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Effectiveness of exposure-based treatment for childhood anxiety disorders: An open clinical trial to test its relation with indices of emotional processing and inhibitory learning

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ABSTRACT

Background and objectives: The current study examined how effectiveness of exposure-based CBT was related to indices of emotional processing and inhibitory learning during exposure exercises.
Methods: Adolescents with anxiety disorder(s) (N = 72; age 11–19; 85% girls) received a group-based, intensive two-week treatment of which effectiveness was indexed by the SCARED and by ratings of anxiety and approach towards individualized goal situations. To index emotional processing, subjective units of distress (SUDs) were used to indicate both initial and final fear level, and absolute, relative, and total dose of fear reduction. To index inhibitory learning, subjective threat expectancies (STEs) were used to indicate initial and final threat expectancy, and absolute, relative, and total dose of expectancy change.
Results: From pre-treatment to follow-up, there was a large-sized reduction of anxiety symptoms, small-sized decrease of subjective anxiety and a large-sized increase in subjective approach towards individual treatment goals. Higher fear levels prior to exposure were related to a larger decrease of symptoms. Higher threat expectancies after exposure exercises were independently associated with less decrease of anxiety and increase of approach towards treatment goals. Total dose of experienced fear reduction and total dose of experienced expectancy change were (partly) independently related to more increase in approach towards individualized goal situations.
Limitations: As patients also received other treatment elements, the results cannot be interpreted unequivocally.
Conclusions: The pattern of findings seems to indicate that emotional processing (as indexed by fear reduction) and inhibitory learning (as indexed by expectancy change) are both relevant in exposure-based CBT.

1. Introduction

Although exposure is generally considered to be the key component of cognitive behavioral therapy (CBT) for childhood anxiety disorders (Kendall et al., 2005; Peris et al., 2015), the theoretical foundations and proposed mechanisms of change that should guide exposure-based practice are still a matter of debate. This might explain why a full recovery after CBT for childhood anxiety disorders is only reported in half to two-third of the cases (James, Reardon, Soler, James, & Creswell, 2020). To improve effectiveness of exposure-based CBT, there is a need for a better understanding of what effect of exposure determines its anxiety reducing outcomes.

The emotional processing theory (EPT) has been the predominant model guiding exposure-based CBT (Foa & Kozak, 1986; Foa & McNally, 1996). This theory emphasizes within-session *fear habituation* (i.e., reduction in fear response due to repeated presentation of a stimulus) as the primary process underlying successful treatment. Following this theory, the guiding principle for exposure treatment is "stay in the situation until fear subsides". However, both animal (Woods & Bouton, 2008) and adult (Craske et al., 2008; Culver, Stoyanova, & Craske, 2012; Kircanski et al., 2012) research failed to consistently support a crucial role of within-session fear habituation in extinction of fear or decrease of anxiety symptoms. The more recent inhibitory retrieval theory (IRT) (Craske et al., 2008), therefore provided an alternative explanation for

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the effectiveness of exposure, and proposes that the primary process underlying successful treatment is the disconfirmation of threat beliefs (i.e., reduction in fear response due to breaking up a contingency) rather than fear habituation within sessions (Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014). Following this theory, the guiding principle for exposure treatment is "trigger (unrealistic) fearful expectations acutely before each exposure trial and selectively consolidate (realistic) safety outcomes after each trial".

Fear habituation is commonly measured as reduction of within-session subjective units of distress (SUDs). The EPT proposes that exposure activates a fear structure, which is a set of propositions about a stimulus (e.g., giving a speech), a response (e.g., racing heart), and their meaning (e.g., rejection) that are stored in memory (Lang, 1979). For emotional processing to occur, this fear structure first needs to be activated (initial fear activation), indicated by a heightened fear level (SUDs) prior to or at the start of exposure. Next, fear reduction during the exposure session is taken to indicate within session habituation, which in turn indicates that emotional processing occurred.

However, previous research in children and adolescents did not find a significant association between initial fear activation during exposure and post-treatment severity of obsessive-compulsive disorder (OCD) or anxiety disorder (Benito et al., 2018; Hedtke, Kendall, & Tiwari, 2009; Peterman, Carper, & Kendall, 2016). Although a secondary analysis revealed that stronger initial fear activation was significantly associated with lower anxiety symptom severity at one-year follow-up (Peterman et al., 2016), this was only the case for children with separation and/or social anxiety disorder, and not for children with generalized anxiety disorder. Moreover, studies involving youth with OCD (Kircanski & Peris, 2015) or anxiety disorders (Peterman et al., 2016), did not find a significant association between within-session fear reduction and severity of OCD or anxiety disorders at post-treatment or follow-up. In both of these studies, within-session fear reduction was calculated by subtracting post-exposure SUDs from peak SUDs or pre-exposure SUDS, then dividing this by the number of exposure sessions to come to an average score. Using the same calculation, Benito et al. (2018) found no significant association between within-session fear reduction and treatment outcome. However, when within-session fear reduction was calculated based on the total sum of decreases in SUDs during a given session, stronger within-session fear reduction was associated with significantly greater reduction in severity of OCD post-treatment. It thus seems that treatment effectiveness might be related to the total dose of experienced fear reduction during an exposure session.

The currently dominant IRT account of exposure (Craske et al., 2008) emphasizes the critical role of *expectancy violation* and implies that disconfirmation of threat beliefs, rather than fear habituation within sessions, is the primary process underlying successful treatment (Craske et al., 2014). Expectancy violation is commonly measured as within-session reduction of subjective threat expectancies rated on a Visual Analogue Scale (VAS) (Bond, Shine, & Bruce, 1995; Craske et al., 2014, 2022). For inhibitory learning to occur, the threat expectancy first needs to be activated (threat expectancy activation), indicated by a high threat expectancy rating prior to or during exposure. The mismatch between this threat expectancy and the actual (non-)occurrence of the threat (within-session expectancy violation) indicates that inhibitory learning occurred.

So far, one study in adults did not find a significant association between stronger threat expectancy prior to exposure and post-treatment severity of panic disorder with agoraphobia (Duits et al., 2016). However, a more recent study among adolescents and adults with anxiety disorders found that stronger threat expectancies prior to exposure were associated with less symptom reduction (Pittig et al., 2023). Previous research also showed that stronger expectancy violation as indexed by the discrepancy between expected vs actual distress, trended towards less clinician-rated improvement of childhood OCD at mid-treatment (Kircanski & Peris, 2015). However, this association became non-significant at post-treatment and three-month follow-up. On the contrary, stronger within-session violation of expected vs actual distress was significantly associated with more rapid OCD symptom reduction during treatment in a more recent study (Guzick, Reid, Balkhi, Geffken, & McNamara, 2020). However, the IRT highlights the importance of violating threat expectancies rather than distress expectancies. Following this suggestion, a recent study in adults assessed the role of threat expectancy violation in imaginal exposure therapy for post-traumatic stress disorder (PTSD) (de Kleine, Hendriks, Becker, Broekman, & van Minnen, 2017). In this study, stronger expectancy violation was not related to a greater reduction of PTSD symptoms. In line with this, a study on the role of threat expectancy violation in virtual reality exposure therapy for adult speech anxiety failed to find a relationship between violation of threat expectancies and the reduction of speech anxiety symptoms (Scheveneels, Boddez, van Deale, & Hermans, 2019). Recently, a study based on 8484 exposure exercises of 605 adolescent and adult patients with anxiety disorders showed that it was indeed not expectancy violation itself (i.e., the mismatch between threat expectancy and occurrence) that predicts better treatment outcome. Instead, expectancy change (i.e., the difference between original and adjusted expectancy after exposure), and prediction-error learning rate (i.e., the individual extent to which expectancy violation is transferred into expectancy change) were found to be predictive of better treatment outcome (Pittig et al., 2023).

