Cardiac Defense Reactivity and Cognitive Flexibility in High- and Low-Resilience Women

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Cardiac Defense Reactivity and Cognitive Flexibility in High- and Low-Resilience Women

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Abstract

The present study analyzes, in a sample of 54 young women, the relationships between high or low resilience, measured with the Connor-Davidson Resilience Scale questionnaire and the Spanish adaptation of the Resilience Scale, and two indices of psychophysiological and neuropsychological adaptability, the cardiac defense response (CDR) and cognitive flexibility. The results showed that the more resilient people, in addition to having better scores on mental health questionnaires, obtained better scores in cognitive flexibility than the less resilient people. Regarding the CDR, both groups showed the typical response pattern to unexpected intense noise, with two successive acceleration-deceleration components. However, the more resilient people had a larger initial acceleration-deceleration, which is indicative of greater vagal control, than the less resilient people. No significant differences were found in the second acceleration-deceleration, which is indicative of sympathetic control. The present findings broaden the understanding of how resilient people change their adaptable responses to address environmental demands.

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1 Introduction

Resilience is the process of adapting well in the face of adversity, trauma, tragedy, threats or even significant sources of stress (American Psychological Association, 2014). Moreover, resilience involves the ability to recover and maintain adaptive behavior after stressful events. Psychophysiological and neuropsychological systems involved in the successful regulation and modification of emotions and cognitions are potential underpinnings of resilience. The parasympathetic nervous system facilitates adaptation to stress by modifying some physiological responses, such as respiration and heart rate (Porges, 2007). Higher resting vagal control is linked to social and psychological well-being (Kok & Fredrickson, 2010) and trait positive emotionality (Oveis et al., 2009). In addition, cognitive flexibility is likely critical in a threatening situation, where ongoing cognitive processes need to be inhibited and resources shifted to processing the current threat.

Despite the importance of adaptation and recovery from stressful events in resilience, only a few studies have focused on the psychophysiological mechanisms of resilience. Existing findings have suggested an adaptive response, characterized by higher vagal tone, in the recovery period among resilient people (Lü, Wang, & You, 2016; Smeets, 2010; Souza et al., 2007, 2013), and those presenting with higher resilience showed reduced heart acceleration (Souza et al., 2007). Individuals with high trait resilience and high resting heart rate variability show more regulation in terms of their subjective arousal experiences in the presence of threats (Hildebrandt, McCall, Engen, & Singer, 2016).

The present study focuses on two indices of psychophysiological and neuropsychological adaptability in high- and low-resilience people: the cardiac defense response (CDR) and cognitive flexibility. The CDR is characterized by a complex pattern of heart rate changes to an unexpected intense noise with two accelerative-decelerative components during the 80 seconds after stimulus onset (Vila et al., 2007). The first acceleration-deceleration reaches its accelerative peak at approximately seconds 2-3, whereas the second acceleration-deceleration reaches its accelerative peak at approximately seconds 30-35 (see Figure 1). These two components are mediated by sympathetic and parasympathetic cardiac control, with parasympathetic dominance during the first acceleration-deceleration and sympathetic dominance during the second acceleration-deceleration (Fernández & Vila, 1989; Garrido et al., 2020; Reyes del Paso, Vila, & García, 1994). The CDR is modulated by attentional and emotional tasks, with the amplitude of the accelerative components being potentiated by attending to external visual cues (Ramírez, Guerra, Muñoz, Perakakis, Anllo-Vento, & Vila, 2010; Vila, Pérez, Fernández, Pegalajar, & Sánchez, 1997) and by looking at unpleasant pictures (Sánchez et al., 2002, 2009). This potentiated response pattern, with marked reduction of the first deceleration, has been found to be associated with chronic worry (Delgado et al., 2009) and post-traumatic stress disorder (Norte et al., 2019; Schalinski, Elbert, & Schauer, 2013). Building on these data and on the defense cascade model (Lang, Bradley, & Cuthbert, 1997), Vila et al. (2007) proposed the attentional-motivational model of cardiac defense. This model suggests that the CDR involves two successive phases: an initial phase of heart rate acceleration-deceleration, linked to attentional protective processes, including the interruption of ongoing activity and increased attention to external environmental cues, and a second phase of heart rate acceleration-deceleration, linked to motivational protective processes aimed at preparation for active defense.

