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The Effects of Training Contingency Awareness During Attention Bias Modification on Learning and Stress Reactivity

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Current attention bias modification (ABM) procedures are designed to implicitly train attention away from threatening stimuli with the hope of reducing stress reactivity and anxiety symptoms. However, the mechanisms underlying effective ABM delivery are not well understood, with awareness of the training contingency suggested as one possible factor contributing to ABM efficacy. Here, 45 high-anxious participants were trained to divert attention away from threat in two ABM sessions. They were randomly assigned to one of three training protocols: an implicit protocol, comprising two standard implicit ABM training sessions; an explicit protocol, comprising two sessions with explicit instruction as to the attention training contingency; and an implicit-explicit protocol, in which participants were not informed of the training contingency in the first ABM session and informed of it at the start of the second session. We examined learning processes and stress reactivity following a stress-induction task. Results indicate that relative to implicit instructions, explicit instructions led to stronger learning during the first training session. Following rest, the explicit and implicit groups exhibited consolidation-related improvement in performance, whereas no such improvement was noted for the implicit-explicit group. Finally, although stress reactivity was reduced after training, contingency awareness did not yield a differential effect on stress reactivity measured using both self-reports and skin conductance, within and across sessions. These results suggest that explicit ABM administration leads to greater initial learning during the training protocol while not differing from standard implicit administration in terms of off-line learning and stress reactivity.

Keywords: anxiety; attentional training; explicit information; learning; stress reactivity

Attention bias toward threat-related stimuli has been associated with clinical and subclinical anxiety, with evidence indicating this bias to play a causal role in stress reactivity (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Mathews & MacLeod, 2005; Van Bockstaele et al., 2014). In light of these findings, attention bias modification (ABM) procedures have been designed to train anxious individuals' attention

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away from negative stimuli with the hope of reducing anxiety reactivity and symptoms (Bar-Haim, 2010; Hakamata et al., 2010; MacLeod & Mathews, 2012). One of the most widely used ABM procedures relies on the dot-probe task (MacLeod, Mathews, & Tata, 1986), in which pairs of threat and neutral stimuli are briefly presented simultaneously, while to-be-identified targets subsequently appear at the location vacated by the neutral stimuli, thus introducing a contingency between neutral stimuli and target location (MacLeod et al., 2002). While meta-analyses indicate small-to-medium effect sizes of ABM procedures for anxiety (e.g., Beard, Sawyer, & Hofmann, 2012; Hakamata et al., 2010; Hallion & Ruscio, 2011; Linetzky, Pergamin-Hight, Pine, & Bar-Haim, 2015; MacLeod & Mathews, 2012; Mogoase, David, & Koster, 2014; but see Cristea, Kok, & Cuijpers, 2015, for a different interpretation of the effect size), the mechanisms and parameters underlying effective ABM delivery are not well understood. Elucidating the best-suited parameters of ABM as a procedure might give rise to better ABM efficacy, assuming that clinical efficacy with ABM can be achieved only when tapping into reliable underlying attentional processes (e.g., MacLeod & Clarke, 2015; MacLeod & Grafton, 2016).

When examining the efficacy of a treatment or an intervention protocol, researchers and clinicians are typically concerned with near- and far-transfer of the targeted treatment effect. Near-transfer effects relate to posttreatment improvements in performance on tasks that are very similar to the tasks applied in treatment. In ABM, near-transfer effects are usually reflected in attention bias reductions evident post-training, as measured by the same task used in training but with application of slightly different stimuli, or by performance improvements on other quite similar attentional tasks. Unlike near-transfer effects, far-transfer effects are indicated by improved performance on tasks that are seemingly remote from the specific task used in training (Melby-Lervåg, Redick, & Hulme, 2016). Thus, in far-transfer effects lies the promise of any intervention designed to enhance psychological well-being. In ABM, the ultimate far-transfer effects would be reflected in reduced symptom levels or improved performance on tasks designed to induce stress, such as public speaking tasks for socially anxious individuals (e.g., Amir, Weber, Beard, Bomyea, & Taylor, 2008).

Awareness of the attentional contingency introduced during ABM training has been suggested as a possible parameter affecting ABM efficacy (e.g., Bar-Haim, 2010; MacLeod & Clarke, 2015). In a typical ABM protocol, participants are not explicitly made aware of the training contingency and are not asked to actively try and shift their attention away from threat stimuli. Instead, participants are expected to implicitly learn the contingency and modify their attention patterns (Hertel & Mathews, 2011; MacLeod & Mathews, 2012). Unlike more classic cognitive therapies in which patients are explicitly taught to employ top-down effortful attentional control in order to divert continuous attention away from anxiety-provoking thoughts (e.g., Wells, 2013), ABM procedures target automatic attentional biases, and hence are presumed to be most effective when the intended associations are implicitly acquired (e.g., Bar-Haim, 2010; Hertel & Mathews, 2011; Linetzky et al., 2015; MacLeod & Clarke, 2015).

However, awareness of the training contingency may lead to stronger acquisition (i.e., better ABM effect) and, consequently, to a greater reduction in anxiety symptoms and stress reactivity compared with implicit ABM administration. A number of studies examining the effects of explicit versus implicit instructions during attention training procedures have demonstrated that among nonanxious participants, explicit instruction produces greater reduction in attention bias compared with standard implicit administration (Grafton, Mackintosh, Vujic, & MacLeod, 2014; Krebs, Hirsch, & Mathews, 2010; Nishiguchi, Takano, & Tanno, 2015). Nishiguchi et al. (2015) compared the effects of an explicit and implicit dot-probe-based ABM administration among nonanxious university students who underwent a three-session training protocol of 160 trials per session. Attention bias was measured before and after training. Only explicitly trained participants showed reduction in negative attentional bias in a dot-probe task and faster attentional disengagement from negative stimuli in a gap-overlap task. However, the effect of explicit and implicit training on stress reactivity was not assessed in this study.

