



Challenges to the traditional exposure paradigm: Variability in exposure therapy for contamination fears

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ARTICLE INFO

Article history:

Received 17 July 2011

Received in revised form

2 October 2011

Accepted 19 October 2011

Keywords:

Exposure therapy

Fear hierarchy

Blocked and constant exposure

Variability

Heart rate

Skin conductance

ABSTRACT

Background and objectives: Traditional models and methods of exposure therapy utilize a fear hierarchy, whereby patients complete sets of exposures in a graduated manner, with the goal of fear habituation within and between sessions. In the current experiment, we examined whether this typical exposure paradigm was necessary to achieve clinical improvement.

Method: Fifty undergraduate participants scoring in the top quartile of a self-report measure of contamination fears were randomly assigned to one of two groups: blocked and constant exposure (BC Group) and random and variable exposure (RV Group). Both groups completed three weekly sessions of exposure treatment, with subjective and psychophysiological indices of fear recorded throughout. Subjective, behavioral, and psychophysiological dependent measures were evaluated by an independent assessor at pre-treatment (PRE), post-treatment (POST), and two-week follow-up (2WFU).

Results: Both the BC Group and RV Group exhibited decreases in subjective fear from PRE to POST and 2WFU, with no significant differences between groups. Partialing group, greater variability in subjective fear during exposure predicted lower subjective fear at 2WFU.

Limitations: Despite significant findings for subjective fear, behavioral and psychophysiological findings were limited. Follow-up studies should investigate questions regarding traditional exposure within a clinical group.

Conclusions: These results support the notion that traditional exposure is sufficient, but not necessary, to produce clinical improvement in contamination-related fears. There may be benefits to variability in fear level during exposure, and evaluation of emotion variability during exposure therapy for other anxiety disorders is warranted.

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1. Introduction

1.1. Traditional exposure therapy

Traditional exposure therapy involves a gradual progression from one feared item to the next across a hierarchy, although within each item, the exposure practice is generally unvaried. Clinicians have been guided by the premises of emotion processing theory (Foa & Kozak, 1986; Foa & McNally, 1996), in which initial fear activation (IFA), within session habituation (WSH), and between session habituation (BSH) of fear are seen as critical indices of corrective learning throughout exposure therapy. The application of this theory is to repeat exposure to a phobic stimulus the number of times and

the length of time necessary for fear to subside. That is, exposure practice should proceed in a blocked and constant manner, while fear should gradually habituate, over the course of exposure therapy. However, the available evidence provides mixed evidence for IFA and limited to no evidence for WSH or BSH as predictors of treatment outcome (Baker et al., 2010; reviewed in Craske et al., 2008), albeit often based on studies with significant methodological weaknesses. Moreover, we have argued that whereas fear reduction typically occurs, it represents performance in the moment rather than learning that influences responding over the long-term (Craske et al., 2008), and that pure habituation is a poor model of real-world experiences with feared stimuli.

In the present experiment, we directly investigated whether these traditional concepts of exposure were necessary to achieve clinical improvement. First, we compared a blocked and constant exposure group to a group involving random and variable exposure

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(i.e., stimulus variability). Second, we examined exposure process measures of IFA, WSH, BSH, as well as variability in indices of fear (i.e., emotion variability) in relation to treatment outcome.

1.2. Drawing on theory from learning and memory

Evidence from the basic learning and memory literature suggests that the typical exposure paradigm – blocked and constant exposure along with fear habituation – may be less effective than variable exposure and variability in affect during exposure. First, the assumption that performance during “instruction” (i.e., expression of fear during exposure therapy) is a reliable index of learning (i.e., fear at follow-up testing) is not supported by memory research (Bjork & Bjork, 2006). That is, latent learning experiments in animals and motor learning experiments in humans show that learning happens over intervals in which there are no changes in performance, and that little or no learning can happen across intervals in which there are substantial changes in performance (Adams & Reynolds, 1954; Christina & Bjork, 1991; Schmidt & Bjork, 1992; Tolman & Honzik, 1930; see Bjork & Bjork, 2006). Furthermore, in the context of emotional learning, there is evidence for discordance at the neurobiological level between the expression of emotion versus learning and memory. For example, the amygdala is central to learning and memory of emotionally arousing stimuli, but is not critical to the expression of emotion (Canli, Zhao, Brewer, Gabrieli, & Cahill, 2000). Finally, within fear extinction learning (the original model for exposure therapy; see Eelen & Vervliet, 2006), behavioral and/or physiological fear during extinction training in rodent samples is not representative of learning at the process level and does not predict performance upon re-test, when the strength of new learning is assessed (e.g., Bouton, Garcia-Gutierrez, Zilski, & Moody, 2006; Plendl & Wotjak, 2010; Rescorla, 2006).