[Insert Figure 1 here]

The CDR paradigm also allows the recording of other psychophysiological variables, including the skin conductance response, a sympathetically mediated response reflecting the level of arousal associated with emotional and cognitive mechanisms (Dawson, Schell, & Filion, 2007). Skin conductance has been implicated in resilience after trauma exposure, showing, in people with post-traumatic stress disorder, an increase in electrodermal reactivity in response to a variety of threat stimuli (McTeague et al., 2010; Pole, 2007). Heightened reactivity in people with low resilience would be coherent with the expected sympathetic activation during the second acceleration-deceleration component of the CDR, linked to the preparation for active defense.

Resilience also represents a constant mode of flexible and adaptable responses to cope with the demands of a changing environment. These adaptive responses are characterized by high flexibility to adjust our behavior to the demands of the context that surrounds us (Ionescu, 2012; Kashdan & Rottenberg, 2010; Ottaviani, Shapiro, & Couyoumdjian, 2013). One important aspect of this flexible behavior is the cognitive flexibility to be able to appropriately adjust one's behavior according to a changing environment (Armbruster, Ueltzhöffer, Basten, & Fiebach, 2012). In the face of a threat, it is essential to inhibit and, at the same time, activate different cognitive processes to avoid interferences and facilitate the use of resources necessary to cope with the situation. It is likely that this association between high resilience and high cognitive flexibility, reported in various studies (Genet & Siemer, 2011; Hildebrandt et al., 2016; Soltani, Shareh, Bahrainian, & Farmani, 2013), might be mediated by increased vagal control. Vagal control would facilitate the activation of attentional protective mechanisms, including the interruption of ongoing activity, and increase attention to external environmental cues. In contrast, low resilience could be associated with less flexibility, less vagal control and less capacity to activate attentional protective mechanisms. In fact, inflexibility in shifting and inhibition has been linked to psychopathological correlates of low resilience, such as anxiety (Eysenck, Derakshan, Santos, & Calvo, 2007; Sheppes, Luria, Fukuda, & Gross, 2013) and depression (Whitmer & Banich, 2007).

Investigating the psychophysiological and neuropsychological mechanisms of resilience is particularly relevant for young people because they frequently encounter new challenges in their life, and cumulative lifetime adversity exposure predicts resilience in response to a range of subsequent stressors (Seery & Quinton, 2016). Young women specifically have lower scores on resilience measures (Consedine, Magai, & Krivoshekova, 2005; Stratta et al., 2013), and they are more vulnerable to developing stress disorders after serious stressors or trauma (Bangasser & Valentino, 2014; Donner & Lowry, 2013; Hegadoren, Lasiuk, & Coupland, 2006).

Therefore, the general objective of this study was to compare two groups of young women with high versus low resilience on measures of cardiac defense reactivity and cognitive flexibility. Taking into account the literature on both adaptive mechanisms, we expected that the high-resilience group, compared to the low-resilience group, would exhibit a CDR pattern indicative of greater vagal control (larger first acceleration-deceleration) and greater cognitive flexibility. No differences are expected regarding the second acceleration-deceleration and the skin conductance response, the indices of sympathetic activation.

2 Methods

2.1 Participants

The sample comprised 54 female undergraduate students from the University of Granada: 27 with high resilience scores and 27 with low resilience scores on two well-validated questionnaires (Arrebola-Moreno et al., 2014; Serrano-Parra et al., 2012). This sample was selected from the highest and lowest quartiles of an initial sample of 575 students. They had a mean age of 19.98 years (standard deviation = 2.83). The exclusion criteria were undergoing psychiatric or pharmacological treatment and having visual or auditory deficits or cardiovascular problems. The University of Granada Human Research Ethics Committee approved the study. All participants read the study's explanatory statement and signed an informed consent form. All of them were compensated 15 euros for their participation. Low resilience has been associated with elevated trait anxiety and mental health symptoms (Haskett, Nears, Ward, & McPherson, 2006; Hu, Zhang, & Wang, 2015; Karreman & Vingerhoets, 2012; Liu, Wang, & Li, 2012; Windle, 2011). We measured these aspects using the State-Trait Anxiety Inventory–Trait scale (STAI-T) questionnaire (Spielberger, Goursch, & Lushene, 1982) and the Symptom Checklist-90-R (Derogatis, 1994). Table 1 shows the scores of both resilience groups in each of these questionnaires. As indicated in the table, statistically significant differences between the two groups appeared in all measures.

[Insert Table 1 here]

2.2 Design

A cross-sectional, descriptive and comparative study of two groups (high versus low resilience) was used with the objective of evaluating the differences between the groups in cardiac defense response and cognitive flexibility. The defense paradigm consisted of the presentation of an unexpected and intense noise of 105 dB, 500 ms duration, and instantaneous risetime through headphones after a resting period of 7 minutes with continuous recording of the electrocardiogram (ECG) and the skin conductance (SC).