Krebs et al. (2010) investigated the effects of implicit and explicit ABM on posttraining worry persistence in nonanxious participants. One ABM session of 576 dot-probe trials either toward or away from threat was applied, with half of the participants in each training type receiving implicit or explicit instruction about the trained contingency. After training, participants were instructed to focus on their breathing and report on thought intrusions before and after a 5-min instructed-worry period. Results indicated that for both attentional training toward threat and attentional training away from threat, explicit instruction yielded larger attentional change in the intended training direction relative to implicit training. In addition, ABM increased worry only under explicit ABM administration. Finally, Grafton et al. (2014) also found superior bias change in explicit relative to implicit instruction on a dot-probe training protocol among nonanxious participants. However, in this study, only implicit ABM administration led to attenuated self-reported stress reactivity, with no effect for explicit administration. Grafton et al.'s (2014) results suggest that explicit ABM administration may lack far-transfer effects of cognitive training to stress reactivity, which has been shown to occur with implicit ABM administration in anxious as well as nonanxious participants (e.g., Amir et al., 2008; Heeren, Reese, McNally, & Philippot, 2012; MacLeod et al., 2002), using both self-report and physiological measures. However, to date, Grafton et al. (2014) was the only study to examine far-transfer effects of an explicit ABM training procedure to stress levels following an unrelated stress-induction task, albeit using only a self-report measure of stress reactivity among nonanxious participants.

To summarize, despite these preliminary reports, several key questions regarding the effect of contingency awareness on ABM as a procedure for reducing anxiety remain unanswered. First, the effects of instructed awareness in anxious participants, the population that is typically targeted by ABM, have not yet been studied. Second, previous studies examining explicit ABM have relied solely on self-reports of anxiety and stress reactivity. Adding physiological measures of stress and arousal could complement such indices by providing an alternative indicator of stress reactivity (e.g., Heeren et al., 2012; Lazarov, Dar, Liberman, & Oded, 2012). Finally, although the above-reviewed studies examined the effect of explicit ABM administration on attention bias scores, explicit instruction effects on incremental learning processes during ABM training has yet to be studied. It has been shown that implicit and explicit knowledge of task rules are associated with distinct patterns of learning (Vidoni & Boyd, 2007; Willingham & Goedert-Eschmann, 1999), and thus offer a reasonable next step for investigation.

Recent research examining ABM procedures began to elucidate the nature of the learning processes underlying standard implicit administration of dot-probe-based ABM protocols in an attempt to clarify and analyze processes occurring during ABM, possibly responsible for inducing near- as well as far-transfer effects after training. This new line of research has emerged in an attempt to look beyond the endpoint outcome of ABM, in which attention bias and symptom levels are usually measured (Abend, Pine, Fox, & Bar-Haim, 2014), and to examine the learning processes occurring within and between treatment sessions. Specifically, like in other domains of learning, ABM training has been shown to rely on two distinct learning phases: within-session (online) learning and between-session (off-line) learning consolidation (Abend et al., 2013; Abend, Pine, et al., 2014). Online learning refers to repetition-dependent improvement in task performance occurring within sessions, while off-line learning refers to enhanced performance evident following a postpractice rest interval. Thus, characterizing learning across these two phases of ABM training under implicit versus explicit instruction could shed further light on the specific learning phases that may be affected by instruction type (Robertson, Pascual-Leone, & Miall, 2004), and on how these might affect subsequent stress reactivity. In addition, while anatomically separable and capable of working independently, implicit and explicit learning processes have been shown to interact. Explicit knowledge acquisition has been shown to enhance learning when implicit learning is not possible or compromised (e.g., Vidoni & Boyd, 2007; Willingham, 2001; Willingham & Goedert-Eschmann, 1999). Indeed, prior research suggests that relative to nonanxious participants, anxious participants display greater difficulties and slower online learning on the dot-probe task (Abend, Pine, et al., 2014). It is therefore of interest to also examine the possibility of introducing explicit instruction for anxious patients who fail to acquire the intended contingencies or fail to show reduction in stress reactivity via implicit learning processes.

The aim of the current study was to examine the effect of instructed awareness of the training contingency in ABM (i.e., providing explicit instruction as to the nature of the contingency embedded in the task) with regard to learning processes and stress reactivity. Specifically, this study examined the differences between explicit and implicit ABM administration in learning processes occurring within and between sessions (i.e., online and off-line learning, respectively), and in far-transfer effects of learning as reflected in performance on a stress-induction task delivered after training. Participants high on trait anxiety underwent two ABM sessions 72 hours apart allowing delineation of both within-session online learning effects and between-session off-line consolidation effects. In each session, participants' attention was trained away from threat and then their stress reactivity following a stress-induction task was assessed. A between-groups design compared three training conditions differing by the instructions provided prior to each ABM session: (a) implicit, in which participants were not informed of the training contingency embedded in the task before each of the two training sessions; (b) explicit, in which participants were explicitly informed about the training contingency embedded in the task before each of the two training sessions; and (c) implicit–explicit, in which participants were not informed of the training contingency in the first training session, but were explicitly informed of the contingency at the start of the second session. This third condition was included to examine the effects of change in instructed contingency awareness on learning and stress reactivity. Online and off-line learning were assessed by examining reductions in reaction time within and between sessions. Far-transfer effect via stress reactivity was assessed using both self-reports and skin conductance level (SCL) following standardized stress-induction protocols.

