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Cognitive Mechanisms of Social Anxiety Reduction: An Examination of Specificity and Temporality

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Cognitive theories posit that exposure-based treatments exert their effect on social anxiety by modifying judgmental biases. The present study provides a conservative test of the relative roles of changes in judgmental biases in governing social anxiety reduction and addresses several limitations of previous research. Longitudinal, within-subjects analysis of data from 53 adults with a *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994) social phobia diagnosis revealed that reductions in probability and cost biases accounted for significant variance in fear reduction achieved during treatment. However, whereas the reduction in probability bias resulted in fear reduction, the reduction in cost bias was merely a consequence of fear reduction. A potential implication is that exposure-based treatments for social anxiety might focus more attention on correcting faulty appraisals of social threat occurrence.

Keywords: cognitive–behavioral treatment, exposure therapy, mediation, social anxiety, social phobia, treatment mechanisms

Although exposure-based treatments have been shown to be efficacious for the treatment of social phobia, many who receive these treatments do not respond or they report relapse (Davidson et al., 2004; Liebowitz et al., 1999). Consequently, enhancing the potency of exposure-based treatments is the focus of a number of current treatment research efforts (e.g., Clark et al., 2003; Hofmann et al., 2006). These efforts can be informed by a greater understanding of the mechanisms by which exposure-based treatment exerts its effects on social anxiety.

Cognitive theories emphasize the importance of faulty threat appraisals in the maintenance of anxiety disorders (Beck, Emery, & Greenberg, 1985; Clark, 1986; Clark & Wells, 1995). These theories propose that pathological anxiety is maintained by the tendency to (a) associate feared stimuli or fearful responses with an unrealistically high probability of harm (i.e., probability bias) and (b) exaggerate the negative consequences of the anticipated harmful event (i.e., cost bias). Foa and colleagues (Foa, Huppert, & Cahill, 2006; Foa & Kozak, 1986) have proposed further that probability bias may be more important in anxiety disorders that are characterized by concerns about severe negative outcomes, whereas cost bias may be more important in anxiety disorders that are characterized by concerns about mild negative events. Accordingly, they suggested that cost bias may be more prominent in social phobia relative to the other anxiety disorders because social phobia sufferers are concerned about mild negative events in addition to severe negative events (Foa et al., 2006). Evidence to date indeed has suggested that both probability and cost biases (referred to as *judgmental biases*) contribute to the maintenance of social phobia (Foa, Franklin, Perry, & Herbert, 1996; Lucock & Salkovskis, 1988; Poulton & Andrews, 1996; see also Foa et al., 2006, for review). These findings have formed the empirical basis for the hypothesis that clinical improvement in social anxiety achieved through treatment is mediated by the modification of judgmental biases.

A number of recent studies have examined the cognitive mediation hypothesis (Foa et al., 1996; Hofmann, 2004; McManus, Clark, & Hackmann, 2000). Although the studies have varied with respect to design, measures, and analytic strategies, they converge with respect to some basic methodological features. Specifically, all have included measures of the proposed mediators (judgmental biases) and clinical status (i.e., social anxiety) before and after treatment (i.e., pretreatment, posttreatment, and follow-up assessment). Furthermore, all have assessed judgmental biases using self-report measures that ask respondents to indicate the perceived probability and cost associated with hypothetical negative social scenarios (e.g., “during a job interview, you will freeze,” “someone you know will not say hello to you”; Foa et al., 1996).

Although the studies consistently have shown that successful treatment of social anxiety is associated with significant changes in judgmental biases, the relative importance of changing the probability bias versus the cost bias for achieving social anxiety reduction remains unclear. Foa et al. (1996) found that changes in cost bias are more important determinants of therapeutic change relative to changes in probability bias. They based this conclusion on an analysis that revealed that pre- to posttreatment change in symptoms was associated with residualized pre- to posttreatment gain scores for cost bias but not for probability bias. Additional support suggesting that changes in cost bias may mediate therapeutic change in social phobia comes from an analysis of data from a recent randomized controlled trial (Hofmann, 2004). Consistent

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with the cognitive mediation hypothesis, pre- to posttreatment changes in cost bias significantly reduced the variance in pre- to posttreatment improvement accounted for by treatment. However, given that the study did not include a measure of probability bias or other potential mediating variables, no conclusions can be made regarding the relative importance of change in cost versus probability bias.

The conclusion that reduction of cost bias is more important than reduction of probability bias has been challenged. Employing a methodological and statistical approach similar to that of Foa et al. (1996), McManus et al. (2000) examined the relationship between pre- to posttreatment symptom and judgmental bias changes among patients with social phobia who received cognitive treatment, pharmacological treatment, or placebo. Changes in cost bias did not explain variance in social anxiety reduction after controlling for changes in probability bias. On the basis of these findings and those reported by Foa et al. (1996), the authors concluded, "it would seem prudent for cognitive-behavioral therapists to place a strong emphasis on changing patients' estimates of both the probability and the cost of feared social outcomes" (pp. 208–209).

Although the findings reviewed above are consistent with the hypothesis that social anxiety reduction is guided by the modification of judgmental biases, methodological limitations of the existing research leave open several possible alternative interpretations. For example, judgmental biases may simply be correlates or consequences of social anxiety reduction; because the relevant variables were measured only before and after treatment, it is impossible to determine the temporal relationship between the proposed mediators and outcome. In addition to the issue of temporality, the studies have not demonstrated the specificity of the associations among treatment, judgmental biases, and social anxiety. More specifically, the studies have not ruled out alternative putative mediators of treatment change. Consequently, the results provide only limited confidence that the change in judgmental biases, as opposed to change in another plausible third variable, drives social anxiety reduction. An additional limitation of the studies to date concerns the manner in which judgmental biases have been assessed. Up to now, the studies have relied on cost or probability estimates in hypothetical situations. Yet, other studies suggest that subjects' ratings of threat-relevant constructs in response to hypothetical threat scenarios correspond poorly to measures of these same constructs obtained in vivo (Menzies & Clarke, 1995; Williams & Watson, 1985).

