive training group, a mindfulness interoceptive training group, and a non-intervention control group. The training comprised two 1-h sessions per week over three weeks. All participants underwent psychological and psychophysiological assessment procedures prior to and after the intervention. Four participants (three in the mindfulness cognitive training group and one in the control group) discontinued participation. The final numbers of participants were 15 in the mindfulness interoceptive training group, 12 in the mindfulness cognitive training group and 14 in the control group. Sample size was estimated appropriate based on treatment studies of chronic worry that employed similar psychophysiological measures (Delgado et al., 2010; Stapinski, Abbott, & Rapee, 2010). The assessment and the training procedure were carried out for the three groups during the same academic time period. It should be noted, however, that the post-intervention assessment was closer to the final exams, a condition that might have increased the stress level in all groups.

2.3. Assessment procedure

2.3.1. Self-report measures

The participants completed the following questionnaires prior to and after the intervention program: (a) *Penn State Worry*

Questionnaire (PSWQ; Meyer et al., 1990; Spanish version by Sandin, Chorot, Valiente, & Lostao, 2009; the internal consistency of this questionnaire is 0.95, and the temporal stabilities are between 0.74 and 0.92 for the Spanish and English versions); (b) the *Beck Depression Inventory* (BDI; Beck Rush, Shaw, & Emery, 1979; Spanish version by Sanz & Vázquez, 1998; the internal consistencies of the Spanish version of this inventory are 0.83 for clinical samples and 0.90 for non-clinical samples, and the test-retest reliabilities are between 0.60 and 0.72); (c) the *Positive and Negative Affect Schedule* (PANAS; Watson, Clark, & Tellegen, 1988; Spanish version by Sandín et al., 1999; the internal consistencies of the Spanish version of the positive and negative PANAS scales are 0.87 and 0.91, respectively); (d) the *Perceived Stress Scale* (PSS; Cohen, Kamark, & yMermelstein, 1983; Spanish version by Remor (2006); the internal consistency of the Spanish version is 0.81, and the test-retest reliability is 0.73); (e) the *Mindfulness Attention Awareness Scale* (MAAS; Brown & Ryan, 2003; Spanish version by Soler et al., 2012; the internal consistency of the Spanish version is 0.90, and the reliability is 0.86); and (f) the *Frieburg Mindfulness Inventory* (FMI-14; Buchheld, Grossman, & Walach, 2001; Walach, Buchheld, Buttenmüller, Kleinknecht, & Schmidt, 2006; the internal consistency of the original inventory is 0.93). The latter two questionnaires assess two different aspects of mindfulness. The MAAS is a 15-item scale that explicitly measures aspects of open and receptive attention without any reference to emotional aspects, such as compassion, kindness, or empathy; whereas the FMI-14 is a 14-item scale that measures the overall construct of mindfulness and includes items that are explicitly related to self-attributions of non-judgmental attitudes, openness to experience, empathy, and kindness.

2.3.2. Physiological measures

The psychophysiological assessment procedures performed prior to and after the intervention program included recordings of skin conductance, electrocardiogram (to measure heart rate and heart rate variability) and respiration (to measure respiratory sinus arrhythmia). The assessment procedure was divided into three periods, based on a similar procedure used by Delgado et al. (2010): (a) a baseline resting period that included 5 min of rest with no specific relaxation instructions; (b) a worry period that included 5 min of self-induced worry instructions; and (c) a mindfulness period that included 5 min of mindfulness instructions (either interoceptive, cognitive, or control). The first period served to stabilize the participant's physiological measures after the placement of electrodes and sensors prior to initiate the recording. The second period served to activate worry and the associated physiological measures. The third period served to assess the effect of the training condition on the physiological measures. Prior to the Worry and Mindfulness periods, the participants read specific instructions regarding the performance of the task on a computer monitor. The instructions for the Worry period were identical across groups and were as follows: '*During the next 5 min, you should worry as you normally do about anything that currently affects you; try to worry as intensively as you can'*. The initial sentence of the instructions for the Mindfulness period was identical across groups (i.e., '*During the next 5 min, you should focus your attention on the present moment with acceptance*'). Next, each group received specific instructions as follows: (a) the cognitive group received instructions to '*acknowledge the thoughts that appear in your consciousness without getting involved; let them pass; if you find your mind divagating, go back and focus your attention on the present moment and being aware of your thoughts*'; (b) the interoceptive group received instructions to '*acknowledge the sensations and feelings that appear in your consciousness without getting involved; let them pass; if you find your mind divagating, go back and focus your attention on the present moment and being aware of your sensations and feelings*'; and the control group received instructions to '*acknowledge the thoughts, sensations and feelings that appear in your consciousness without getting involved; let them pass; if you find your mind divagating, go back and focus your attention on the present moment and being aware of your thoughts, sensations and feelings*'.