2.3 Measures and Instruments

2.3.1 Resilience scales. We used two different questionnaires to ensure accurate identification (via cross-validation) of high- and low-resilience participants: the CD-RISC 25 (Connor & Davidson, 2003) and the Resilience Scale (Wagnild & Young, 1993).

The CD-RISC consists of 25 items, each rated on a 5-point scale (0-4) from not true at all (0) to true nearly all the time (4). Higher scores reflect greater resilience capacity, and the total score can range from 0 to 100. The questionnaire had good psychometric properties in the validation study in the US population (Cronbach's alpha of 0.89). The Spanish translated and validated version was provided by Mª D Serrano-Parra of the University of Castilla la Mancha (Serrano-Parra et al., 2012).

The Resilience Scale (RS) consists of 25 closed-ended items scored according to a Likert scale, with seven alternatives ranging from 1 (strongly disagreement) to 7 (totally agreement); higher scores indicated higher resilience, with a range from 25 to 175 for the total score. The Cronbach's alpha coefficient was 0.91 for the scale. In this study, the Spanish version of the RS was used (Arrebola-Moreno et al., 2014).

2.3.2 Self-report measures for anxiety and psychopathology. State-Trait Anxiety Inventory–Trait scale (STAI-T) questionnaire (Spielberger et al., 1982). This questionnaire assesses trait anxiety using 20 items with a Likert-type response scale with four alternatives ranging from 0 (almost never) to 3 (almost always). The scale has anxiety-absent and anxiety-present questions. The total score is obtained by adding each item score after the investment of the anxiety-absent questions. There is considerable evidence on the psychometric properties of the scale (Spielberger, 1982).

Symptom Checklist-90-Revised (SCL-90-R; Derogatis, 1994). The SCL-90-R is a self-report measure of psychopathology for people aged at least 13 years. It consists of 90 items that represent nine dimensions, each one containing 6-13 items. Items are rated on a five-point Likert scale of distress, ranging from “not at all” (0) to “extremely” (4). The Global Severity Index (GSI) is the average score for all response items and serves as an overall measure of mental distress. The questionnaire is considered suitable for screening overall psychopathology among inpatients and community youth (Rytilä-Manninen et al., 2016).

2.3.3 Intensity and unpleasantness of the noise. Participants rated separately the subjective intensity and unpleasantness of the noise using a scale from 0 to 100 (0 = not at all intense/unpleasant, 100 = extremely intense/unpleasant).

2.3.4 Physiological measures. Physiological responses were recorded using a Biopac MP150 polygraph at a sampling rate of 1000 Hz. For the CDR, the heart rate was derived from the ECG. The positive electrode was placed on the left wrist, and the negative electrode was placed on the right wrist. The ground electrode was placed on the left ankle (i.e., derivation I). The CDR was estimated following the procedure outlined by Vila, Fernández, and Godoy (1992). The beat-to-beat heart rate during the 80 s after stimulus onset, converted to weighted average every second, was expressed as a differential score with respect to a baseline of 15 s. Then, the 80 second-by-second heart rate were reduced to the medians of 10 progressively longer intervals: 2 of 3 seconds (seconds 1-3 and 4-6), 2 of 5 seconds (seconds 7-11 and 12-16), 3 of 7 seconds (seconds 17-23, 24-30 and 31-37) and 3 of 13 seconds (seconds 38-50, 51-63 and 64-76)

SC was recorded from two standard Sensormedic Ag/AgCl electrodes with electrolytic isotonic paste placed in the hypothenar eminence of the left hand. The response was defined following a procedure similar to the CDR. The changes in skin conductance during the 80 s after stimulus onset were averaged every second and expressed as a differential score with respect to a baseline of 3 s. Then, the 80 second-by-second values were reduced to the medians of the same 10 intervals used for the CDR.

2.3.5 Cognitive flexibility. The CAMBIOS test (Seisdedos, 2004) is a neuropsychological test to evaluate cognitive flexibility. The test consists of checking whether there had been a change between successive five-to-nine-sided polygonal figures, with a gray circle in the center of the figure, according to a set of rules (the number of sides, the size of the figure and the intensity of the gray circle). The test has 27 items, each containing three figures drawn on a single horizontal row. In between the three figures, there is an empty space with a small circle with several cues (triangles, squares and arrows), indicating the type of rule used for the transformation of the next figure on its right. The task of the participant, working with time limitations, is to confirm whether each of the transformed figures in the 27 items complies with the given cues. The coefficient of confirmation of the questionnaire by split-half (even and odd elements) obtained a correlation of 0.92.

