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Original articles

Physiological reactivity to phobic stimuli in people with fear of flying

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Abstract

Objective: The nature of the relationship between physiological and subjective responses in phobic subjects remains unclear. Phobics have been thought to be characterized by a heightened physiological response (physiological perspective) or by a heightened perception of a normal physiological response (psychological perspective). **Method:** In this study, we examined subjective measures of anxiety, heart rate (HR), and cardiac autonomic responses to flight-related stimuli in 127 people who applied for fear-of-flying therapy at a specialized treatment center and in 36 controls without aviophobia. **Results:** In keeping with the psychological perspective, we found a large increase in subjective distress (η^2=.43) during exposure to flight-related stimuli in the phobics and no change in subjective distress in the controls, whereas the physiological responses of both groups were indiscriminate. However, in keeping with the physiological perspective, we found that, within the group of phobics, increases in subjective fear during exposure were moderately strong coupled to HR (r=.208, P=.022) and cardiac vagal (r=.199, P=.028) reactivity. In contrast to predictions by the psychological perspective, anxiety sensitivity did not modulate this coupling. **Conclusion:** We conclude that subjective fear responses and autonomic responses are only loosely coupled during mildly threatening exposure to flight-related stimuli. More ecologically valid exposure to phobic stimuli may be needed to test the predictions from the physiological and psychological perspectives.

Keywords: Flight phobia; Aviophobics; Respiratory sinus arrhythmia (RSA); Pre-ejection period (PEP); Anxiety sensitivity

Introduction

The prevalence of people with varying degrees of fear of flying is estimated at 7–40% of the general population in industrialized countries [1,2]. Curtis [3] reports a lifetime prevalence of 13.2% of people who are impaired by fear of flying, while Depla [4] mentions that 6.9% of all people experience serious interference in daily life and social functioning due to fear of flying. In view of recent events like the 9/11 bombing this percentage is not expected to decrease. Although distinguished by their fear of flying from other types of phobics, flying phobics are a heterogeneous group. Fear of flying can be the manifestation of one or more other phobias, such as claustrophobia or social phobia. It can also be the effect of generalization of one or more natural environment phobias, such as fear of heights, falling, storms, water, instability, etc. Fear of losing control and a high need to have control over a situation is often associated with fear of flying [1,5–7].

As much as eight out of 10 symptoms experienced by individuals with specific phobias during exposure to a phobic stimulus might be related to bodily sensations [8,9]. This applies in full to aviophobia where physiological sensation is one of the major symptoms reported. Physiological discomfort is used prominently in the diagnosis of fear of flying, and it is often invoked as one of the main measures of treatment effectiveness [10]. In spite of the importance of physiological sensations in fear of flying, many studies on aviophobics evaluate these sensations exclusively by verbal report. This

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might be problematic, as the relationship between self-reported feelings of anxiety and actual physiological reactivity has proven to be complex [11–21].

Two distinct theoretical perspectives have been proposed. In the physiological perspective, a historical extension of the original formulation by James [22] and Lange [23], exaggerated subjective arousal is thought to arise from exaggerated physiological arousal during exposure to anxiety-related stimuli. Increased sympathetic and decreased parasympathetic nervous system activity is sensed through afferent feedback from the affected organs (sweat glands, heart, lungs) and causes anxiety [24–29]. In the psychological perspective, the primary deficit in phobics is not exaggerated physiological arousal, but a tendency to focus attention on bodily sensations and/or overinterpret these signals as danger signals. In this perspective, and combining both viewpoints, anxiety sensitivity is seen as a key moderator between the experience of bodily sensations and anxiety [30,31]. Anxiety sensitivity is the fear of anxiety-related bodily sensations, based on the belief that the sensations have harmful somatic, psychological, or social consequences [32]. Individuals with high anxiety sensitivity are prone to interpret normal bodily sensations in a threatening manner, whereas those with low anxiety sensitivity experience these sensations as unpleasant but nonthreatening. Anxiety sensitivity is believed to be a dispositional variable distinguishable from trait anxiety [33].

