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Attention Feedback Awareness and Control Training (A-FACT): Experimental test of a novel intervention paradigm targeting attentional bias

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ABSTRACT

We present an experimental investigation of a novel intervention paradigm targeting attentional bias – Attention Feedback Awareness and Control Training (A-FACT). A-FACT is grounded in the novel hypothesis that training awareness of (biased) attentional allocation will lead to greater self-regulatory control of attention and thereby ameliorate attentional bias and its maladaptive sequelae. To do so, A-FACT delivers computerized, personalized, real-time feedback regarding a person's (biased) allocation of attention concurrent with its expression. In a randomized control experimental design, we tested A-FACT relative to an active placebo control condition among anxious adults ($N = 40$, 52.5% women, $M(SD) = 24.3(4)$ years old). We found that relative to the placebo control condition, A-FACT led to: (a) reduced levels of attentional bias to threat; (b) (non-significantly) lower rate of behavioral avoidance of exposure to an anxiogenic stressor; and (c) faster rate of emotional recovery following the stressor. The findings are discussed with respect to the novelty and significance of the proposed conceptual perspective, methodology, and intervention paradigm targeting attentional bias.

Attention gates, prioritizes, and filters what and how humans process the almost infinite stimuli making up our environment, including those stimuli that we most fear and crave. Shaping conscious and nonconscious experience, learning, and memory, few bio-psycho-behavioral processes are more basic or "upstream" in human mentation as attention and thus important to human adaptation. Accordingly, dysregulation in our adaptive preferential allocation of attention to our environment – *attentional bias* – underlies a range of human maladaption. Multiple lines of research have posited that attentional biases trigger a bio-psycho-behavioral cascade underlying the etiology and maintenance of various forms of maladaptation including anxiety, mood and addiction-related disorders (Bishop, 2008; Cisler & Koster, 2010; Field & Cox, 2008; Mathews & MacLeod, 2005; Shechner et al., 2012; Van Bockstaele, Verschuere, Tibboel, De Houwer, Crombez, & Koster, 2013).

Yet, in contrast to the fast-growing body of research on attentional biases and related human maladaption, the field's capacity to ameliorate attentional biases and their "down-stream" sequelae, are limited (Browning, Holmes, & Harmer, 2010; Hallion & Ruscio, 2011; Heeren, De Raedt, Koster, & Philippot, 2013; Hertel & Mathews, 2011; Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013). Indeed, established therapeutic modalities, including psycho- and pharmaco-therapies, have demonstrated mixed, and at best, small therapeutic effects on attentional bias (Hallion & Ruscio, 2011; Hertel & Mathews, 2011). Similarly Attentional Bias Modification Training (ABMT), the first (and only) attempt to-date to target attentional biases specifically, has demonstrated modest effects. Recent meta-analyses demonstrate that even the short-term effects of ABMT with respect to anxiety reduction are modest ($g = .16$, $CI = .05–.27$), bias reduction conditioned within one paradigm (e.g., dot-probe) may not generalize to other paradigms (e.g., visual search) (Hallion & Ruscio, 2011; Hertel & Mathews, 2011; Van Bockstaele, Koster, Verschuere, Crombez, & De Houwer, 2012) and some recent efforts to replicate ABMT findings have failed (Carlbring et al., 2012; Julian, Beard, Schmidt, Powers, & Smits, 2012); though, large differences in

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estimation of the magnitude of ABMT effects have been reported between meta-analyses (cf., Beard, Sawyer, & Hofmann, 2012; Hakamata et al., 2010). Thus, despite the potential significance for basic and clinical research, the range of conceptual and methodological approaches to target attentional biases is, surprisingly, very limited. We therefore propose a novel conceptual perspective, methodology, and therapeutic approach to capture and impact attentional biases.

We theorized that therapeutically targeting attentional bias could be achieved through a novel intervention methodology helping a person to monitor and gain awareness of their well-rehearsed, often automatic biased allocation of attention. So doing we theorized could facilitate self-regulatory control of (biased) attention. This hypothesis emerged from a range of basic and clinical psychological science literatures, including: (1) work on mindful attention and meta-cognitive awareness (i.e., mindfulness, decentering, self-distanced perspective, meta-awareness), demonstrating the capacity and salutary properties of attending to and gaining awareness of various internal states (Farb et al., 2007; Hölzel et al., 2011; Kross & Ayduk, 2011; Schooler et al., 2011); (2) evidence of the foundational role of attentional dyscontrol in attentional bias and related neurobiology of anxiety and related disorders (e.g., Bishop, 2008; Bishop, Duncan, Brett, & Lawrence, 2004; Derryberry & Reed, 2002; Eysenck, Derakshan, Santos, & Calvo, 2007), pointing to the promise of training self-regulatory attentional control to intervene in the maintenance and maladaptive role(s) of attentional biases (Heeren et al., 2013; Wiers et al., 2013); (3) a growing body of cognitive neuroscience data regarding the nexus between awareness, monitoring, attention, and cognitive control processes (Ansorge, Fuchs, Khalid, & Kunde, 2011; Berti et al., 2005; Koivistoa, Kainulainena, & Revonsuoa, 2009; Posner & Rothbart, 1998; Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004; Ridderinkhof, van den Wildengberg, Segalowitz, & Carter, 2004), pointing to the promise of therapeutically exploiting this neurobiological inter-connectivity as a basis for intervening in the maintenance of attentional biases by training awareness and related control; and (4) bio- and neuro-feedback literatures which have documented the effects of feedback on awareness of well-rehearsed, automatic, and unmonitored internal processes (e.g., hypertension), as well as the effects of awareness on self-regulatory control of these processes (Hammond, 2005; Moore, 2000; Schwartz, 1975; Schwartz & Andrasik, 2003).