One explanation for the limited empirical support for EPT or IRT based processes in the treatment of anxiety disorders may reside in the measures that were used to index these processes in previous studies. So far, fear habituation and expectancy violation have typically been assessed within exposure *sessions*. When only looking at change within sessions, increasing or varying difficulty of exposure exercises over the course of treatment is ignored. As a consequence, there might be little change in fear level and threat expectancy within exposure sessions, even when relevant changes do occur within exposure *exercises*. Hence, for examining what effect of exposure determines its effectiveness, it may be important to focus on indices of fear habituation and expectancy violation within exposure exercises rather than within exposure sessions (e.g., Pittig et al., 2023).

In the current study we therefore examined the association between change in anxiety symptoms and within-exercise processes rather than within-session processes. Treatment consisted of two-week group-based highly intensive exposure-based CBT for adolescents with (an) anxiety disorder(s). This intensive treatment format allowed for multiple exposure exercises, and was therefore suitable to test to what extent initial and final fear level, within-exercise fear reduction, initial and final threat expectancy, and within-exercise expectancy change were related to treatment effectiveness. Due to lack of consistency in previous findings regarding both the relevance of EPT and IRT based processes in successful outcome of exposure-based CBT for childhood anxiety disorders, this study followed a descriptive approach.

2. Methods

2.1. Participants

In total, 72 adolescents were included in this study. Since the start of the program in the summer of 2016, 94 adolescents enrolled in the two-week group-based highly intensive exposure-based therapy at [institute]. The last treatment groups that were included in this study finished therapy on November 1st, 2019. Data were collected as part of regular care, therefore no ethical approval was sought for this study. Instead, adolescents and their parents were contacted by their mental health professional and were asked to provide active consent to use the data for the current study in retrospect. Not all adolescents could be reached and of those who could be reached, consent was provided by 72 adolescents and their parents (76.6%), via an online informed consent form that could be filled in until December 20th, 2019. The included adolescents were admitted to the group for treatment of their primary anxiety

disorder and were aged between 11 and 19 years. Diagnostic information was retrieved from their patient files, see Table 1.

2.2. Treatment

Adolescents received a two to seven persons group-based highly intensive exposure-based therapy for eight days, spread out over two weeks on Mondays, Tuesdays, Thursdays, and Fridays. During the two Wednesdays and the weekend adolescents were asked to practice at home. Parents were invited on the Tuesdays of the treatment to receive psycho-education on anxiety and to practice together with their child. During psycho-education, the rationale and structure of treatment were explained to the adolescents and parents (i.e., exposure to the feared situation aims to reduce fear and challenge expectancies). Each treatment day, the program followed the same agenda. Each morning session (10 a.m.–12:30 p.m.) consisted of learning anxiety management strategies like: relaxation, cognitive restructuring, problem-solving, and self-reward. Each afternoon session (1:30 p.m.–4 p.m.) consisted of therapist-guided and self-guided exposures to feared situations in multiple contexts. The treatment was provided by post-master level psychologists who were familiar with CBT and experienced in working with anxious adolescents.

On the first treatment day, adolescents formulated a list of ten different situations in which they felt anxious. These situations were rated from 1 (least scary) to 10 (most scary) to form a fear hierarchy of exposure exercises (e.g., asking where a product is in the supermarket). The fear hierarchy was used during treatment as a guideline for exposure, but with exposure exercises being done mostly in random and pragmatic order (i.e., when the group decided to go to the supermarket for exposure practice, all adolescents picked the exercises from their hierarchy that they were able to do in a supermarket). The treatment protocol used was based on the Dutch adapted version of the Coping Cat program (Kendall & Hedtke, 2006), although the FEAR plan (i.e., Feeling frightened?; Expecting bad things to happen?; Actions and attitudes that can help?; Results and rewards?) to guide exposure was adjusted so that exposure provided opportunity for both fear habituation and expectancy violation (see 'process measures'). Therapists were post-master level psychologists who were trained to guided the formulation of (testable) threat expectancies (having a heart attack during/-after a panic attack; fainting; blushing heavily or being laughed at; e.g., "When I ask the staff where I can find a product in the supermarket, they will start to laugh at me", and attempts to maximally violate expectancies by designing exposure exercises during which the adolescent could put the expectancies to the test accordingly. After practicing an exposure exercise, therapists sat down with the adolescent to evaluate the adolescents' fear level and threat expectancies.

Table 1
Diagnostic information of the patients (n = 72).

	M (SD)/n (%)
Age	15.8 (1.6)
Female gender	61 (84.7%)
Primary anxiety disorder	
1 Social phobia	52 (72.2%)
2 Specific phobia	10 (13.9%)
3 Panic disorder with agoraphobia	8 (11.1%)
4 Panic disorder without agoraphobia	1 (1.4%)
5 Separation anxiety disorder	1 (1.4%)
Number of diagnoses	2.19 (0.97)
Previous treatment	
1 Cognitive behavioral therapy (CBT)	47 (65.3%)
2 Parent training	4 (5.6%)
3 CBT and parent training combined	14 (19.4%)
On stable medication	27 (37.5%)

a. Antidepressant (n = 18).
b. Anxiolytic (n = 5).
c. Methylphenidate (n = 4).

2.3. Procedure

As pre-treatment assessment, participants filled in the outcome measures (see below) to assess symptom level on the first treatment day. This was repeated on the last treatment day as post-treatment assessment, and two to eighteen (median = 4) months after the end of treatment as follow-up assessment. Process measures (see below) were assessed before and after each exposure exercise on a FEAR plan to assess initial and final fear level (FL), initial and final threat expectancy (TE), within-exercise fear reduction (FR), and within-exercise expectancy change (EC).