To study the divergent predictions as derived from the physiological and psychological perspective, simultaneous assessment of subjective and physiological responses during exposure to phobic stimuli is needed. To date, surprisingly few studies have simultaneously assessed the changes in subjective fear levels during exposure to simulated or real flights in aviophobics together with physiological reactivity. These studies usually recorded increases in heart rate (HR) and respiration rate or decreases in HR variability (HRV), a measure of cardiac parasympathetic control, as the main physiological outcome variables. Using HR, for example, Beckham [34] found high levels of synchrony over time between physiological arousal and subjective anxiety during flight exposure. Synchrony over time even exhibited prognostic value for positive treatment outcome in their study. Contrasting results were obtained in a randomized double-blind placebo design by Wilhelm and Roth [35]. They tested the effect of alprazolam (a benzodiazepine) during two flights in women suffering from fear of flying. During the first flight, alprazolam significantly reduced anxiety compared to placebo, whereas HR was in fact higher. On the second flight, without alprazolam, women who had been on alprazolam had both higher levels of self-reported anxiety and higher levels of HR, whereas the women who had been on a placebo had lower levels of self-reported anxiety together with a nearly significant decrease of HR. Bornas et al. [36] compared four groups of psychology students, selected for low or high scores on a fear-of-flying questionnaire and either low or high HRV levels during a baseline measurement. Low HRV fearful flyers reported higher levels of anxiety than any other group when confronted with flight-related pictures and sound, while high HRV fearful flyers did not report higher levels of anxiety than controls. Finally, Ekeberg et al. [37,38] used catecholamines rather than HR or RSA as their main variable to index physiological reactivity in flight phobics. They too reported only low correlations between the psychological and physiological response to flight phobia stress [21]. Taken together, the extant studies suggest that subjective report and physiological reactivity are often not in synchrony.

In the present study, we reexamine the relationship between subjective and physiological reactivity in individuals with fear of flying when confronted with flight-related stimuli. We first compared phobics to nonphobic controls to test whether the physiological reactivity of the phobics, in parallel to their larger subjective reactivity, was larger than that of nonphobic controls. Secondly, we assessed the concordance between self-reported anxiety and physiological markers of anxiety within a relatively large group of people who applied for fear of flying therapy at a specialized treatment center. Thirdly, we investigated whether the association of self-reported anxiety and physiological markers of anxiety was moderated by individual differences in anxiety sensitivity. The physiological perspective predicts a higher reactivity in phobics than in nonphobics to flight-related stimuli and, within the group of phobics, a significant correlation between physiological reactivity and the amount of self-reported fear. The psychological perspective predicts a weaker concordance between subjective and physiological arousal, which may be limited to individuals who score high on anxiety sensitivity. We extend the work in previous studies, which focused on HR and measures of parasympathetic activity, by adding the pre-ejection period (PEP), a measure of sympathetic nervous system activity. Our focus on cardiac parameters reflects two major considerations: measurements needed to be as noninvasive as possible and they needed to respond to changes in psychological state over a time scale of a few minutes. The PEP and respiratory sinus arrhythmia (RSA, a measure of parasympathetic control) measures are uniquely qualified to meet both demands [39,40].

Method

Participants

Participants were phobics who applied for therapy at the VALK Foundation during the research period and nonpaid volunteers without fear of flying who acted as a control sample. The VALK Foundation is a facility that specializes in treating flying phobics. It is a joint enterprise of the Department of Clinical, Health and Neuropsychology at Leiden University, KLM Royal Dutch Airlines, Transavia

Airlines, and Amsterdam Airport Schiphol. Most people who apply for treatment at this facility are self-referrals, although lately more and more patients are referred by health care agencies, health professionals, and company health programs.