Building on the aforementioned studies, we designed the present study to examine the relative importance of the modification of judgmental biases to changes in social anxiety observed with a brief exposure-based treatment protocol. Instead of conducting assessments merely before and after treatment, we administered measures for the relevant constructs repeatedly during the course of treatment. This procedure allows for a careful examination of temporality (Kazdin & Nock, 2003; Smits, Powers, Cho, & Telch, 2004). Obtaining multiple measures within treatment sessions also allows the estimation of separate parameters for within-session change (i.e., change in reactions to feared stimuli during each session) and between-session change (i.e., change in initial reactions to feared stimuli across sessions). Foa and Kozak (1986) suggested that these two types of change (along with fear activation) are indicators of emotional processing of fear; in a recent review, Foa et al. (2006) concluded that between-session change may be a stronger predictor of recovery compared with within-session change. Delineating the relations between judgmental biases and fear for within- and between-session change separately thus holds promise for advancing understanding of the mechanisms underlying the effects of exposure-based treatment for social anxiety.

To provide some evidence of the mediational specificity of judgmental biases, we included a plausible rival third variable that might account for change in social anxiety. We selected *fear expectancy* given its long tradition as a mediational candidate in theories of fear reduction (Kirsch, 1985; Reiss, 1980; Reiss & McNally, 1985). Evidence supporting the role of fear expectancy and anxiety disorders comes from several lines of investigation, including studies identifying fear expectancy as a distinct factor motivating fear and avoidance among people with severe fears (Gursky & Reiss, 1987; McNally & Steketee, 1985; cf. Reiss, 1991) and agoraphobic avoidance among people with panic disorder (Telch, Brouillard, Taylor, & Agras, 1989). Fear expectancy modification procedures also have been shown to lead to fear reduction (Kirsch, 1983; Paul, 1966). Finally, changes in fear expectancy have been shown to predict fear reduction in other phobic reactions (Valentiner, Telch, Ilai, & Hehmsoth, 1993; Valentiner, Telch, Petruzzi, & Bolte, 1996).

On the basis of the research reviewed above, we hypothesized that individuals suffering from social phobia undergoing exposure-based treatment would report significant reductions in fear, and that changes in judgmental biases (probability and cost) would mediate the association between exposure and fear reduction, controlling for changes in fear expectancy. Moreover, consistent with cognitive theory, we predicted that changes in judgmental biases would drive reductions in fear and not merely be a consequence of fear reduction. We also examined whether the relation between judgmental biases and fear reduction differs across probability bias and cost bias and differs for within- and between-session change, but we offer no a priori hypotheses regarding such differences.

Method

Participants

The sample consisted of 53 participants involved in a randomized trial investigating the efficacy of videotape feedback procedures for the treatment of social phobia (Smits, Powers, Buxkamper, & Telch, 2006). All participants met the following criteria: (a) principal Axis I diagnosis of social phobia as determined by Composite International Diagnostic Interview (CIDI-Auto; World Health Organization, 1997); (b) significant fear of public speaking as determined by peak fear ratings during an impromptu speech task; (c) fluent in written and verbal English; (d) negative for current psychosis, bipolar disorder, or past history of seizures, nor were they actively suicidal; and (e) no recent change in psychotropic medications. Fifty-eight percent were female, and ages ranged from 18 to 51 years (M = 22.09 years, SD = 5.95). The sample was 78% Caucasian, 10% Asian American, 6% Hispanic, 2% African American, and 1% Native American; 3% did not provide a response.

Procedure

Detailed procedures for the randomized trial, which were approved by an institutional review board, have been described elsewhere (see Smits et al., 2006). In short, after written informed consent was obtained, potentially eligible participants were administered the CIDI-Auto and an impromptu speech task. Eligible participants were randomly assigned to one of four conditions: (a) exposure treatment plus videotape feedback of performance ($n = 19$), (b) exposure treatment plus videotape feedback of audience reactions ($n = 20$), (c) exposure treatment without feedback ($n = 23$), or (d) credible placebo ($n = 15$). It was explained to participants in each of the exposure conditions that social anxiety is often fueled by exaggerated beliefs about being negatively evaluated by others. The role of avoidance in the maintenance of pathological fear was explained along with instructions emphasizing the importance of repeated exposures as a method for overcoming fears. Participants assigned to the videotape feedback conditions also received the explanation that videotape feedback was a procedure designed to help examine the discrepancy between perceived and actual images of social performance situations.

Exposure treatment consisted of repeated public speaking exercises (i.e., exposure trials) before a four-member audience. Each participant attended three 75-min treatment sessions within a 1-week period. At the beginning of each session, participants selected a topic on which to give a 3-min speech. They were allowed 10 min to prepare a general outline of the speech and then were asked to deliver the speech five times without the use of their outline or notes. All speeches were video recorded. Between repetitions of the speeches, participants in the videotape feedback conditions received videotape feedback, and participants in the no-videotape feedback condition watched a video on a neutral topic. Following the guidelines of Harvey, Clark, Ehlers, and Rapee (2000), we presented cognitive preparation first, followed by feedback; we instructed participants to focus on the material presented in the videotape rather than on how they felt during the speech.

Given that the objective of the present study was to investigate mediators of change in fear over time among subjects receiving exposure-based treatment, we selected for our analyses all participants who were assigned to the three exposure treatment conditions and who completed at least two of the three treatment sessions ($n = 53$). As we have reported previously (Smits et al., 2006), there were no differences in pre- to posttreatment changes in social anxiety among the three exposure treatment conditions; thus, we did not consider the effects of exposure group status in the present study.

Measures

To ensure correct temporal sequencing, measures of the proposed mediators (probability bias, cost bias) and the rival mediating variable (fear expectancy) were completed prior to each exposure trial, and the outcome variable (fear) was measured immediately following each exposure trial. This procedure yielded data for 5 time points within each session, for a total of 15 time points across all three sessions.