Drawing on these literatures, we theorized that, (1) awareness of one's own (biased) attentional allocation is fully tenable and may be learned; (2) awareness-of-attention will facilitate cognitive control of biased allocation of attention; (3) so doing should ameliorate bias-mediated behavioral dysfunction (e.g., escape-avoidance in anxiety) underlying anxiety psychopathology. In addition to facilitating control of attentional allocation, awareness of bias is expected to also moderate (buffer) the psychopathogenic effect(s) of (uncontrolled) attentional bias, certain components of attention underlying bias (e.g., hyperviligance) (Armstrong & Olatunji, 2012; Heeren et al., 2013), or in certain conditions under which limited resources are available to invest in awareness-enabled cognitive control. In such instances, however, self-monitoring and bias awareness is expected to enable the capacity to engage in alternative behaviors to those driven by unmonitored, uncontrolled attentional bias (e.g., approach behavior in contrast to escape-avoidance in anxiety psychopathology), and thereby neutralize its psychopathogenic effects. This salutary mechanism of feedback-facilitated awareness may thus, for some or in some contexts, also serve as a "second-line of defense" in the event of transient attentional dyscontrol. As there is no methodology in the published literature to help enable a person to monitor and gain awareness of their well-rehearsed, often automatic allocation of attention, we developed Attention Feedback Awareness and Control Training (A-FACT).

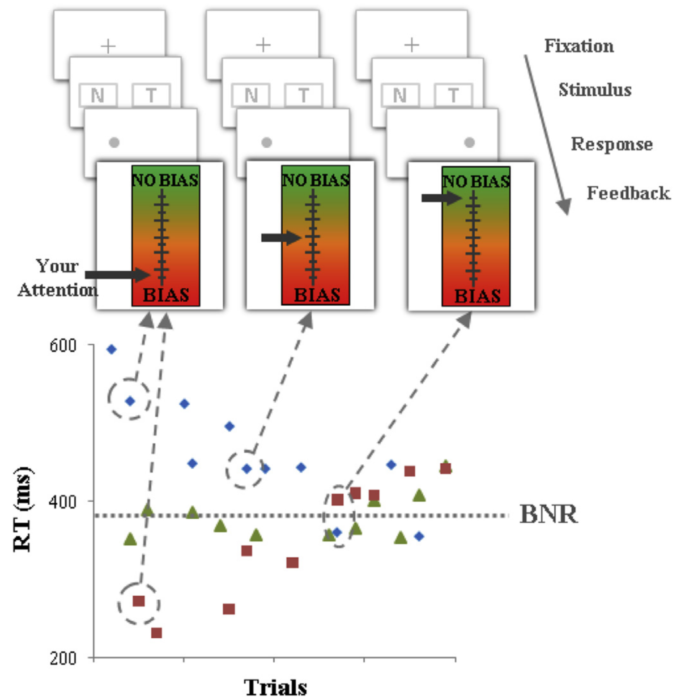

Fig. 1. A-FACT Heuristic illustration. *Note.* Each data point represents single trial response time (RT). N = Neutral stimuli; T = Threatening stimuli. ◆ Incongruent Trial (IT); ■ Congruent Trial (CT); ▲ Neutral Trial (NT). BNR = Baseline Neutral Response Time.

Attention Feedback Awareness and Control Training (A-FACT). The proposed research introduces *A-FACT* — the delivery of real-time feedback regarding one's (biased) allocation of attention concurrent with the measured expression of the phenomenon. A-FACT delivers feedback to a person in real-time based on her/his attentional allocation as measured by behavioral responding (e.g., response time or any index of attention such as eye-movements) to established attentional paradigms. Immediately following a participant's attentional allocation, she/he is provided with real-time feedback regarding the degree to which her/his attention was biased on the current trial (see Fig. 1 for illustration). We theorized that feedback may be particularly well-suited to training awareness-of-attention and self-regulatory control of attention. Indeed, literature from a range of disciplines (e.g., neuroscience, physiology) have documented the central role of (internal) feedback systems in learning and self-regulatory adjustment of a wide-range of human behavior (e.g., pain, language, error monitoring, eating) (Basbaum & Fields, 1978; Botvinick, Braver, Barch, Carter, & Cohen, 2001; Makino, Hashimoto, & Gold, 2002; Postma, 2000).

Aims. The primary aim of this controlled laboratory experiment was to test whether, relative to an active placebo control condition, A-FACT ameliorates attentional bias to threat among anxious adults.[1] Theoretically, in so far as real-time feedback engenders awareness-

[1] An active placebo control condition was selected rather than an ABMT or other intervention control condition for a number of reasons. First, A-FACT is not proposed as an alternative or competing methodology to ABMT or any other extant intervention per se — a "horse-race" is not the intent of this investigation or introduction of A-FACT. Second, ABMT is typically delivered over multiple training sessions (Bar-Haim et al., 2007; Beard et al., 2012; Hakamata et al., 2010; Hallion & Ruscio, 2011), and there is very limited evidence that a single laboratory session of ABMT reduces bias (e.g., Heeren et al., 2013; Julian et al., 2012). Accordingly, a single-session ABMT analog would have been a questionable control condition. Instead, the chosen active placebo condition was designed to control for the effect of instructions as well as experimentally manipulated participant expectancy and goal regarding the training (see details in Procedure section); and thus a rigorous control condition at this early stage in the development of the intervention.

of-attention and thereby self-regulatory control, then bias reduction should result. The second aim was to test whether, relative to the active placebo control condition, A-FACT leads to (a) reduced behavioral avoidance (greater tolerance) of an anxiogenic threat-exposure stressor post-intervention, and (b) greater subjective emotional recovery following the stressor. Theoretically, in so far as A-FACT reduces bias to threat, then it should also neutralize the "down-stream" anxiogenic process triggered by exposure to threat. Escape-avoidance behavior in response to fear-eliciting or anxiogenic stress as well as rate of emotional recovery to such stress are central to the etiology and maintenance of anxiety-related problems (Barlow, 2004; Hofmann, Ellard, & Siegle, 2012).