2.4. Instruments and measures

All physiological measures were recorded with a Biopac instrument (model MEC-110C) that was controlled with AcqKnowledge software (Biopac System Inc., Goleta, CA) at a sample rate of 1000 Hz. *Skin conductance* (SC) was recorded with an EDA100C amplifier using two standard Ag/AgCl electrodes that were filled with isotonic electrolyte paste and placed on the hypothenar eminence of the left hand. The mean SC values were obtained for each of the three 5-min periods (i.e., baseline, worry, and mindfulness). *Heart rate* (HR) *and heart rate variability* (HRV) were derived from the EKG recorded at lead II (i.e., the right arm and left leg) using an ECG100C amplifier and Ag/AgCl disposable electrodes. The mean HR and HRV in the time domain (i.e., the *Root Mean Square of Successive Differences*; RMSSD) were obtained for each of the three 5-min periods using the KARDIA software (Perakakis, Joffily, Taylor, Guerra, & Vila, 2010). HRV refers to the cyclic variations in the heart rate and is obtained by calculating the time interval between successive heartbeats. When HRV is analysed in the time domain using the *Root Mean Square of Successive Differences (RMSSD)*, the obtained index reflects the fast variations in the heart rate, being analogous to the High Frequency band of the spectral analysis of HR variations, which is mediated by parasympathetic (vagal) control. *Respiratory sinus arrhythmia* (RSA) was derived from the EKG and the respiration signal, the later being recorded using a RSP100C amplifier and a TSD201 thoracic transducer. The RSA is a measure of the heart rate cyclic changes associated with respiration: heart rate increases during inhalation and heart rate decreases during exhalation. This cardio-respiratory synchrony is mediated by parasympathetic (vagal) control. The mean RSA amplitude was obtained for each of the three 5-min periods via application of the peak-valley method with the software developed by Reyes del Paso (1992). The E-Prime software (Psychology Software Tools, Inc., Pittsburgh, PA) was used to control and synchronize the presentation to the participants of the written instructions on a Samsung Sync Master monitor (model P2270).

2.5. Mindfulness training procedure

The first session for both mindfulness training groups began with a brief explanation of the basic principles of mindfulness that was followed by 15–20 min of guided meditation. In subsequent sessions, the duration of the meditation period was gradually increased to 40–45 min. The last part of each session was dedicated to the following: (a) encouraging the participants to practice at home daily and to generalise the mindfulness attitude learned during the session to everyday situations; (b) identifying difficulties during the meditation practice and suggesting strategies for coping with these difficulties; and (c) deepening the participants' understanding of the mindfulness principles based on their comments.

The specific guided meditation for the mindfulness interoceptive group was structured as follows. First, the participants' attention was directed to their body positions, and instructions to adopt a comfortable upright posture with a non-rigid spinal cord were provided. Second, the participants were guided to recognise and accept their current overall bodily and emotional-affective states. Third, the participants were guided to focus their attention on the "here and now" with an attitude of openness, curiosity, and interest in what was currently happening in terms of the experience of sensations. The participants were provided instructions that, if they were distracted or their attention wandered from the present state, they should re-focus their attention on the present moment using breathing as an anchor, if that was helpful. Additionally, the participants were given the suggestion to scan their bodily sensations from their feet to their head with openness and equanimity while noting the changeable and transitory nature of these sensations. Fourth, at certain moments, the participants were given the opportunity to briefly label any sensation or feeling that may have arisen during their current experience without elaborating any judgement about that experience. Fifth, the participants were instructed to generate feelings of empathy, love and compassion towards themselves, the people close to them, and all living beings, in that order. Sixth, the participants generated self-instructions to promote the generalisation of the awareness of sensations and to cultivate the choice of mindful actions in everyday contexts.

The specific guided meditation for the mindfulness cognitive group was structured as follows. First, the participants' attention was directed to their body position, and instructions to adopt a comfortable upright posture with a non-rigid spinal cord were provided. Second, the participants were instructed to recognise and accept their current overall mental state. Third, the participants were instructed to focus their attention on the "here and now" with an attitude of openness, curiosity, and interest regarding what was happening in their minds in terms of mental processes. The participants were also instructed that, if distractions or digressions occurred, they should re-focus their attention on the present mental state using breathing as an anchor if that was helpful. Additionally, the participants were invited to become aware of how thoughts arose and vanished in their minds, to adopt an attitude of acceptance and equanimity, and to note the changeable and transitory nature of their thoughts. Fourth, at certain moments, the participants were given the opportunity to briefly label their current mental state without elaborating any judgement about that state. Fifth, the participants were encouraged to generate feelings of empathy, love, and compassion toward themselves, the people close to them, and all living beings, in that order. Sixth, the participants generated self-instructions to promote the generalisation of the awareness of their mental processes and to cultivate the choice of mindful actions in everyday contexts.

2.6. Statistical analyses

The self-report data obtained after the interventions were first transformed into differential scores with respect to the data obtained prior to the interventions (i.e., change scores). Next, the transformed data were analysed via one-way analyses of variance (ANOVAs) with a single between-group factor (i.e., Group, which had three conditions: interoceptive, cognitive, and control). Similarly, the physiological data obtained after the intervention for each of the three 5-min periods (i.e., baseline, worry, and mindfulness) were first transformed into differential scores with respect to the data acquired during the same pre-intervention time periods. Next, the transformed data were analysed via 3 x 3 ANOVAs with a between-group factor (i.e., Group, which had 3 conditions: interoceptive, cognitive, and control) and a repeated-measures factor (i.e., Periods, which had 3 conditions: baseline, worry, and mindfulness). Additionally, in order to check the expected similar effect of worry and mindfulness in the three groups at pre-intervention, a similar 3 x 3 ANOVA was performed on the physiological variables at pre-intervention. The expected effects of the worry period in the three groups were increases in skin conductance and heart rate, and decreases in heart rate variability and respiratory sinus arrhythmia, with respect to baseline. The expected effect of the mindfulness period at pre-intervention was a return to baseline. The Greenhouse-Geisser epsilon correction was applied to the repeated measures factor to control for violations of sphericity and the partial eta squared is also presented (η_p^2). The results are reported with the original degrees of freedom and the corrected p values. Post-hoc comparisons were performed using Student's t test. The level of significance was set at $p < .05$ for all analyses.