Judgmental biases. Prior to each exposure trial, participants completed a modified version of the Appraisal of Social Concerns Scale (ASC; Telch, Lucas, Smits, Powers, Heimberg, & Hart, 2004). The ASC is a 20-item, self-report scale that asks participants to rate their concern about the visibility of anxiety symptoms, impaired performance, and negative responses from others in a social situation. The scale has shown good internal consistency, test–retest reliability, and convergent and discriminant validity (Schultz et al., in press; Telch et al., 2004). To limit the number of ratings at each of the exposure trials while maintaining the ability to measure judgmental biases, we administered 10 items from the original ASC that reflected outcomes relevant to the public speaking task in which participants were asked to perform. Participants rated separately the probability (i.e., the chance that the outcome will occur) and cost (i.e., how bad it would be when the outcome occurs) on a 0 to 100 scale for the following items: sweating, blushing, trembling, poor voice quality, mind going blank, losing control, appearing stupid, appearing incompetent, being incoherent, people ridiculing you. The ratings for the items of each scale were averaged to produce two subscales labeled (a) Probability Bias, $\alpha = .82$, and (b) Cost Bias, $\alpha = .91$.

Fear expectancy. Prior to each exposure exercise, participants rated the level of fear they expected to experience during their next speech on a 0 (*no fear*) to 100 (*extreme fear*) scale.

Fear. On completion of each exposure exercise, participants rated the highest level of fear experienced during the previous speech on a 0 (*no fear*) to 100 (*extreme fear*) scale.

Results

Analytic Overview

Conceptually, demonstration of mediation involves establishing that a mediating variable partially or fully accounts for the relation between a predictor and an outcome variable. This presumes a certain pattern of temporal and statistical relations among the variables. For example, the predictor variable must temporally precede the mediator and outcome variables, and the magnitude of the relation between the predictor and outcome variable must be reduced (partial mediation) or extinguished (full mediation) when the mediating variable is included in the prediction model (Baron & Kenny, 1986).

Using an individual growth modeling approach, we can examine such relations within persons over time (Kenny, Korchmaros, & Bolger, 2003; Moscovitch, Hofmann, Suvak, & In-Ablon, 2005). We used this analytic strategy, which has been termed *lower level mediation analyses* (Kenny et al., 2003), in the present study. Thus, in our analyses, time (with exposure trial as the indicator of time) was the predictor variable, judgmental biases and fear expectancy were the mediator variables, and fear was the outcome variable. Because the 15 exposure trials were administered over three sessions, we coded for two classes of time effects: *within-session effects* (change in reactions to feared stimuli during each session), coded as the cumulative number of trials at each time point within each session (1–5); and *between-session effects* (change in initial reactions to feared stimuli across sessions), coded to distinguish one session from the next. Coding to capture these two effects allowed us to model the relation of time to fear reduction (the predictor–outcome relation) within each of the three sessions as well as from Session 1 to Session 2 and from Session 2 to Session 3.

In evaluating our hypotheses, we first conducted a within-person analysis of the patterns of change over time in the variables of interest, demonstrating within- and between-session change in the judgmental biases, fear expectancy, and fear. Second, we evaluated the relative contributions of the hypothesized mediating variables (judgmental biases) to the within- and between-session relation of exposure trials to fear (controlling for fear expectancy). This analysis allowed us to examine whether the relation of time (exposure trials) to fear is accounted for by the mediating variables. Finally, we used a within-person, autoregressive cross-lagged panel analysis to examine the temporal and reciprocal relations between each of the hypothesized mediating variables (probability and cost biases) and fear. All analyses were conducted using HLM version 6.0 (Raudenbush, Bryk, Cheong, & Congdon, 2004).

Step 1: Change as a Function of Time

Before examining whether changes in probability and cost biases help explain changes in fear, it is important to know that the

