Subjective and physiological reactivity to flight in people with fear of flying

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Chapter 6

Psychological distress and physiological reactivity during in vivo exposure in people with aviophobia

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ABSTRACT

Objective: Exposure is regarded to be a crucial component of therapies for phobias. According to Emotional Processing Theory (EPT), the success of exposure therapy is predicted by activation of subjective and physiological fear responses and their within-session habituation and between-session adaptation. This study tested this prediction for aviophobia.

Methods: Seventy-nine participants following a highly standardised treatment program for aviophobia provided self-reported and physiological (heart rate, respiratory sinus arrhythmia and pre-ejection period) measurements of fear activation, within-session habituation and between-session adaptation during exposure to flight-related stimuli, a flight simulator, and during two real flights. Multiple regression analyses were conducted to examine whether these measurements predicted therapy outcome up to 3 years after finishing therapy, including number of flights flown in this period.

Results: Both subjective and physiological arousal measurements indicated strong fear activation and large within-session habituation and between-session adaptation during exposure. Flight-anxiety measures showed large improvements up to three years after treatment (η^2 between .72 - .91). Lower self-reported anxiety during flight exposure was associated with lower flight-anxiety after exposure (R^2 = .15) and more flights flown (R^2 = .14). Within-flight habituation or between-session adaptation of self-reported anxiety had no relationship with treatment outcome. Within-flight habituation of HR reactivity (R^2 = .10) and respiratory sinus arrhythmia reactivity (R^2 = .11) was associated with lower flight-anxiety directly after the flight, but not on flight-anxiety three years after finishing therapy or on long-term flying behaviour.

Conclusions: The results provide only weak support for Emotional Processing Theory. Low self-reported anxiety during in-vivo flight exposure was the best predictor of successful long-term therapy outcome.

INTRODUCTION

A third of the general population in the western world has trouble flying without worries, and again one third of this group does not fly at all (1, 2). Yet only a few of all those people face their fear and start therapy. Although highly efficacious on the short term (3), little is known about therapy effectiveness in the long run. Fear of Flying (FOF) is a heterogeneous phenomenon and often includes, or is a combination of, acrophobia, claustrophobia, fear of losing control, fear of a crash, and panic and social phobias. Although classified as a specific phobia, also known as simple phobia, fear of flying is far from simple in view of the heterogeneous and compound nature of this phobia. This is mirrored in the divergent outcomes of the studies on this subject (1, 2, 4-6). Especially the physiological reactivity to flight-stressors is complex (7-17). Therapy often tackles the multitude of underlying phenomena with a combination of providing information, cognitive restructuring, relaxation training and graded exposure (2, 3). The latter exposure is often regarded as the crucial component of therapies for phobias and other anxiety disorders. According to emotional processing theory (EPT), exposure to the feared stimulus activates the fear network, and activation of this fear network is seen as a necessary condition for improvement (18). The concept of a fear network stems originally from Lang (19) and Rachman (20). "Fear structures" within the fear network comprise of a "network" of stimulus (e.g. turbulence), response (e.g. racing heart) and meaning (e.g. we will crash, I will die) components. Activating any part of the fear structure (e.g. a racing heart) will generalize to activate other parts of the structure (18, 19, 21, 22). Emotional processing involves incorporating new information into an existing fear structure, allowing for both a decrease and an increase in the emotional response. Integration of new information that is incompatible with the existing fear structure will reduce fear by replacing (18) or competing with (23) the original fear structure.

According to EPT, successful emotional processing is indicated by within-session habituation of fear responses, reflected in reduced subjective anxiety and physiological arousal during exposure. Although ample evidence exists for beneficial effects of treatment on within-session habituation, there is only scant evidence to suggest that this within-session habituation translates into long-term treatment outcome (22, 24). Beneficial effects of treatment on the adaptation of subjective anxiety and physiological arousal across multiple exposures are the second indication of successful emotional processing expected by EPT. This between-session adaptation is believed to involve higher levels of cognitive operations and long-term habituation (or extinction, but to avoid confusion we conform to the EPT convention and use habituation throughout

the paper) by means of evaluative learning (21, 24). Most studies on different phobic behaviors find support for a positive relationship between between-session adaptation and long-term treatment outcome (for an overview see 22). However, some report little (21) or no predictive value of between-session adaptation for treatment outcome (25). To our knowledge no research on the relationship of between-session adaptation and outcome has been published within the framework of fear of flying.

In this study we report on both subjective and physiological reactivity in individuals with fear of flying to flight-related stimuli and to real-flight. A large sample of aviophobics who applied for therapy was followed up from diagnostic assessment up to three years after finishing therapy to examine how their fear of flying and actual long-term flight behavior were affected by treatment. We first assessed fear activation as the increase in self-reported anxiety and physiological arousal during exposure to flight-anxiety inducing videos, a flight simulator and two real flights. Secondly, we assessed whether within-session habituation and between-session adaptation of self-reported anxiety and physiological arousal predicted the short and long-term effects of exposure therapy. Flight anxiety scores taken directly after two exposure flights were used as an indication for short-term effect. Flight anxiety three years after finishing therapy, and the number of flights taken in this three-year period were used as an indication of long-term effects. We predicted better therapy outcome (less flight anxiety, more flights) for participants with a more pronounced activation of the fear network during exposure, with a higher within-session habituation during exposure and a larger between-session adaptation. Furthermore, we expected that the prediction of therapy outcome would be improved by adding measurements of physiological reactivity to self-report of anxiety.

METHODS AND MATERIALS

Participants

The 79 participants (37 men) with an average age of 40.4 (S.D. = 11.0, range from 20 to 61 years) in this study were aviophobics, who participated in a cognitive-behavioral group treatment (CBGT) to overcome their fear of flying. Most participants were self-referrals. Health care agencies, health care professionals and company health programs referred a minority of participants. Airline personnel were excluded from this study. Other reasons for exclusion were current use of cardioactive medication like β blockers, pharmacotherapeutic medication and a concurrent panic disorder of such severity according to the treating psychotherapist that it would seriously interfere with the

treatment of fear of flying. Inclusion criteria were a good understanding of the Dutch language and no flight scheduled before end of the CBGT. Written informed consent was obtained from all participants before the start of the diagnostic process. The Leiden University Medical Center medical ethics committee approved the research protocol.