Method

Participants

Forty high-anxious (State-Trait-Anxiety Inventory (STAI)[2] – Trait Anxiety scores ≥ 42; Derakshan, Ansari, Hansard, Shoker, & Eysenck, 2009; Massar, Mol Kenemans & Baas, 2011; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) young adult participants ($M(SD)_{age}$ = 24.3(4.0) years-old, $range_{age}$ 18–37; 52.5% female) were recruited from a university community in Israel. Only participants whom demonstrated attentional bias to threat were included (see *Procedure* section). Potential participants were excluded on the basis of the following criteria: (a) impaired eyesight (uncorrected); (b) lack Hebrew-language reading and speaking fluency; or (c) current psychopharmacological treatment for anxiety or depression due to possibility that these agents may threaten the internal validity of the study by impacting estimates of attention bias and responsiveness to training. The ethnic/religious composition of the sample was 60.5% Jewish, 13.2% Muslim, 8% Druze, 8% Christian and 10% other – a relatively diverse and representative sample relative to population norms in Israel (Israel Central Statistics Bureau, 2011).

Measurement

Attentional Bias Measurement. The visual emotional dot probe task (MacLeod, Mathews, & Tata, 1986; see Mogg et al., 2000 for a detailed description) was used to measure attentional bias. Participants were presented with a fixation cross (500 ms), followed by 250 ms blank screen, followed by two stimuli presented simultaneously for a duration of 500 ms – one stimulus was presented to the left of the fixation cross and the other to the right, one of which was immediately replaced by a small black probe (50% per side). Participants were instructed to first focus their gaze on the fixation cross and then, as quickly and accurately as possible, press one of two (left or right) response box buttons corresponding to the location of the probe. A random interval of 500–1500 ms preceded the next trial. On incongruent trials (IT), the probe appeared in the location of the neutral stimulus, whereas on congruent trials (CT) the probe appeared in the location of the threat stimulus. Additional trials include neutral trials (NT) in which neutral–neutral stimuli were presented. See Table 1 for the composition of trial types in the study procedure.

[2] STAI was used as a measure of non-specific anxiety for a number of reasons. First, it has been used most widely in extant attention bias to threat research (e.g., Bar-Haim et al., 2007), and thus useful for facilitating comparison between the present and extant studies of bias. Second, the focus of this research is on the psychopathological process of attentional bias, not on any specific form or disorder of anxiety (Insel et al., 2010). Levels of anxious arousal were only used as a broad marker of individuals likely to demonstrate attentional bias to threat. Finally, to further describe the sample, we administered more specific measures of anxiety and depression (see Table 3).

Table 1
Study procedure: stimuli.

Procedure		Stimuli Set[a]	# Trials	# Threat stimuli/set	# Trials/ threat category
Baseline assessment of bias[b]		A	160[c]	10	16
Training blocks	Block 1	B	100[d]	10	12
(A-FACT) or placebo (control)	Block 2	C	100[d]	10	12
Post-training assessment of bias[b]		A	160[c]	10	16
Anxiogenic stressor		D	10[c]	5	1

Note.
[a] Each picture set (A,B,C,D) is composed of unique threat stimuli from all five threat categories. Picture sets were counterbalanced across participants.
[b] Emotional Spatial Dot Probe Task (MacLeod et al., 1986; Mogg et al., 2000).
[c] 50% Neutral–trials.
[d] 60% Neutral–trials.

Procedure

I. *Baseline Assessment*. Potential participants completed the trait anxiety section of the State-Trait-Anxiety Inventory (STAI; Spielberger et al., 1983). The identified sub-sample of high-anxious participants completed an online battery of self-report measures (see Table 4) and then attended a single laboratory session. Upon arrival to the laboratory, participants completed the State STAI, and provided a rating of their present moment state anxiety (Subjective Units of Anxiety (SUA); 0 = *no anxiety* to 100 = *extreme anxiety*). The experimenter, blind to condition, read participants a brief explanation that task instructions would be delivered via instructions on the computer monitor throughout the experiment. Participants then completed the emotional visual dot probe task (MacLeod et al., 1986; Mogg et al., 2000) to measure baseline (pre-intervention) levels of attentional bias to threat (Table 1 for details).

Computation of Attentional Bias. First, 5 bias scores were computed – 1 for each of 5 threat stimulus categories (see Fig. 2). Bias Score (BS) is the Mean RT on Incongruent Trials (IT) – Mean RT on Congruent Trials (CT). Participants were included if they demonstrated BS > 10 ms in ≥2 threat categories or BS > 20 ms in 1 category. Accordingly, the total BS estimate per participant was computed idiographically as the mean BS across threat categories in which each participant demonstrated BS > 10 ms. The 10 ms BS cutoff was determined based on (a) pilot testing, (b) our effort to include as many participants as possible with a range of attentional bias levels (not only individuals with very high levels of bias at baseline), (c) effect size and confidence interval of estimates attentional bias to threat in meta-analyses (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Shechner et al., 2012); and (d) estimation that BS ≥ 10 ms reflects clinically meaningful levels of bias in a wide range of bias modification studies (Amir, Beard, Burns, & Bomyea, 2009; Bar-Haim et al., 2007). Multiple categories of threat were tested so as to most comprehensively reflect the breadth of the phenomenon of attentional bias to threat among anxious adults, and thereby not select a narrow non-representative sub-sample of anxious persons demonstrating bias to one unique and non-generalizable threat category (e.g., angry faces). Furthermore, selection of multiple threat categories permitted the unique capacity to test the effects of personalized feedback training, as detailed below.