Method

PARTICIPANTS

At Tel-Aviv University, 353 undergraduate students were first screened using the trait subscale of the State-Trait Anxiety Inventory (STAI; Spielberger, 1983; see "Measures" below). Students who scored at the top of the STAI-Trait distribution and had a score greater than 45 were invited to participate. The final study sample included 45 participants (*M* age = 23.7 years, *SD* = 3.16, range = 20–37 years, 35 females). Participants were randomly assigned to one of the three experimental groups. Our choice of group size was based on a power analysis. Based on our previous work examining learning processes in a similar two-session ABM procedure with a similar population (Abend et al., 2013; Abend, Pine, et al., 2014), we calculated the group size needed for a difference in learning gains of approximately 5% under constraints of alpha = 5% and power = 80%. This yielded $n = 15$ per group. The three groups did not differ on STAI-Trait mean scores, age, or gender distribution, all $ps > .10$. The study was approved by the local Institutional Review Board and participants provided written informed consent.

MEASURES

Trait Anxiety

Trait anxiety was assessed using the trait subscale of the STAI (Spielberger, 1983). The STAI-Trait consists of 20 items relating to general anxious moods answered on a 4-point scale ranging from 1 (*almost never*) to 4 (*almost always*). Item scores are summed with a total score ranging from 20 to 80. The STAI-Trait subscale has good internal consistency (ranging from .86 to .92) and high test–retest stability (ranging from .73 to .86). The STAI also has acceptable convergent and discriminant validity (Spielberger, 1983). Cronbach's alpha of the STAI-Trait in the current sample was .85.

A cutoff score of 45 on the STAI-Trait was chosen for the present study in line with previous studies using this score to dichotomized participants into low- and high-anxiety groups (e.g., Di Marco et al., 2006; Millar, Jelicic, Bonke, & Asbury, 1995). In addition, previous reports indicate that the average score among nonclinical volunteers is 33.39, with an *SD* of 6.32 (Bieling, Antony, & Swinson, 1998). Thus, a 45 cutoff score denotes an anxiety score that is approximately 2 *SD*s above the mean, strengthening the characterization of the current studied group as highly anxious. Finally, Bieling et al. (1998) reported the average score among clinical anxious populations to range from 47.39 in specific phobia to 55.94 in social anxiety disorder, average scores that are similar to the average score of participants in the current sample (*M* = 52.67).

Stress Reactivity

Skin Conductance Level (SCL). Sympathetic modulation of skin sweat glands secretions in response to the stress-induction protocols was used to index physiological arousal (Andreassi, 2000; Lazarov, Dar, Oded, & Liberman, 2010; Nagai, Goldstein, Fenwick, & Trimble, 2004; Shapiro, Melmed, Sgan-Cohen, Eli, & Parush, 2007). SCL (in MicroSiemens) was continuously measured using a MindWare data acquisition system, with a sampling rate of 1,000 Hz, and analyzed using the MindWare EDA analysis software (MindWare Technologies, Gahanna, OH), following the parameters recommended by the Society for Psychophysiological Research Guidelines (e.g., Boucsein et al., 2012; Roth et al., 2014). SCL was monitored with two disposable 1–1/2-in foam electrodes placed on the palmer surface of the middle phalanx of the first and third fingers of the participant's nondominant hand. Skin conductance reactivity to the stress-induction tasks was assessed and indexed by subtracting the mean SCL obtained for the prestressor epoch from the mean value recorded during the stress epoch (Δ SCL; e.g., Roth et al., 2014).

Subjective Stress Reactivity. Subjective stress reactivity was assessed using a computerized visual analogue scale (VAS; Abend, Dan, Maoz, Raz, & Bar-Haim, 2014; MacLeod et al., 2002). Participants were instructed to place the cursor at the scale position best representing their current level of anxiety ("How anxious do you feel right now?"). Anchors of the scale were a score of 0 (*not anxious at all*) and 30 (*very anxious*). This instrument has been found to be valid, reliable, and sensitive to changes in stress levels (Abend, Dan, et al., 2014).

Attention Bias Modification (ABM)

The ABM task was delivered using a variant of the classic word-based dot-probe task (MacLeod et al., 1986, 2002). The task consisted of 432 trials, divided into 9 blocks (48 trials each). Each trial (Figure 1A) began with a white fixation cross displayed for 500 ms presented at the center of the screen. Next, as in most standard ABM procedures (see Cisler & Koster, 2010, for a review), a word pair was presented for 500 ms, with each word