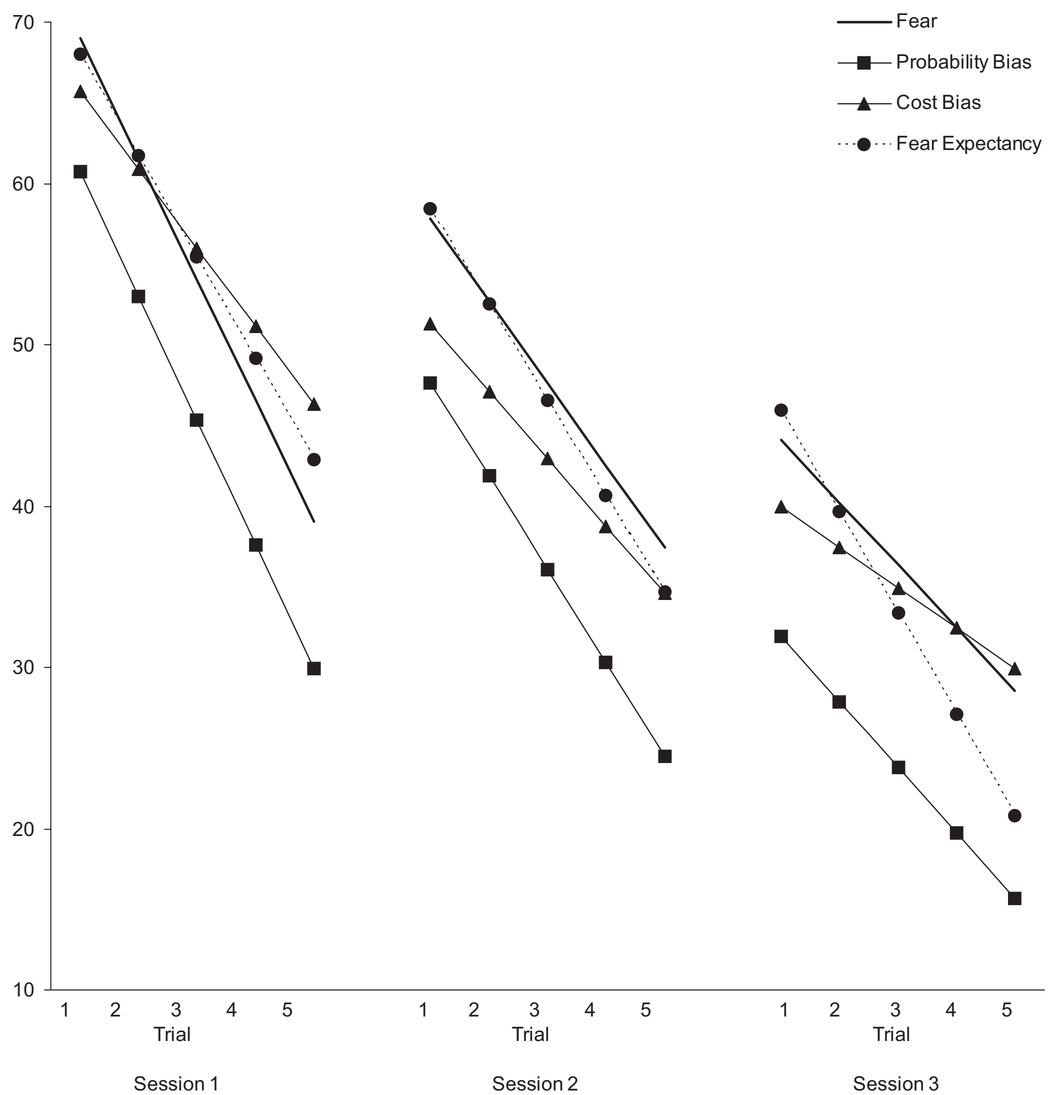

Figure 1. Step 1: Within-session and between-session change for the study variables. 0 = *no fear* (fear and fear expectancy), *not likely at all* (probability bias), or *not bad at all* (cost bias); 100 = *extreme fear* (fear and fear expectancy), *extremely likely* (probability bias), or *extremely bad* (fear and fear expectancy).

variables did indeed change over the course of treatment. To evaluate this, we calculated individual growth models for fear (outcome variable), probability bias and cost bias (proposed mediating variables), and fear expectancy (rival mediator). A piecewise growth model was estimated for each variable that allowed for different slopes within each of the three sessions and for between-session rebound (following Singer & Willett, 2003). For each of the models, three within-session change coefficients were estimated. These reflect the slopes across the five exposure trials within each of the three sessions. We also coded two dummy variables to allow for discontinuities in the growth curves between Sessions 1 and 2 and between Sessions 2 and 3. Following Foa and Kozak's (1986) conceptualization of between-session change, we coded these dummy variables so that the first reflected the difference in scores from the beginning of Session 1 to the beginning of Session 2, and the second reflected the difference in scores from the beginning of Session 2 to the beginning of Session 3. These coefficients, therefore, captured between-session effects. Each of the within-session and between-session slopes and intercepts were specified as random coefficients.[1]

The form of the piecewise growth curves was similar for all of the study variables (see Figure 1). For simplicity, we describe the results for the outcome variable only (i.e., fear). Results for the other variables are summarized in Table 1. Fear declined significantly within Session 1, $b = -7.48$, $t(50) = 10.29$; Session 2, $b = -5.10$, $t(50) = 6.54$; and Session 3, $b = -3.88$, $t(50) = 4.97$, all $ps < .001$. Thus, fear declined an average of about 7.5 units per exposure trial in the first session, 5 per trial in the second session, and 4 in the third session. The variance (between individuals) of

[1] Coding scheme is available on request.

Table 1
Within-Session and Between-Sessions Parameters of Change for the Study Variables, Step 1

Parameter	Fear		Probability bias		Cost bias		Fear expectancy	
	b	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI
Within-session slope								
Session 1	−7.48	−6.0, −9.0	−7.71	−6.7, −8.8	−4.86	−3.5, −6.2	−6.28	−4.7, −7.8
Session 2	−5.10	−3.5, −6.7	−5.79	−4.7, −6.8	−4.18	−3.1, −5.2	−5.94	−4.5, −7.4
Session 3	−3.88	−2.4, −5.4	−4.06	−3.0, −5.1	−2.51	−1.3, −3.7	−6.29	−4.5, −8.1
Between-sessions slope								
Session 1, 2	−11.20	−6.2, −16.2	−13.09	−8.7, −17.5	−14.45	−9.8, −19.1	−9.56	−5.8, −13.4
Session 2, 3	−13.70	−6.3, −21.1	−15.70	−11.9, −19.5	−11.32	−7.1, −15.6	−12.48	−7.5, −17.5
Intercept	68.18	64.1, 72.3	60.73	55.5, 66.0	65.73	60.8, 70.6	67.88	64.4, 71.4

Note. Within-session slopes reflect the rate of change per trial over the five trials within each session. Between-sessions slopes reflect change from session to session at exposure Trial 1 in each session. 95% CI reflects the 95% confidence interval for each parameter. All *p*s $< .001$; all variances significant at $p < .05$.

each of the three slopes was significant (all *p*s $< .01$), indicating individual variability in the rate of reduction in fear across trials within sessions. Fear also declined between sessions; it was lower at the beginning of Session 2 than at the beginning of Session 1, $b = -11.20$, $t(50) = 4.54$, $p < .001$, and at the beginning of Session 3 than at the beginning of Session 2, $b = -13.70$, $t(50) = 3.65$, $p = .001$. Thus, the average decline in fear from Session 1 to Session 2 was about 11 units; from Session 2 to Session 3, it was 14 units. The variances of these coefficients were also significant (both *p*s $< .01$), indicating differences across individuals in change in fear between sessions.

Step 2: Do Reductions in Judgmental Biases Account for Reductions in Fear?