3. Results

3.1. Self-report measures

Table 1 shows the means and the standard deviations of the self-report measures of each group prior to and after the intervention programs. One-way ANOVAs of the change scores revealed significant Group effects for chronic worry (PSWQ: $F(2, 36) = 3.178$, $p < .05$, $\eta_p^2 = .150$), depressive symptoms (BDI: $F(2, 37) = 5.21$, $p < .01$, $\eta_p^2 = .220$), negative affect (PANAS: $F(2, 37) = 5.863$, $p < .006$, $\eta_p^2 = .341$) and mindfulness (MAAS: $F(2, 37) = 3.32$, $p < .152$, $\eta_p^2 = .09$; FMI: $F(2, 37) = 4.16$, $p < .024$, $\eta_p^2 = .183$). After the intervention, the participants in the mindfulness interoceptive group exhibited significantly lower scores than did the control group in chronic worry ($p < .02$), depressive symptoms ($p < .003$), and negative affect ($p < .002$). The same participants also exhibited significantly higher scores than did the control group on both mindfulness scales (MAAS: $p < .03$; FMI: $p < .01$). The participants in the mindfulness cognitive group exhibited significantly lower scores than did the control group in depressive symptoms ($p < .04$) and negative affect ($p < .02$). These participants also exhibited significantly higher scores than did the control group in one of the mindfulness scales (FMI: $p < .03$). No significant differences were found between the two intervention groups with the exception of one of the mindfulness scales (MAAS: $p < .04$); the mindfulness interoceptive group exhibited higher scores on this scale.

3.2. Physiological measures

Table 2 shows the means and the standard deviations of the physiological measures of each group prior to and after the intervention program for each recording period: baseline, worry, and mindfulness. The Group x Period ANOVAs on the physiological data prior to intervention showed significant Period effects in SC ($F(2, 76) = 20.92$, $p < .0001$, $\eta_p^2 = .355$), HR ($F(2, 72) = 7.65$, $p < .005$, $\eta_p^2 = .175$), and RSA ($F(2, 74) = 5.00$, $p < .014$, $\eta_p^2 = .119$). In the three cases, significant differences appeared between worry and baseline periods, with significant increases during worry in SC ($p < .0001$) and HR ($p < .005$), and significant decreases during worry in RSA ($p < .012$). During the mindfulness period, these three physiological variables tended to return towards baseline, but with still significant differences respect to baseline in SC ($p < .001$) and HR ($p < .043$), and significant decreases with respect to worry period in SC ($p < .001$) and HR ($p <. 015$). No significant group differences were found in this response pattern.

3.2.1. Skin conductance change after intervention

The Group x Period ANOVA yielded a marginally significant Group effect ($F(2, 38) = 2.70$, $p < .08$, $\eta_p^2 = .124$). Neither the effect of Period nor the interaction was significant. Although non-significant, the two intervention groups exhibited, after the intervention, reductions in SC values across the three recording periods (i.e., baseline, worry, and mindfulness), whereas the control group exhibited a small increase (see Fig. 1A). Post-hoc comparisons revealed significant differences between the

Table 1
Mean (and standard deviation) of the self-report measures for each group before and after the intervention program.

	Assessment	PSWQ	BDI	PANAS (N)	PANAS (P)	PSS	FMI	MAAS
Control group	PRE	67.2 *(4.0)*	12.4 *(7.8)*	24.7 *(6.6)*	27.4 (6.6)	29.6 *(7.6)*	32.9 *(4.8)*	51.1 *(13.8)*
	POST	64.6 *(8.5)*	11.5 *(7.8)*	25 *(7.2)*	29.9 (7.6)	30.7 *(5.3)*	32.6 *(4.3)*	50.4 *(14.4)*
Mindfulness cognitive group	PRE	67.5 *(5.4)*	13.7 *(8.4)*	29 *(8.0)*	28.3 (7.1)	32.6 *(6.8)*	29.6 *(6.2)*	56.7 *(10.8)*
	POST	59.5 *(9.0)*	8.5 *(7.2)*	24.1 *(7.7)*	32.3 (8.0)	28.1 *(6.2)*	34.1 *(7.6)*	53.6 *(9.4)*
Mindfulness interoceptive group	PRE	67.8 *(3.9)*	15.3 *(6.8)*	29.9 *(8.0)*	27.7 (6.4)	32.2 *(6.3)*	28.7 *(5.4)*	49.2 *(12.2)*
	POST	57.9 *(6.5)*	8.0 *(4.4)*	23.6 *(3.0)*	30.8 (6.5)	26.2 *(5.4)*	34.4 *(4.0)*	55.4 *(8.1)*

PSWQ = Penn State Worry Questionnaire; BDI = Beck Depression Inventory; PANAS = Positive and Negative Affect Schedule; PSS = Perceived Stress Scale; FMI = Frieburg Mindfulness Inventory; MAAS = Mindfulness Attention Awareness Scale.

mindfulness interoceptive group and the control group ($p < .03$). No significant differences were found between the mindfulness cognitive group and the control group, and between the two intervention groups.

3.2.2. Heart rate change after intervention

The Group x Period ANOVA yielded a significant Group effect ($F(2, 36) = 6.12$, $p < .005$, $\eta_p^2 = .254$). Neither the effect of Period nor the interaction was significant. As shown in Fig. 1B, after the intervention, the mindfulness interoceptive group exhibited a significant reduction in HR across the three periods compared to the control group, which displayed an increase in HR across these periods ($p < .001$). The mindfulness cognitive group did not differ from the control group. No significant differences were found between the two intervention groups.

3.2.3. Heart rate variability (RMSSD) change after intervention

The Group x Period ANOVA yielded a significant Group effect ($F(2, 37) = 4.05$, $p < .03$, $\eta_p^2 = .180$). Neither the effect of Period nor the interaction was significant. As shown in Fig. 1C, after the intervention, the mindfulness interoceptive group exhibited a significant increase in RMSSD values across the three periods compared to the control group, which displayed a decrease across these periods ($p < .009$). The mindfulness cognitive group also exhibited a decrease, but the difference between this decrease and the increase of the interoceptive group was only marginally significant ($p < .07$).