During the recruitment period, 210 phobic clients who applied for treatment received written information regarding the present study at their home address a few weeks before their first visit. Out of this group, 142 were considered eligible for the study. The largest group of clients (n=27) was excluded because they were airline personnel (both cabin and flight deck crewmembers). Other reasons for exclusion were unwillingness to participate in physiological recordings (n=17), a scheduled flight within the 2 weeks after recruitment (n=8), lack of time (n=5), no aviophobia (n=3), current use of cardioactive medication like β blockers (n=3). Another 15 clients were excluded from analyses because of equipment failure during physiological recordings. This left 127 phobic clients (57 men) with an average age of 40.5 (S. D.=11.0), who fulfilled the *DSM-IV* criteria for specific situational phobia furnishing usable data.

In the same period, 39 nonpaid volunteers without fear of flying and with an average age of 43.4 (S.D.=13.5) successfully completed a part of the same protocol. Volunteers were recruited through the social network of the research institution's staff. Healthy subjects were matched with the sample of patients on age and sex. Three of them received a positive diagnosis for aviophobia during the intake and were excluded. The final 36 nonphobics (17 men) had flown at least several times; most of them had flown within 18 months of the experiment. Two subjects made their last flight 2 years before the experiment; one subject had not flown for 10 years. None of the control subjects was ever treated for fear of flying.

Before the start of the experiment, informed consent was obtained from all participants. The research protocol was approved by the local medical ethics committee.

Procedures

All measurements took place at the VALK facility. Upon arrival, clients and control subjects were informed about the procedure. It was emphasized that participation was voluntary, and neither participation nor refusal to participate impacted on the quality of treatment. After informed consent was given, six electrodes were attached and connected to the Vrije Universiteit Ambulatory Monitoring System (VU AMS) which records the thorax impedance and the ECG in freely moving subjects as described in detail elsewhere [39–43]. Subjects were then seated upright and partook in three experimental conditions, always in the same fixed order. Subjects first watched a neutral video for 6 min, followed by a flight video of the same length. The flight video consisted of a flight safety demonstration video of a Boeing 747 with sound followed by some video shots of a landing Boeing 737, without sound. This video was followed by a recovery period of 6 min in which subjects were asked to relax and read a magazine. From the start of the video presentation to the end of the recovery period, subjects were left alone in the experimental room. Subjective units of distress (SUD) were measured at four discrete moments: before the start of the experiment, directly after both video presentations, and at the end of the recovery period. Subjects were prompted to fill out SUDs by text messages on the television screen.

Next, subjects were taken to a different experimental room and administered VALK's regular battery of questionnaires used for diagnostic purposes on fear and phobias and fear of flying in particular. Some paper-and-pencil questionnaires were added especially for this experiment. Finally, in a semistructured interview by a fully qualified psychotherapist, more information was gathered about flying behavior, life events, and other relevant information. Thereafter, the electrodes and the ambulatory recording device were removed.

Physiological recordings

The three target variables were HR, PEP, and RSA. The PEP is considered a measure of sympathetic cardiac control [44], whereas RSA is a measure of parasympathetic control [45]. Scoring of these variables from thorax impedance and the ECG is described in detail elsewhere [39,42]. Briefly, from the ECG (sampling rate 1000 Hz) the HR was obtained from the time between two adjacent R waves. PEP was defined from the ECG and ICG as the time interval from the Q-wave onset, the onset of the electromechanical systole, to the B point (from the ICG), which signals the opening of the aortic valves [40,44]. RSA was obtained from the ECG and respiration signals by subtracting the shortest interbeat interval (IBI) during HR acceleration in the inspirational phase from the longest IBI during deceleration in the expirational phase (i.e., the peak-through method) [46]. When no phase-related acceleration or deceleration was found, the breath was assigned a RSA score of 0. Automatic scoring of PEP and RSA was checked by visual inspection of the impedance and respiratory signal from the entire recording.

Using a visual display of the output of an inbuilt vertical accelerometer, we identified three artefact-free periods that lasted at least 5 min each: neutral video presentation, flight video presentation, and recovery after the video presentation. Average HR, PEP, and RSA were determined across each of these periods.

Questionnaires

All questionnaires were administered in the Dutch language.