II. *Randomization to Condition*. Eligible participants were then randomly assigned to either the (1) Attentional Feedback Awareness and Control Training (A-FACT) condition, or (2) active placebo control condition. All participants were told that they demonstrated biased or preferential allocation of attention in the presence of threatening cues. Specifically, all participants were told that,

Fig. 2. Example threat-neutral stimulus pairs by threat categories. *Note*. Each vertical couple of pictures represents one Threat-Neutral Pair, one per threat category. From left to right: Attacking Dogs, Angry Faces, Attacking snakes, Weapon, Violence; most stimuli sourced from the International Affective Pictures System (Lang, Bradley, & Cuthbert, 1999).

"The computer has tested the way you allocate your attention, and found that your attention is affected by threatening stimuli."

A-FACT. In the A-FACT condition, participants were instructed that they would next complete a task similar to the one they had just completed (baseline emotional dot probe), but which is designed to reduce bias or the degree to which their attention is influenced by threat pictures. Participants were told that they would receive feedback regarding their allocation of attention. Participants were then introduced to the A-FACT feedback scale (Fig. 1) to ensure that they understand it and to reduce the amount of attentional resources needed to process the scale during the feedback procedure itself. Participants were told that the feedback would be presented following occasional trials, and that each feedback stimulus (reflecting "the degree to which their attention was influenced by a threatening picture") related to the single immediately preceding trial only. Participants were instructed to try to learn from the feedback in order to reduce their bias by allocating their attention in a balanced way to all visual stimuli regardless of their content. Additionally, they were instructed that they were, again, to respond to the location of probe as quickly and accurately as possible. See Table 1 for overview of training blocks.

Each participant in the A-FACT condition completed two training blocks (counter-balanced), 100 trials/block, composed of 20 ITs, 20 CTs, and 60 NTs randomly distributed across each block, and thus up to 40 feedback trials delivered per block. Two additional buffer NTs preceded each block as in the dot probe procedure at baseline. The difference between the first and second training blocks was the specific set of stimuli presented – two unique sets of stimuli were used, one per training block. Participants received a 3-min break between training blocks. The rationale for providing feedback over two training blocks and with respect to two sets of stimuli was to facilitate consolidation of learning even within the single A-FACT training session, and to increase the generalizability of feedback-based learning about one's attentional allocation (bias) beyond a specific set of visual stimuli. Neither of the training sets of stimuli included threat-neutral stimulus pairs from the testing set administered at baseline and post-training assessments of bias.

Table 2
Perceived threat ratings among independent sample ($N = 20$).

	Neutral	Threat[a]	Dogs	Faces	Snakes	Weapon	Violence
Mean	1.07	3.01	3.14	2.22	3.27	3.05	3.36
(*SD*)	(0.15)	(0.79)	(0.96)	(0.87)	(1.05)	(1.02)	(0.81)
Observed Range	1–1.67	1.73–4.27	1.67–4.83	1–4.33	1.5–5	1.67–5	2.33–5

Note.
[a] Threat = Mean of perceived threat ratings across all five threat stimulus categories.

Personalized Feedback: Computation. First, prior to delivery of feedback, each participant's individual Baseline Neutral trial mean Response time (BNR) was computed. During the training phase of the experiment, individualized BNR was used as an empirical reference to determine the degree to which each participant's RT on each specific CT or IT differed from their BNR, and therefore bias expressed on each individual CT/IT. NTs were used as the reference point for "no bias" because, by definition, bias to threat cues cannot be observed on NTs and so doing provided a sensitive, idiographic reference for non-biased RT per participant (Fig. 1). Second, we operationally defined the "bias" pole of the feedback scale as reflecting a value >1.5 *SD*s slower (for ITs) or faster (for CTs) than her/his idiographic BNR. This value was selected based on (a) pilot testing; (b) estimation that 1.5 *SD* typically corresponds to ~90 ms – very large absolute levels of attentional bias (Bar-Haim et al., 2007; Hallion & Ruscio, 2011; Shechner et al., 2012); and (c) our effort to ensure that various levels of bias may be meaningfully reflected along the continuous feedback scale. Thus, the individualized reference and range of values based on each participant's distribution of responses during the baseline bias assessment phase permitted sensitive, idiographic real-time feedback (Fig. 1). Furthermore, feedback was delivered to each participant only with respect to the specific idiographic threat cue categories (i.e., attacking dogs, attacking snakes, violence, weapons, angry faces; see Fig. 2) for which she/he demonstrated bias at baseline. In addition, feedback was not presented on error trials (e.g., incorrect probe position response) or "outlier" trials (i.e., RT > 3 *SDs* above participant's total mean RT, or RT < 200 ms); such responses are not likely to reflect attention specifically (Bar-Haim et al., 2007; Bradley, Mogg, Wright, & Field, 2003).

Personalized Feedback: Presentation. Each feedback scale stimulus was presented for 3 s, followed by 1.5 s of a blank screen ITI preceding the next trial fixation cross. Following feedback, a random number of either 1 or 2 NTs were presented prior to the presentation of the next CT or IT to prevent predictability of feedback presentation and help ensure task engagement on subsequent CT/IT trials following a CT/IT feedback trial.

Active Placebo Control Condition. Identical to the A-FACT condition, participants were instructed that they would next complete a task similar to the one they had just completed (baseline emotional dot probe), but which was designed to reduce bias or the degree to which their attention is influenced by threat pictures. Participants were instructed that their task is again to respond to the location of probe as quickly and accurately as possible. Control condition participants completed an additional dot probe task, identical to the baseline dot probe. Task duration, and the number of CT, IT and NT were identical to the A-FACT procedure (Table 1).

III. *Post-training emotional dot probe: Attentional bias re-test*. Following the training phase, all participants again completed

Table 3
Emotion intensity ratings for threat stimuli among independent sample ($N = 20$).