3.2.4. Respiratory sinus arrhythmia (RSA) change after intervention

The Group x Period ANOVA yielded a significant Group effect ($F(2, 37) = 3.45$, $p < .042$, $\eta_p^2 = .157$). Neither the effect of Period nor the interaction was significant. As shown in Fig. 1D, after the intervention, the mindfulness interoceptive group exhibited a significant increase in RSA values across the three periods compared to both the control ($p < .03$) and the mindfulness cognitive groups ($p < .03$). No significant differences were found between the control group and the mindfulness cognitive group.

4. Discussion

The major findings of our study can be summarised as follows. First, compared to the control group, after the intervention, the mindfulness interoceptive group exhibited significant reductions in the self-report measures of worry, depressive symptoms, and negative affect and significant increases in the two self-report measures of mindfulness (MAAS and FMI). The mindfulness interoceptive group also exhibited, after the intervention, significant reductions in skin conductance and heart rate and significant increases in heart rate variability and respiratory sinus arrhythmia. Second, compared to the control group, after the intervention, the mindfulness cognitive group exhibited significant reductions in the self-report measures of depressive symptoms and negative affect and significant increases in one of the self-report measure of mindfulness (FMI). No significant differences in any of the physiological measures between this group and the control group were

Table 2
Mean (and standard deviation) of the physiological measures for each group before and after the intervention program.

			Base line	Worry period	Mindfulness period
SC	Control group	PRE	0.71 *(0.6)*	1.04 *(0,8)*	0.90 *(0.7)*
		POST	1.07 *(1.2)*	1.31 *(1.4)*	1.27 *(1.3)*
	Mindfulness cognitive group	PRE	1.18 *(1.0)*	1.99 *(1.5)*	1.91 *(1.8)*
		POST	1.07 *(0.9)*	1.43 *(1.0)*	1.17 *(0.9)*
	Mindfulness interoceptive group	PRE	1.47 *(1.1)*	2.35 *(1.9)*	1.79 *(1.4)*
		POST	0.73 *(0.4)*	1.34 *(2.0)*	1.25 *(2.0)*
HR	Control group	PRE	68.06 *(5.6)*	69.7 *(6.2)*	68.4 *(5.9)*
		POST	74.2 *(7.5)*	75.4 *(8.1)*	74.6 *(7.8)*
	Mindfulness cognitive group	PRE	72.3 *(5.9)*	75.5 *(4.7)*	73.2 *(6.3)*
		POST	74.3 *(5.8)*	74.7 *(5.1)*	73.7 *(5.6)*
	Mindfulness interoceptive group	PRE	78.6 *(8.5)*	82.1 *(1.2)*	79.9 *(8.8)*
		POST	75.5 *(5.0)*	77.3 *(6.5)*	75.4 *(4.0)*
RMSSD	Control group	PRE	46.8 *(22.6)*	44.1 *(20.7)*	46.5 *(23.7)*
		POST	39.0 *(19.2)*	35.5 *(17.6)*	36.7 *(17.5)*
	Mindfulness cognitive group	PRE	46.1 *(14.2)*	46.6 *(16.3)*	44.9 *(16.2)*
		POST	42.2 *(9.8)*	39.5 *(9.2)*	43.0 *(11.6)*
	Mindfulness interoceptive group	PRE	41.7 *(27.6)*	37.4 *(24.4)*	43.0 *(11.6)*
		POST	48.6 *(23.8)*	41.5 *(15.9)*	51.1 *(29.9)*
RSA	Control group	PRE	83.7 *(62.9)*	62.4 *(36.6)*	68.2 *(40.5)*
		POST	68.8 *(38.3)*	57.3 *(27.2)*	65.3 *(33.2)*
	Mindfulness cognitive group	PRE	80.0 *(31.3)*	71.8 *(28.8)*	73.4 *(25.1)*
		POST	67.1 *(12.2)*	59.7 *(16.3)*	70.8 *(17.4)*
	Mindfulness interoceptive group	PRE	73.9 *(59.7)*	63.8 *(48.8)*	70.4 *(58.2)*
		POST	103.7 *(59.0)*	83.6 *(54.2)*	100.2 *(55.8)*

SCR = Skin Conductance; HR = Heart Rate; RMSSD = Root Mean Square Successive Differences; RSA = Respiratory Sinus Arrhythmia.