Flight Anxiety Situations

The Flight Anxiety Situations (FAS) questionnaire was used to assess the degree of anxiety experienced in different flying-related situations on a five-point Likert-type scale, ranging from 1 (*no anxiety*) to 5 (*overwhelming anxiety*). The 32-item self-report inventory consists of three subscales: (a) an Anticipatory Flight Anxiety Scale, containing 14 items that pertain to anxiety experienced when anticipating a flight; (b) an In-Flight Anxiety Scale, containing 11 items measuring anxiety experienced during a flight; and (c) a Generalized Flight Anxiety Scale, containing seven items assessing anxiety experienced in connection with airplanes in general. The psychometric properties of the Dutch FAS proved to be excellent [10,47]. The internal consistency of the subscales of the FAS in the present study was good to excellent, with Cronbach's alpha ranging from 0.86 to 0.98.

Flight Anxiety Modality

The Flight Anxiety Modality (FAM) questionnaire was used to assess the symptoms by which flying-related anxiety was expressed. Each symptom is rated on a five-point Likert-type scale, ranging from 1 (*not at all*) to 5 (*very intensely*). The 18-item self-report inventory consists of two subscales: (a) a Somatic Modality scale, pertaining to physical symptoms; and (b) a Cognitive Modality scale, related to the presence of distressing cognitions. The psychometric properties of the Dutch FAM proved to be good to excellent [10,47]. The internal consistency of the two subscales of the FAM questionnaire in the present study was good, with Cronbach's alpha of 0.89 and 0.88, respectively.

Visual Analogue Flight Anxiety Scale

The Visual Analogue Flight Anxiety Scale (VAFAS) was used to examine to what extent subjects were anxious about flying. The one-tailed scale ranges from 0 (*no flight anxiety*) to 10 (*terrified or extreme flight anxiety*) [10].

Subjective Units of Distress

The Subjective Units of Distress (SUD) scale was used to examine to what extent subjects were feeling anxious at several moments. Subjects had to indicate their perceived anxiety on a scale from 1 (*totally relaxed*) to 10 (*extremely anxious*) [48].

Anxiety Sensitivity Index

The Anxiety Sensitivity Index (ASI) [49] was used to assess fear of anxiety-related symptoms. It is a 16-item self-report questionnaire designed to measure the dispositional tendency to fear the somatic and cognitive symptoms of anxiety. The items are rated on a five-point Likert-type scale, ranging from 0 (*very little*) to 4 (*very much*). The ASI scale consists of three subscales: (a) AS physical concern, (b) AS cognitive concern, and (c) AS social concern. The instrument's psychometric properties and predictive values are good [50,51]. In the present study, only the subscale for physical concern and the overall ASI total score were used. The internal consistency of both scales in the present study was good, with Cronbach's alpha of 0.88 and 0.87, respectively.

Data analysis

Comparison of phobic and nonphobic control subjects on sociodemographic characteristics and the FAS/FAM/VAFAS scales was performed with one-way ANOVA or a χ^2 test where appropriate. Of the physiological variables, RSA had to be log (ln) transformed to obtain normal distributions. Due to scheduling conflicts, only a fraction of all nonphobic control subjects partook in the neutral-video condition (all completed the flight video and recovery conditions). We used MIXED ANOVA as our main analysis strategy in the comparison of controls and phobics. MIXED ANOVA deals with the partial missing data without having to exclude subjects. In the ANOVA on SUD scores, sex, group (phobic, nonphobic), and condition (entrance, video neutral, video flight, and recovery) were the fixed factors. In the ANOVA on RSA, PEP, and HR, sex, group (phobic, nonphobic), and condition (video neutral, video flight, and recovery) were the fixed factors.

To see whether there were concordant changes in self-reported anxiety and the physiological markers of anxiety within the group of phobics, we created two reactivity scores for each of the three physiological variables that reflected the response to the flight video (flight video–neutral video) and the extent of recovery after the flight video (flight video–recovery). We then used these reactivity scores in multiple regression analyses to predict the increase in SUD values from the neutral-video to the flight-video condition and the decrease in SUD values from the flight-video to the recovery condition, after correcting for age and sex. Anxiety sensitivity measures and the product of anxiety sensitivity with the change scores for RSA, PEP, and HR were added to the regression models to test for an interaction between anxiety sensitivity and physiological reactivity. All independent variables were centered to eliminate multicollinearity problems.