Results of Step 1 indicated that fear declines over the course of treatment (both within a session and across sessions). We hypothesized that this relation of time to reduction in fear is mediated by probability bias and cost bias, controlling for fear expectancy as a plausible rival mediator. Figure 2 depicts the model tested to evaluate this hypothesis. For visual simplicity, the model reflects the relations among the variables for one point in time (the modeling analyses calculated the relations among these over the 15

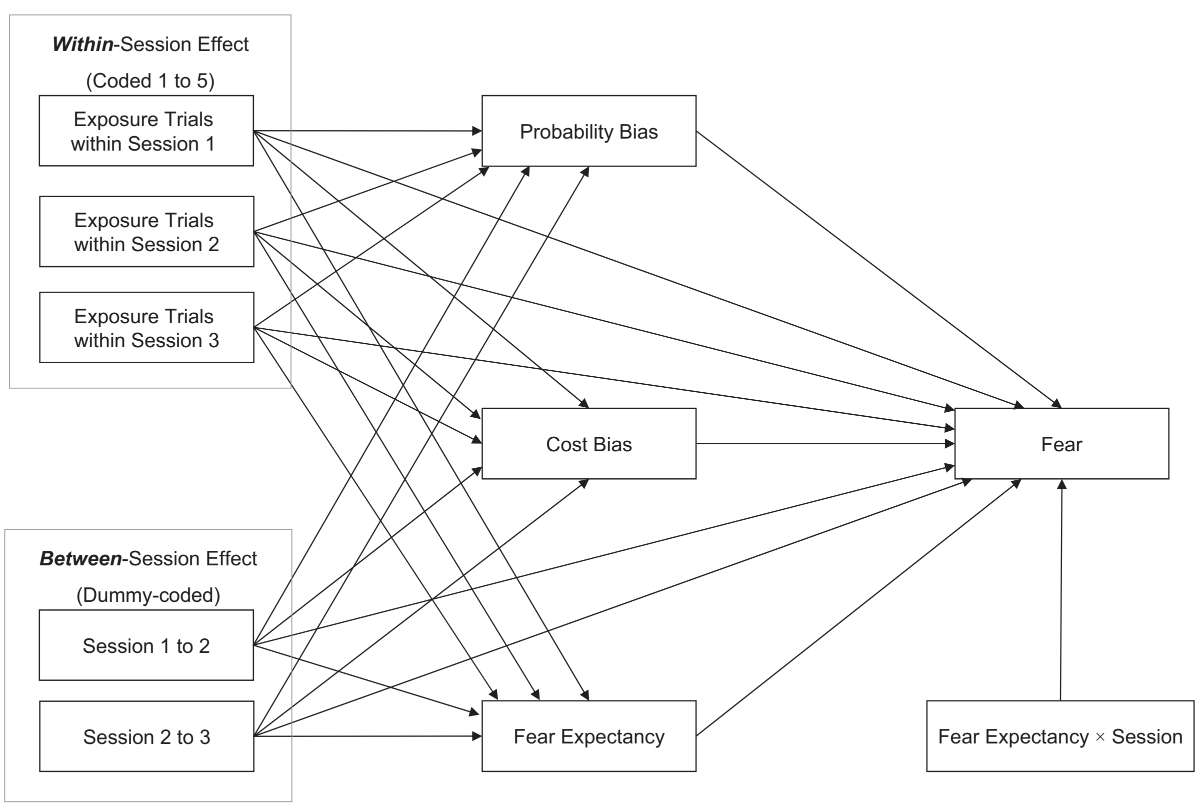

Figure 2. Step 2: Pathways mediating the relation of time (exposure trials) to fear.

time points at which measurements were taken for each participant). In the model, the within- and between-session effects are linked to fear reduction both directly and indirectly (the indirect link is via the mediating variables). To estimate these effects, we added the mediating variables as time-varying covariates (TVCs) to the model for fear from Step 1, just as mediating variables are added as predictors to regression models in which the outcome is regressed on the predictor(s) when evaluating mediation in a typical between-subjects design (Baron & Kenny, 1986). Specifying the mediators as TVCs allows them to vary across the 15 exposure trials at which they were measured. Probability bias, cost bias, and fear expectancy were centered at their respective grand means. Because the relation between each of these variables and fear could conceivably vary across the three sessions, we also included TVC × Session interaction terms, coded to allow different relations between each TVC and fear across the three sessions. The interaction terms for probability and cost biases were not significant, so they were dropped from subsequent analyses; however, there were stronger relations between fear expectancy and fear in Sessions 2 and 3 than in Session 1, so the interaction terms for Fear Expectancy × Session were retained.

The results of the analysis are summarized in Table 2. Probability bias, $b = 0.26$, $t(50) = 3.87$, $p < .001$, and cost bias, $b = 0.10$, $t(50) = 2.20$, $p < .05$, were each associated with fear. Fear expectancy was also associated with fear, $b = 0.19$, 0.33, and 0.36, in Sessions 1, 2, and 3, respectively (all $ps < .01$).[2] Including the mediators in the model yielded within-session slopes that were considerably smaller than the slopes estimated in Step 1, in which the mediators were excluded. Specifically, change in fear, after controlling for cost bias, probability bias, and fear expectancy, was –4.04 units per trial in Session 1, $t(50) = 6.28$, $p < .001$, compared with –7.48 in Step 1; –1.46 in Session 2, $t(50) = 2.42$, $p < .02$, compared with –5.10 in Step 1; and –.58 in Session 3, $p = ns$, compared with –3.88 in Step 1. The inclusion of the mediators also reduced the change from Session 2 to Session 3, $b = -6.54$, $p = ns$, compared with –13.70 in Step 1. These results suggest that the mediating variables collectively reduced the relation between time and fear both within and between sessions. Moreover, there were specific and independent effects for probability bias and cost bias even when controlling for the putative explanatory third variable, fear expectancy.

Table 2
Regression Coefficients Predicting Fear, Step 2

Variable	b	95% CI
Probability bias	0.26*	0.13, 0.39
Cost bias	0.10*	0.01, 0.19
Fear expectancy		
Session 1	0.19*	0.05, 0.33
Session 2	0.33*	0.20, 0.46
Session 3	0.36*	0.23, 0.49
Within-session change		
Session 1	−4.05*	−2.80, −5.30
Session 2	−1.47*	−0.03, −2.67
Session 3	−0.58	0.99, −2.15
Between-sessions change		
Session 1, 2	−14.17*	−4.68, −23.66
Session 2, 3	−6.54	−1.85, −14.93

Note. There were stronger relations between fear expectancy and fear in Sessions 2 and 3 than in Session 1, so the interaction terms for Fear Expectancy × Session were retained in the model.
* $p < .05$.