2.4 Apparatuses

- A Biopac MP150 polygraph connected to a PC-Pentium-4 with AcqKnowledge 4.2 software (Biopac Systems, Inc., Goleta, California) was used to record the ECG with the ECG100C amplifier and the SC with the EDA100C amplifier.
- A Coulbourn V85-05 sound generator connected to an IMQ Stage Line amplifier was used to produce the white noise presented binaurally through AKG K 240 headphones. The sound intensity was calibrated using a Brüel & Kjaer sound-level meter, model 2235, together with an artificial ear model 4153.

2.5 Procedure

For the sample selection, all participants received the information of the experiment in the classroom (i.e., descriptions of the voluntary nature of the participation in the study and the type of psychophysiological experiment). During this first contact, all participants completed the resilience questionnaires. Once the sample was selected, the participants were contacted by telephone or email for participation in the experimental session with fifteen euros for financial compensation. The session in the laboratory consisted of three phases:

(1) Pre-experimental phase: Upon arrival at the laboratory, the participant was informed about the procedure to be followed in the session, signed the informed consent form, and completed a personal interview to confirm the selection criteria. Then, the resilience questionnaires were administered again, followed by the STAI-T and CAMBIOS tests. Once these measures were completed, the electrodes were attached, and the signals were checked. Finally, the ambient temperature was taken, the headphones were placed, and the participant was left alone in a semidarkened room.

(2) Experimental phase: The participant performed the experimental task while the experimenter remained in an adjacent room and controlled the operation of all devices. The participant was monitored by a video camera.

(3) Post-experimental phase: The headphones were removed before the removal of the electrodes. Then, the participant completed the intensity/unpleasantness scales and the SCL-90-R questionnaire.

2.6 Statistical Analyses

Statistical analysis was performed using SPSS 22 software. The normality of the distribution of the questionnaire data was assessed using the Kolmogórov-Smirnov test, and depending on the data distribution, we used Student's t-test, the Mann-Whitney U test, or the Wilcoxon signed-rank test to compare the two resilience groups. Cognitive flexibility was analyzed by means of a single-factor ANCOVA, controlling for mental distress symptomatology (the Global Severity Index) as a covariate. Regarding the CDR and the SC response, we used two 2 (Group) x 10 (Median) repeated-measures ANCOVAs, controlling for mental distress symptomatology (the General Severity Index) as a covariate. The use of this covariate is justified based on the significant relationship between mental stress symptomatology and both cognitive flexibility (Kashdan & Rottenberg, 2010) and the CDR (Schalinski et al., 2013). The Greenhouse-Geisser correction was applied to the repeated-measures factor (Median) to control for the violation of sphericity. The results are provided with uncorrected degrees of freedom, corrected *p* values, and eta squared (ηp^2) as a measure of effect size. In the case of a significant Group x Median interaction, a post hoc analysis checked whether the differences between groups affected the first acceleration-deceleration component (Medians 1 to 4) or the second acceleration-deceleration component (Medians 5 to 10) of the CDR.

3 Results

3.1 Cognitive Flexibility

The results of the single-factor ANCOVA revealed significant differences between the two groups ($F_{[1, 50]} = 13.56$, $p = 0.001$, $\eta p^2 = 0.210$). Participants in the high-resilience group had higher cognitive flexibility scores than those in the low-resilience group (high-resilience group: M = 17.10, SE = 0.97; low-resilience group: M = 13.23, SE = 0.97). No significant interaction was found with the covariate ($p = 0.43$).

3.2 Psychophysiological Measures

3.2.1 Cardiac defense response. Figure 2 presents the CDR. Both groups showed the typical response pattern with two accelerative-decelerative components. However, the high-resilience group showed a greater first acceleration-deceleration than the low-resilience group. The low-resilience group, in addition to displaying a reduced first deceleration that did not reach the baseline value, showed an advanced peak of the second acceleration with respect to the peak of the high-resilience group.