Results

Sociodemographic characteristics: phobics and controls

Table 1 shows the sociodemographic characteristics for the group of phobic clients and the control group. Neither group differed significantly on sociodemographic characteristics, but control subjects had made significantly more flights than phobic subjects.

As shown in Table 2, scores on the VAFAS scale and all FAS and FAM (sub-) scales for both groups were reasonably in line with the established norms for these questionnaires [47]. Controls had slightly lower scores than reported for a sample of 1012 nonphobic healthy controls, but the flying phobics had almost the same means and standard deviations as reported for subjects with aviophobia [47]. Significant group differences were found in the expected direction for the VAFAS and all FAS/FAM subscales. Eta square (η^2),

Table 1
Number of participants, sociodemographic characteristics, and flight experience for the group of phobic clients and the control group

	Controls	Phobic clients
Number of participants		
Total	36	127
Men	17 (47.2%)	57 (44.9%)
Women	19 (52.8%)	70 (55.1%)
Age (years)		
Total	43.4 (13.5)	40.5 (11.0)
Men	44.5 (12.7)	42.3 (9.8)
Women	42.4 (14.4)	39.0 (11.7)
Health		
Body mass index (kg/m^2)	23.3 (2.3)	3.4 (2.5)
Sports hours per week	24.3 (3.3)	2.6 (2.4)
Education		
Basic	1 (3%)	5 (4%)
Low	8 (22%)	39 (31%)
Medium	10 (28%)	13 (10%)
High	17 (47%)	69 (54%)
Employment		
Self-employed	7 (20%)	26 (21%)
Paid employment	22 (61%)	86 (68%)
School/study	3 (8%)	2 (2%)
Without paid work	4 (11%)	12 (9%)
Flight experience		
Never flown	0	7 (5.6%)
Flew within previous year	27 (75%)	33 (26.0%)*
Average number of flights	68.9 (91.8)	21.6 (33.0)*

Values are shown as mean (S.D. or %).

* Phobics differ from controls at P<.001 (two tailed).

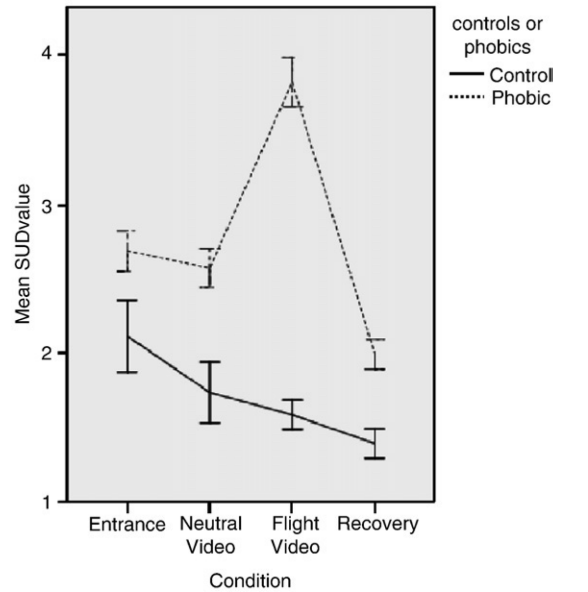

Fig. 1. Mean subjective distress for flight phobics and control subjects at entrance and in response to the three experimental conditions. Error bars represent 1 S.E.M.

being the effect size statistic for one-way ANOVA, showed a large effect for all measures. By convention, η^2 values of .01, .06, and .14 are interpreted as small-, medium-, and large effect sizes, respectively.