Demonstrating as above that there is a reduction in the relation between time (exposure trials) and fear when the mediating variables are included in the model is one step in a traditional approach to evaluating mediation (Baron & Kenny, 1986). It does not, however, provide information about the statistical significance or magnitude of the mediating effects. We evaluated the significance of each of the mediated pathways using the joint effects test proposed by Mackinnon, Lockwood, Hoffman, West, and Sheets (2002), which is a direct test of the statistical significance of mediated pathways. We then calculated the proportion (P_M) of each total effect that was accounted for by each mediator. To do this, we compared the total effect of each of the five determinants of fear reduction over time (the three variables representing the within-session effects and the two variables representing the between-session effects) to the amount of each effect that was mediated by each of the three mediators (see Shrout & Bolger, 2002, for detailed discussion of this approach). Results of the test of the significance of each mediating path and the proportion of each effect that was mediated are summarized in Table 3.

Each of the mediated pathways accounted for significant variance in the within- and between-session relations of time and fear. The proportion of variance accounted for by probability bias mediation ranged from 27% to 30% within sessions. In comparison, the variance accounted for by cost bias ranged from 7% to 13%. Fear expectancy mediation accounted for 16% to 59% of the reduction in fear within sessions.[3] Results for mediation of between-session effects on fear were similar to the within-session effects. Specifically, probability bias accounted for 30%, cost bias accounted for 8% to 13%, and fear expectancy accounted for 16% to 30% of the decline in fear between sessions.

Step 3: Direction of the Relations of Probability Bias and Cost Bias With Fear

Our final analysis was designed to investigate the causal interplay between the reduction in judgmental biases and fear, allowing evaluation of whether judgmental biases cause changes in fear, whether changes in fear drive changes in judgmental biases, or whether the relationship is reciprocal. Cross-lagged panel designs

[2] The mediating variables (probability bias, cost bias, and fear expectancy) were highly intercorrelated within subjects over trials (ranging from $r = .62$ to .74). Although correlations of this magnitude do not necessarily indicate multicollinearity, we examined the possibility that multicollinearity might exist in a combination of the predictors. In HLM, multicollinearity is indicated when one or more of the off-diagonal correlations of the Tau matrix are very close to 1 or –1. Our highest such correlation was .75, not threatening the threshold of multicollinearity. Other indications of multicollinearity (e.g., inflation of the standard deviation of the regression coefficients, large fluctuations in the coefficients) were also not present.

[3] The proportion of the effect that was mediated by fear expectancy required calculations in addition to those for the other mediating effects because the association of fear expectancy and fear varied across the sessions. We followed the guidelines of Tein, Sandler, Mackinnon, and Wolchik (2004) for assessing moderated mediation to calculate the Sobel z test and the P_M for fear expectancy.

Table 3
Mediating Effects of Probability Bias, Cost Bias, and Fear Expectancy, Step 2

	Mediator											
	Probability bias				Cost bias				Fear expectancy			
Effect	α	β	Sobel z	P_M	α	β	Sobel z	P_M	α	β	Sobel z	P_M
Within-session effects												
Session 1	−7.71	0.26	−3.75	0.27	−4.86	0.10	−2.17	0.07	−6.28	0.19	−2.53	0.16
Session 2	−5.79	0.26	−3.65	0.30	−4.18	0.10	−2.18	0.08	−5.94	0.33	−4.30	0.38
Session 3	−4.06	0.26	−3.45	0.27	−2.51	0.10	−1.99	0.07	−6.29	0.37	−4.42	0.59
Between-sessions effects												
Session 1, 2	−13.09	0.26	−3.22	0.30	−14.45	0.10	−2.13	0.13	−9.56	0.19	−2.35	0.16
Session 2, 3	−15.70	0.26	−3.50	0.30	−11.32	0.10	−2.08	0.08	−12.48	0.33	−3.54	0.30
Intercept	60.73				65.73				67.88			

Note. P_M = proportion of the relationship mediated. The alphas in this table are the regression coefficients in which the mediator is the dependent variable and the predictors are the within- and between-session effects. The betas are the regression coefficients in which fear is the dependent variable and the predictors are all of the mediators plus the three within-session and two between-sessions effects as depicted in Figure 2. $p < .05$ for all Sobel $z > 1.96$.

are among the most effective techniques for assessing direct effects of one variable on another over time (Kessler & Greenberg, 1981; Menard, 1991) and are useful in examining reciprocal relations among variables. Recalling the assessment procedure used in this study, for each of the 15 trials over the three sessions, participants first completed measures of probability and cost biases for a forthcoming speech, then gave their speech, and finally rated the fear experienced during the speech. Thus, ratings of probability and cost preceded the exposure trial and the rating of fear at each assessment. The cross-lagged panel diagram representing the temporal order of assessments at each trial is summarized in Figure 3.

Step 3 involved a series of analytical steps. First, the within-subjects regression coefficients relating the variables in the model were computed. Each predictor was included in the model as a TVC, and each regression coefficient represents the relation between the variables across trials within subjects. As shown in Figure 3, fear at each time point (t) was predicted by probability bias and cost bias, each measured just before the trial (t), and by fear at the previous trial (t – 1). Thus, across the three sessions, there were 12 data points for each individual (i.e., 4 for each session [Trials 2–5] because the previous trial was included as a predictor). We initially included interaction terms allowing the relation of fear with probability bias and cost bias at trial t, and with fear at trial t – 1, to differ across each of the three sessions; these interaction terms for probability bias and cost bias were not statistically significant, and thus they were dropped from the model. Finally, to model fear most accurately, and to ensure that the effects of each variable in the model were not confounded by its relationship with trials, we included as control variables in the model the three variables representing the number of exposure trials within the three sessions and the two variables representing the between-session effects.[4]

To complete the analyses, we computed the models with probability bias and cost bias as dependent variables (see Figure 3). The models for these variables were similar to the model for fear. That is, each model predicted the dependent variable for 12 trials within subjects; each of the dependent variables was determined by its value at the previous trial (t – 1) and by fear at the previous trial (t – 1). Furthermore, each of the predictors was allowed to have a different relationship with the dependent variable during each of the three sessions. Control variables were also included to represent the within-session and between-session effects on the dependent variable. Initial results indicated that the only relationship that differed over sessions was the autoregressive relationship (i.e., the relationship between the dependent variable and itself at the previous time point differed across sessions). Again, we retained only those interaction terms that were significant.