2.4. Outcome measures

2.4.1. Screen for child anxiety related disorders (SCARED)

Anxiety symptoms were measured with the Dutch revised (Muris, Dreessen, Bögels, Weckx, & van Meelink, 2004) digital child version of the SCARED (Birmaher et al., 1997). This questionnaire of 71 items rated on a 3-point Likert scale (1–3) contains seven subscales: of which the generalized anxiety disorder (GAD), separation anxiety disorder (SAD), social phobia (SoP), panic disorder (PD), and specific phobia (SpP) subscales were included in the current study. A SCARED total score was calculated based on the sum of the GAD, SAD, SoP, PD, and SpP subscales, thereby omitting the obsessive-compulsive disorder (OCD) and post-traumatic stress disorder (PTSD) subscales since these disorders were not the focus of the current treatment. A Cronbach's alpha of .94 at pre-treatment, 0.91 at post-treatment and 0.94 at follow-up indicated that the internal consistency of the 58-item SCARED anxiety disorder subscales was excellent.

2.4.2. Anxiety and Approach Scale (AAS)

On the first treatment day, adolescents formulated five scary situations that were set as individualized treatment goals and used in the idiosyncratic Anxiety and Approach Scale (AAS; Nauta & Scholing, 1998). Most situations were similar to those in the fear hierarchy, while there could also be thematically similar situations that could not be practiced in the group but rather in the weekend, like "Going shopping with a friend". For each item (i.e., goal situation) the adolescents rated their anxiety and approach tendencies as if they had to expose themselves to their goal situation at that moment, for example: "Asking a shop attendant for help". Anxiety was rated on a 9-point Likert scale from 'not scary at all' (0) to 'very scary' (8). Approach was rated on a 9-point Likert scale from 'would never do this' (0) to 'would always do this' (8). Scores on the five items were averaged to obtain a total anxiety score and approach score per assessment. Regular assessment of individualized goals during treatment is being recommended (Creswell et al., 2020), as this may provide a more sensitive and personally relevant measure of progress than overall symptom reduction (Law & Jacob, 2013).

2.5. Process measures

SUDs were provided by the adolescent using a 'minimum anxiety' (0) to 'maximum anxiety' (10) scale. SUDs were scored before and after each exposure exercise on the FEAR plan. SUDs were used to index initial fear level (FL) as well as final fear level (FL), and absolute, relative, and total dose of fear reduction (FR). STEs ratings were provided by the adolescent using a 'minimum likelihood' (0) to 'maximum likelihood' (100) Visual Analogue Scale (VAS; Bond et al., 1995; Pittig et al., 2023). For every exposure exercise, adolescents stated their threat expectancy and answered "How likely do you think it is that this would actually happen?". STEs were filled in before and after each exposure exercise on the FEAR plan. STEs were used to index initial threat expectancy (TE) as well as final threat expectancy (TE), absolute, relative, and total dose of expectancy change (EC).

2.5.1. Initial FL/TE

The average SUDs/STEs at the start of the exposure exercises of an individual patient was used to calculate initial FL/TE.

2.5.2. Final FL/TE

The average SUDs/STEs at the end of the exposure exercises of an individual patient was used to calculate final FL/TE.

2.5.3. Absolute FR/EC

Absolute FR/EC was calculated as the average SUDs/STEs decrease across exposure exercises of an individual patient (i.e., SUDs/STEs at the start of the exercise – SUDs/STEs at the end of the exercise).

2.5.4. Relative FR/EC

Because the impact of absolute FR/EC on treatment outcome may depend on the pre-exercise (initial) SUDs/STEs, we also calculated relative FR/EC that accounts for the individual initial FL/TE. Relative FR/EC was computed as the proportion of SUDs/STEs decreases across exposure exercises of an individual patient while taking their initial FL/TE into account (i.e., (SUDs/STEs at the start of the exercise – SUDs/STEs at the end of the exercise)/SUDs/STEs at the start of the exercise)).

2.5.5. Total dose FR/EC

The total dose of FR/EC was calculated as the sum of SUDs/STEs decreases across exposure exercises (i.e., summing (SUDs/STEs at the start of the exercise – SUDs/STEs at the end of the exercise)) (Benito et al., 2013).

2.6. Design

This study was a non-experimental naturalistic observation of group-based highly intensive exposure-based CBT for adolescents with (an) anxiety disorder(s).

2.7. Statistical analysis

A priori power analyses suggested that to be able to detect bivariate correlations among process and outcome variables with alpha = .05 and power = .80, a total sample of 49 was required (correlation of 0.35: Peterman et al., 2016). However, dropout and potential loss of power due to missingness had to be taken into account, hence the required sample size was increased by approximately 25%, resulting in 49 + 12 = 61 participants. To correct for multiple comparisons a Bonferroni-Holm correction was performed to adopt an alpha of .01.

To evaluate missingness, independent samples t-tests were conducted to check whether participants with missing data were significantly different from participants without missing data. Then, Little's Missing Completely at Random test was conducted to assess if data was likely missing at random. If so, multiple imputation was used to handle missing data, as this is considered a good strategy for dealing with missing data (Van Buuren, 2011). To be transparent, we conducted both intent-to-treat (ITT) and completer analyses for all outcomes. For the ITT analyses, forty datasets were imputed using predictive mean matching with all demographic variables as predictors and the outcomes on SCARED-pre-post-FU, AAS-pre-post-FU, initial and final FL, absolute, relative, and total dose of FR, initial and final TE, absolute, relative, and total dose of EC as both predictors and outcomes of the imputed data. For the completer analyses, we used all available data without imputation of missing values, see Appendix.

First, paired samples t-tests were run between pre- and post-treatment, and pre-treatment and follow-up on the outcome variables. Second, paired samples *t*-test were run to assess differences between initial and final FL and initial and final TE. The reported within-subject effect sizes (Cohen's *d*) were derived from the sample standard deviation of the mean difference. Third, bivariate correlations within and between EPT and IRT process variables were computed. Fourth, change in symptoms and anxiety was calculated by subtracting post-treatment and follow-up from pre-treatment SCARED and AAS-Anxiety scores, so that positive values indicated a decrease of symptoms or anxiety. In addition, change in approach was calculated by subtracting pre-treatment scores from post-treatment and follow-up AAS-Approach scores, so that positive values indicated an increase of approach. Fifth, we used bivariate correlations to examine whether change scores were associated with the process variables. Last, we conducted post-hoc analyses, which can be found in the Appendix.

3. Results

3.1. Preliminary analyses

3.1.1. Missing data analysis

Not all patient files and/or paper files could be retrieved due to omission of assessments during and after treatment, therefore we had to deal with some missing data. To check whether missingness at post-treatment or follow-up was related to pre-treatment differences, we compared the pre-treatment scores of those who did participate in the post-treatment or follow-up assessments with those who did not. These tests showed that the groups did not significantly differ with regard to their pre-treatment scores on the outcome measures (SCARED-post: t (63) = 0.61, p = .541; SCARED-FU: t (63) = -0.26, p = .798; Anxiety-post: t (46) = 1.88, p = .066; Anxiety-FU: t (46) = 1.24, p = .223; Approach-post: t (43) = 1.63, p = .110; Approach-FU: t (43) = −1.87, p = .066). Moreover, Little's Missing Completely at Random test was non-significant, suggesting that the missing data were likely to be missing at random (X^2 (316) = 313.14, p = .54). These findings further indicate that we can use the ITT analyses to interpret the results, which are described below. For the completer analyses and missing data per time point, see Appendix.