	Sadness	Anger	Disgust	Anxiety	Guilt	Embarrassment	Interest	Joy	Amusement	Love	Cheerfulness
Mean (*SD*)	1.30 (0.25)	1.43 (0.42)	1.56 (0.4)	2.53 (0.65)	1.03 (0.1)	1.02 (0.06)	1.26 (0.23)	1.02 (0.06)	1.06 (0.11)	1.00 (0)	1.01 (0.04)
Observed Range	1–1.8	1–2.6	1–2.2	1.6–3.8	1–1.4	1–1.2	1–1.6	1–1.2	1–1.4	1–1	1–1.2

emotional dot probe task, identical to the baseline (pre-intervention) task. At re-test, participants were instructed that their task was to again respond to the location of the probe as quickly and accurately as possible. A-FACT participants were informed that this time they would not receive feedback during the task.

IV. *Anxiogenic threat exposure stressor post-training: Behavioral avoidance, subjective anxiety, and emotional recovery*. Participants were first instructed to rate their levels of (current) state anxiety (SUA 0–100). Participants were then exposed to presentation of a randomized series of 5 threatening (negatively-valenced, high-arousal, fear-eliciting images) and 5 emotionally-neutral stimuli on a large full-screen display, one stimulus representing each threat category (Erk et al., 2003; Pretz, Totz, & Kaufman, 2010). Each stimulus was displayed for a maximum duration of 15 s. Participants were instructed that they were free to terminate the presentation of each image by pressing a key in the event that they feel unable to continue to view any specific image(s) (see Leyro, Zvolensky, & Bernstein, 2010; Zvolensky, Leyro, Bernstein, & Vujanovic, 2011 for reviews of similar behavioral distress tolerance tasks). In the second phase of the anxiogenic stressor task, following the static presentation of anxiety eliciting image, participants were shown a brief movie clip (120 s) in which a person is trying to escape a villain in a dark, scary basement ("Silence of the Lambs", 1995; Rottenberg, Ray, & Gross, 2007). Again, participants were instructed that they could terminate exposure to the film clip. Following termination of the anxiogenic stressor task, participants were instructed to rate their levels of (current) state anxiety (post-stressor SUA). Then, to index emotional recovery, participants were asked to again rate their (current) levels of state anxiety after resting for 60 s. Finally, participants were debriefed and compensated via course credit or $20 payment.

Materials and apparatus

Stimuli. Threat and neutral stimuli were, when available, selected from the International Affective Pictures System (Lang, Bradley, & Cuthbert, 1999), guided by published studies of threat-related bias and fear elicitation, and digitally resized to 8-cm width × 5-cm width–height (Bardeen & Orcutt, 2011; Bradley et al., 2003; Mikels et al., 2005; Mogg et al., 2000) (Fig. 2). We also selected additional images online in the event that the IAPS collection did not have a sufficient number of stimuli for each of the threat categories (18 IAPS images, 12 images selected online).

Table 4
Baseline (pre-intervention) anxiety-related measures by condition.

	A-FACT *M*(*SD*)	Control *M*(*SD*)	$t_{(38)}$	*p*
STAI – trait anxiety	49.55 (5.83)	50.39 (6.9)	.42	ns
OASIS	6.14 (3.58)	5.17 (2.61)	−.96	ns
IDAS – panic	13.52 (5.13)	13.18 (2.79)	−.25	ns
IDAS – social anxiety	10.76 (3.25)	10.56 (3.76)	−.18	ns
IDAS – depression	46.71 (11.04)	46.88 (10.54)	.05	ns
STAI-state anxiety	37.86 (9.31)	40.56 (10.95)	.83	ns
Subjective anxiety ratings	22.54 (21.43)	18.22 (15.38)	−.72	ns

Note. Measures were translated from English to Hebrew and then back-translated by a separate party using structured guidelines (Brislin, 1970; Geisinger, 1994). *State-Trait-Anxiety Inventory* (STAI; Spielberger et al., 1983), *Overall Anxiety Severity and Impairment Scale* (OASIS; Norman, Hami Cissell, Means-Christensen, & Stein, 2006), *Inventory of Depression and Anxiety Symptoms* (IDAS; Watson et al., 2007).

Selection of stimuli was further guided by pilot testing to ensure that stimuli (and categories) were experienced as threatening and elicited fear, specifically. Selected stimuli were rated by an additional sample of $N = 20$ independent raters (university students), who were asked to rate how threatening the stimuli were (1 = *not threatening at all* to 5 = *extremely threatening*) and to what degree a list of emotions were felt for 1 stimulus/category (1 = *not at all* to 5 = *very strongly*) (Tables 2 and 3). Putatively threatening stimuli were rated as significantly more threatening to participants than emotionally-neutral stimuli ($t_{(19)} = 11.5$, $p < .001$). Additionally, threatening stimuli were rated as eliciting significantly elevated levels of anxiety, specifically, relative to all other negatively-valenced emotions including sadness, anger, disgust, guilt, and embarrassment ($t_{(19)} = 8.88$, $p < .001$) and positively-valenced emotions including, interest, joy, amusement, love, and cheerfulness ($t_{(19)} = 10.17$, $p < .001$).

Experimental set-up. The experiment was run via E-Prime experimental presentation software (Schneider, Eschman, & Zuccolotto, 2002). Computations were conducted via E-prime run-time customized scripts. The experimental session was conducted on a Hewlett–Packard computer and 19″ CRT monitor, in an acoustically-insulated room, with a one-way observation window and camera. Participants' responses were measured via Psychology Software Tools Serial Response Box™.

Results

Data preparation. For pre- and post-intervention attentional bias measurement tasks, RT outliers (trial RT < 200 or >1500 ms, trial RT > or <3 *SDs* of participant's mean RT; $M(SD) = 2.92(3.24)$ outlier trials/participant, 1.83% pre- and post-test trials/participant) and error-response trials (i.e., "left" response when probe appeared on the right; $M(SD)_{\#\ errors} = 9.98(8.38)$, 4.4% of pre- and post-test trials) were discarded, based on a priori criteria for valid trial selection.