Self-report data: phobics and controls

A significant group-by-condition interaction was found for self-reported distress [F(3, 355)=7.74, P<.001], together with a main effect of group [F(1, 496)=49.83, P<.001]. In Fig. 1, it can be seen that the phobics had higher levels of fear throughout and that the interaction with condition was driven by a selective increase in SUDs in the phobic group during the flight video (η^2=.43). A significant main effect of sex was found with female subjects (mean SUD 2.77) reporting higher levels of fear than male subjects (mean SUD 2.28) [F(1, 596)=5.04, P<.05], but sex did not interact with group or condition.

Table 2
Measures of flight-related anxiety and somatic complaints for flight phobics and control subjects

	Controls (n=36)		Phobic clients (n=127)		Effect size (η^2)
	Mean	S.D.	Mean	S.D.	
FAS					
Anticipatory anxiety	12.5	1.8	41.9*	10.2	.65
In-flight anxiety	12.2	2.8	35.4*	9.6	.56
Generalized flight anxiety	7.11	.47	12.7*	4.7	.24
Sum score	35.1	5.2	100.0*	21.8	.66
FAM					
Somatic complaints	11.7	1.2	26.0*	9.1	.36
Cognitive complaints	8.1	1.9	23.1*	7.3	.49
VAFAS	.56	.74	7.8*	1.4	.86

* Phobics differ from controls at P<.001 (two tailed).

Physiological data: phobics and controls

In contrast to the substantial group-by-condition effect in subjective responses, no significant group-by-condition interactions were found in any of the three physiological variables. In fact, there was no significant main effect of condition in either group. Significant main group effects did emerge for overall RSA and PEP levels. Phobic subjects had significantly shorter PEP values than controls, indicating higher cardiac sympathetic control [F(1, 377)=9.85, P<.01], and significantly longer RSA values, indicating higher parasympathetic control [F(1, 326)=5.04, P<.05]. Average HR for the phobic subjects was not significantly higher than that of controls in all conditions. Table 3 shows the average HR, RSA, and PEP for the three conditions, together with the average level across all conditions in both groups.

Correlations between SUD reactivity and physiological reactivity

Although the average physiological reactivity from the neutral video to the flight video was close to zero, inspection of the distribution of the reactivity scores showed striking individual differences as illustrated for RSA and HR reactivity to the flight video in Fig. 2. In response to the

Table 3
Mean and S.D. of the three physiological variables, HR, RSA, and PEP, for flight phobics and controls during the three experimental conditions

	Variable					
	HR		RSA		PEP	
Condition	Mean	S.D.	Mean	S.D.	Mean	S.D.
Neutral video						
Control	69.2	9.8	37.6	27.2	116.3	16.6
Phobics	71.6	11.8	49.9	31.0	112.7	19.8
Flight video						
Controls	69.1	9.5	42.3	22.0	124.6	16.8
Phobics	71.4	11.1	48.7	25.9	114.5	21.2
Recovery						
Control	69.4	9.4	42.9	21.4	124.2	17.6
Phobics	72.3	10.8	48.3	26.1	113.3	21.6
Overall						
Controls	69.2	9.4	41.0	21.9	121.4	17.2
Phobics	71.7	11.2	49.0*	26.6	113.4**	20.8

Phobics differ from controls at $^*P<.05$ and $^{**}P<.01$ (two tailed).

phobic stressor, some subjects showed the expected decreases in parasympathetic activity, whereas others showed an unexpected *increase* in RSA. These individual differences were most pronounced in the phobic group.

In the phobic group, the changes in HR and RSA were significantly correlated to the increase in SUD values from the presentation of the neutral video to the flight video such that increased fear was accompanied by a parallel increase in HR (r=.208, P=.022) and a decrease in RSA (r=−.199, P=.028). This modest coupling was lost during recovery, however, and no significant correlation was found between the decrease in anxiety from the flight video to the recovery period and the parallel changes in HR, RSA, or PEP during this same time interval. Control subjects showed no correlations at all between the SUD reactivity and physiological reactivity scores.