3.1.2. Descriptive statistics

Means, standard deviations and range of the outcome variables are presented in Table 2. Means, standard deviations and range of the process variables are found in Table 3. Overall, we collected 1042 exposure records (i.e., FEAR plans). On average, participants filled in the FEAR plan for 17 (SD = 10) exposure exercises during the two-week treatment (range 4–52).

3.2. Main analyses

3.2.1. Outcome variables

Overall, anxiety symptoms as indexed by the SCARED decreased significantly from pre- to post-treatment (t (71) = 5.99, p < .001; medium Cohen's d = 0.71) and from pre-treatment to follow-up (t (71) = 8.70, p < .001; large Cohen's d = 1.03). Anxiety in individualized goal situations decreased significantly from pre- to post-treatment (t (71) = 2.29, p = .013; small Cohen's d = 0.27) and from pre-treatment to follow-up (t (71) = 3.30, p < .001; small Cohen's d = 0.39). In addition, approach in individualized goal situations increased significantly from

Table 2
Descriptive statistics of outcome variables pre-treatment, post-treatment, and follow-up (ITT).

	Pre-treatment	Post-treatment	Follow-up
Anxiety symptoms (SCARED)			
M (SD)	57.22 (15.81)	48.17 (15.85)	41.08 (12.30)
Range	11.00–91.00	10.00–91.00	5.00–70.00
Anxiety in goal situations (AAS-anx)			
M (SD)	5.50 (1.75)	5.00 (1.04)	4.72 (1.23)
Range	0.00–7.80	0.90–7.20	0.20–7.80
Approach in goal situations (AAS-app)			
M (SD)	2.75 (1.00)	3.83 (1.02)	4.52 (1.14)
Range	0.60–5.80	1.40–7.60	1.80–8.00

Table 3
Descriptive statistics of process variables (ITT).

Variable	M (SD)	Range
Emotional processing (SUDs)		
Initial Fear Level	6.72 (0.92)	3.46–9.00
Final Fear Level	3.71 (1.15)	0.40–7.71
Absolute Fear Reduction	2.95 (0.94)	1.21–6.57
Relative Fear Reduction	0.45 (0.13)	0.14–0.88
Total dose Fear Reduction	53.75 (37.85)	12.00–227.00
Inhibitory learning (STEs)		
Initial Threat Expectancy	63.31 (13.50)	25.26–95.00
Final Threat Expectancy	37.58 (13.96)	2.73–71.00
Absolute Expectancy Change	25.69 (11.98)	5.50–65.94
Relative Expectancy Change	0.42 (0.17)	0.12–0.92
Total dose Expectancy Change	460.10 (417.77)	40.00–2830.00

pre- to post-treatment (t (71) = −7.97, p < .001; large Cohen's d = −0.94) and from pre-treatment to follow-up (t (71) = −10.93, p < .001; large Cohen's d = 1.29).

3.2.2. Process variables

On average, final fear levels and final threat expectancies were consistently lower than initial fear levels (t (71) = 24.87, p < .001; large Cohen's d = 2.93) and initial threat expectancies (t (71) = 18.23, p < .001; large Cohen's d = 2.15). Regarding relative FR and relative EC, 100% of the patients showed an overall reduction of fear level and a reduction of threat expectancy of positive magnitude (i.e., relative FR or EC > 0). The average proportion of FR was M = 0.45, indicating that a patient's overall fear level reduced by 45%. The average proportion of EC was M = 0.42, indicating that a patient's overall threat expectancy reduced by 42%.

3.2.3. Relationship among process variables

Bivariate correlations between the process variables are shown in Table 4. Within each theoretical framework, process variables showed low, and moderate to strong associations (r = .06 - 0.88 for EPT; r = 0.16 - 0.84 for IRT). Initial fear level was positively correlated with absolute fear reduction (r = 0.33, p = .005), and initial threat expectancy was positively correlated with absolute expectancy change (r = 0.40, p < .001), probably reflecting that higher fear levels or higher threat expectancies prior to exposure leave more room for fear reduction or expectancy change. On the contrary, final fear level was negatively correlated with absolute (r = −0.55, p < .001) and relative fear reduction (r = −0.76, p < .001), and final threat expectancy was negatively correlated with absolute (r = −0.47, p < .001) and relative expectancy change (r = −0.84, p < .001), suggesting that higher fear levels or higher threat expectancies after exposure are indicative of limited fear reduction or expectancy change.

Between both theoretical frameworks, indicators of emotional processing and inhibitory learning also showed low, and moderate to strong associations (r = 0.03–0.85). A strong positive correlation was found between total dose of fear reduction and total dose of expectancy change (r = 0.85, p < .001), even after controlling for the total dose of exposure (i.e., number of exposure exercises (r = 0.63, p < .001)). This suggest that the strong association between total dose of fear reduction and total dose of expectancy change could not mainly be explained by the total dose of exposure.

3.2.4. Relationship of process variables and change in outcome variables

Bivariate correlations between the different process variables and change in outcome variables are shown in Table 5 and in Figs. 1–5 in the Appendix. For pre- to post-treatment change in outcome variables, no significant correlations with process variables were found.

3.2.4.1. EPT indices. Regarding pre-treatment to follow-up change in outcome variables within the EPT framework, higher initial fear level was moderately correlated to a larger decrease of symptoms as indexed by the SCARED. In addition, higher total dose of fear reduction was moderately correlated to a larger increase in approach towards individual goals.

3.2.4.2. IRT indices. Regarding pre-treatment to follow-up change in outcome variables within the IRT framework, higher final threat expectancy was moderately correlated to a smaller decrease of anxiety and smaller increase in approach towards individual goals. Relative and total dose of expectancy change were both moderately correlated to a larger increase in approach from pre-treatment to follow-up.

Table 4
Pearson's correlations between the process variables (ITT).

	Process variable	Initial Fear Level	Final Fear Level	Absolute Fear Reduction	Relative Fear Reduction	Total dose Fear Reduction	Initial Threat Expectancy	Final Threat Expectancy	Absolute Expectancy Change	Relative Expectancy Change	Total dose Expectancy Change
EPT	Initial Fear Level		.52*	.33*	−.06	.29¯	.41*	.27¯	.14	−.03	.23
	Final Fear Level			−.55*	−.76*	−.25¯	.19	.38*	−.23	−.30*	−.15
	Absolute Fear Reduction				.88*	.59*	.11	−.24¯	.40*	.35*	.39*
	Relative Fear Reduction					.45*	−.03	−.34*	.36*	.38*	.26¯
	Total dose Fear Reduction						.04	−.32*	.41*	.39*	.85*
IRT	Initial Threat Expectancy							.62*	.40*	−.16	.23¯
	Final Threat Expectancy								−.47*	−.84*	−.34*
	Absolute Expectancy Change									.80*	.66*
	Relative Expectancy Change										.52*
	Total dose Expectancy Change										

Note. EPT = Emotional Processing Theory, IRT = Inhibitory Retrieval Theory. Two-tailed, *significant at 0.01 level, ¯trend significant at 0.05 level.