Therapeutic procedure

Participants in this study followed a highly standardized treatment program for fear of flying at the VALK foundation in The Netherlands, as described in detail elsewhere (6). Briefly, the fear of flying program starts with a diagnostic assessment, followed by individual therapeutic sessions covering relaxation and breathing techniques, psychological factors involved in fear and anxiety, and coping skills. Claustrophobia, acrophobia, traumatic transportation accidents and traumatic social events were addressed if applicable. Participants started a two-day cognitive-behavioral group treatment (CBGT) within 5 weeks from diagnostic assessment. The first day of group treatment offered technical information on flying and psycho-education. The second day of CBGT started with cognitive training. The afternoon focused on exposure and included in vivo exposure to two simulated flights in a full motion cabin flight simulator normally used for cabin crew flight safety training and two real flights on a commercial airliner.

Data Collection Procedure

Before the start of the diagnostic assessment, before each individual therapeutic session, and at the beginning of both days of CBGT, an ambulatory monitoring device was attached to record changes in physiological arousal. During all visits to the VALK facility, and the first day of CBGT, subjects were regularly exposed to an anxiety inducing flight video. The flight video was preceded by a neutral video. Different videos, each lasting six minutes, were used on each repetition. Video exposure moments were before the start of the diagnostic phase, at the end of each individual session and three times during the first day of CBGT. Subjective units of distress (SUD) were measured directly after neutral and flight video presentations. On the second day of CBGT, SUD's were collected midway in the morning program (shortly before the start of the in-vivo exposure), directly after both simulator flights and during both flights directly after doors closed, during cruise flight and after landing before doors open. The day after the exposure flights, data was analysed off-line. The ambulatory monitoring device has an event marker and a built-in vertical accelerometer. Both the therapist and the accompanying pilot kept a detailed log during both flights. All these resources were used to select movement-free and artefact-free periods that lasted at least 5 minutes each around the times the SUDs were collected. Physiological reactivity scores were computed based on these 5-minute periods

to ensure the temporal overlap of the subjective and physiological measurements of fear activation. After disembarkation, participants filled out questionnaires on flight phobia. Thereafter, the ambulatory recording device and electrodes were removed. Post-treatment flight anxiety data were collected at three months and one year after CBGT. Participants furnished long-term effects of therapy by providing a flight anxiety score three years after therapy, and the number of flights flown within these three years. Data collection was from October 2006 to October 2010. The entire timeline for the data collection, therapeutic and follow-up procedure is captured in figure 1.

Physiological recordings

Heart Rate (HR), Respiratory Sinus Arrhythmia (RSA) and the Pre-Ejection Period (PEP) were recorded using the VU-AMS (version 4.6, Vrije Universiteit Amsterdam, The Netherlands; www.vu-ams.nl). The VU-AMS is a lightweight ambulatory device that unobtrusively records the electrocardiogram (ECG) and impedance cardiogram (ICG) continuously by means of six Ag-AgCl electrodes attached to the torso region (26, 27). Subjects habituate easily to the device while maintaining full freedom of motion. The apparatus has an event marker and a built-in vertical accelerometer, which output can be used to select movement free periods for analysis. RSA is a measure of parasympathetic control (28), whereas PEP is considered a measure of sympathetic cardiac control (29). Scoring of these variables was automatic, followed by visual inspection of the impedance and respiratory signal from the entire recording. Details on scoring of these variables, recording methodology, reliability and validity are described elsewhere (30, 31). 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 opening of the aortic valves (27, 29). RSA was obtained from the ECG and thorax impedance derived respiration signals by subtracting the shortest interbeat interval during HR acceleration in the inspirational phase from the longest interbeat interval during deceleration in the expirational phase (i.e. the peak-through method) (32). When no phase-related acceleration or deceleration was found, the breath was assigned a RSA score of zero. Fear responses are characterized by increases in HR, shortening of the PEP and decrease in RSA.