[Insert Figure 2 here]

The 2 x 10 (Group x Time) ANCOVA yielded a significant Median effect ($F_{[9, 459]} = 5.83$, $p = 0.0001$, $\eta p^2 = 0.103$) and a significant Group x Median interaction ($F_{[9, 459]} = 2.59$, $p = 0.036$, $\eta p^2 = 0.048$). Follow-up analysis of this interaction revealed significant differences between the two groups in the first acceleration-deceleration component (Medians 1 to 4): $F_{[3, 153]} = 5.55$, $p = 0.01$, $\eta p^2 = 0.098$. No significant differences were found in the second acceleration-deceleration component (Medians 5 to 10): $F_{[5, 255]} = 1.452$, $p = 0.234$, $\eta p^2 = 0.028$. Regarding the covariate, a significant Median x Covariate interaction was also found ($F_{[9, 459]} = 4.63$, $p = 0.001$, $\eta p^2 = 0.083$).

3.2.2 Skin conductance.

Figure 3 presents the SC response. Both groups showed a marked response, reaching maximum amplitude at Median 3 (approximately second 9), followed by a slow tendency towards recovery.

[Insert Figure 3 here]

The 2 x 10 (Group x Median) ANCOVA yielded only a significant Median effect ($F_{[9, 459]} = 11.64$, $p = 0.0001$, $\eta p^2 = 0.185$).

3.3 Intensity and Unpleasantness of the Noise

The results of the unpleasantness scale showed significant differences between the two groups, with the high-resilience group evaluating the noise as less unpleasant than the low-resilience group (U= 187.50; $p = 0.009$; high resilience: M = 72.50, SD = 14.25; low resilience: M = 85.56, SD = 10.59). No significant differences were found in the intensity scale (U=240.50*; p =0.11)*.

4 Discussion

We found that young women with high resilience, compared to those with low resilience, have better cognitive flexibility and a CDR pattern to an unexpected intense noise with a greater first acceleration-deceleration. These group differences survived after controlling for mental stress symptomatology, a common correlate of both cognitive flexibility and the CDR. High-resilience participants also evaluated intense noise as significantly less unpleasant than low-resilience participants. No group differences were found in the second acceleration-deceleration, in the skin conductance response, or in the subjective intensity of the noise. However, a nonsignificant tendency was observed in the timing of the peak of the second acceleration, which was found to be advanced in the low-resilience group relative to the high-resilience group.

These results confirm our hypothesis. Better cognitive flexibility is consistent with the notion that the ability to adapt behaviors to changing environments is key to resilience. Similarly, the differences observed in the pattern of the CDR between the high-resilient and low-resilient participants, focused on the first acceleration-deceleration component, suggest that high-resilient people have a more adaptive defense reaction to an aversive stimulus that may signal danger than low-resilient people. According to the attentional-motivational model of cardiac defense, the first acceleration-deceleration, mediated by vagal control, involves the activation of an attentional protective mechanism aimed at interrupting ongoing activity and increasing attention towards the detection and analysis of potential threats. The lack of significant differences in the second acceleration-deceleration component and in the skin conductance response supports this interpretation. This suggests that the key aspect differentiating high and low resilience is not so much the activation of a sympathetically mediated protective mechanism aimed at preparation for active defense as the activation of an attentional protective mechanism aimed at attending and coping with environmental changes.

Our finding linking high resilience with better cognitive flexibility is consistent with previous evidence (Genet & Siemer, 2011; Soltani et al., 2013). Psychological flexibility also appears to be a key factor in post-trauma adaptation (Kumpula, Orcutt, Bardeen, & Varkovitzky, 2011; Orcutt, Bonanno, Hannan, & Miron, 2014). In addition, psychological flexibility that implies rapid and flexible responses to changing environmental circumstances has been discussed as a health-protective feature in human development in general (Kashdan & Rottenberg, 2010) and in emotion regulation in particular (Bonanno & Burton, 2013; Hildebrandt et al., 2016).

The pattern of CDR found in our low-resilience group is also consistent with previous findings. A similar pattern has been found in people with chronic worry (Delgado et al., 2009) and post-traumatic stress disorder (Norte et al., 2019; Schalinski et al., 2013). In these cases, the CDR pattern is characterized by a marked reduction or disappearance of the first deceleration followed by an earlier second acceleration-deceleration. This modified CDR pattern has been interpreted (Vila et al., 2007) in terms of reduced activation of the attentional protective phase (presumably due to a pre-existing state of higher vigilance) followed by an advancement of the motivational protective phase, the phase linked to active defense, such as fight or flight. The reduction of the first deceleration in the low-resilience group is evident in our study. Although not significant, the tendency of the second acceleration to advance is also evident. This pattern of cardiac defense reactivity, linked to reduced vagal control, suggests a less adaptive form of facing environmental threats.