Table 5
Pearson's correlations between the outcome and process variables (ITT).

	Variable	Pre-treatment – post-treatment			Pre-treatment - follow-up		
		Anxiety symptoms (SCARED)	Anxiety in goal situations (AAS)	Approach in goal situations (AAS)	Anxiety symptoms (SCARED)	Anxiety in goal situations (AAS)	Approach in goal situations (AAS)
EPT	Initial Fear Level	.09	.01	.13	.37*	−.05	.10
	Final Fear Level	.07	.05	−.04	.28~	−.06	−.16
	Absolute Fear Reduction	.04	.00	.12	.05	.06	.25~
	Relative Fear Reduction	−.05	−.03	.08	−.15	.06	.24~
	Total dose Fear Reduction	.12	.14	−.24~	.24~	.25~	.40*
IRT	Initial Threat Expectancy	−.25~	−.17	−.01	.20	−.23	−.12
	Final Threat Expectancy	−.10	−.19	−.20	.26~	−.35*	−.38*
	Absolute Expectancy Change	−.16	.04	.21	−.08	.15	.30~
	Relative Expectancy Change	−.04	.11	.21	−.13	.23	.37*
	Total dose Expectancy Change	−.01	.10	.15	.15	.26~	.40*

Note. EPT = Emotional Processing Theory, IRT = Inhibitory Retrieval Theory. Two-tailed, *significant at 0.01 level, ~trend significant at 0.05 level.

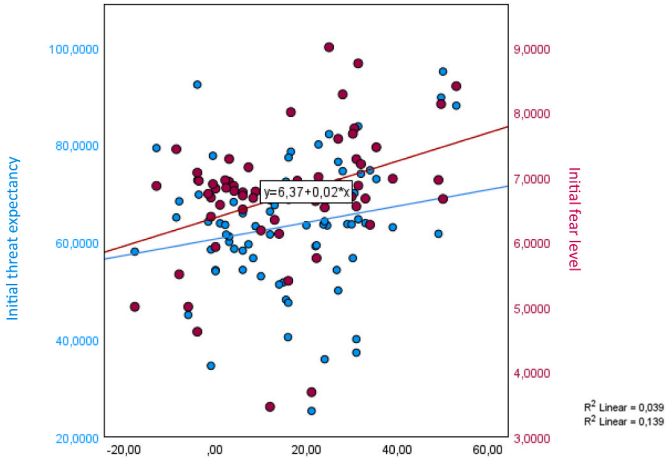

Fig. 1. Anxiety symptoms (pre-treatment to follow-up) – initial.

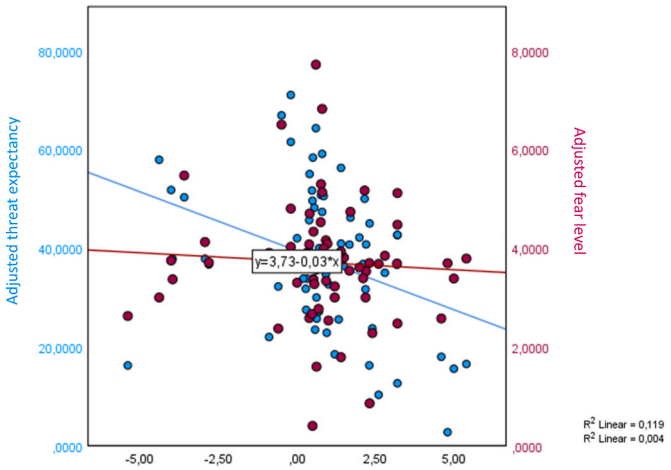

Fig. 2. Anxiety symptoms (pre-treatment to follow-up) – adjusted.

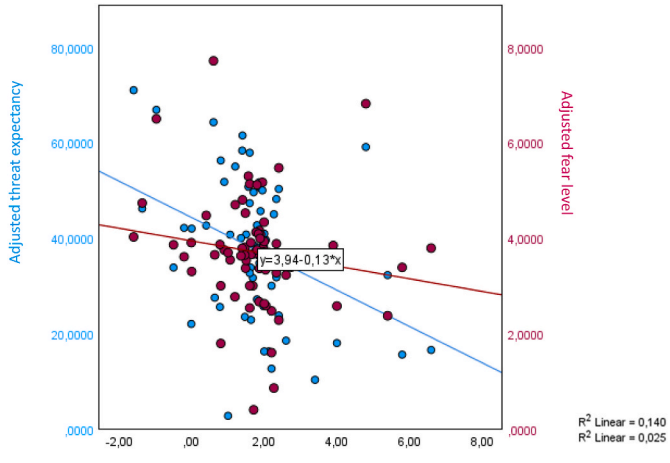

Fig. 3. Approach in goal situations (follow-up vs. pre-treatment) – adjusted.

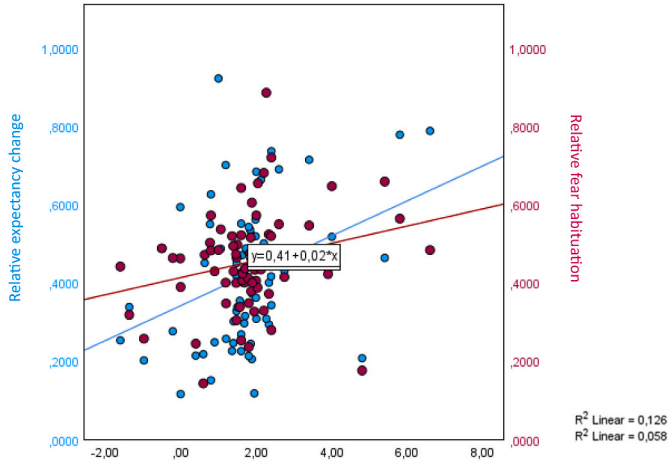

Fig. 4. Approach in goal situations (follow-up vs. pre-treatment) – relative.

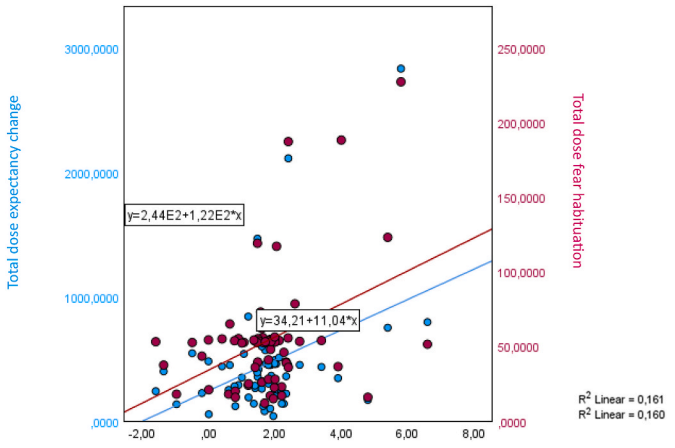

Fig. 5. Approach in goal situations (follow-up vs. pre-treatment) – total dos.