Baseline (pre-intervention) attentional bias and anxiety levels. Of the 40 participants, 12.5% demonstrated bias towards one threat category, 37.5% two categories, 27.5% three categories, 20% four categories, and 2.5% five categories. Moreover, 67.5% of participants demonstrated bias to violence, 52.5% to angry faces, 52.5% to attacking snakes, 50% to weapons, and 40% to attacking dogs. No differences were observed between conditions with respect to number of threat categories to which participants/condition demonstrated bias (A-FACT $M(SD) = 2.73(1.03)$ vs. Control $M(SD) = 2.5(1.04)$, $t_{(38)} = -.69$, n.s). Furthermore, analyses testing condition (A-FACT vs. Control) by binary bias status (bias vs. no-bias; BS > 10 ms) per threat category, revealed no between-group differences ($\chi^2 < 2.43$, n.s) – such that rates of biases to each of the threat categories did not differ between conditions. Consistent with successful randomization, no between-group differences were observed with respect to pre-intervention levels of trait or state anxiety (Table 4). However, marginally elevated baseline levels of attentional bias to threat were found among the A-FACT group ($M(SD) = 36.81(13.9)$ relative to the control group ($M(SD) = 28.0(10.9)$; $t_{(1,38)} = -2.19$, $p = .04$).

Aim 1: Bias Reduction. To test whether participants who received A-FACT demonstrated significantly reduced levels of attentional bias to threat relative to the active placebo control condition, we conducted a repeated measures Analysis of Covariance (ANCOVA) of time (Pre- and Post-Intervention) × condition (A-FACT or Control). Pre-to-post intervention change in RT on neutral trials (neutral trials RT pre-intervention − post-intervention) was entered as a covariate, so as to determine whether pre-post-intervention reductions in BS may be alternatively accounted for by a methodological artifact of faster RT (as a possible performance by-product of feedback) rather than due to reduced bias. First, a main effect of time on BS was found ($M(SD)_{pre}$ = 32.86(13.26); $M(SD)_{post}$ = 10.41(20.14); $F_{(1,37)} = 21.36$, $p < .05$, partial $\eta^2 = .37$). As predicted, this main effect was qualified by a significant time × condition interaction demonstrated that whereas A-FACT BS at pre-test ($M(SD)$ = 36.81(13.9)) was somewhat greater than Control BS at pre-test ($M(SD)$ = 28.02(10.95)), A-FACT BS at post-test was significantly lower ($M(SD)$ = 4.63(22.76)) than Control BS at post-test ($M(SD)$ = 17.48(13.94); $F_{(1,37)} = 8.03$, $p < .05$, partial $\eta^2 = .18$) (Fig. 3). There was no significant effect for pre-to-post intervention change in RT on neutral trials with respect to pre-to-post reduction in BS ($F_{(1,37)} = .52$, *n.s*). Furthermore, an additional ANCOVA, in which picture set order was included as a between-subjects factor (covariate), revealed no main effect for picture set ($F_{(1,33)} = 2.2$, n.s), set × time interaction ($F_{(2,33)} = 2.32$, n.s), or set × condition interaction ($F_{(2,33)} = 1.17$, n.s) – such that set order was not related to the observed results. To further test the clinical significance of the effect of condition on bias levels, we tested the % of cases, by condition, who demonstrated 0-levels of bias towards threat (BS < 10 ms) relative to those whom demonstrated any degree of bias (BS ≥ 10 ms) at post-test. We observed that bias was fully “ameliorated” in 68.2% of A-FACT participants ($n = 15/22$) relative to 33.3% of Control participants ($n = 6/18$) ($\chi^2 = 4.82$, $OR = .23$, $CI_{95\%} = .06–.88$, $p < .05$).

Aim 2: Behavioral and Emotional Responding to Anxiogenic Stressor. To test the effect of condition on behavioral avoidance of exposure to anxiogenic threatening images we conducted a Fisher's Exact test of condition (A-FACT vs. Control) × termination status (Terminated vs. Did not Terminate). 22.2% of control participants terminated 1 or more anxiogenic stimuli relative to only 4.5% of A-FACT participants; although in the predicted direction, this effect failed to reach statistical significance ($p = .12$). Second, 38.9% of control participants terminated the anxiogenic film clip relative to 22.7% of A-FACT participants; although in the predicted direction, this effect also failed to reach statistical significance ($\chi^2 = 1.23$, $p = .13$).

To test the effect of condition on subjective emotional recovery to the anxiogenic stressor, we first tested whether the anxiogenic stressor elicited elevated levels of anxiety, as intended. We conducted a repeated measures ANOVA of time (pre-stressor and post-stressor) × condition (A-FACT or Control). As predicted, we observed a main effect for time ($F_{(1,38)} = 11.24$, $p < .05$, partial $\eta^2 = .29$), such that state anxiety levels increased from pre-stressor, in both A-FACT ($M(SD)$ = 20.6(24.9)) and Control ($M(SD)$ = 19.8(19.0)) conditions to post-stressor ($M(SD)$ = 38.2(35.4) and $M(SD)$ = 33.2(27.8); respectively), and no interaction of time × condition was observed ($F_{(1,38)} = .20$, *n.s*) such that the stressor elicited similar levels of state anxiety in both conditions. Next, to test whether A-FACT participants demonstrated faster emotional recovery relative to the control participants, we conducted a repeated measures ANOVA of time (post-stressor and post-recovery) × condition (A-FACT or Control). As predicted, a main effect of time ($F_{(1,35)} = 16.68$, $p < .05$, partial $\eta^2 = .32$) was qualified by an interaction of time × condition ($F_{(1,35)} = 3.37$, $p < .05$, partial $\eta^2 = .09$) such that A-FACT participants returned to their pre-stressor levels of state anxiety ($M(SD)$ = 19.0(29.5)) whereas control participants demonstrated significantly lesser levels of subjective emotional recovery and did not return to their pre-stressor levels ($M(SD)$ = 27.2(24.0)) (Fig. 4).