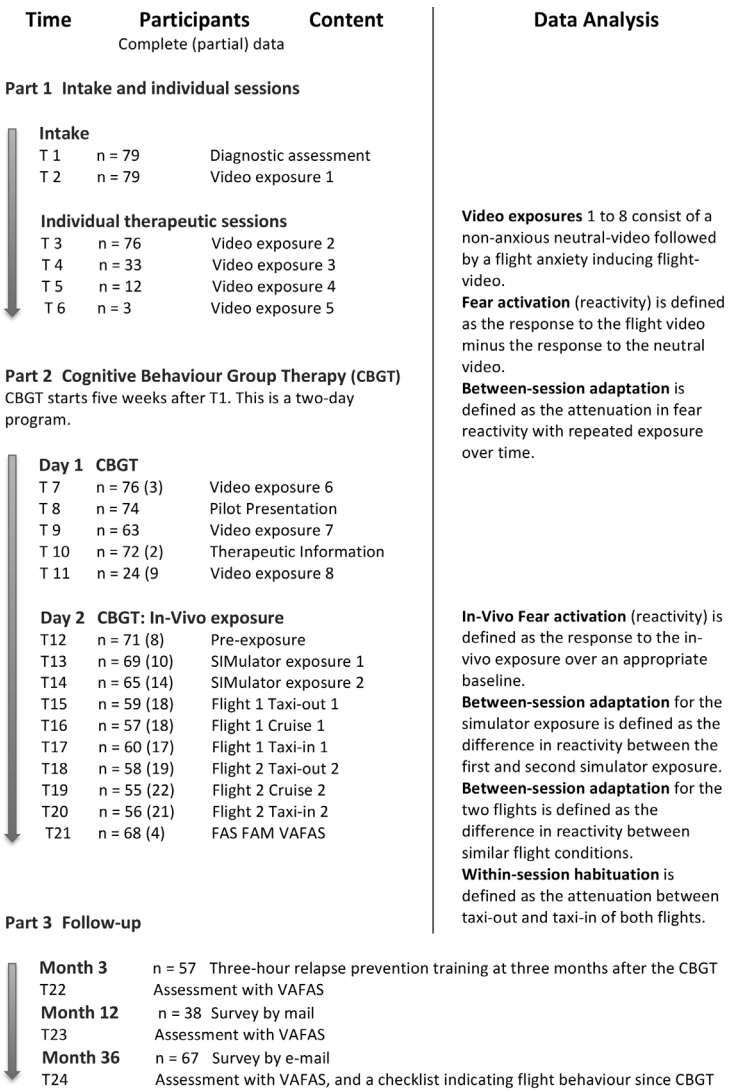

Figure 1. Schematic representation of the data collection and therapeutic and follow-up procedures with information on data loss and data analysis. Data analysis conveys definitions of reactivity scores for video exposure and for in-vivo exposure. Data loss indicates the number of participants furnishing complete data at these moments. Between brackets is the number of participants furnishing incomplete data. Mainly one or more electrodes not recording properly caused data loss during in-vivo exposure. FAS = Flight Anxiety Situations questionnaire, FAM = Flight Anxiety Modality questionnaire, VAFAS = Visual Analogue Flight Anxiety Scale, CBGT = Cognitive Behavioral Group Therapy.

QUESTIONNAIRES

VAFAS

The single-item one-tailed Visual Analogue Flight Anxiety Scale (VAFAS) was used to examine to what extent participants were anxious about flying. The scale ranges from 0 ("No flight anxiety") to 10 ("Terrified or extreme flight anxiety") (33).

SUD

The Subjective Units of Distress (SUD) scale was used to examine to what extent participants were feeling anxious at several moments. Participants had to indicate their perceived anxiety on a one-tailed scale from 1 ("totally relaxed") to 10 ("extremely anxious") (34).

FAS

The Flight Anxiety Situations (FAS) questionnaire assesses anxiety related to flying experienced in different flight or flight related situations. The 32-item self-report inventory uses five point Likert-type scales. The FAS consists of three subscales: (a) an Anticipatory Flight Anxiety Scale, assessing anxiety experienced when anticipating a flight, (b) an In-Flight Anxiety Scale, measuring anxiety experienced during a flight and (c) a Generalized Flight Anxiety Scale, assessing anxiety experienced in connection with airplanes in general (33, 35). The internal consistency of the subscales of the FAS in the present study was good to excellent, Cronbach's Alpha ranging from .77 to .95.

FAM

The Flight Anxiety Modality (FAM) questionnaire is an 18 item self-report inventory that was used to assess the symptoms by which flying related anxiety was expressed. Each symptom is rated on a 5-point Likert-type scale. The FAM 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 (33, 35). The internal consistency of the two subscales of the FAM in the present study was good to excellent, Cronbach's Alpha ranging from .74 to .91.

Fear activation, within-session habituation and between-session adaptation

To quantify individual differences in fear activation during exposure to the phobic stimuli we used the changes in subjective distress scores and physiological arousal over an appropriate baseline in a sitting posture. For the video exposure, reactivity scores for each of the three physiological variables (HR, RSA and PEP) and the SUD variable were

created that reflected the response to the flight video compared to the neutral video. The baseline used to compute fear activation for the pre in-vivo exposure period, for both simulated flights and both exposure flights during the second day of CBGT, consisted of the average of all non-fearful conditions during the morning program of the first day of CBGT. Baseline for SUD was defined as the average SUD value reported halfway through the morning program in combination with the SUDs reported directly after the first and second neutral video presentations. For the three physiological variables baseline was the average of the morning program of the first day of CBGT excluding the flight videos, so encompassing both neutral videos and the pilot presentation. In support of the averaging steps, ANOVA showed no significant differences in SUD, HR, PEP or RSA across these separate conditions constituting the baseline (data not presented, but available on request).

Within-session habituation scores were created for the two flights separately by subtracting the reactivity at the end of the flight (Taxi-In) from the reactivity at the start of the flight (Taxi-Out). For the SUD this reflects the decrease in subjective distress in the course of a flight. For HR, RSA and PEP this reflects the decrease in physiological arousal in the course of a flight.

Between-session adaptation for the video stimuli was operationalized as the attenuation in reactivity with repeated exposure over time. Between-session adaptation for the simulator was obtained by subtracting reactivity from the second simulated flight from reactivity to the first simulated flight. Likewise, for real flight between-session adaptation scores were created for taxi-out, cruise, taxi-in by subtracting reactivity to the second flight from reactivity to the first flight. For instance, for subjective distress at taxi-out, between-session adaptation reflects the decrease in SUD reactivity from taxiing-out during the first to taxiing-out during the second flight. Figure 1 provides a schematic representation of fear activation, within-session habituation and between-session adaptation.

Therapy outcome

Short-term effect of therapy outcome was operationalized as the flight anxiety score taken just after both exposure flights (VAFAS post-flight). Long-term effect of therapy outcome was operationalized as the flight anxiety scores three years after treatment, and number of flights taken in this three-year period.

Missing data

Participants in this study were not a homogeneous group. Several participants had never flown before. Some had made more than 25 return flights before onset of their phobia. While most participants needed only one or two sessions, three participants did not require any preparatory sessions before start of the CBGT. Twelve participated in the third individual therapeutic session, and just three participants needed all four therapeutic sessions. The low number of participants during the third and fourth individual therapeutic session severely restricted meaningful conclusions on the video responses during these sessions. We therefore excluded these sessions from the analyses of the video responses. Missing data analysis showed no systematic differences in the video responses to the first two sessions for participants who participated in more than two individual sessions and participants who attended two or fewer individual therapeutic sessions. Because of scheduling conflicts, a few participants were unable to attend to video presentations during the first or second individual sessions. Because of time constraints not all participants viewed the third video presentation at the end of the first day of CBGT. This led to the adoption of MIXED ANOVA RM as the main analysis strategy as it handles missing cells in repeated measures data without removing subjects.

One flight was cancelled due to adverse weather, resulting in the loss of flight-data of two participants. All other participants furnished subjective data during both days of CBGT, including both flights. Physiological data of two participants was lost due to equipment failure during flight. The security checks at the airports were a major challenge for the physiological measurements. The electrodes of the ambulatory measurement device required a physical patting down of all participants, after security screening 19% of the recording devices did not record one or more variables properly during one or both flights. In total, 55 participants provided uncorrupted physiological data at all flight phases, while another 20 participants furnished partially usable physiological data. Figure 1 depicts loss of data at the different times.