4. Discussion

The current study examined to what extent indices of emotional processing (EPT) and indices of inhibitory learning (IRT) were related to the effectiveness of exposure-based therapy for adolescents with (an) anxiety disorder(s). The major results of this study can be summarized as follows: First, there was a medium to large-sized reduction of anxiety disorder symptoms, and a small-sized decrease of anxiety as well as a large-sized increase in approach towards individual goals from pre- to post-treatment and follow-up. Second, 100% of the patients showed a reduction of fear level and a reduction of threat expectancy across exposure exercises. A patient's overall fear level reduced by 45% and a patient's overall threat expectancy reduced by 42% over the course of the exposure exercises. Third, within and between each theoretical framework, process variables showed moderate to strong associations. Fourth, no associations between process variables and pre- to post-treatment change in outcome variables were found. Regarding pre-treatment to follow-up change in outcome variables, (i) higher initial fear levels prior to exposure were associated with a larger decrease of anxiety disorder symptoms, even after accounting for patient's initial threat expectancies; (ii) higher final threat expectancies after exposure were associated with a smaller decrease of anxiety and a smaller increase in approach towards individual goals, even when taken patient's final fear levels into account; (iii) higher relative expectancy change was associated with a larger increase in approach, even after accounting for patient's relative fear reduction; and (iv) total dose of fear reduction and total dose of expectancy change were both associated with a larger increase in approach. However, total dose of fear reduction and total dose of expectancy change did not show unique associations with treatment outcome as indexed by increased approach towards individual goals from pre-treatment to follow-up.

4.1. Theoretical considerations

Regarding the EPT, we found higher fear levels prior to exposure exercises to be associated with lower symptom severity at follow-up, which is in line with previous research by Peterman et al. (2016) but contrasting with other previous studies (Benito et al., 2018; Hedtke et al., 2009). Also in line with previous research, we found no significant association between within exercise fear reduction and symptom severity at post-treatment and follow-up when indices of habituation were measured as the *average* decreases in SUDs across exposure exercises (Kircanski & Peris, 2015; Peterman et al., 2016; Benito et al., 2018). When fear reduction was measured as the *sum* of decreases in SUDs during exercises, a higher total dose of fear reduction was associated with somewhat greater symptom reduction and less avoidance towards individual treatment goals at follow-up. It thus seems that adolescents who showed relatively high fear prior to each exposure exercise and/or who conducted multiple exercises – thus who experienced more fear reduction in absolute sense – benefitted most from treatment in the long term.

Regarding the IRT, we found that when threat expectancies did not reduce substantially and patients still showed high threat expectancies after exposure, they also showed a smaller decrease of anxiety and a smaller increase in approach towards their treatment goals from pre-treatment to follow-up. Consistent with other studies in adults however (de Kleine et al., 2017; Scheveneels, Boddez, Van Daele, & Hermans, 2019), more absolute expectancy violation (as indexed by initial threat expectancies) was not related to reduction of symptoms from pre- to post-treatment or follow-up. Yet, in line with the recent study by Pittig et al. (2023), only relative expectancy change and total dose of expectancy change were related to a larger increase in approach towards patients' individual treatment goals from pre-treatment to follow-up. It thus seems that adolescents for whom threat expectancies stayed high during exposure benefitted less from treatment, which stresses the importance of violating threat expectancies during treatment. However, not expectancy violation itself, but higher expectancy change was associated with more approach towards individual goals at follow-up. Successful exposure thus requires expectancy violation to induce actual expectancy change in order to improve approach behavior. This is important, because approach behavior is considered key in tackling avoidance, which has been acknowledged as crucial in anxiety disorder persistence (Wolpe, 1958).

Important to note here is that the correlational analysis not only showed that both EPT and IRT variables were related to treatment outcome, but that the variables derived from these theories were also moderately to strongly interrelated. This might indicate that fear reduction also promoted the experience of threat expectancy violation or that threat expectancy violation also led to fear reduction, and/or that both variables are under influence of (an)other (third) variable(s) like changes in coping skills, and/or that both variables are indices of the same process. After all, in the updated version of the EPT, emotional processing is proposed to result in a new non-fear structure that competes with the original fear structure (Foa & McNally, 1996). Similarly, the IRT proposes that inhibitory learning results in an inhibitory non-threat expectancy that competes with the excitatory threat expectancy (Craske et al., 2008). The main difference between the two theories is that in the EPT fear habituation is assumed critical for new learning (i.e., emotional processing), while in the IRT expectancy violation is assumed critical for new learning (i.e., inhibitory learning). The current study raises the question whether fear habituation and expectancy violation are in fact both indices of the same process, namely the presumed belief change originating from exposure to the feared situation. Maybe expectancy change is a more explicit measure and fear reduction a more implicit measure of this belief change. Also, given their interdependency, maybe both processes are needed for eventual change in behavior (e.g., given their interdependent association with increase in approach). However, given the limited explained variances found in this study, other processes than fear habituation and/or expectancy violation seem to be playing a role here too (e.g., distress tolerance; Forsyth, Eifert, & Barrios, 2006; motivational processes to stay harm-free; Craske, Treanor, Zbozinek, & Vervliet, 2022), given that only moderate associations between these processes and treatment outcome were found.

4.2. Strengths and limitations

This is the first study to date that systematically assessed emotional processing and inhibitory learning at the same time in a reasonably large clinical sample of adolescents with anxiety disorders following evidence-based treatment in a naturalistic setting. An important difference with the recent study by Pittig et al. (2023) is that we assessed the unique predictive value of different process variables while accounting

for other relevant process variables, which allowed us to gain insight in what effect of exposure determines its anxiety reducing outcomes. However, it should be noted that we did not include measures of threat occurrence, so we could not evaluate individual learning rate (Pittig et al., 2023) or assess whether initial threat expectancies were indeed reflective of absolute expectancy violation. Also, instead of peak fear we assessed initial fear, which might reflect anticipatory anxiety instead of actual fear activation (Rupp, Doebler, Ehring, & Vossbeck-Elsebusch, 2017). Second, in the current design we did not assess between-exercise or between-session fear habituation or expectancy violation. Also, because the order in which the exposure exercises were conducted was not recorded, we could not check or control for carry-over effects from one exercise to another or gain insight into the dynamics between process variables across sessions, limiting out analysis to summary variables collapsed across exposure sequence. For future research it is therefore recommended to always number the order of the exposures to be able to know the sequence of the exercises. Third, our study was underpowered to detect small associations between process variables and outcome variables. Last, previous research showed that the extent to which exposure-related processes are associated with treatment outcome is not only influenced by the way they are measured (Benito et al., 2018), but also by the intervention being used (Deacon et al., 2013; Kennedy & Hawks, 2021; Salkovskis, Hackmann, Wells, Gelder, & Clark, 2007). In our study, roughly half of adolescents' treatment time was devoted to CBT components other than exposure. It is thus unknown how much of the observed improvement is due to exposure versus the other components, or the extent to which the other components may have influenced the extent to which the process variables were related to treatment outcome (e.g., adolescents with high initial threat expectancies might have relied more on anxiety management strategies that could have reduced the effect of exposure; Whiteside et al., 2020). However, as exposure is often combined with other CBT components in clinical practice, the study holds an ecologically valid design.