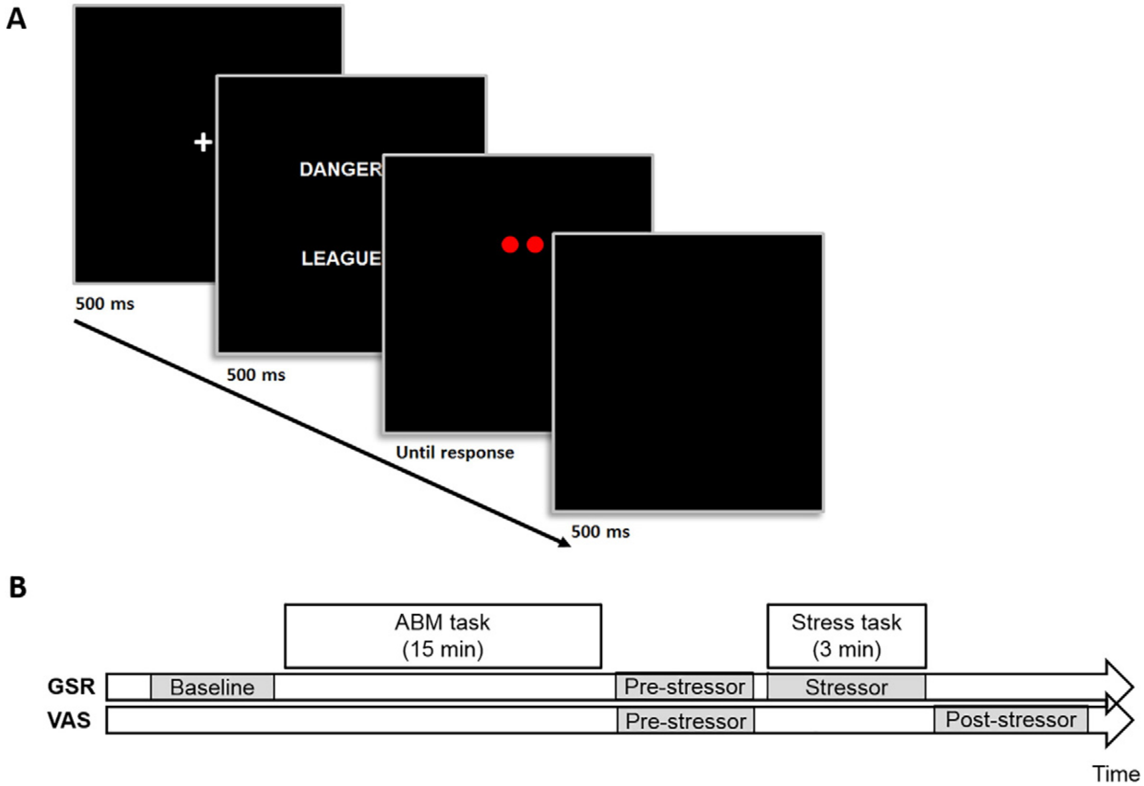

FIGURE 1 Trial sequence of the ABM task (A) and procedure for each session (B) in the study. Baseline, prestressor, and during-stressor SCL measurements were each 3 minutes long. *Note*. ABM = attention bias modification; SCL = skin conductance level; VAS = visual analogue scale.

written in 1 cm-high white text. One word appeared directly above the location of the previously presented fixation cross, while the other appeared directly below it. A distance of 3 cm separated the two words. The word pair was then replaced by a target probe that appeared in one of the two locations vacated by the words. The probe type was either a pair of red dots or a single red dot. Participants were instructed to determine which of the two probes appeared by pressing one of two prespecified mouse buttons as quickly as possible without compromising accuracy. The probe remained on the screen until a response and then the next trial commenced. As in previous studies examining ABM administration (see Hakamata et al., 2010, for a review), the probe appeared in the location previously occupied by the neutral word in every trial, thus training attention away from threat. Following completion of each block, participants were given a short break randomly ranging from 25 to 50 seconds (Abend, et al., 2013; Abend, Dan, et al., 2014). The end of the break was announced on the screen and the start of the next block was initiated by the participant.

Word stimuli consisted of 36 threat-neutral word pairs. Within each pair, number of letters and frequency of usage were matched. Threat-word location, probe type, and word pairs were counterbalanced within each block.

The ABM task was delivered using one of two sets of instructions (instructed contingency awareness). All participants first received the standard instructions for the dot-probe task as described above. Next, the experimenter notified participants that after the experimenter left the room, a slide would appear and that the participant should follow the instructions appearing on the slide. Written instructions were provided in this format, as opposed to verbal instructions from an experimenter, to ensure that all experimenters remained blind to group assignment. In the explicit task administration, the slide read as follows: "One of the two words that will appear on the screen will have a negative connotation while the other will be neutral. The target will appear in the location previously occupied by the neutral word, thus it is preferable to focus on this word while completing the task." In the implicit task administration, the additional slide contained only a request to press the space bar when ready, with no additional information or instruction. In the implicit–explicit condition participants received the standard implicit set of instructions during Session 1 while receiving the explicit instruction during Session 2.

Stress-Induction Tasks
Two stress-induction tasks were employed to assess stress reactivity following each of the two ABM training sessions. Two such tasks were needed so that each task was novel to the participant during each of the two stress reactivity sessions. A pilot test with 20 participants demonstrated the two tasks to induce comparable levels of stress, as indexed by SCL and VAS score. In the current study, each participant performed one task per session, with order of tasks counterbalanced across participants.

Auditory Serial Addition Task. In this task (Veldhuijzen van Zanten et al., 2004), 90 single-digit numbers were presented audibly one after the other, with a 2-second time interval between numbers. Participants were asked to add each current presented number to the number presented just before it and then state the answer out loud (preferably before the interval ended and the next number was presented). Numbers were delivered using an audio file and the entire task was 3 minutes long. To enhance threat cues concerning failure, participants were told that most people make about 12 mistakes during that time (Grafton et al., 2014).

Arithmetical Subtraction Task. In this task, participants were asked to count down from the number 10,000 in steps of 13 (Kirschbaum, Pirke, & Hellhammer, 1993). They had 3 minutes to complete the task and were told that most people reach the number 9,600 within the allocated time.

We chose to use these stress-inducing tasks in accordance with previous ABM studies examining far-transfer effects of ABM, in which emotional reactions to very different experiences, such as stressful anagrams or speaking in front of an audience, were found to be ameliorated posttraining (e.g., Grafton, Ang, & MacLeod; 2012; Grafton et al., 2014; Haeffel, Rozek, Hames, & Technow, 2012; MacLeod et al., 2002). As in previous studies (e.g., Grafton et al., 2014), in order to increase internally generated threat cues concerning failure implications, participants were told before the stress-induction task that it was part of a study investigating the relation between mathematical ability and academic achievement, and that if they scored in the lower or upper 10th centile of performance, they would be offered to participate in future studies. The statement regarding the performance of "most people" was introduced to make the stress manipulation more marked. During the task, the experimenter sat opposite to participants, checked each response, and notified participants if they made mistakes.