Long-term effect of therapy outcome was operationalized as the flight anxiety scores three months, one year and three years after treatment, and number of flights taken in this three-year period. However, only 57 out of 79 participants attended the follow-up session three months after CBGT, and a mere 38 participants returned written questionnaires one year after therapy. Response rate (n=67) three years after CBGT was considerably higher when we used email for data collection. Consequently, analysis of long-term effect of therapy was restricted to the three-year follow-up data from these 67 participants. Missing data analysis on all physiological data and all questionnaire data

available revealed no systematic differences between completers and the participants lost to follow-up.

Data Analysis

RSA and Number of Flights Flown within three years of end of therapy were log (Ln) transformed to obtain normal distributions. Video reactivity was analyzed by means of MIXED ANOVA repeated measures analyses, with time of assessment (time) and condition (neutral video or flight video) as fixed repeated measures factors. Fear activation is reflected in the significance of the condition main effect. Between-session adaptation is reflected in significance of the interaction of time with condition. Repeated measures MIXED ANOVA with condition (baseline, sim1, sim2, flight1 taxi-out, flight1 cruise, flight1 taxi-in, flight2 taxi-out, flight2 cruise, flight2 taxi-in) were used to analyse the in-vivo reactivity during the second day of CBGT. Omnibus significance of the condition effect was followed by post-hoc inspection of reactivity to the individual conditions (i.e. the difference between exposures and the baseline) to test fear activation in these conditions. Between-session adaptation was tested by planned contrasts of the reactivity to both simulator flights (T13-T14) and reactivity to similar conditions during both real flights (T15-T18, T16-T19, T17-T20). Within-session habituation was tested by comparing reactivity to taxi-out and taxi-in during both flights (T15-T17 and T18-T20). The significance level was set at .01.

Multiple regression analyses were used to assess whether fear activation, within-session habituation and between-session adaptation of self-reported anxiety and physiological arousal predicted the short and long-term effects of exposure therapy. Predictor variables were the reactivity scores reflecting fear activation, and the contrasts between reactivity scores reflecting within-session habituation and between-session adaptation as outlined previously. Outcome variables were the short-term and long-term effects on fear of flying and actual flight behaviour. Reactivity, habituation and adaptation scores with a zero-order correlation with $p \leq .01$ were included into the regression equations. Such full models are in agreement with the Journals guidelines. Although the use of full models avoids selection bias, these models are often large and complicated (36). In view of the large number of predictive variables, and to safeguard against overfitting and underfitting, in a secondary analysis redundant predictors were removed by means of bidirectional elimination based on maximizing the adjusted R-Square, that is, mainly removing items with a high mutual correlation and low semi-partial correlation (36-40). As nearly identical results were obtained compared to the full model, we report on the latter analysis only.

RESULTS

Clinical characteristics

On average participants received 1.7 (S.D. = .9) individual therapeutic sessions between the diagnostic assessment and start of the CBGT. Three participants did not require any preparatory sessions before start of the CBGT while only three participants needed all four therapeutic sessions. Table 1 depicts FAS and FAM scores at assessment and post-flight. Eta square (η^2), the effect size statistic for repeated measures ANOVA, showed a large effect for all measures. All values were in line with the established range for these questionnaires (33, 41).

Table 1. Measures of flight-related anxiety at assessment (n = 79) and post-flight (n = 72)

	Assessment score		Post-flight score		
	Mean	SD	Mean	SD	Effect size η^2
FAS					
Anticipatory anxiety	43.4	8.8	24.6	13.9	.60
In-flight anxiety	37.4	8.1	19.4	7.2	.82
Generalized flight anxiety	13.1	4.6	9.1	2.5	.46
Sum score	104.4	18.3	58.9	20.8	.79
FAM					
Somatic complaints	25.8	8.9	15.7	4.4	.65
Cognitive complaints	24.4	7.4	11.7	5.0	.75

Post-flight scores differ from assessment scores at $p < .001$
FAS = Flight Anxiety Situations Questionnaire, FAM = Flight Anxiety Modality Questionnaire, SD = Standard Deviation, η^2 = Eta square, the effect size statistic for repeated measures ANOVA.

Video exposure

Fear activation

Table 2 shows values for SUD and all three physiological variables at the different times of assessment. For the SUD variable a significant condition effect (neutral – flight) was found [$F(1, 88.9) = 94.2$, $p < .001$, mean difference 1.1, 95% confidence interval 1.3 - 0.88]. Post-hoc analyses of the condition effect revealed that participants reported significantly more distress to a flight video than to a neutral video at all measurement moments. Of

the physiological variables only RSA showed a significant condition effect [F(1, 134.6) = 4.1, p = .004, mean difference .054, 95% confidence interval 0.02 - 0.09]. Five of six times participants had significant shorter RSA values (less parasympathetic control) during the flight video compared to the neutral video.

Between-session adaptation

For the SUD variable a significant time-by-condition interaction [F(5, 58.8) = 3.5, p = .008] was found that was caused entirely by a peak response to the first video exposure at the diagnostic assessment (T2), as can be seen in figure 2. RSA showed no significant time-by-condition interaction effect [F(5, 128.7) = 2.5, p = .034]. Because HR and PEP reactivity to the flight videos were non-significant, no between-session adaptation analyses were performed.

Table 2. Mean (SD) of SUD, HR, RSA and PEP during neutral- and flight-video presentations.