Altogether, our results align with the view that resilience is associated with better flexibility/adaptation of cognitive and physiological resources against challenges and threats, acting as a buffering variable of physical and mental health (Holden, Hernandez, Wrenn, & Belton, 2017; Martínez-Martí & Ruch, 2017; Sarkar & Fletcher, 2014; Smith & Zautra, 2008; Wagnild, 2009).

To our knowledge, this is the first study showing differences in high- and low-resilience women using the cardiac defense paradigm. The implications of our results should be evaluated taking into account methodological strengths and limitations. One of the strengths is the sample selection method to ensure the correct allocation of participants to groups, based on two resilience questionnaires completed at two different times (several months before and on the day of the experimental session). Regarding limitations, it is important to note that the sample included only young women. Thus, our findings cannot be generalized to men or older women. There is consistent evidence showing that women are less resilient than men (Consedine et al., 2005; Stratta et al., 2013). On the other hand, young women have a lower probability of having experienced traumatic events, and the occurrence of these events is important for enhancing and maintaining resilience. Future research will have to confirm our findings in those populations.

In conclusion, the present study provides evidence about the concept of resilience being directly linked to mental health and two indices of neuropsychological and psychophysiological adaptability: cognitive flexibility and the cardiac defense response. The pattern of the heart rate response differentiating high- and low-resilience participants, focused on the first acceleration-deceleration component of the CDR, suggests the presence of an attentional protective mechanism, vagally mediated, as a key feature of resilience. Together with cognitive flexibility, this mechanism may help to explain the successful adaptation of highly resilient people when facing stressful and traumatic events.

Impact Statement

High and low resilient women differ in two indices of neuropsychological and psychophysiological adaptability: cognitive flexibility and cardiac defense. These indices suggest that resilience is linked to the ability to adapt behaviors to changing environments and to react to threatening cues with cognitive protective mechanisms, vagally mediated, aimed at interrupting ongoing activity and increasing attention to the environmental changes.

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Disclosure Statement

There is no conflict of interest in the present study for any of the authors.

Tables

Table 1

Resilience Scores and Psychopathological Characteristics of the High- and Low-Resilience Groups

	High resilience		Low resilience		
	Mean	*SD*	Mean	*SD*	*p*
CD-RISC 1	85.44	5.56	48.85	6.7	0.0001
CD-RISC 2*	83.63	7.81	51.78	9.63	0.0001
RS 1	153.96	6.36	105.33	10.81	0.0001
RS 2*	152.3	8.72	105.3	13.39	0.0001
STAI-T score	16.22	8.72	33.37	8.33	0.0001
SCL-90-R total score	36.22	25.9	108.52	60.89	0.0001
Global Severity Index (GSI)	0.4	0.29	1.21	0.68	0.0001
Somatization	5.85	4.62	14.59	10.72	0.001
Obsessive-compulsive	5.74	5.12	15.89	6.91	0.0001
Interpersonal sensitivity	3.81	3.73	14.52	8.58	0.0001
Depression	5.37	4,32	20.15	11.11	0.0001
Anxiety	4.67	3.79	10.52	6.9	0.0001
Hostility	2.26	1.97	4.56	4.36	0.026
Phobic anxiety	1	1.73	4.59	6.02	0.001
Paranoid ideation	2.81	3.09	7.19	5.66	0.001
Psychoticism	1.48	1.91	8.33	7.7	0.0001
Additional scale	3.22	3.07	8.19	5.48	0.0001

* Resilience questionnaires administered the second time (the day of experimental session). Wilcoxon signed-rank test comparing the scores of each group on the two administrations revealed no significant differences (all *ps* > 0.2).

Figure Captions

Figure 1. Typical pattern of the cardiac defense response: average second-by-second heart rate response (left) and the same data expressed in terms of the medians of 10 intervals (right) (Adapted from Vila et al., 2007).

Figure 2. CDR pattern in each group over the 10 median time intervals. The numbers in the x-axis represent the midpoint of each time interval.

Figure 3. SCR pattern in each group over the 10 median time intervals. The numbers in the x-axis represent the midpoint of each time interval.