Discussion

We tested a novel conceptual, methodological, and intervention paradigm targeting attentional biases underlying anxiety, mood, addiction and related disorders. We theorized that therapeutically targeting attentional bias may be achieved through a novel intervention methodology helping a person to monitor and gain awareness of their well-rehearsed, often automatic biased allocation of attention. So doing, we theorized, would facilitate self-regulatory control of (biased) attention. Accordingly, we developed Attention Feedback Awareness and Control Training (A-FACT). In a controlled laboratory experiment among high-anxious adults we tested the salutary effects of A-FACT, relative to an active placebo control condition, with respect to (a) attentional bias to threat and (b) behavioral avoidance of and emotional recovery from an anxiogenic stressor.

Results provided promising initial experimental proof-of-principle evidence for the capacity of A-FACT to deliver computerized, idiographic, real-time feedback regarding the online expression of participants' (biased) allocation of attention. First, relative to an active placebo control condition, participants in the A-FACT condition demonstrated statistically and clinically significant reductions in attentional bias to threat. Indeed, whereas pre-intervention levels of bias were elevated (Mean BS = 36.8 ms),

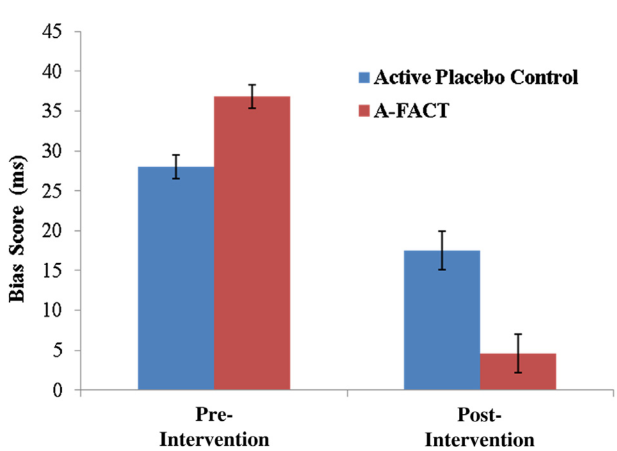

Fig. 3. Attentional bias reduction by condition pre-to-post intervention.

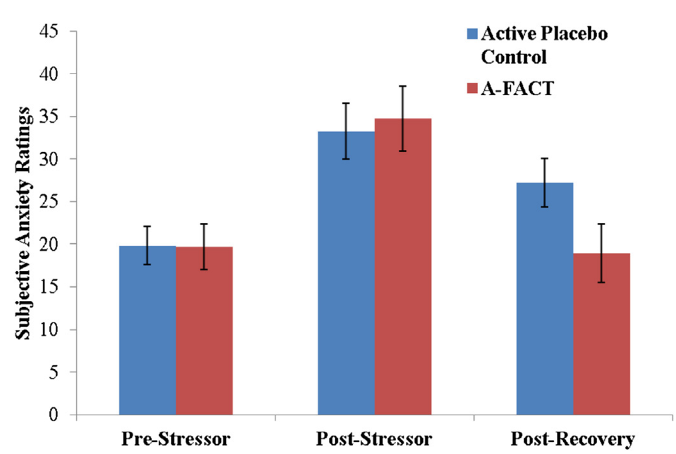

Fig. 4. Subjective anxiety recovery by condition following anxiogenic stressor.

post-intervention levels were very low (Mean BS = 4.6 ms); such that 68.2% of A-FACT participants (relative to 33.3% of participants in the control condition) showed 0-levels of attentional bias towards threat at post-intervention. Second, participants who received A-FACT, relative to the placebo control, demonstrated faster subjective emotional (state anxiety) recovery following exposure to the controlled laboratory anxiogenic stressor. These data are consistent with theorizing regarding the anxiogenic role of bias to threat and the adaptive anxiolytic implications of substantive reductions in bias due to A-FACT. Furthermore, we found preliminary evidence that A-FACT participants demonstrated reduced behavioral avoidance or elevated threat-related distress tolerance in response to anxiogenic stress exposure – though these effects did not reach statistical significance. These data provided modest, initial evidence that attentional bias reduction, in the context of A-FACT, was associated with some "down-stream" anxiolytic effects important to the maintenance of anxiety-related processes.

At this early stage in the development of the A-FACT intervention paradigm, it is important that a scientifically plausible mechanism is proposed (Baker, McFall, & Shoham, 2009; Heeren et al., 2013). As is typical of novel intervention development research, however, the putative mechanism(s) through which A-FACT led to the observed salutary effects were not measured directly. Whether, as theorized, feedback-mediated awareness-of-attention temporally preceded and causally engendered enhanced self-regulatory control of (biased) attention may only be cautiously inferred from the present findings. Accordingly, future study should test whether A-FACT engenders awareness-of-attention, enabling greater self-regulatory control of (biased) attentional allocation, thereby bias reduction, which consequently neutralizes the "down-stream" anxiogenic effects of unmonitored and uncontrolled bias. Such future work may also benefit by attempting to test or rule-out alternative mediating mechanisms (e.g., Heeren et al., 2013). Furthermore, it is important to highlight that we do not propose that a person cannot have awareness of her/his (biased) attentional allocation without A-FACT – to the contrary. Indeed, we posit that real-time feedback concurrent with one's expression of biased attentional allocation may facilitate this innate capacity for such awareness and related control. Thus, we propose that future study explore the herein theorized phenomenon(a) of monitoring and awareness of attentional bias and, specifically, their role(s) in the expression and maladaptive sequelae of attentional bias.