PROCEDURE

Participants were tested individually in the laboratory. Each participant took part in two experimental sessions, held 72 hours apart. We chose to use a 2-day ABM procedure to echo previous ABM learning studies (Abend et al., 2013; Abend, Dan, et al., 2014). Before Session 1, participants were randomly assigned to one of the three instructed contingency awareness conditions. At the beginning of each session (see Figure 1B), participants were instructed to view a 3-minute PowerPoint presentation of landscapes to serve as an adaptation period that minimized the possibility of group differences in SCL baseline levels prior to the start of the procedure. Next, the ABM training session commenced, lasting approximately 15 minutes. Upon completion of the ABM task, participants completed the prestressor VAS. Next, SCL was recorded for 3 minutes to serve as a prestressor reference measure. Participants then completed the stress-induction task, during which SCL was continuously recorded. Finally, participants completed the poststressor VAS. Session 2 applied an identical procedure with the exception that participants completed the alternative stress task. Additionally, participants in the implicit–explicit training group were notified of the training contingency at the beginning of the second training session. Each session lasted approximately 1 hour.

Importantly, in line with previous studies examining learning processes during ABM training (Abend et al., 2013; Abend, Dan, et al., 2014), we did not measure attention bias before training. Administration of one task (e.g., bias assessment) and then the other (e.g., bias modification) would have resulted in undesired learning interference effects, as reported for different types of skill learning (e.g., Walker, Brakefield, Hobson, & Stickgold, 2003), including the dot-probe task based on our prior extensive piloting. Measuring classic attention bias prior to ABM training would potentially confound results and limit our inferences concerning learning processes. Thus the present study assessed the effects of learning via response-time reductions (near transfer) and self-reported and physiological stress reactivity (far transfer).

Data Analysis and Outcome Measures
For analyses of the outcome measures during Session 1 we pooled together the implicit and the implicit–explicit groups, as these conditions were identical in this session. In Session 2 we compared the three separate groups.

Learning Processes
Data Cleaning. Trials with reaction time (RT) < 150 ms or > 2,000 ms or incorrect responses were excluded (Abend et al., 2013). Also excluded were

trials with RTs deviating by more than 2.5 *SD*s from their block mean.

Online Learning. As in prior studies (Abend et al., 2013; Abend, Dan, et al., 2014; Doyon et al., 2009; Korman et al., 2007), online learning gains were calculated as mean RT on each of the nine blocks of the training session normalized to the mean RT of Block 1. Thus, an increasing online gains curve reflects performance improvement. The effect of instructed contingency awareness on online learning was assessed using repeated-measures analysis of variance (ANOVA) on online gains in Blocks 1–9. Block (1–9) served as a within-subject factor and contingency awareness condition (implicit, explicit) as a between-subjects factor.

Off-Line Learning. To assess off-line learning gains dependent on postpractice rest, we normalized the mean RT of the first block of Session 2 relative to the last (ninth) block of Session 1 (Abend et al., 2013; Abend, Dan, et al., 2014; Korman et al., 2007). Positive off-line gains indicate the emergence of learning consolidation processes (Karni et al., 1998). The effect of contingency awareness on off-line learning was assessed using a one-way ANOVA on mean normalized off-line gains, with instructed contingency awareness (implicit, explicit, implicit–explicit) serving as the between-subjects variable.

Stress Reactivity

A one-way ANOVA on mean baseline SCL was first used to assess a priori differences among the three groups.

The effect of contingency awareness on SCL was assessed for each session using a one-way ANOVA on Δ SCL. The effect of contingency awareness on self-reported stress reactivity was assessed for each session using repeated-measures ANOVA on VAS scores with contingency awareness (implicit, explicit, implicit–explicit) as a between-subjects factor, and time (prestress, poststress) as a within-subject factor.

Significant interaction effects were followed by Tukey post hoc tests. All tests were two-tailed ($\alpha \leq .05$). Effect sizes are reported using η^2_p and Cohen's d when appropriate. Kolmogorov-Smirnov tests on all dependent variables per experimental condition revealed that the distribution of none of the variables was significantly different from the normal distribution, thereby permitting the use of parametric statistical tests.

Results

LEARNING EFFECTS

Online Learning

Both implicit (implicit and the implicit–explicit groups pooled together) and explicit groups demonstrated robust online learning during Session 1 (17.2% and 23.6% mean gain, respectively; see Figure 2A). Overall, we observed a significant main