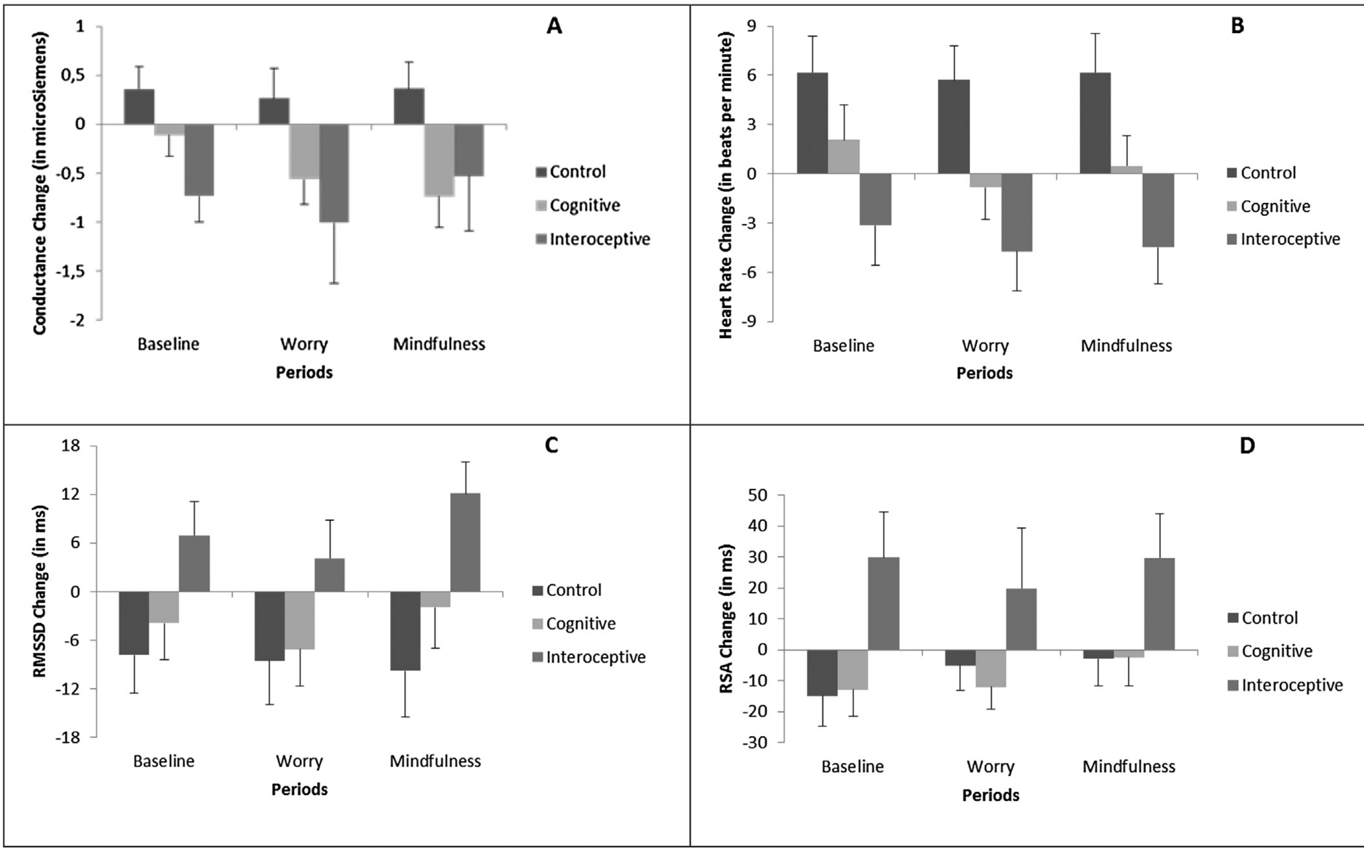

Fig. 1. Skin Conductance (A), Heart Rate (B), Heart Rate Variability (C), and Respiratory Sinus Arrhythmia (D) change after the intervention (post minus pre score) as a function of the three recording periods: Baseline, Worry, and Mindfulness. Skin Conductance and Heart Rate (A and B), two indices of autonomic activation, show larger reductions after the intervention in the interoceptive group, whereas Heart Rate Variability and Respiratory Sinus Arrhythmia (C and D), two indices of emotional and autonomic regulation, show larger increases after the intervention in the same interoceptive group. Bars are standard error of the mean.

found. Third, compared to the mindfulness cognitive group, after the intervention, the mindfulness interoceptive group exhibited significant increases in one of the self-report measures of mindfulness (MAAS) and one of the physiological measures (RSA).

It should be noted that the physiological changes from pre-intervention to post-intervention were similar in the three recording phases (baseline, worry, and mindfulness), as reflected by the lack of significant effect of the Period factor or the Group $\times$ Period interaction. However, before intervention the Period factor was significant in three physiological variables (SC, HR, and RSA), with significant increases in SC and HR and significant decreases in RSA during the worry and, to a lesser extent, the mindfulness period, compared to baseline. Therefore, the absence of significant Period effect in the physiological changes from pre-intervention to post-intervention does not mean that worry and mindfulness had no differential effect with respect to baseline after intervention. It means that the positive, negative, o no changes after the intervention, which depended on the group, affected equally to the three recording periods. The better physiological effect of the interoceptive training across the three periods may be explained as a general effect of this type of training on the person's basal autonomic regulatory capacity, which can be manifested in any circumstance, including the baseline period.

In general, our findings are consistent with the two hypotheses of the present study. Both self-report and physiological measures provided some evidence that (a) the cognitive and interoceptive components of mindfulness can be dissociated with appropriate training (hypothesis 1), and (b) one mindfulness component was superior to the other in the treatment of chronic worry (hypothesis 2). The following three lines of evidence should be considered: self-reported worry, self-reported mindfulness (MAAS), and all of the physiological measures. Regarding self-reported worry, although both interventions were effective in reducing depressive symptoms and negative affect, the interoceptive training was superior in reducing chronic worry, as compared to the control group. This finding fits better with Borkovec's somatic theory of chronic worry (Borkovec et al., 2004) than with alternative cognitive theories (Dugas et al., 1998; Wells, 2005). According to Borkovec's theory, chronic worry is a cognitive avoidance response to perceived threats that is acquired and maintained because it momentarily reduces the somatic experience of anxiety. The participants in the mindfulness interoceptive group may have learned to experience the aversive somatic sensations of anxiety that were linked to their worries with conscious equanimity and thus been able to reduce such worries to a greater extent. In contrast, the participants in the mindfulness cognitive group may have learned to be aware of their worries with conscious equanimity at a cognitive level (*meta-cognitive insight*) and thus reduce those worries to a lesser extent.

One of the two self-report measures of mindfulness also supports the superiority of the interoceptive training. These two scales assess different aspects of mindfulness. The FMI scale measures the overall construct of mindfulness and explicitly includes items related to non-judgment, equanimity, acceptance, kindness, and patience (Bishop et al., 2004). In contrast, the MAAS scale explicitly measures the attentional component of mindfulness by emphasising the receptive and open nature of this component of mindfulness. Our results showed that, although both training groups exhibited significant increases in mindfulness compared to the control group as measured by the FMI scale, the mindfulness interoceptive group exhibited increased mindfulness compared to both the control and cognitive groups as measured by the MAAS scale. This divergence, which is consistent with the lack of correlations between the different indices of mindfulness (Brown, Ryan, Loverich, Biegel, & West, 2011; Grossmann, 2011), can also be understood in the context of Borkovec's theory of chronic worry. As a result of training, the participants in the mindfulness interoceptive group may have overcome the cognitive over-elaboration of their worries and the demand for attentional resources associated with their worries to a greater extent and therefore increased the availability of new attentional resources to more adaptively relate to environmental contingencies (Williams, 2010). In contrast, the participants in the mindfulness cognitive group may have maintained the demands for attentional resources associated with their worries to a greater extend, likely due to the persistence of the cognitive avoidance of aversive somatic sensations.