Second, basic research indicates that retention of learned non-emotional material is enhanced by random and variable practice (Magill & Hall, 1990). Even though variation increases difficulty throughout learning, Bjork and Bjork (1992, 2006) proposed that variation enhances long-term outcome. According to their model, variation increases the storage strength of information to be learned by making retrieval of past learning easier via the availability of cues that were present during prior learning. In addition, drawing from stimulus fluctuation theory (Estes, 1955), variation results in pairing the information to be learned with more retrieval cues, thus enhancing retrievability because the cues associated with new learning are more likely to be present in a situation where retrieval is required (Bjork, 1988). Furthermore, variation is posited to result in generation and application of a rule that captures the invariance among tasks. That is, despite dissimilarities, the basic principles are the same across tasks and can be applied regardless of situational differences. In other words, variation leads to generalization. The benefit of varying the to-be-learned material has been demonstrated with motor and verbal learning tasks (Schmidt & Bjork, 1992).

1.3. Previous exposure therapy research

To date only two studies have compared the traditional exposure approach to a more variable exposure approach. One study revealed that exposure to varied phobic stimuli (i.e., multiple spiders) led to better maintenance of treatment gains at follow-up than did exposure to a constant stimulus (i.e., a single spider) (Rowe & Craske, 1998). In addition, we found some benefits to random and variable, compared to blocked and constant, exposure for height phobias (Lang & Craske, 2000). In the random/variable condition, participants practiced exposure to heights in random order, such as 8th floor, 2nd floor, 10th floor, and 3rd floor balconies in more than one situation (e.g., inside versus outside stairwell) and approached the

precipice in different ways (e.g., looking out versus down). This was compared to blocked exposure to the same balconies repeatedly before moving to the next floor, with the same manner of approaching the height during each exposure trial. The random/variable practice resulted in lower self-reported general anxiety, although not specific fear of heights, one month later despite higher peak levels of fear, including heart rate, throughout exposure. The role of variability in fear itself during exposure has not been explored. Enhanced learning achieved through emotion variability would be most appropriately assessed at follow-up, as the prefrontal brain structures involved in the exposure process are central to long-term retrievability of learning (Maren & Quirk, 2004; Sotres-Bayon, Cain, & LeDoux, 2006). Clearly, the topics of stimulus and emotion variability in exposure need further investigation.

1.4. Study aims and hypotheses

This study aimed to build upon previous clinical, empirical, and theoretical literature by examining whether the concepts of traditional exposure were necessary to achieve clinical improvement in contamination-related fears. First, we hypothesized that a random and variable exposure group would show greater fear reduction than a blocked and constant exposure group across dependent measures at post-treatment (POST) and two-week follow-up (2WFU). Second, to measure idiosyncratic exposure processes, we partialled experimental group and hypothesized that IFA, WSH, and BSH would not reliably predict clinical improvement, whereas greater variability in fear during exposure would predict greater fear reduction at 2WFU.

2. Materials and methods

2.1. Design

The study was a 2 (Group) × 3 (Occasion) mixed design, comparing blocked and constant exposure (BC Group) to random and variable exposure (RV Group). Each participant (P) was randomized to one of the two groups and completed three weekly sessions of exposure treatment. Dependent measures were evaluated by an independent assessor at pre-treatment (PRE), post-treatment (POST), and two-week follow-up (2WFU).