Type of Video	SUD	HR(bpm)	RSA(msec)	PEP(msec)
Neutral Video T2	2.6 (1.4)	72.0 (11.7)	51.3 (33.7)	93.0 (16.0)
Flight Video T2	4.0 (1.8)	71.9 (10.2)	48.3 (27.0)	93.5 (16.6)
Neutral Video T3	2.2 (1.3)	67.8 (11.6)	48.3 (30.5)	108.7 (22.4)
Flight Video T3	3.3 (1.6)	68.1 (10.6)	48.5 (27.5)	110.7 (22.5)
Neutral Video T4	2.1 (1.0)	70.4 (9.4)	43.2 (21.9)	96.5 (19.1)
Flight Video T4	3.4 (1.7)	70.3 (8.8)	39.8 (21.5)	95.7 (21.7)
Neutral Video T7	2.6 (1.5)	74.4 (12.1)	43.5 (31.9)	101.3 (21.0)
Flight Video T7	3.5 (1.6)	74.3 (11.7)	43.3 (27.8)	101.6 (21.5)
Neutral Video T9	2.1 (1.0)	73.2 (10.8)	48.6 (34.8)	97.3 (17.2)
Flight Video T9	2.9 (1.4)	74.9 (10.1)	41.6 (26.8)	97.9 (18.5)
Neutral Video T11	2.2 (1.1)	64.6 (8.4)	53.0 (25.2)	108.4 (21.6)
Flight Video T11	2.9 (1.6)	66.0 (9.1)	52.8 (27.5)	107.8 (22.6)

SUD = Subjective Units of Distress, HR = Heart Rate, RSA = Respiratory Sinus Arrhythmia,
PEP = Pre-Ejection Period. T2 = before diagnostic assessment (n = 79),
T3 = after individual therapeutic session 1 (n = 76), T4 = after individual therapeutic session 2 (n = 33),
T7 = first video before Cognitive Behavioral Group Therapy (CBGT) day 1 (n = 76),
T9 = second video midway CBGT day 1 (n = 63), T11 = third video after CBGT day 1 (n = 24).

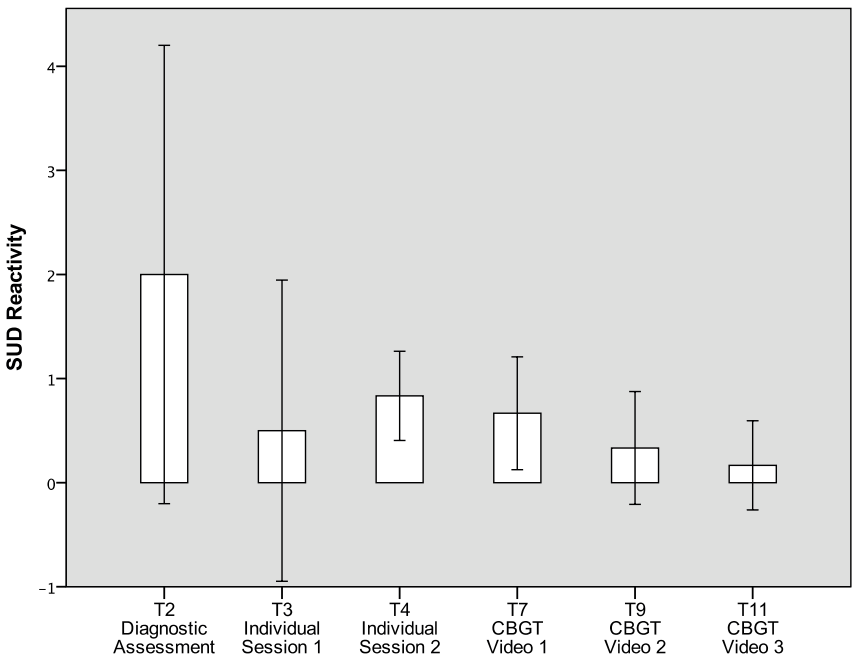

Figure 2. SUD video-reactivity before diagnostic assessment (T2 n = 79), after the first two individual therapeutic sessions (T3 n = 76, T4 n = 33) and at the first day of Cognitive Behavioral Group Therapy; T7 = first video before CBGT day 1 (n = 79), T9 = second video midway CBGT day 1 (n = 63), T11 = third video after CBGT day 1 (n = 33). Error Bars reflect 95% CI. SUD = Subjective Units of Distress, CBGT = Cognitive Behavioral Group Therapy.

Simulated flight and actual flight exposure

Fear activation

Table 3 shows absolute levels of the four variables during the baseline, pre-exposure and all eight exposure moments. MIXED ANOVA showed a significant effect of condition for SUD [$F(9, 179) = 29.0$, $p < .001$], HR [$F(9, 125.9) = 56.2$, $p < .001$], RSA [$F(9, 143.3) = 13.6$, $p < .001$] and PEP [$F(9, 86.5) = 5.3$, $p < .001$]. Post-hoc inspection showed significant fear activation for HR, RSA and PEP during each of the exposures (all $p \leq .001$). SUD reactivity showed significant fear activation for both simulator flights, taxi-out flight 1, cruise flight 1 (all $p \leq .001$) and taxi-out flight 2 ($p = .004$). As visualized in figure 3, subjective distress reactivity peaked at the first simulated flight and the beginning of both real flights but decreased from the first to the second simulated flight and during both real flights, even reaching significant ($p < .001$) lower levels than the baseline value at the

end of the second flight. In striking contrast to the flight related videos, the simulator and in-vivo exposure induced strong physiological reactivity. HR already responded to both simulated flights, but strongest responses were found during the beginning of both real flights. HR reactivity diminished during both flights, but remained 10-15 beats above baseline values throughout the entire day. Also RSA and PEP remained well below baseline during the entire day. Strongest parasympathetic and sympathetic reactivity were seen at the beginning of the first real flight.

Table 3. Mean (SD) of SUD, HR, RSA and PEP during the second day of cognitive behavioral group therapy prior to and during flight-related exposure.