Regression analysis

Multiple regression analyses were performed to test the hypothesis that phobics who score high on anxiety sensitivity in combination with a heightened physiological reaction to flight stressors show a concordant higher increase in self-reported anxiety when confronted with these stressors. For the operationalization of AS, we used both the total score on the ASI and the physical concern subscale, thereby maximizing the possibility to find a relationship between changes in self-reported distress and a physiological marker of anxiety. Because only neutral to flight reactivity was significantly associated with SUDs, we proceeded with the regression analyses limited to this reactivity only.

Physiological reactivity, anxiety sensitivity, and their interaction did not significantly predict the increase in self-reported anxiety from the neutral to the flight video for the phobic subjects, although the interaction of the ASI physical concern subscale with PEP reactivity nearly reached significance (r=−.21, P<.07). Overall, flight phobics who

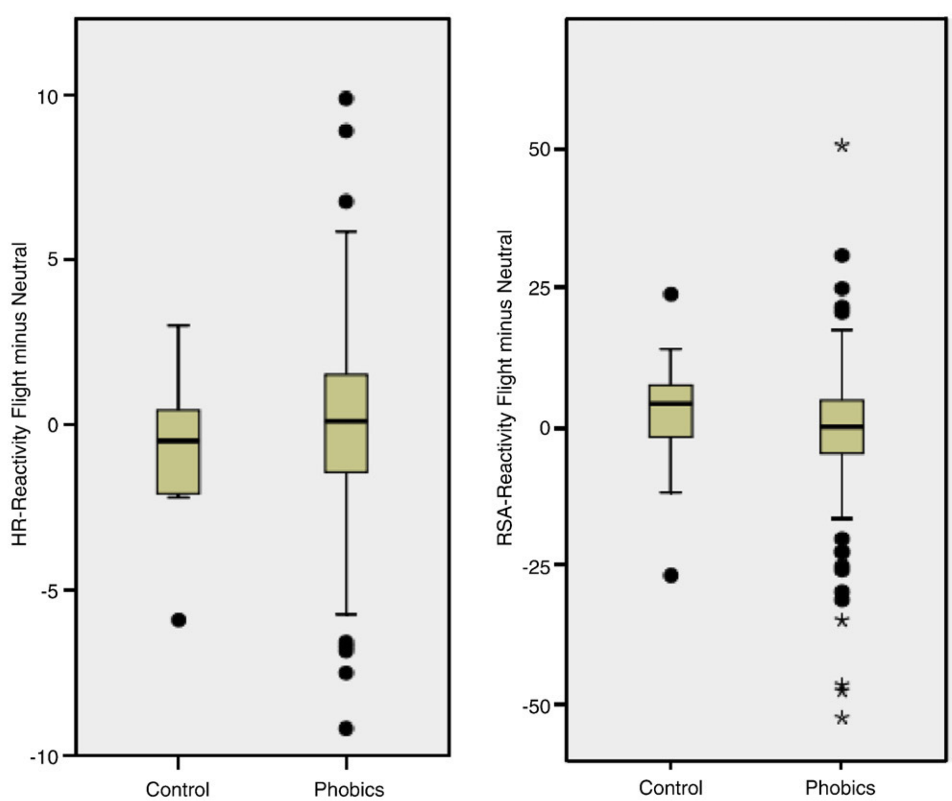

Fig. 2. Box plots of HR and RSA reactivity to the flight video for flight phobics and control subjects.

are afraid of anxiety-related bodily sensations did not report more distress than phobics who score low on this trait, even when they show stronger physiological responses.

Discussion

This study examined the effects of flight-related stimuli in a relatively large sample of aviophobics and a control group without fear of flying. Both subjective measures of anxiety and cardiac autonomic responses were recorded. Results indicate that strong subjective fear responses in flight phobics may be induced by exposure to flight-related stimuli without the typical increase in sympathetic and decrease in parasympathetic activity seen during the classical 'fight–flight' response. However, the patterning of cardiac parasympathetic reactivity did predict increases in distress during the flight video. Specifically, phobics with the lowest increase in subjective distress were characterized by an increase in RSA and a decrease in HR, whereas the phobics with the highest increase in subjective distress showed a decrease in RSA and an increase in HR. These findings add to the many studies which have shown that the relationship between self-reported feeling of anxiety and physiological reactivity to stressors is complex [11–21,35,52,53].