Figure 3 summarizes the results for Step 3. Previous levels of fear predicted current fear except during Session 1 (b = 0.00, p = *ns*; b = 0.44, $p < .001$; and b = 0.49, $p < .001$, for Sessions 1 through 3, respectively), and probability bias predicted later fear (b = 0.26, $p < .001$). In this model, cost bias did not predict later fear. Turning to the results predicting probability bias and cost bias, prior fear was a significant predictor of both probability bias, b = 0.19, $p < .05$, and cost bias, b = 0.15, $p < .05$. The autoregressive (stability) coefficients for probability bias and cost bias were large, but they decreased across sessions (for probability, b = 0.63, 0.47, and 0.33 for the three sessions, all ps < .001, and for cost, b = 0.58, 0.49, and 0.40, all ps < .001).[5] Taken together, these results indicate that probability bias was a determinant of later fear and fear was a determinant of later probability bias. However, cost bias did not predict later fear reductions, but fear did predict later changes in cost bias.

Discussion

Understanding how exposure-based treatments work to alleviate social phobia is crucial for enhancing treatment efficacy. Recent studies aimed at advancing this understanding have yielded results

[4] Fear expectancy, a control variable in earlier analyses, was not included in these analyses as our interest was in the relative utility of cost and probability judgments for reducing fear. However, similar results emerged when we repeated these analyses and included fear expectancy as an additional variable.

[5] Results for the control variables (within- and between-session effects) have been presented in earlier models and do not vary substantially here. For simplicity, we present only the results for the focal variables of interest.

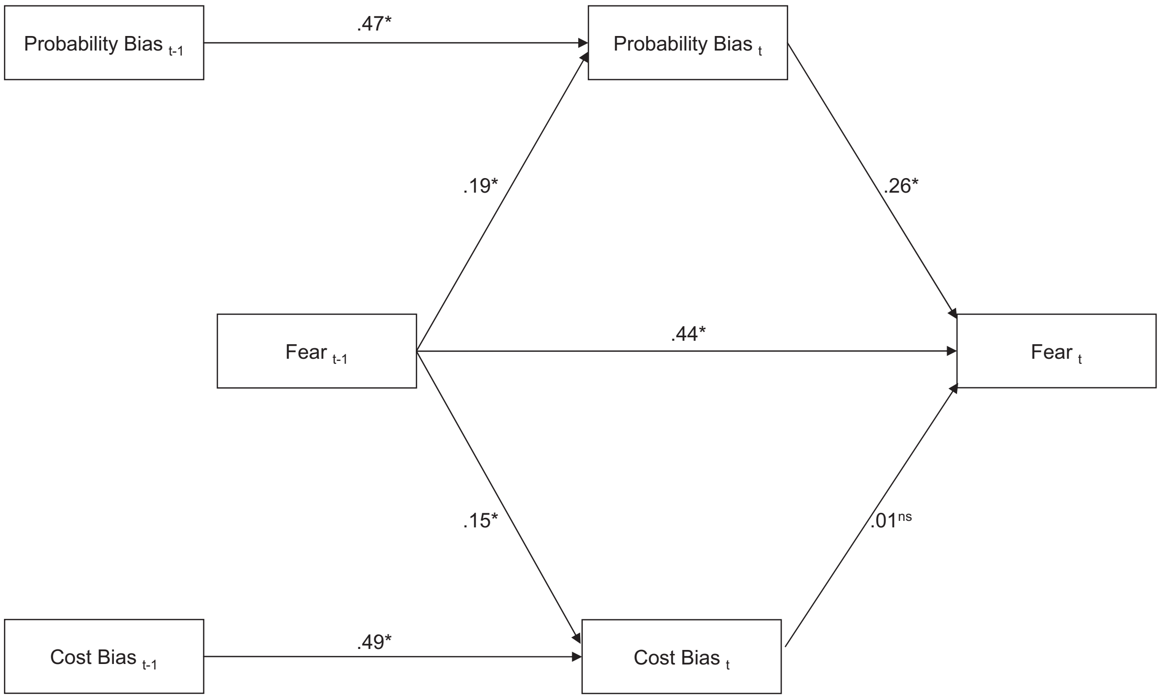

Figure 3. Step 3: Direction of the relations of probability bias and cost bias with fear. The subscripts *t* and *t* – 1 represent the trial at time *t* and the previous trial, respectively. To simplify the visual presentation, where there were different coefficients for the different sessions, we show the coefficient for Session 2 (in every case, this coefficient was intermediate to the coefficients for Sessions 1 and 3). $^*p < .05$

consistent with a cognitive mediation hypothesis that exposure-based treatments exert their effect through the modification of judgmental biases. Our results add to knowledge about how changes in judgmental biases and social anxiety unfold. Specifically, our findings provide further information about the nature and magnitude of these cognitive mediation processes in the treatment of social anxiety, tease out the relative contributions of probability and cost biases to fear reduction, and shed light on how the changes in judgmental biases and fear influence one another over time.

Step 1 demonstrated that within-person reductions occurred in judgmental biases and fear within sessions and between sessions of exposure treatment. Step 2 revealed that probability and cost biases independently account for variance in fear reduction within and between sessions, with change in probability bias accounting for a greater proportion of variance in fear reduction than change in cost bias (i.e., 27%–30% vs. 7%–13%). Step 3 demonstrated a reciprocal relationship between probability bias and fear but a unidirectional relation between cost bias and fear. Specifically, reductions in probability bias predicted reductions in fear, which in turn predicted further reductions in probability bias. In contrast, reductions in cost bias did not predict reductions in fear, but reductions in fear predicted subsequent reductions in cost bias.