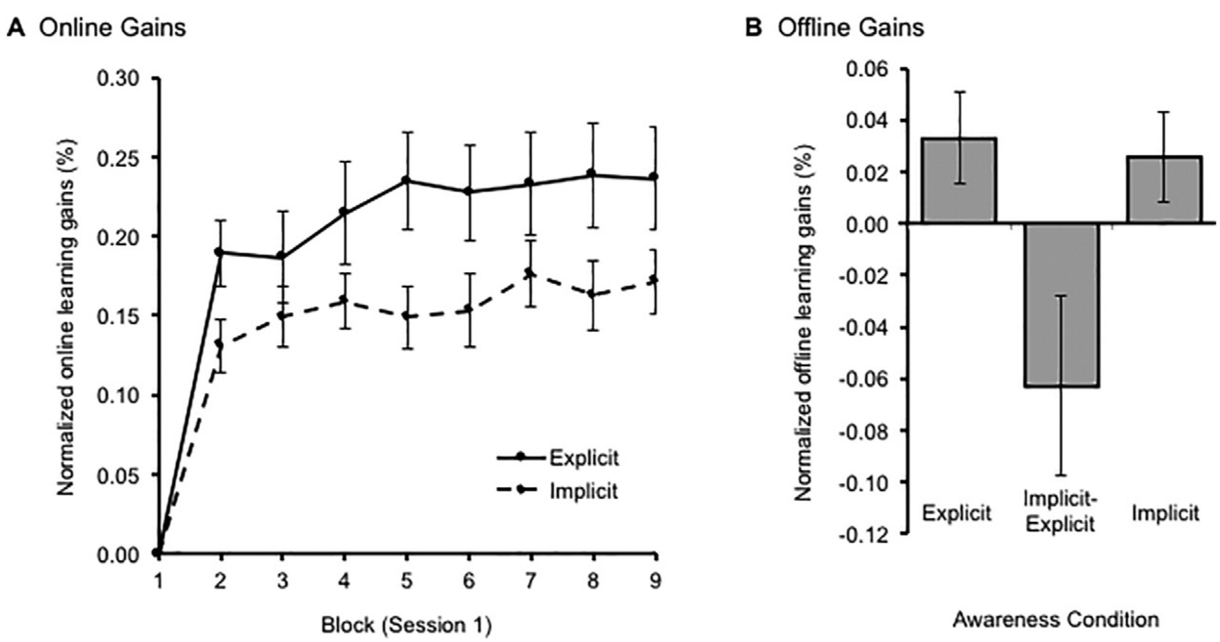

FIGURE 2 Mean (A) online learning gains in Session 1 and (B) off-line learning gains by contingency awareness condition. Bars indicate standard error of the means.

effect of block, $F(8, 344) = 59.69$, $p < .001$, $\eta^2_p = .58$, which was qualified by a significant Contingency Awareness × Block interaction effect, $F(8, 344) = 2.32$, $p = .019$, $\eta^2_p = .05$, supporting the observation that explicit instruction led to a greater improvement in performance over time relative to implicit instructions.

A significant Contingency Awareness × Block interaction effect was also found for Session 2, $F(16, 336) = 2.23$, $p = .0004$, $\eta^2_p = .01$. Follow-up analyses revealed significantly greater mean online gains during Session 2 in the implicit–explicit group compared with the implicit ($p = .007$, $d = 0.94$) and explicit ($p = .018$, $d = 0.83$) groups. There was no significant difference in online gains between the implicit and the explicit groups ($p = .73$, $d = 0.11$). Moreover, the mean gain in these groups did not differ from zero (one-sample t tests against zero, $ps > .50$), replicating our previous findings (e.g., Abend et al., 2013; Abend, Dan, et al., 2014).

Offline Learning

A significant difference in off-line learning gains among the three contingency awareness conditions was found, $F(2, 42) = 4.37$, $p = .019$, $\eta^2_p = .17$ (see Figure 2B). Post hoc analyses revealed significantly lower off-line learning gains in the implicit–explicit condition, compared with the implicit ($p = .047$, $d = 0.80$) and the explicit ($p = .029$, $d = 0.87$) conditions. No significant difference was found between the explicit and implicit conditions ($p = .977$, $d = 0.07$).

STRESS REACTIVITY

Due to technical errors, one participant's prestressor VAS score and another participant's poststressor VAS score were not collected during Session 1.

First, we checked for a priori differences in mean SCL levels among the three (unpooled) groups at baseline (see Table 1). A one-way ANOVA on baseline SCL levels indicated no significant differences among the groups, $F(2, 42) = 1.75$, $p = .19$, $\eta^2_p = .07$, reflecting no a priori group differences.

Table 1
Descriptive Statistics of the Three Groups

	Implicit		Explicit		Implicit–explicit	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*
STAI-T	51.28	6.05	51.78	3.60	54.95	7.31
Baseline SCL	6.58	7.85	3.26	3.55	3.73	3.02
Session 1						
ΔSCL	3.32	3.25	4.73	2.72	4.63	2.71
Prestress VAS	5.73	7.74	3.30	3.87	3.40	4.64
Poststress VAS	9.79	9.69	9.67	8.87	9.80	10.67
Session 2						
ΔSCL	3.65	3.35	3.25	1.88	2.85	2.46
Prestress VAS	5.00	7.83	5.93	8.49	3.13	4.25
Poststress VAS	6.73	8.14	8.93	8.65	7.60	8.51

Note. $n = 15$ in each group. STAI-T = State-Trait Anxiety Inventory-Trait; SCL = skin conductance level; VAS = visual analogue scale.

In Session 1, no differences between the implicit and explicit groups on Δ SCL were found, $F(1, 43) = .68$, $p = .41$, $\eta^2_p = .01$, reflecting similar physiological stress reactivity to stress induction in both groups. With regard to VAS scores, a main effect of time was noted, $F(1, 41) = 20.99$, $p < .001$, $d = 0.72$, with an increase in self-reported stress from pre- to post-stressor ($M = 4.16$, $SD = 5.69$ to $M = 9.75$, $SD = 9.54$, respectively), but no interaction effect, $F(1, 41) = .41$, $p = .52$, $\eta^2_p = .01$. Thus, ABM training under the two awareness conditions yielded similar stress reaction patterns when measured physiologically and subjectively self-reported (see Table 1).

Similar results emerged for Session 2. Again, no differences between the groups on Δ SCL was noted, $F(2, 42) = .35$, $p = .71$, $\eta^2_p = .01$. Likewise, a similar effect was noted for Session 2 VAS scores, $F(1, 42) = 8.45$, $p < .01$, $d = 0.40$, with an increase from pre- to poststressor assessment ($M = 4.68$, $SD = 7.04$ to $M = 7.76$, $SD = 8.29$, respectively), with no interaction effect, $F(2, 42) = .56$, $p = .57$, $\eta^2_p = .02$. Thus, in both sessions training under the two awareness conditions yielded similar stress reactions (see Table 1).

Finally, to examine group differences in stress reactivity changes across sessions we computed a self-reported stress reactivity change score by subtracting the prestressor VAS score from that of the poststressor VAS score (Δ VAS; see Table 1). We then subjected the ΔVAS and ΔSCL scores to two separate repeated-measures ANOVAs with session (Session 1, Session 2) as a within-subject factor and contingency awareness (implicit, explicit, implicit–explicit) as a between-subjects factor. Both analyses yielded a significant main effect of session, $F(1, 42) = 4.75$, $p = .03$, $d = 0.31$ for Δ SCL, and $F(1, 40) = 4.09$, $p = .048$, $d = 0.35$ for Δ VAS scores, with both measures decreasing significantly from Session 1 to Session 2 across groups. There were no significant interaction effects, reflecting no differences between the groups in stress reactivity changes from Session 1 to Session 2.