The strong variation in the direction of cardiac parasympathetic reactivity, shown in Fig. 2, is intriguing and could reflect more than just a random fluctuation against a mean reactivity of zero. Indeed, our RSA data are strongly reminiscent of similar data in dental phobics presented by Bosch et al. [54,55], who found that exposure to a video with dental surgery invoked an average increase in RSA rather than a decrease, with large individual differences in the direction and the magnitude of the RSA response found there, too. Increased parasympathetic activity was seen in blood phobics as well [56], although the effect was relatively minor [57]. We suggest that exposure to phobic stimuli is a complex stressor in that it can invoke both fight–flight responses, characterized by increased sympathetic and reciprocal decreased parasympathetic activity, and a passive coping response (freeze), characterized by increased sympathetic activity paired to *increased* parasympathetic activity.

Taken together, these findings do not confirm the usual prediction made from the physiological perspective in which the subjective fear response is thought to reflect feedback from the increased fight–flight responses generated by fear circuits in the brain (hippocampus–amygdala–hypothalamus). Only 4% of the increased fear during the flight video was explained by a physiological factor. At the same time, our results also do not unequivocally support the psychological perspective which argues that, during exposure to phobic stimuli, the ongoing physiological signals get more attention and are overinterpreted as danger signals [12,33,58–61]. Specifically, we could not confirm the hypothesized effects of anxiety sensitivity that are part of the psychological perspective. Flight phobics who are afraid of anxiety-related bodily sensations (high ASI-total and high ASI-physical concern) did not report a stronger increase of distress than phobics who score low on this trait, even when they showed the typical fight–flight response.

Averaged across all experimental conditions, i.e., even during neutral and recovery periods, phobics as a group reported increased anxiety levels compared to controls, which was coupled to lower baseline levels of PEP and higher RSA. This pattern of increased sympathetic activity paired to increased parasympathetic activity may be evoked by the sheer anticipation of exposure to phobic stimuli, while recovery from this effect seems to be delayed. A potential explanation for the increased (anticipatory) anxiety, which honors both physiological and psychological contributions, might be found in a larger interoceptive awareness at baseline in phobics than in controls. Generally, interoceptive awareness, for instance, operationalized as heart beat perception, is not very accurate [62] and most people underestimate their HR [63,64]. Accurate perception is, however, slightly more prevalent among panic disorder patients, and people with accurate perception have higher anxiety sensitivity scores [62]. This may be related to the specific pattern of parasympathetic activation and sympathetic co-activation evident in baseline PEP and RSA of the phobics, which may result in a more forceful contraction of the heart which is known to increase the ease of heart beat perception [62,65,66].

A major limitation of this study is the low ecological validity of the stimuli used. The video stimulation may simply not have elicited sufficient emotional reactions. In other studies with generalized anxiety disorder patients, aviophobics, and dental phobic patients, the uses of video scenes to evoke psychophysiological reactions have been proven to be effective [11,14,16,67–73], but Bornas et al. [36] who used pictures instead of videos report that the addition of sound might be crucial to elicit proper physiological reactions. They found different reactions to pictures with and without sound within subsamples of flying phobics and nonphobics. Here, we used an exposure video composed of a flight safety demonstration with sound followed by three video shots of a landing airplane without a corresponding sound and this may have attenuated physiological reactivity. Future research could benefit from stimuli that resemble the feared object better.

In conclusion, we find that subjective fear responses and autonomic responses are only loosely coupled during mildly threatening exposure to flight-related materials. A relatively large discrepancy was found in subjective distress during exposure to flight-related stimuli between phobics and controls, whereas the physiological responses of both groups were indiscriminate, which argues in favor of the psychological perspective. In keeping with the physiological perspective, however, we find that, within the group of phobics, increases in subjective fear during exposure are moderately strongly coupled to HR and cardiac vagal reactivity. More ecologically valid exposure to phobic materials may be needed to more robustly test the predictions from the physiological and psychological perspectives.

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