	SUD	HR(bpm)	RSA(msec)	PEP(msec)
Baseline value	2.5 (1.2)	72.8 (10.0)	43.1 (26.0)	102.1 (20.2)
T12 Pre-exposure	3.2 (1.6)	78.8 (11.3)	38.9 (20.1)	96.1 (17.6)
T13 Simulator 1	4.3 (1.8)	86.9 (13.5)	32.3 (19.3)	91.5 (16.2)
T14 Simulator 2	3.0 (1.5)	86.7 (11.7)	34.5 (16.4)	91.5 (15.8)
T15 Taxi-out 1	4.0 (1.8)	98.4 (14.5)	27.9 (18.6)	87.6 (15.0)
T16 Cruise 1	3.5 (2.0)	91.1 (12.7)	33.7 (19.6)	91.4 (17.5)
T17 Taxi-in 1	2.3 (1.5)	88.2 (11.2)	32.1 (16.2)	90.8 (14.9)
T18 Taxi-out 2	3.0 (1.8)	91.5 (14.6)	30.7 (19.2)	90.0 (15.9)
T19 Cruise 2	2.5 (1.8)	87.6 (12.8)	33.7 (20.1)	91.2 (15.9)
T20 Taxi-in 2	1.6 (1.1)	84.3 (11.8)	33.7 (20.9)	92.9 (17.4)

N varies from 55 to 79. SUD = Subjective Units of Distress, HR = Heart Rate, RSA = Respiratory Sinus Arrhythmia, PEP = Pre-Ejection Period.

Between-session adaptation

Between-session adaptation from the first simulator flight (T13) to the second simulator flight (T14) was significant for SUD reactivity and RSA reactivity (all $p < .001$). During the real flights, all planned contrasts [taxi-out flight 1 (T15) versus taxi-out flight 2 (T18), cruise flight 1 (T16) versus cruise flight 2 (T19), taxi-in flight 1 (T17) versus taxi-in flight 2 (T20)] showed significant between-session adaptation for SUD ($p < .001$) and HR ($p < .01$). RSA reactivity showed a trend for between-session adaptation from T15 to T18 ($p < .05$), while PEP reactivity showed a trend for between-session adaptation from T17 to T20 ($p < .05$). Solid arrows in figure 3 display the significant between-session adaptation.

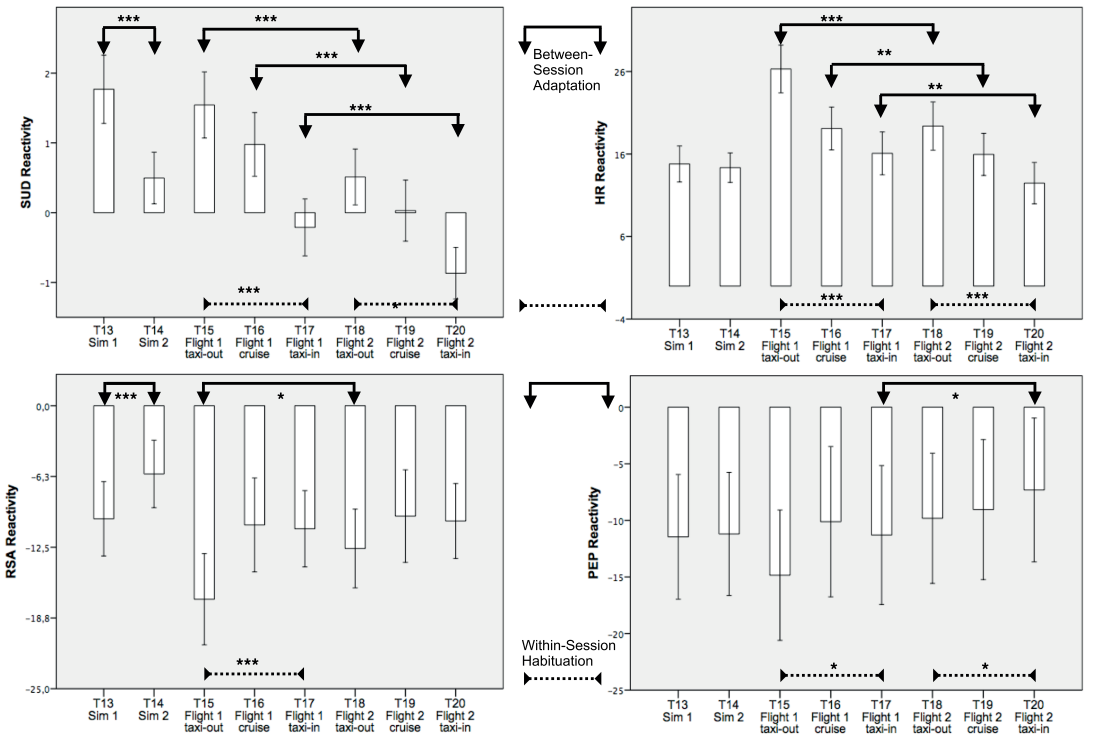

Figure 3. SUD reactivity (top left pane), HR reactivity (top right pane), RSA reactivity (bottom left pane) and PEP reactivity (bottom right pane) at both simulated flights, and at taxi-out, cruise and taxi-in during two real flights. Error Bars reflect 95% CI. SUD = Subjective Units of Distress, HR = Heart Rate, RSA = Respiratory Sinus Arrhythmia, PEP = Pre-Ejection Period, Sim = Simulator, CI = confidence interval.
*significant at p = .05 **significant at p = .01 ***significant at p = .001

Within-session habituation

Both SUD reactivity and HR reactivity showed a significant ($p < .001$) within-session decrease during both flights (T15-T17 and T18-T20), with a trend for PEP reactivity in the same direction ($p < .05$). RSA within-session habituation reached significance only for the first flight (T15-T17, $p < .001$). Dotted arrows in figure 3 display the significant within-session habituation.

Short-term and long-term therapy outcome

Figure 4 depicts flight anxiety scores (VAFAS) at diagnostic assessment (T1), post-flight (T21), at follow-up three months after CBTG (T22), and one (T23) and three (T24) year after

treatment. Values at T1 (diagnostic assessment) were in line with the established norms for people seeking treatment for fear of flying (33, 41). Eta-square showed large effect sizes for the reduction in flight anxiety between diagnostic assessment and all later conditions, ranging from .91 at post-flight to .72 three years after therapy.

Multiple regression analyses were performed to examine whether therapy outcome could be predicted by activation of the fear network and within-session habituation and between-session adaptation of self-reported anxiety and physiological arousal. Reactivity scores for SUD, HR, RSA and PEP were all used as predictors to which the changes in reactivity within exposure sessions were added (within-session habituation), as well as the changes in reactivity across first and second exposures (between-session adaptation). Physiological variables were added in a second step to assess whether prediction improved by adding the measurements of physiological reactivity to self-report of anxiety.