Figures

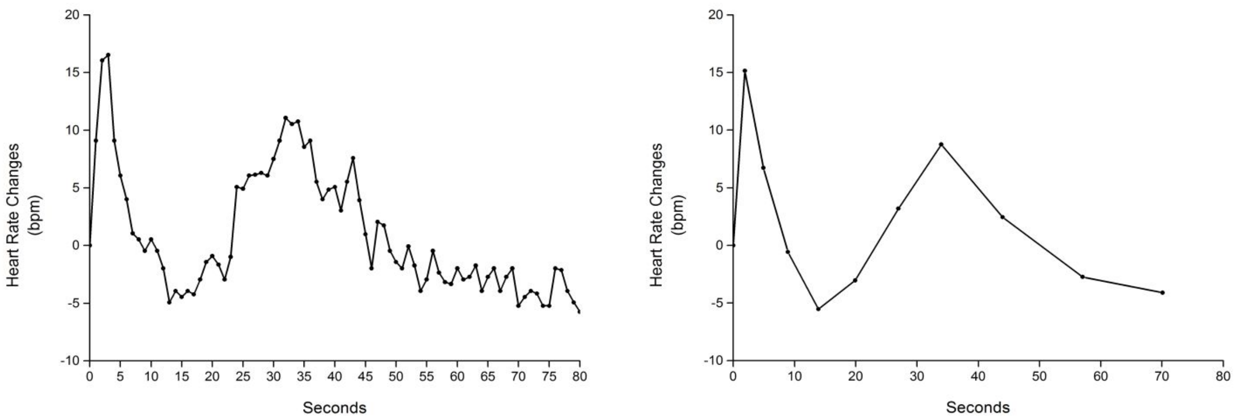
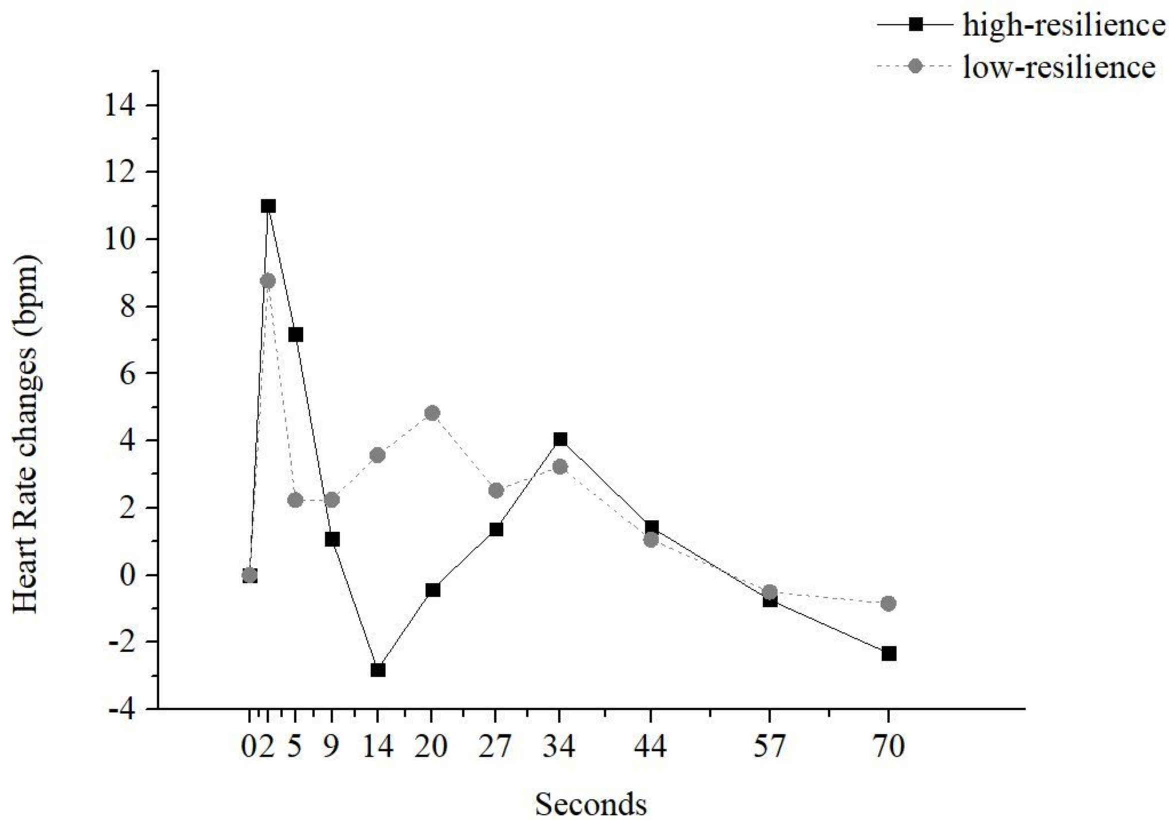