A-FACT and the implications of the present findings are not limited to threat-related attentional bias or anxiety. Theoretically, A-FACT is relevant to training awareness-of-attention and self-regulatory control, and thereby bias modification, with respect to any desired/undesired behavior mediated by attentional bias. For example, applications of A-FACT include biases of attention to escape-avoidance or safety signals and anxiety-related disorders, positive/negative emotion cues and mood disorders, drug and negative reinforcement opportunity cues and addictions, or food/reward cues and eating problems, etc. In summary, we propose that the capacity to measure and deliver real-time feedback regarding (biased) allocation of attention in real-time via A-FACT may represent a novel and significant conceptual, methodological, and intervention paradigm.

The observed findings may also provide insight into the nature of attentional bias. First, these data contribute additional experimental evidence that attentional bias to threat may function as a malleable causal risk factor for anxiogenic responding to threat exposure (Van Bockstaele et al., 2013; Zvolensky, Schmidt, Bernstein, & Keough, 2006). Second, these findings may furthermore help guide the development of hypotheses regarding the anxiolytic mechanisms of attentional bias reduction. Specifically, in the present investigation, we did not predict that A-FACT would reduce anxious responding to the stressor. Indeed, in A-FACT, participants are not trained to preferentially attend towards or away from anxiety-eliciting cues. To the contrary, A-FACT for anxiety-related attentional bias to threat is grounded in established cognitive-behavioral theory. Specifically, adaptive responding to anxiogenic stressors is characterized by direct and flexible engagement with feared stimuli *despite* experiencing anxiety (Foa & Kozak, 1986; Lang, 1977; Mennin, Ellard, Fresco, & Gross, 2013). Future work may test whether attentional bias reduction, in the context of A-FACT specifically or more generally, may lead to adaptive behavioral responding (e.g., reduced escape-avoidance behavior) and enhanced subjective emotional recovery following anxiogenic threat exposure; and/or whether such bias reduction may also lead to reduced levels of state anxiety and/or anxious reactivity to such exposure (Van Bockstaele et al., 2013). Though the present study was limited to a single experimental session, the observed anxiolytic effects of bias reduction were consistent with the former and not observed with respect to the latter.

A number of differences and similarities between A-FACT and extant intervention approaches are noteworthy. First, in contrast to ABM, there is no contingency in A-FACT between stimulus and probe location (cf. MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). In A-FACT, probe location is random, as in standard administration of the dot probe to measure attentional bias; in A-FACT, real-time trial-level feedback regarding a participant's (biased) attentional allocation is simply delivered back to her/him. Second, A-FACT offers a methodology distinct not only from ABM and other CBMs, but also from cognitive control training tasks (CCT; Siegle, Ghinassi, & Thase, 2007; Wiers et al., 2013). In contrast to CCTs that tax and thereby train working memory and executive control, A-FACT is more similar to bio- and neuro-feedback paradigms (Hammond, 2005; Moore, 2000); wherein real-time feedback regarding targeted internal states is provided to facilitate awareness of these states and thereby the capacity to engage down- and up-regulatory cognitive control (p. 5). Furthermore, training awareness for the purpose of facilitating self-regulatory behavioral and cognitive control – theory that drove the development of A-FACT – is in line with core tenets and techniques (e.g., self-monitoring, present moment attention) of traditional and third-wave cognitive-behavior therapies and mindfulness-based interventions (Mennin et al., 2013).

The present study is limited in a number of respects. First, though demonstrating elevated levels of anxiety and bias towards threat, the sample was small. It is important that future study replicates and extends the present findings. Second, effects were observed within a single experimental session. Larger-scale intervention study of A-FACT is needed (e.g., multiple training sessions, maximizing training effects and their generalizability) and testing the effects of A-FACT beyond the laboratory, across contexts and over time are important to continued evaluation of its potential clinical implications. Third, the assessment measurement and feedback methodology in the present study were limited to the modified dot probe methodology. Future study should test the generalizability of the effects of A-FACT in other paradigms (e.g., spatial cueing, visual search). This was nevertheless an important starting point as bias to threat and anxiety, and bias modification, has been most extensively studied within this methodological context (Van Bockstaele et al., 2013). Fourth, the A-FACT methodology in this first study was limited to behavioral responding reflecting covert attention; neither measurement of bias nor feedback entailed other indices of attention, such as eye-movements reflecting distinct components of (overt) attention bias (Armstrong & Olatunji, 2012). Fifth, future studies may compare A-FACT to sham-feedback, feedback not delivered in real-time (e.g., post-block), or a condition in which cognitive control is trained more generally but without delivery of feedback (Wiers et al., 2013). Finally, A-FACT was not tested relative to ABMT. There is very limited evidence that at single laboratory session of ABMT reduces bias (e.g., Heeren et al., 2013; Julian et al., 2012); ABMT is typically delivered over multiple sessions (Bar-Haim et al., 2007; Beard et al., 2012; Hakamata et al., 2010; Hallion & Ruscio, 2011). Thus, a single-session ABMT analog could be construed as a questionable control condition. However, a randomized control investigation of *multi-session* A-FACT vs. ABMT, with respect to attentional bias and anxiety-related outcomes, as well as with respect to the common or distinct mechanisms underlying these effects, may be one important future direction for this area of work.

In summary, despite their potential significance, extant conceptual and methodological approaches to therapeutically target attentional biases are limited. In the present study, we proposed and tested a conceptually and methodologically novel intervention paradigm targeting attentional biases – Attention Feedback Awareness and Control Training (A-FACT). Results provided promising initial experimental proof-of-principle evidence for the capacity of A-FACT to deliver computerized, idiographic, real-time feedback regarding the online expression of participants' (biased) allocation of attention with salutary effects on bias to threat and adaptive responding to an anxiogenic stressor.

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