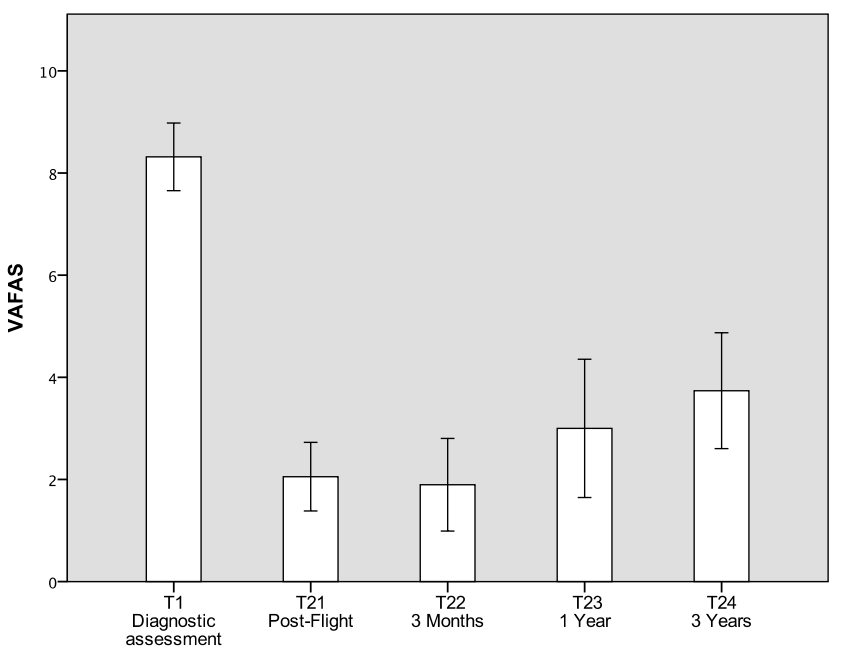

Figure 4. Bar chart of flight anxiety scores (VAFAS) at diagnostic assessment (T1 n = 79), post-flight (T21 n = 77), 3 months after treatment (T22 n = 57), and 1 (T23 n = 38) and 3 (T24 n = 67) years after treatment. Error Bars reflect 95% CI. VAFAS = Visual Analogue Flight Anxiety Scale, CI = confidence interval.

Short-term effect (flight anxiety post-flight) was predicted (R^2 = .36) by SUD reactivity during the cruise portion of the first flight (SUD at T16), in combination with HR within-session habituation over flight 1 (T15 – T17) and RSA within-session habituation over flight 2 (T18 – T20). Within-session habituation of physiological reactivity acted according to the expectation; greater HR within-session habituation over flight 1 and greater RSA within-session habituation over flight 2 were associated with less flight anxiety post-flight (Table 4). The direction of the effect for the SUD, however, was not as expected. Higher, not lower, self-reported distress reactivity during the cruise portion of the first flight was associated with higher levels of flight anxiety post-flight.

Long-term effect as defined by the VAFAS score three years after treatment was predicted (R^2 = .29) by SUD reactivity pre-exposure (T12), in combination with HR reactivity still present at the end of the second exposure flight (T20). Higher levels of SUD reactivity just before in vivo exposure corresponded with higher levels of flight anxiety three years after treatment, while a lower HR reactivity at the end of the second flight was associated with less flight anxiety three years after treatment (Table 4).

Number of flights taken in the three-year period after treatment was predicted only by SUD reactivity (R^2 = .14) during the cruise portion of the first flight (T16), as no other predictors met the inclusion criteria for the regression analysis. Again, higher, not lower, levels of self-reported distress reactivity during the cruise portion of the first flight were associated with fewer flights flown (Table 4).

Table 4. Prediction of therapy outcome by subjective and physiological reactivity and their within-session habituation and between-session adaptation (n = 67).

	Beta	SE	t	p	Zero-order correlation	R	R-Square
VAFAS Post-flight							
Step 1						.393	.154
SUD-reactivity Cruise Flight 1 (T16)	.393	.097	2.99	.004	.393		
Step 2						.600	.360
SUD-reactivity Cruise Flight 1 (T16)	.388	.086	3.13	.002	.393		
HR WSH Flight 1 (T15-T17)	-.332	.018	-2.84	.007	-.321		
RSA WSH Flight 2 (T18-T20)	.301	.522	2.58	.013	.336		
VAFAS three years after therapy							
Step 1						.455	.207
SUD-reactivity Pre-exposure (T12)	.455	.231	3.39	.001	.455		
Step 2						.534	.285
SUD-reactivity Pre-exposure (T12)	.406	.225	3.11	.003	.455		
HR-reactivity Taxi-in Flight 2 (T20)	.284	.036	2.17	.035	.353		
Number of Flights within three years							
SUD-reactivity Cruise Flight 1 (T16)	-.376	.046	-3.14	.003	-.376	.376	0.141

VAFAS = Visual Analogue Flight Anxiety Scale, SUD = Subjective Units of Distress, HR = Heart Rate, RSA = Respiratory Sinus Arrhythmia, WSH = Within-Session Habituation.

DISCUSSION

In this study we followed a relatively large sample of treatment-seeking individuals with aviophobia during and after a highly standardized treatment program to overcome fear of flying. Participants in this study showed large improvements on flight anxiety measures up to three years after treatment. During exposure therapy, self-reported distress reactivity and physiological reactivity to flight-related stimuli, a flight simulator and during two real flights were assessed.

Results indicated strong fear activation for both self-report and all physiological variables during in-vivo exposure. In addition, the expected within-session habituation and between-session adaptation were evident in both subjective and physiological arousal measures. Fear activation during the flight video was only evident for self-report measures and parasympathetic activity, which is in line with reports by Bornas et al. (8, 9, 42) and Busscher et al. (4) that artificial flight stimuli elicit mixed physiological results.