4.3. Conclusions

Our data showed that exposure-based CBT is successful in activating, violating and changing fear levels and threat expectancies. In addition, our data suggest that exposure exercises need to induce high fear levels for being effective in reducing fear symptoms, and high total dose of both expectancy change and fear reduction to promote better treatment outcome as indexed as increased approach of goal situations. However, given the interrelatedness of the variables assessed, future research is needed to be able to come to more final conclusions about the differential relevance of emotional processing and inhibitory learning in exposure-based CBT.

CRediT authorship contribution statement

Rachel de Jong: Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration, Methodology, Formal analysis, Data curation. **Miriam J.J. Lommen:** Writing – review & editing. **Peter J. de Jong:** Writing – review & editing, Conceptualization. **Wiljo J.P.J. van Hout:** Writing – review & editing. **Adina C.E. Duin-van der Marel:** Writing – review & editing, Validation, Investigation. **Maaike H. Nauta:** Writing – review & editing, Visualization, Conceptualization.

Declaration of competing interest

The last author (Prof. Dr. Maaike Nauta) is the author of the Dutch version (Nauta & Scholing, 2007) of the Coping Cat treatment protocol for childhood anxiety disorders (English version by Kendall & Hedtke, 2006). An adapted version of this protocol was used as treatment protocol in the current study.

Data availability

Data will be made available on request.

Acknowledgement

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Appendix

Post-hoc analyses

As post-hoc analyses, we first used linear regression models to examine whether change in outcome variables from pre- to post-treatment and follow-up showed unique associations with the process variables within each theoretical framework. For every outcome variable, we only included those indices that were found to show a significant bivariate correlation with that outcome variable. Second, we used linear regression models to examine whether an index that showed a significant bivariate correlation with an outcome variable, showed an association with treatment outcome that was independent of its equivalent from the other theoretical framework (e.g., total dose FR and total dose EC). This way, we could assess the unique contribution of a predictor from one theoretical framework while statistically controlling for the equivalent from the other theoretical framework. Results of the post-hoc analyses can be found in the Appendix.

Predictive value within each theoretical framework

Since none of the bivariate correlations between the process variables and the pre-post change scores were significant ($p < .01$; see Table 5), there was no ground to conduct post-hoc regression analyses to test if and to what extent each of the indices showed an independent relationship with the outcome (pre-post change) scores. The post-hoc regression analyses were therefore restricted to pre-follow-up change scores. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (e.g., all $VIF < 10$).

EPT indices. First, we tested if the relationship between initial FL and pre-treatment to follow-up decrease of anxiety symptoms as indexed by the SCARED, was (partly) independent of final FL and total dose of FR (which both showed comparable bivariate correlations with this outcome variable yet failed to reach the threshold of $p < .01$). The overall regression model was significant ($R^2 = 0.20$, $F(3, 68) = 5.53$, $p = .002$), but neither initial FL nor final FL showed an independent relationship with the reduction in SCARED scores (see Table 6). Instead, total dose of FR showed a near significant independent relationship with decrease of anxiety symptoms. Second, we tested whether the relationship between total dose FR and pre-treatment to follow-up increase in approach to individual goals, was independent of the other EPT variables that showed (near) significant bivariate correlations

with this outcome variable (absolute FR and relative FR). The overall regression model was significant ($R^2 = 0.17$, F (3, 68) = 4.64, $p = .005$). The positive relationship between total dose of FR and approach towards individual goals remained significant when absolute FR and relative FR were included in the equation (see Table 6), indicating that total dose of FR showed a relationship with this outcome variable that was at least partly independent of the other indices of EPT.

IRT indices. First we tested to what extent the relationship between final TE and pre-treatment to follow-up decrease of anxiety towards individual goals, was independent of total dose EC (which showed a near significant bivariate correlation with this outcome variable). The overall regression model was significant ($R^2 = 0.14$, F (2, 69) = 5.71, $p = .005$). The negative relationship between final TE and decrease of anxiety appeared largely independent of total dose EC (see Table 6). Second, we tested to what extent final TE, relative EC, total dose EC, and the near significant variable absolute EC showed independent associations with pre-treatment to follow-up increase of approach towards individual goals. The overall regression model was significant ($R^2 = 0.23$, F (4, 67) = 4.93, $p = .002$). Total dose EC showed a positive relationship with approach towards individual goals that was at least partly independent of the other IRT variables (see Table 6). None of the other IRT variables showed an independent relationship with this outcome variable.

Table 6
Linear regression results for pre-treatment to follow-up outcome variables (ITT)

EPT	Predictor	β	*SE*	*t*	*p*
Anxiety symptoms (SCARED)	Initial FL	2.731	2.541	1.08	.286
	Final FL	3.629	2.009	1.81	.075
	Total dose FR	0.107	0.054	1.98	.052
Approach in goal situations (AAS)	Absolute FR	−0.242	0.384	−0.63	.530
	Relative FR	2.259	2.615	0.86	.391
	Total dose FR	0.015	0.005	2.92	.005
IRT	Predictor	β	*SE*	*t*	*p*
Anxiety in goal situations (AAS)	Final TE	−0.042	0.017	−2.44	.017
	Total dose EC	0.001	0.001	1.36	.179
Approach in goal situations (AAS)	Final TE	−0.036	0.024	−1.49	.141
	Absolute EC	0.003	0.029	0.09	.926
	Relative EC	−1.181	2.928	−0.40	.688
	Total dose EC	0.001	0.000	2.32	.024

Note. FL = fear level, FR = fear reduction, TE = threat expectancy, EC = expectancy change.

Specificity of the indices from both theoretical frameworks

We used regression analysis to assess the unique predictive value of each process variable that showed a significant bivariate correlation with treatment outcome, by including the equivalent variable from the other theoretical framework in the equation.

The overall regression model including two predictors for reduction of anxiety symptoms was significant ($R^2 = 0.14$, F (2, 69) = 5.69, $p = .005$). The positive relationship between initial FL and symptom reduction was at least partly independent of initial TE (see Table 7), whereas initial TE did not show an independent relationship with symptom reduction.

The overall regression model for decrease of anxiety towards individual goals ($R^2 = 0.13$, F (2, 69) = 4.92, $p = .010$) showed that the negative relationship between final TE and decrease of anxiety appeared largely independent of final FL (see Table 7), whereas final FL did not show an independent relationship with decrease of anxiety.