Figure 1



high-resilience
low-resilience
Heart Rate changes (bpm)
14
12
10
8
6
4
2
0
-2
-4
0
2
5
9
14
20
27
34
44
57
70
Seconds

Figure 2

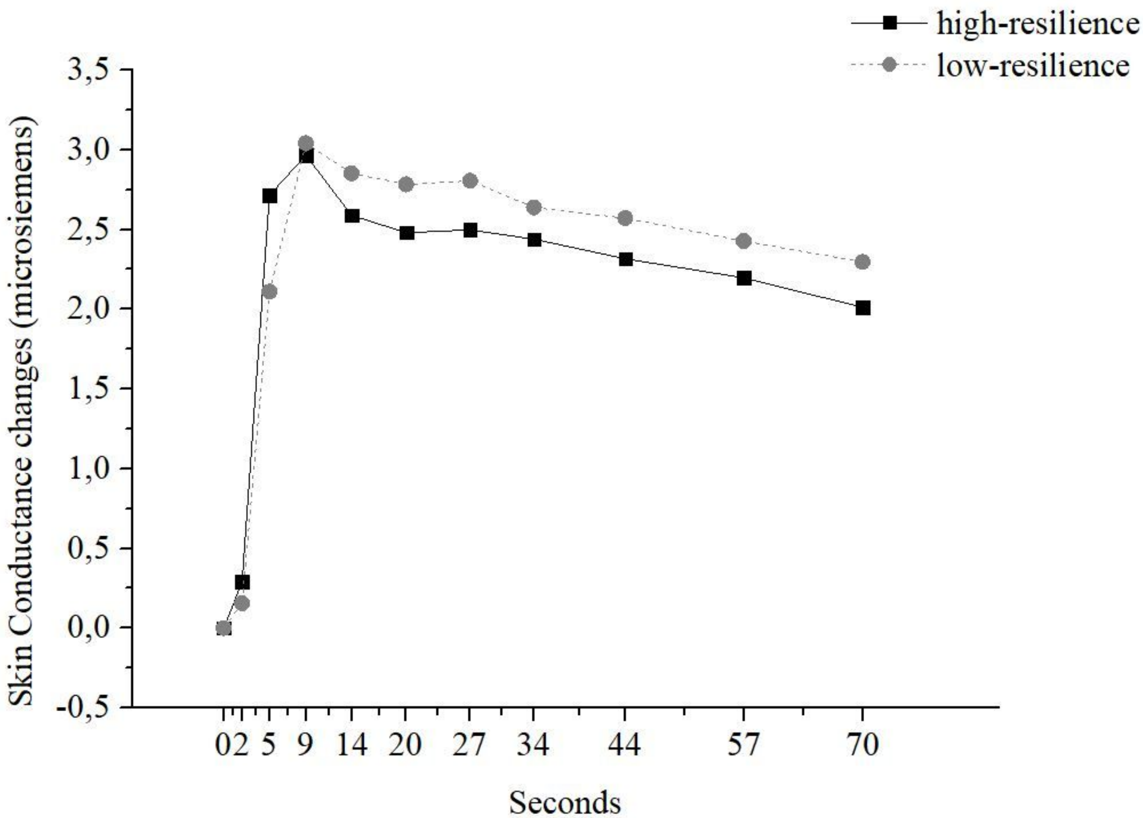

high-resilience
low-resilience
Skin Conductance changes (microsiemens)
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
-0,5
0 2 5 9 14 20 27 34 44 57 70
Seconds

Figure 3

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April 10, 2019,

Dear Prof. Monica Fabiani,

We wish to submit an original research article entitled "Cardiac Defense Reactivity and Cognitive Flexibility in High- and Low-Resilience Women" for consideration for publication in *Psychophysiology*.

We confirm that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere.

In this paper, we show that women with high resilience, compared to those with low resilience, have better scores in cognitive flexibility and a more adaptive pattern of cardiac defense reactivity to an unexpected intense noise. This pattern, characterized by a greater first acceleration-deceleration, suggests the activation of an attentional protective mechanism, vagally mediated, aimed at interrupting ongoing activity and increasing attention towards the detection and analysis of potential threats.

We believe that this manuscript is appropriate for publication in *Psychophysiology* due to the relevance of the concept of resilience and the need for advancement on its underlying psychophysiological mechanisms.

We have no conflicts of interest to disclose.

Please address all correspondence concerning this manuscript to me at juliaotero@ugr.es.

Thank you for your consideration of this manuscript.

Sincerely,

Julia Otero