Regarding the psychophysiological measures, the mindfulness interoceptive group was clearly the only group to show a significant improvement due to mindfulness training. Skin conductance and heart rate, which are two indices of the activation of the autonomic nervous system (Berntson, Quigley, & Lozano, 2007; Dawson, Schell, & Filion, 2007), were significantly reduced in this group after the intervention compared to the control group. Additionally, heart rate variability (RMSSD) and respiratory sinus arrhythmia (RSA), which are two indices of vagal regulation of the autonomic nervous system (Porges, 2011; Thayer, Åhs, Fredrikson, Sollers III, & Wager, 2012), were significantly increased in this group after the intervention compared to both the control (RMSSD and RSA indices) and the mindfulness cognitive (RSA index) groups. This increase in vagal control after interoceptive training is particularly relevant because it has been repeatedly demonstrated that people with high levels of chronic worry and patients with generalised anxiety disorder (GAD) have reduced vagal tones (Delgado et al., 2009; Hofmann et al., 2005; Thayer & Brosschot, 2008; Thayer, Friedman, & Borkovec, 1996). Thus, it is reasonable to assume that mindfulness interoceptive training produced a significant change in this psychophysiological marker of autonomic deregulation that is associated with high levels of chronic worry. Again, this finding can be understood in the context of Borkovec's theory if it is assumed that interoceptive exposure to the aversive somatic sensations of anxiety facilitated the breakdown of the vicious circle that sustains chronic worry (Borkovec et al., 2004); i.e., after the anxiety sensations were no longer perceived as aversive, cognitive avoidance through worrying lost its functionality.

The strength of the evidence in support of the dissociation between the cognitive and interoceptive components of mindfulness is, however, limited by the fact that participants in the cognitive group, although trained to focus on their mental/cognitive state, were also given initial instructions to feel the sense of sitting and the breath and to use the breath as an anchor. Therefore, it is unlikely that participants in the cognitive condition solely attended to cognitive material, as instructed, and participants in the interoceptive condition solely focused on interoceptive sensations, as instructed.

In addition, some methodological limitations should be accounted for when evaluating the theoretical and clinical implications of our study. First, our group sizes were small ($n = 15$), and additional attrition particularly affected the mindfulness cognitive group ($n = 3$) and the control group ($n = 1$). Although similar sample sizes have proved adequate for the reliable demonstration of differential effects in the same physiological measures used in the present study (Bradley, Cuthbert, & Lang, 1996; Delgado et al., 2010; Stapinski et al., 2010), the relatively small sample size may have increase the probabilities of type I and II errors in some of our analyses. Second, our intervention program was relatively short. It is possible that longer interventions may have increased the beneficial effects of both types of intervention and eliminated the observed differences that favoured the interoceptive component, although the differences could also be augmented. Third, our participants were all female with high scores in chronic worry and no diagnosis of generalized anxiety disorder (GAD), which prevents the generalisability of our findings to men and women with clinical GAD. Fourth, we did not follow up our participants because our aim was to examine the short-term dissociation of the cognitive and interoceptive components of mindfulness in the treatment of chronic worry. Future research aimed at determining whether the specific changes observed in our study persist over time is warranted. Fifth, the study was carried out during an academic period that could have increased the stress level at the post-intervention assessment in all groups, given the greater proximity to final exams. This may explain the observed tendency to show some deterioration in the physiological indices of autonomic regulation in the control group after intervention. Although this academic timing effect was also present in the two intervention groups, future research should carefully avoid this type of confound.

Despite these limitations, our study confirmed previous evidence that training programs based on mindfulness can reduce the clinical symptoms of people with high levels of chronic worry and that such reduction is most likely mediated through a process of learning new mechanisms for emotional and physiological regulation that are contrary to those that generate and sustain chronic worry (Delgado et al., 2010). Additionally, the present study showed that, in the context of treating chronic worry, the interoceptive component of mindfulness can be somewhat dissociated from the cognitive component and that, when both components are applied separately, and compared to a control group, the interoceptive component is more effective than the cognitive component in producing subjective and physiological indices of improvement. Therefore, it seems relevant to underline the importance of using explicit instructions towards interoceptive awareness when teaching mindfulness meditation to individuals who report chronic worry. Our study leaves the question of whether combining both components would increase the effectiveness of mindfulness-based treatments of chronic worry unanswered. Moreover, our study does not answer the question of whether mindfulness treatments are more effective than other psychological treatments because our control group did not received any intervention.

Indeed, the superiority of mindfulness as a therapeutic tool compared to other psychological treatments remains a controversial issue mainly due to the paucity of well-controlled clinical studies with appropriate treatment comparisons (Allen et al., 2006; Arch & Craske, 2006; Lau & Yu, 2009; Toneatto & Nguyen, 2007). Nevertheless, our present findings are important because they advance knowledge about the explanatory mechanisms that underlie mindfulness as an effective tool in the treatment of chronic worry. As noted by Hölzel et al. (2011), it is important to understand the specific functions of the different components of mindfulness in the treatment of psychological disorders. The present study showed that, although both mindfulness components were effective in improving some clinical symptoms of people with high levels of chronic worry when applied separately, only the interoceptive component was effective in improving the physiological indices of autonomic regulation. This relevant finding contributes to the advancement of our knowledge about the underlying neurophysiological mechanisms of mindfulness and reinforces the scientific status of mindfulness as a therapeutic tool.