Discussion

The present study was designed to examine the effect of awareness of the training contingency (i.e., using explicit instructions) during ABM on learning and subsequent stress reactivity in anxious participants. Results indicate that relative to implicit instruction, explicit instruction led to stronger online learning gains. Following rest, the explicit and implicit groups exhibited a greater off-line improvement in performance relative to the participants who changed from implicit learning in Session 1 to explicit instruction of the embedded contingency in Session 2 (implicit–explicit group). Finally, contingency awareness did not yield a differential effect on stress reactivity measured subjectively and physiologically during Session 1, Session 2, and across sessions.

The results demonstrating greater online learning gains under explicit relative to implicit ABM administration are in line with previous findings indicating an advantage for explicit administration in terms of acquisition of the ABM attentional contingency, reflecting a greater ABM effect on attention bias (Grafton et al., 2014; Krebs et al., 2010; Nishiguchi et al., 2015). Importantly, the current results extend these previous findings by highlighting learning processes as a possible mechanism underlying improved contingency acquisition following explicit instruction. These obtained differences in online learning may reflect the involvement of distinct neural mechanisms and cognitive processes (Hazeltine, Grafton, & Ivry, 1997; Rauch et al., 1995; Vidoni & Boyd, 2007; Willingham & Goedert-Eschmann, 1999). Previous research has linked implicit learning to metabolic change in primary and supplementary motor cortices and the putamen, as well as premotor cortex, caudate, and thalamus. Conversely, explicit learning has been linked to metabolic change in prefrontal and premotor cortices as well as primary visual cortex, peri-sylvian cortex, and cerebellar vermis (Grafton, Hazeltine, & Ivry, 1995; Rauch et al., 1995). The lack of online learning differences between the implicit and explicit groups in Session 2 are in line with previous evidence indicating that online learning represents a unique phase of initial skill acquisition saturating early in practice (Hauptmann, Reinhart, Brandt, & Karni, 2005). This result is also in accord with previous studies on ABM learning processes (Abend et al., 2013; Abend, Dan, et al., 2014) in which online gains emerged only during the first ABM practice session but not during subsequent sessions. The greater online gains exhibited by the implicit–explicit group compared with the two other groups suggest that informing participants of the contingency following an implicit training session enabled them to significantly improve their performance within the subsequent session, highlighting the potential advantage of explicit ABM administration with regard to immediate learning gains.

While a clear advantage for explicit administration was evident with regard to online learning, this advantage was not found when examining off-line consolidation-related effects. The current results also suggest that making participants aware of the training contingency after they had implicitly trained in Session 1, and just before the start of the second training session (the implicit–explicit group), interfered with participant's ability to demonstrate off-line gains. Importantly, these results do not suggest that consolidation effects in the implicit–explicit group could not emerge if examined by an implicit ABM administration at the beginning of Session 2. Rather, these results indicate that in order to materialize and effectively measure potential off-line consolidation-related gains, consistency in ABM delivery across different sessions must be maintained. Indeed, as stated above, implicit and explicit learning processes have been shown to differ in terms of underlying neural mechanisms and behavioral expression. While explicit learning depends on declarative memory systems and can be assessed directly for example recognition and recall tasks, implicit learning engages procedural memory systems and can be assessed only indirectly by measuring changes in behavior occurring over time (Rauch et al., 1995; Vidoni & Boyd, 2007; Willingham & Goedert-Eschmann, 1999). As such, the shift in contingency awareness before Session 2 might have required participants to perform the task while relying on different cognitive mechanisms, and precluded the expression of off-line consolidation gains in this group (Robertson et al., 2004).

Previous research examining the relation between implicit and explicit processes in the learning of complex rule structures found explicit training to have a negative effect on previous learning when introduced after implicit learning had already been introduced, reflecting an interference effect (Reber, Kassin, Lewis, & Cantor, 1980). In a clinical context, if a patient does not respond to the typical implicit ABM protocol, therapists might consider informing the patient of the embedded contingency. However, the current results from the implicit–explicit group suggest that consolidation effects should not be expected immediately. Given the small sample size and the novelty of the current study, future research incorporating more ABM sessions, as well as a bigger sample, could elucidate whether participants are able to rebound in terms of learning effects with more sessions following the change in awareness.

The current study is the first to examine the effects of explicit and implicit ABM delivery on stress reactivity among high-anxious participants. Previous studies examined the effects of awareness only on midrange anxiety or nonselected participants, using only self-reports (Grafton et al., 2014; Krebs et al., 2010; Nishiguchi et al., 2015). Our results indicate that contingency awareness does not differentially influence stress reactivity, measured subjectively and physiologically, among anxious participants within and across sessions. These findings depart from the findings of Grafton et al. (2014), who found attenuated self-reported stress reactivity only following implicit administration with no far-transfer effects for explicit administration. This discrepancy between the two studies may be related to the fact that in the Grafton et al. (2014) study, the explicit and implicit training conditions were not included within the same study design but rather in two separate studies. Study 1 compared nonanxious participants trained implicitly toward and away from threat, while Study 2 replicated Study 1 but only administering the ABM explicitly. Thus, conclusions regarding implicit and explicit ABM administration were drawn from two different studies, potentially limiting the interpretation of these results.