Our data only partly supported the notion that alleged indicators of successful emotional processing are predictive of future flight anxiety and flight behaviour. Contrary to the expectation derived from EPT, higher levels of self-reported distress activation shortly before start of in-vivo exposure predicted higher levels of flight anxiety three years after finishing therapy. In addition, higher self-reported distress activation during the first exposure flight was associated with higher levels of flight anxiety after exposure, and less flights flown in the three years after therapy. The relationship of self-report of fear activation with negative treatment outcome seen in the current study is not in line with EPT and has recently also been reported for persons following exposure therapy for panic disorder (25), contamination fears (43) and social anxiety disorder (44), while Baker et al. (21) report that fear activation had no relationship with outcome for 44 participants with acrophobia.

The temporal pattern of diminishing physiological and subjective responses to flight (related) exposure has been reported before (7, 10, 14, 45-47). On average, at group level, almost all studies report a simultaneous habituation of both physiological reactivity and subjective reactivity in the course of exposure. Nonetheless, most support for EPT to date on within-session habituation has come from animal studies (24). The few studies with humans show inconsistent results with regard to within-session habituation and treatment outcome, and these yield no evidence for self-report of habituation as an indicator for emotional processing (7, 24, 45). Only Hayes et al. (44), in a study with

38 participants with social anxiety disorder, reports a positive relationship between decreasing SUD scores during exposure, and outcome of therapy, but only during the third (out of 5) exposure session. Here we could not substantiate these findings for flight phobics. Although on average participants had a significant diminution of SUD scores over both flights, this indication of within-session habituation did not predict therapy outcome defined either as subjective fear of flying or flying behaviour on the long-term.

The one finding in keeping with EPT was that the within-session habituation of physiological reactivity was predictive of a positive treatment outcome. Participants with greater HR habituation during the first exposure flight had lower flight anxiety scores after flight than did participants with less HR habituation. Likewise, participants with a larger increase in parasympathetic activity over the second exposure flight had less flight anxiety after the flight than did participants with a smaller increase of parasympathetic activity over flight. At first sight, this corresponds to findings by Beckham et al. (7) in 14 aviophobics (nine treatment and five control participants). The six participants who flew during the two months after exposure to a post-treatment test flight had a significantly higher HR just prior take-off, and nearly significant greater HR reduction during the test flight, than the eight participants who did not fly during the next two months. Within our group of 67 treatment completers we confirm an effect of within-session HR habituation during flight on flight-anxiety post-flight, but not on flight anxiety three years after finishing therapy or on long-term flying behaviour.

Clearly, these findings should be seen in the light of potential confounding of within-session habituation by the effects of 'general post-exposure' relief. For phobic patients, whatever their phobic disorder, subjective account will partly reveal the feeling of relief at the end of an exposure session. The decrease in SUD and physiological arousal across the two in-vivo flights could reflect this relief associated with the end of exposure as compared to imminent exposure to the phobic stimuli at the start of a flight. Participants in this study were well aware that within 45 minutes after their first flight they would board the airplane again for the second exposure flight back home. However, relief effects would be characterized by within-session habituation during the second flight only or at least mostly. Our results indicated a larger within-session habituation during the first flight than during the second flight, which does not suggest a major effect of post-exposure relief.

In the present study, despite all the indicators of adaptation of subjective distress across repeated exposures, no relationship emerged of between-session adaptation with any

treatment outcome. Adding physiological reactivity did not help; neither high levels of fear activation nor stronger between-session adaptation predicted treatment outcome. These findings add to the many studies in other domains that found contradictory results on the predictive power of between-session adaptation (21, 22, 24, 25, 44). A strong point of the current study is the use of a relatively large sample of true aviophobics in combination with self-reports of flight-anxiety and measurements of actual behaviour three years after finishing therapy. Outcome studies within the domain of fear of flying are rare. A few studies included physiological measures, however most studies lack sufficient number of participants, did not use in-vivo exposure or made use of non-clinical participants (for details see 45).

In conclusion, our results do not support most of the predictions derived from EPT. Fear activation acted partly in the opposite direction as expected, between-session adaptation of fear reactivity had no predictive value and only physiological indicators of within-session habituation had a relationship with flight anxiety directly after in vivo exposure, but were not related to long-term outcome measures. Alternatives to EPT are direly needed to explain the effectiveness of exposure therapy to change phobic behaviour. Possibly, the emphasis has been too much on affective processing at the cost of cognitive processing. Basal to exposure therapy are expectancies regarding the possibility of aversive events with negative consequences. Exposure to a feared situation without the expected aversive events actually occurring evokes extinction. Recognition of this mismatch is an information-processing activity. The active ingredient in exposure therapy might therefore be of a cognitive nature, such that changes occur in the expectancy of threat and harm (48), which then lead to reduced fear activation. As effective information processing is known to deteriorate under conditions of fear activation, this may be the source of the detrimental long-term effects we found in participants with the highest SUDs during actual flight (49, 50).

Alternatively, exposure therapy might not reduce fear activation at all but simply enhance willingness to experience and tolerate the symptoms that are induced by fear (25), which might be more challenging with severe fear reactivity. Hence, fear tolerance rather than fear reduction might have to be the primary goal of exposure therapy (22, 51). Meuret (52) reported promising results with acceptance and commitment therapy (ACT) preceding exposure. ACT may facilitate engagement in exposure exercises, thereby maximizing the mismatch effect of expected aversive events not happening, while cognitive therapy preceding exposure may reduce the expectancy of a negative outcome before exposure and thereby lessen the mismatch between initial expectancy and actual outcome (53).

Consolidation of progress could benefit from post-exposure cognitive interventions, instead of pre-exposure cognitive therapy. Recently an increasing number of publications emerged on inhibitory learning independent of fear reduction (24, 53-56). Instead of weakening of the original fear memories, these theories focus on the establishment of new memories that compete with the original fear memories (57). Exposure designed to disconfirm expectancies, exposure in multiple contexts, and the removal of safety signals during exposure could enhance treatment efficacy and prevent relapse by optimizing associative learning (43, 53, 56, 58, 59). Future studies on the effectiveness of exposure therapy focussing on optimizing conditions for exposure, in combination with the nature and timing of ancillary therapies seem warranted. Such studies would do well to measure both subjective as well as physiological aspects of fear activation. The current study confirms that these two domains provide partly independent information.

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