Acknowledgement

We thank the Junta de Andalucía and the Spanish Ministry of Economy and Competitiveness for their support to the present research (HUM-388, PSI2011-28530).

References

Allen, N. B., Chambers, R., Knight, W., Blashki, G., Ciechomski, L., Hassed, C., et al. (2006). Mindfulness-based psychotherapies: a review of conceptual foundations, empirical evidence and practical considerations. *Australian and New Zealand Journal of Psychiatry, 40*, 285–294.

Arch, J. J., & Craske, M. G. (2006). Mechanisms of mindfulness: emotion regulation following a focused breathing induction. *Behaviour Research and Therapy, 44*, 1849–1858.

Baer, R. (2003). Mindfulness training as a clinical intervention: a conceptual and empirical review. *Clinical Psychology: Science and Practice, 10*, 125–143.

Beck, A. T., Rush, A. J., Shaw, B. F., & Emery, G. (1979). *Cognitive therapy of depression: A treatment manual*. New York: Guilford Press.

Berntson, G. G., Quigley, K. S., & Lozano, D. (2007). Cardiovascular psychophysiology. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (3rd ed.). (pp. 182–210). New York: Cambridge University Press.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., et al. (2004). Mindfulness: a proposed operational definition. *Clinical Psychology: Science and Practice, 11*, 230–241.

Borkovec, T. D., Alcaine, O. M., & Behar, E. (2004). Avoidance theory of worry and generalized anxiety disorder. In R. G. Heimberg, C. L. Turk, & D. S. Mennin (Eds.), *Generalized anxiety disorders: Advances in research and practice* (pp. 77–108). New York: Guilford Press.

Bradley, M., Cuthbert, B. N., & Lang, P. J. (1996). Lateralized startle probes in the study of emotion. *Psychophysiology, 33*, 156–161.

Brown, T., Di Nardo, P., & Barlow, D. H. (1994). *Anxiety disorders interview schedule adult version (ADIS-IV): Client interview schedule*. San Antonio, TX: Psychological Corporation.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*, 822–848.

Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: theoretical foundations and evidence for its salutary effects. *Psychological Inquiry, 18*, 211–237.

Brown, K. W., Ryan, R. M., Loverich, T. M., Biegel, G. M., & West, A. M. (2011). Out of the armchair and into the streets: measuring mindfulness advances knowledge and improves interventions: reply to Grossman (2011). *Psychological Assessment, 4*, 1041–1046.

Buchheld, N., Grossman, P., & Walach, H. (2001). Measuring mindfulness in insight meditation (Vipassana) and meditation-based psychotherapy: the development of the Freiburg Mindfulness Inventory (FMI). *Journal for Meditation and Meditation Research, 1*, 11–34.

Carmody, J. (2009). Evolving conceptions of mindfulness in clinical settings. *Journal of Cognitive Psychotherapy, 23*, 270–280.

Cohen, S., Kamark, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24*, 385–396.

Craig, A. D. (2003). Interoception: the sense of the physiological condition of the body. *Current Opinion in Neurobiology, 13*, 500–505.

Dawson, M. E., Schell, A. M., & Filion, D. L. (2007). The electrodermal system. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (3rd ed.). (pp. 159–181). New York: Cambridge University Press.

De Bruin, G. O., Rassin, E., & Muris, P. (2007). The prediction of worry in non-clinical individuals: the role of intolerance of uncertainty, meta-worry, and neuroticism. *Journal Psychopathology and Behavioral Assessment, 29*, 93–100.

Delgado, L. C., Guerra, P., Perakakis, P., Mata, J. L., Pérez, N., & Vila, J. (2009). Psychophysiological correlates of chronic worry cued versus non-cued fear reaction. *International Journal of Psychophysiology, 74*, 280–287.

Delgado, L. C., Guerra, P., Perakakis, P., Vera, M. N., Reyes del Paso, G., & Vila, J. (2010). Treating chronic worry: psychological and physiological effects of a training programme based on mindfulness. *Behaviour Research and Therapy, 48*, 873–882.

Dugas, M. J., Gagnon, F., Ladouceur, R., & Freeston, M. H. (1998). Generalized anxiety disorder: a preliminary test of a conceptual model. *Behaviour Research and Therapy, 36*, 215–226.

Gard, T., Hölzel, B. K., Sack, A. T., Hempel, H., Lazar, S. W., Vaitl, D., et al. (2012). Pain attenuation through mindfulness is associated with decreased cognitive control and increased sensory processing in the brain. *Cerebral Cortex, 22*, 2692–2702.

Grossman, P. (2011). Defining mindfulness by how poorly I think I pay attention during everyday awareness and other intractable problems for psychology's (re) invention of mindfulness: comment on Brown et al. (2011). *Psychological Assessment, 4*, 1034–1040.

Grossman, P., Niemann, L., Schmidt, S., & Walach, H. (2004). Mindfulness-based stress reduction and health benefits: a meta-analysis. *Journal of Psychosomatic Research, 57*, 35–43.

Hofmann, S. G., Moscovitch, D. A., Litz, B. T., Kim, H. J., Davis, L. L., & Pizzagalli, D. A. (2005). The worried mind: autonomic and prefrontal activation during worrying. *Emotion, 5*, 464–475.

Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work. Proposing mechanisms of action from a conceptual and neural perspectiva. *Perspectives on Psychological Science, 6*, 537–559.

Hölzel, B. K., Ott, U., Gard, T., Hempel, H., Weygandt, M., Morgen, K., et al. (2008). Investigation of mindfulness meditation practitioners with voxel-based morphometry. *Social Cognitive and Affective Neuroscience, 3*, 55–61.