Furthermore, in Grafton et al.'s (2014) explicit administration procedure, participants were made aware of the training contingency and were then requested to actively practice the execution of the intended attentional responding and to always quickly shift their attention in the required direction, which according to the authors might have eliminated possible stress reactivity effects (Grafton et al., 2014). Here, although we informed participants in the explicit conditions of the contingency embedded within the task and recommended using this information, we did not explicitly ask them to act on this knowledge. In a related vein, Krebs et al. (2010), who informed participants of the training contingency during an ABM dot-probe attention training, without any active practicing, achieved results echoing our present findings. Specifically, participants who underwent an explicit ABM administration toward threat demonstrated a robust modification of attention, accompanied by a corresponding change in self-reported worry following a subsequent worry-induction task.

One may wonder why the greater online learning gains in the explicit relative to implicit instruction did not translate into differences in stress reactivity—that is, why did better cognitive outcomes (i.e., enhanced learning) not lead to better emotional outcomes (i.e., stress reactivity; Hertel & Mathews, 2011)? First, it is possible that this association could be evident only after sufficient training has taken place. Although some studies reported a single ABM training session to reduce anxiety levels following an anxiety-induction task (e.g., Amir et al., 2008; MacLeod & Mathews, 2012), several meta-analyses suggest that multiple training sessions yield larger effects in reducing stress and anxiety (e.g., Beard et al., 2012; Hakamata et al., 2010; Hallion & Ruscio, 2011). Thus, it could be that the two ABM training sessions included in the current study were not sufficient for detecting differences between groups in stress reactivity despite existing differences in online learning.

In a related vein, it has been suggested that in order to increase transfer effects of learning, one should distribute learning across multiple sessions instead of conducting massive training in a limited number of sessions (Hertel & Mathews, 2011). Indeed, standard ABM protocols frequently consist of prolonged practice (Bar-Haim, 2010), thus providing numerous opportunities for online gains and subsequent consolidation processes (Hauptmann & Karni, 2002; Hauptmann et al., 2005). Hence, future research could examine the relations between learning processes and stress reactivity during extended (multiple sessions) implicit and explicit ABM protocols. Second, it could be that our stress-induction tasks did not yield sufficient stress levels to give rise to group differences in stress reactivity. Indeed, the mean stress reactivity scores in all groups did not exceed a score of 10 (out of a maximum possible score of 30) in Session 1 and a score of 9 in Session 2. Future studies may wish to consider more potent stress-induction procedures. Finally, we tested 15 participants per group as was done successfully in previous studies examining learning processes during ABM (e.g., Abend et al., 2013; Abend, Dan, et al., 2014). However, it could be that this group size is limited in its power to detect differences in far-transfer, stress reactivity effects.

While we noted no significant differences among the three experimental groups in stress reactivity within each session, we did observe an overall decline in stress reactivity from Session 1 to Session 2, as measured subjectively and physiologically. However, we cannot attribute this decline to the effects of ABM. One possibility is that the observed decline in stress reactivity occurred due to similar effects of the different ABM procedures indicating that ABM efficacy is not contingent upon instruction type. Conversely, this reduction could also be the result of simple habituation to the experimental situation indicating no far-transfer effects of training (Hertel & Mathews, 2011) with no specific effect of the delivered ABM procedure. Importantly, however, it was not a goal of the current study to examine the efficacy of ABM as a therapeutic procedure, but rather to compare training under different contingency awareness conditions with regard to learning processes and stress reactivity, examining ABM as a process (e.g., MacLeod & Grafton, 2016). Thus, our conclusions are in regard to group differences in learning and their relation to stress reactivity and not to the efficacy of the ABM procedure per se.

The results of the current study should also be viewed in light of certain limitations and future research considerations. First, as stated above, the current design does not allow ruling out the possibility that the reduction in stress reactivity was due to other factors and not to the ABM procedure. Future research aiming to clarify the effectiveness of explicit and implicit ABM treatment procedures should include a control condition to ensure that clinical changes are indeed due to the attention modification procedure. Second, although participants in this study were selected to be high on trait anxiety, it would be important to replicate these findings with clinically anxious, treatment-seeking participants. Third, ABM treatment protocols typically consist of more than two training sessions in order to maximize therapeutic effect (Hakamata et al., 2010; Linetzky et al., 2015). Hence, future research could examine the effect of explicit training administration on learning gains and stress reactivity applying more ABM sessions. Fourth, as stated earlier, the current study design did not include measures of attention bias before the ABM sessions. As these bias measures typically apply variants of the dot-probe task that are similar to the ones used for ABM training, we chose not to include bias measures in order to avoid learning interference effects induced by administering two very similar tasks. Such measurement of attention bias could potentially be achieved in future studies by applying measures that are far enough removed from the training task (e.g., eye-tracking during a free-viewing task; Lazarov, Abend, & Bar-Haim, 2016). Finally, we did not include a test of contingency awareness posttraining. Thus, we cannot assert with confidence that participants in the implicit condition did not become aware of the training contingency by the end of the procedure. However, prior findings mitigate this concern to an extent by showing that in previous ABM studies participants do not acquire such an awareness (e.g., Bar-Haim, 2010; Hertel & Mathews, 2011). Indeed, some studies reported that the vast majority of participants undergoing active ABM training believe to be part of the control group, despite demonstrating clinical improvements (e.g., Amir et al., 2009). Still, future research could replicate our study while including a contingency awareness test.

In conclusion, the results of the current study could potentially hold clinical implications. To date, all randomized controlled trials examining ABM efficacy in clinical populations have utilized implicit administration (Linetzky et al., 2015); thus, the potential clinical efficacy of ABM with explicit instruction remains unknown. Our finding showing similar effects of implicit and explicit administration on stress reactivity suggests that using explicit ABM protocols may be beneficial, particularly for individuals demonstrating difficulties in acquiring the ABM training contingency implicitly (Hertel & Mathews, 2011). Thus, future research could target anxiety in clinical populations exhibiting deficient implicit learning in an attempt to improve ABM as a procedure to enhance its efficacy as a therapeutic process.

Conflict of Interest Statement

The authors report no known financial interests or conflict of interest associated with this publication.

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