The first regression model for increase of approach towards individual goals ($R^2 = 0.14$, F (2, 69) = 5.62, $p = .005$) showed that the negative relationship between final TE and increase in approach appeared largely independent of final FL (see Table 7), whereas final FL did not show an independent relationship with increase in approach. The second regression model for increase of approach towards individual goals ($R^2 = 0.14$, F (2, 69) = 5.62, $p = .005$) showed that relative EC was a unique predictor of more increase in approach, independent of relative FR (see Table 7), whereas relative FR did not show an independent relationship with increase in approach. The final regression model for increase of approach towards individual goals was significant ($R^2 = 0.17$, F (2, 69) = 7.24, $p = .001$), but neither total dose EC or total dose FR showed an independent relationship with the increase in approach (see Table 7).

Table 7
Linear regression results for pre-treatment to follow-up outcome variables (ITT)

	Predictor	β	*SE*	*t*	*p*
Anxiety symptoms (SCARED)	Initial FL	6.013	2.091	2.88	.005
	Final FL	0.063	0.142	0.443	.659
Anxiety in goal situations (AAS)	Final TE	−0.054	0.018	−3.09	.003
	Final FL	0.144	0.214	0.67	.504
Approach in goal situations (AAS)	Final TE	−0.036	0.012	−3.04	.003
	Final FL	−0.024	0.144	−0.17	.869
Approach in goal situations (AAS)	Relative EC	2.460	0.963	2.554	.013
	Relative FR	1.353	1.327	1.020	.311
Approach in goal situations (AAS)	Total dose EC	0.001	0.001	1.039	.302
	Total dose FR	0.008	0.008	1.028	.307

Note. FL = fear level, FR = fear reduction, TE = threat expectancy, EC = expectancy change.

Completer analyses

For completer analyses we used all available data without imputation of missing values. For available data per process and outcome variable at each time point, see Table 8. Completer analyses gave similar means, standard deviations, ranges and correlations among variables as ITT analyses, see Tables 8–11. However, in the completer analyses three correlations between process and outcome variables no longer reached significance due to the

smaller sample included in the completer analyses. Considering the lower power associated with a smaller sample, we do not regard these findings to be limiting our interpretation of the ITT analyses.

Table 8
Descriptive statistics of outcome variables pre-treatment, post-treatment, and follow-up (COMPLETERS)

	Pre-treatment	Post-treatment	Follow-up
Anxiety symptoms (SCARED)			
M (SD)	57.23 (16.65)	48.16 (19.89)	41.14 (17.76)
Range	11.00–91.00	10.00–91.00	5.00–70.00
n (% mising)	65 (9.7%)	51 (29.2%)	35 (51.4%)
Anxiety in goal situations (AAS-anx)			
M (SD)	5.55 (2.15)	5.00 (1.64)	4.71 (1.91)
Range	0.00–7.80	0.90–7.20	0.20–7.80
n (% mising)	48 (33.3%)	29 (59.7%)	30 (58.3%)
Approach in goal situations (AAS-app)			
M (SD)	2.74 (1.26)	3.83 (1.61)	4.51 (1.77)
Range	0.60–5.80	1.40–7.60	1.80–8.00
n (% mising)	45 (37.5%)	29 (59.7%)	30 (58.3%)

Table 9
Descriptive statistics of process variables (COMPLETERS)

Variable	M (SD)	Range
Emotional processing (SUDs)		
Initial FL	6.71 (1.20)	3.46–9.00
Final FL	3.69 (1.48)	0.40–7.71
Absolute FR	2.94 (1.23)	1.21–6.57
Relative FR	0.44 (0.16)	0.14–0.88
Total dose FR	53.82 (49.81)	12.00–227.00
Inhibitory learning (STEs)		
Initial TE (absolute EV)	63.29 (14.68)	25.26–95.00
Final TE	37.60 (15.20)	2.73–71.00
Absolute EC	25.70 (13.03)	5.50–65.94
Relative EC	0.41 (0.19)	0.12–0.92
Total dose EC	460.33 (454.45)	40.00–2830.00

Note. FL = fear level, FR = fear reduction, TE = threat expectancy, EV = expectancy violation, EC = expectancy change.

Table 10
Pearson's correlations between the process variables (COMPLETERS)

	Process variable	Initial FL	Final FL	Absolute FR	Relative FR	Total dose FR	Initial TE	Final TE	Absolute EC	Relative EC	Total dose EC
EPT	Initial FL		.57*	.33*	−.07	.29	.49*	.34~	.15	−.02	.23
	Final FL			−.59*	−.85*	−.27	.22	.48*	−.26	−.38*	−.16
	Absolute FR				.91*	.59*	.17	−.31~	.48*	.47*	.41*
	Relative FR					.46*	.00	−.42*	.43*	.49*	.29
	Total dose FR						.05	−.43*	.47*	.52*	.88*
IRT	Initial TE							.62*	.40*	−.16	.23
	Final TE								−.47*	−.85*	−.34*
	Absolute EC									.81*	.66*
	Relative EC										.53*
	Total dose EC										

Note. EPT = Emotional Processing Theory, IRT = Inhibitory Retrieval Theory, FL = fear level, FR = fear reduction, TE = threat expectancy, EC = expectancy change. Two-tailed, *significant at 0.01 level, ~trend significant at 0.05 level.

Table 11
Pearson's correlations between the outcome and process variables (COMPLETERS)

	Variable	Pre - post			Pre - follow-up		
		Anxiety symptoms (SCARED)	Anxiety in goal situations (AAS)	Approach in goal situations (AAS)	Anxiety symptoms (SCARED)	Anxiety in goal situations (AAS)	Approach in goal situations (AAS)
EPT	Initial FL	−.02	.08	.22	.65*	−.02	.29
	Final FL	−.17	.18	−.06	.43~	−.06	−.09
	Absolute FR	.18	−.07	.22	.09	.04	.39
	Relative FR	.14	−.17	.17	−.15	−.00	.30
	Total dose FR	.14	.26	.49~	.12	.42	.61*
IRT	Initial TE	−.42*	−.32	−.11	.11	−.29	−.11

(*continued on next page*)

Table 11 (*continued*)

Variable	Pre - post			Pre - follow-up		
	Anxiety symptoms (SCARED)	Anxiety in goal situations (AAS)	Approach in goal situations (AAS)	Anxiety symptoms (SCARED)	Anxiety in goal situations (AAS)	Approach in goal situations (AAS)
Final TE	−.25	−.35	−.41~	.37~	−.45~	−.43~
Absolute EC	−.19	.04	.29	−.32	.21	.39~
Relative EC	.04	.20	.34	−.31	.35	.42~
Total dose EC	−.06	.15	.22	−.17	.35	.48*

Note. EPT = Emotional Processing Theory, IRT = Inhibitory Retrieval Theory, FL = fear level, FR = fear reduction, TE = threat expectancy, EC = expectancy change. Two-tailed, *significant at 0.01 level, ~trend significant at 0.05 level.

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