Kuyken, W., Byford, S., Taylor, R. S., Watkins, E., Holden, E., White, K., et al. (2008). Mindfulness-based cognitive therapy to prevent relapse in recurrent depression. *Journal of Consulting and Clinical Psychology, 76*, 966–978.

Kuyken, W., Watkins, E., Holden, E., White, K., Taylor, R. S., Byford, S., et al. (2010). How does mindfulness-based cognitive therapy work? *Behaviour Research and Therapy, 48*, 1105–1112.

Lau, A., & Yu, A. R. (2009). New developments in research on mindfulness-based treatments: introduction to the special issue. *Journal of Cognitive Psychotherapy, 23*, 179–184.

Linehan, M. (1993). *Cognitive-behavioral treatment of borderline personality disorder*. Nueva York: Guilford Press.

Meyer, T. J., Miller, M. L., Metzger, R. L., & Borkovec, T. D. (1990). Development and validation of the Penn state worry questionnaire. *Behaviour Research and Therapy, 28*, 487–495.

Perakakis, P., Joffily, M., Taylor, M., Guerra, P., & Vila, J. (2010). KARDIA: a Matlab software for the analysis of cardiac interbeat intervals. *Computer Methods and Programs in Biomedicine, 98*, 83–89.

Porges, S. W. (2011). The early development of the autonomic nervous system provides a neural platform for social behaviour: a polyvagal perspective. *Infant and Child Development, 20*, 106–118.

Remor, E. (2006). Psychometric properties of a European Spanish version of the Perceived Stress Scale (PSS). *The Spanish Journal of Psychology, 9*, 86–93.

Reyes del Paso, G. A. (1992). An on-line program to calculate respiratory sinus arrhythmia amplitude. *Behavior Research Methods, Instrument, & Computers, 24*, 464–466.

Roemer, L., Williston, S. K., Eustis, E. H., & Orsillo, S. M. (2013). Mindfulness and acceptance-based behavioral therapies for anxiety disorders. *Current Psychiatry Reports, 15*, 1–10.

Sandín, B., Chorot, P., Lostao, L., Joiner, T., Santed, M. A., & Valiente, R. M. (1999). Escalas PANAS de afecto positivo y negativo: validación factorial y convergencia transcultural/The PANAS Scales of Positive and Negative Affect: factor analytic validation and cross-cultural convergence. *Psicothema, 11*, 37–51.

Sandin, B., Chorot, P., Valiente, R. M., & Lostao, L. (2009). Validación española del cuestionario de preocupación PSWQ: estructura factorial y propiedades psicométricas. *Revista de Psicopatología y Psicología Clínica, 2*, 107–122.

Sanz, J., & Vázquez, C. (1998). Fiabilidad, validez y datos normativos del Inventario para la depresión de Beck. *Psicothema, 10*, 303–318.

Sears, S., & kraus, S. (2009). I think therefore I Om: cognitive distortions and coping style as mediators for the effects of mindfulness meditation on anxiety, positive and negative affect, and hope. *Journal of Clinical Psychology, 65*, 561–573.

Segal, Z. V., Williams, J. M. G., & Teasdale, J. D. (2002). *Mindfulness-based cognitive therapy for depresión*. Nueva York: Guilford Press.

Shapiro, S. L., Carlson, L., Astin, J. A., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology, 62*, 373–386.

Soler, J., Tejedor, T., Soler, A. F., Pascual, J. C., Cebolla, A., Soriano, J., et al. (2012). Propiedades psicométricas de la versión española de la escala Mindful Attention Awareness Scale (MAAS). *Actas Españolas de Psiquiatría, 40*, 19–26.

Sridharan, D., Levitin, D. J., & Menon, D. (2008). A critical role for the right fronto-insular cortex in switching between central-executive and default-mode networks. *Proceedings of the National Academy of Sciences, 34*, 12569–12574.

Stapinski, L. A., Abbott, M. J., & Rapee, R. M. (2010). Evaluating the cognitive avoidance model of generalised anxiety disorder: impact of worry on threat appraisal, perceived control and anxious arousal. *Behaviour Research and Therapy, 48*, 1032–1040.

Thayer, J. F., Åhs, F., Fredrikson, M., Sollers, J. J., III, & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: implications for heart rate variability as a marker of stress and health. *Neuroscience & Biobehavioral Reviews, 36*, 747–756.

Thayer, J. F., & Brosschot, J. F. (2008). The perseverative cognition hypothesis what were we thinking? [Abstract] *Psychophysiology, 45*, S11.

Thayer, J. F., Friedman, B. H., & Borkovec, T. D. (1996). Autonomic characteristics of generalized anxiety disorder and worry. *Biological Psychiatry, 39*, 255–266.

Toneatto, T., & Nguyen, L. (2007). Does mindfulness meditation improve anxiety and mood symptoms? A review of the controlled research. *Canadian Journal of Psychiatry, 52*, 260–266.

Van Veen, V., & Carter, C. S. (2002). The timing of action-monitoring processes in the anterior cingulate cortex. *Journal of Cognitive Neuroscience, 14*, 593–602.

Walach, H., Buchheld, N., Buttenmüller, V., Kleinknecht, N., & Schmidt, S. (2006). Measuring mindfulness-the Freiburg Mindfulness Inventory (FMI). *Personality and Individual Differences, 40*, 1543–1555.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology, 54*, 1063–1070.

Wells, A. (2005). The metacognitive model of GAD: assessment of meta-worry and relationship with DSM-IV generalized anxiety disorder. *Cognitive Therapy and Research, 29*, 107–121.

Williams, J. M. G. (2010). Mindfulness and psychological process. *Emotion, 10*, 1–7.

Zgierska, A., Rabago, D., Chawla, N., Kushner, K., Koehler, R., & Marlatt, A. (2009). Mindfulness meditation for substance use disorders: a systematic review. *Substance Abuse, 30*, 266–294.