The present study addresses important limitations of the existing research and provides a methodologically rigorous test of the cognitive mediation hypothesis. There are a number of features of our methodological approach that are noteworthy. To date, studies of treatment mechanisms in this research area have consistently failed to establish that the change in the proposed mediator occurs before the change in the outcome variable—a necessary precondition for mediation. Establishing such temporal precedence requires that the outcome and the mediator be assessed repeatedly during the course of treatment (Kazdin & Nock, 2003; Smits et al., 2004). Past research also has not adequately addressed the specificity of the effects of the mediating variables. Modeling multiple mediators simultaneously, including plausible rival mediators, conducting repeated measurements, measuring hypothesized causes (e.g., judgmental biases) and effects (fear) in the appropriate temporal order, and controlling for autoregressive effects allow effective delineation of the specific contribution of judgmental biases to fear reduction and address the issue of temporal precedence.

In addition to addressing limitations of previous research regarding the temporality and specificity of the relations between judgmental biases and fear reduction, aspects of our analytic approach and our results have implications for the interpretation of other studies in this area. First, the magnitude of the relationships reported in this research (direct as well as mediating effects) are likely to be more accurate than those resulting from between-subjects designs (which may underestimate relationships because of random between-subjects variation) or from analyses that do not control for autoregressive effects or for effects of other correlated variables (which may overestimate relationships because of the inclusion of correlated effects in the estimate of direct effects when other relevant variables are not partialed out). Second, an individual growth curve approach eliminates random error attributable to between-subjects differences, thereby decreasing Type II error and increasing power. Thus, it is possible that null findings from previous between-subjects studies in this area may in part be attributable to their inherent lower power. In sum, our design and analytic approach have yielded a more rigorous and conservative test of the relative roles of changes in judgmental biases as mechanisms by which exposure-based treatments result in reduced fear while still maximizing our power to detect legitimate effects.

Foa et al. (1996) and Hofmann (2004) suggested that change in cost bias is an important determinant of social anxiety reduction. Although modifications of cost bias were related to changes in fear in the present study, the results of the cross-lagged panel analyses suggest that the reductions in cost bias may be a consequence rather than a cause of fear reduction. McManus and colleagues (2000) suggested that changes in probability bias may predominate in the recovery of social phobia. Our findings point to a strong association between probability bias and fear, and, more important, provide evidence that reduction in probability bias indeed results in subsequent fear reduction. However, as reported previously by McManus et al. (2000), it is possible that the relative importance of improvements in the two judgmental biases to social anxiety reduction varies across different treatment protocols. For example, treatment protocols that include separate sessions of cognitive restructuring aimed at modifying the judgmental biases in addition to exposure (e.g., cognitive–behavioral group therapy; Heimberg & Becker, 2002) may exert their effect on social anxiety by changing both judgmental biases. It is also possible that the observed pattern of the relation between judgmental biases and social anxiety in the present study is unique to brief treatment protocols or perhaps to improvements that occur early in treatment. Similarly, because exposure in our treatment protocol was limited to public speaking exercises, our in vivo measures of judgmental biases were relevant to this specific performance situation, and our results may not generalize to other performance and social interaction situations.

Consistent with recommendations put forth by Foa and Kozak (1986), within-session and between-session change were examined separately. Although the strength of the association of the proposed mediator and outcome variables varied somewhat across the within-session and between-session changes, the pattern of results was similar. In particular, the pattern that emerged was one of gradual and steady improvement on each of the study variables through the course of treatment. One interpretation of this finding is that the mechanism underlying the improvement within sessions is comparable to that underlying the change that occurs over the course of sessions. It is notable that the association of each of the judgmental biases with fear did not differ in magnitude across sessions. Thus, reducing fear by reducing judgmental biases did not serve to disrupt the fundamental relation between them.

The findings for fear expectancy deserve mention. Fear expectancy was included in an attempt to provide evidence for the specificity of the judgmental biases as fear change mechanisms in social phobia. Fear expectancy was selected as a reasonable third variable candidate on the basis of prior research implicating its potential as a mediator of fear reduction during exposure treatment of specific phobias (Valentiner et al., 1993, 1996). Consistent with this work, our mediation analysis indicated that the reductions in fear expectancy appeared to be as influential as reductions in probability bias for improvements in social anxiety. These data suggest that changes in judgmental biases are not the only cognitive factors governing fear change during exposure-based treatments for social anxiety. They also underscore the importance of evaluating multiple mediators simultaneously in treatment mechanism research (Kazdin & Nock, 2003). Further research is needed to determine whether strategies aimed at reducing fear expectancy can augment exposure-based treatment for social phobia.

Our results should be interpreted in the context of the study's limitations. Despite considerable evidence indicating that social phobia has a chronic and unremitting course when left untreated (Bruce et al., 2005; Reich, Goldenberg, Vasile, Goisman, & Keller, 1994), the absence of a no-treatment control condition leaves open the possibility that the marked reductions in fear observed over time were due to the passage of time or repeated assessments rather than the intensive exposure treatment provided to study participants. However, this possibility does not mitigate the major conclusions of the present study. The observed mediating effects are not dependent on treatment as the cause of change. They explain how treatment might result in change if treatment is the causative agent; if not, they simply provide an explanation of how changes in judgmental biases relate to change in fear (and vice versa) over time.

Another limitation of this research is that the cross-lagged panel analyses could be performed on only the within-session changes because the number of treatment sessions was too few to conduct such an analysis of between-session change. The application of the current analytic strategies to outcome studies employing longer treatment protocols would provide valuable information about change between treatment sessions. Additional studies also may clarify whether the nature of the relationship between the modification of judgmental biases and anxiety reduction observed in the present study generalizes across a range of social performance and interaction fears as well as improvements achieved with other treatment modalities (e.g., pharmacological interventions).

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