2.2. Participants

Fifty Ps (25 per group) enrolled in an Introduction to Psychology course at the University of California, Los Angeles, were included in the analyses. Sample demographics were 72% female, and 14% Caucasian, 56% Asian/Asian-American, 6% Latino/Hispanic, 2% African-American, 4% Indian, 8% Bi-racial, and 10% Other. Mean age of Ps was 19.64 years ($SD = 2.46$).

Ps were recruited on the basis of scoring in the top quartile on the Padua Inventory of obsessive compulsive disorder symptoms – Washington State University Revision Contamination Obsessions and Washing Compulsions Subscale (Burns, Keortge, Formea, & Sternberger, 1996). The 10-item subscale was used as a screening method for contamination fears when confronted with various types of items (e.g., dirt, garbage), and possesses good psychometric properties in college samples (Sternberger & Burns, 1990). Ps rated their level of disturbance on a 5-point Likert scale for 10 different instances of potential contact with a contaminated object or situation. Ps' mean score on the subscale was 24.64 ($SD = 5.79$) at the time of recruitment, which is above the mean scores found in previous OCD samples (e.g., Burns et al., 1996; Williams, Turkheimer, Schmidt, & Oltmanns, 2005).

To meet further eligibility requirements, Ps did not endorse any of the following: heart, respiratory, or neurological condition;

current treatment for emotional disorder(s); physician instructions to avoid stressful situations; current pregnancy. These Ps were excluded in order to control for the effects of these variables on dependent measures including autonomic state.

2.3. Materials

2.3.1. Self-report measures

2.3.1.1. Padua Inventory. Ps again completed the 10-item Contamination Obsessions and Washing Compulsions Subscale of the Padua Inventory (PI-WSUR-COWC; Burns et al., 1996) at PRE, POST, and 2WFU.

2.3.1.2. Yale-Brown Obsessive–Compulsive Scale. Ps completed the Yale-Brown Obsessive–Compulsive Scale (Y-BOCS; Goodman, Price, Rasmussen, Mazure, Delgado, et al., 1989; Goodman, Price, Rasmussen, Mazure, Fleischmann, et al., 1989) at PRE, POST, and 2WFU. Y-BOCS measures severity of obsessions and compulsions independent of the content of symptoms, and possesses sound psychometric properties (Goodman, Price, Rasmussen, Mazure, Delgado, et al., 1989; Goodman, Price, Rasmussen, Mazure, Fleischmann, et al., 1989).

2.3.2. Behavioral Avoidance Task (BAT)

2.3.2.1. Behavioral measure. BATs were conducted at PRE, POST, and 2WFU. Ps were asked to hold each of six contaminated items selected to comprise a participant-created hierarchy out of a total of 13 total items (e.g., rag, shoe) for a period of 30 s, progressing from the highest feared of the six items to the lowest of the six items.¹ The number of seconds that Ps handled each item was recorded.

2.3.2.2. Subjective measures. Ps reported onset and offset distress levels for each BAT item, using a 100-point Subjective Units of Distress Scale (SUDS; Wolpe, 1973). Also, Ps reported SUDS and self-efficacy, using 0–100-point Likert scales, at completion of a 2-min anticipatory period prior to the BAT.

2.3.2.3. Psychophysiological measures. (i) *Heart rate.* Heart rate data were monitored continuously using the LifeShirt (VivoMetrics; Wilhelm, Roth, & Sackner, 2003), an ambulatory monitoring system that has been used in a wide variety of experimental studies to investigate physiological processes (Wilhelm, Pfaltz, & Grossman, 2006). Heart rate data were analyzed by VivoLogic 2.8.3. Mean heart rate (beats per minute; HR) was calculated for each BAT item. (ii) *Skin conductance level.* Skin conductance level was recorded through the LifeShirt and analyzed by VivoLogic 2.8.3. Skin conductance signals were recorded using two electrodes attached to the ring and middle fingers of the nondominant hand, washed with water. Skin conductance amplitude was recorded to the nearest microsiemen (μ S). Mean skin conductance level (SCL) was calculated for each BAT item.

2.3.3. Exposure process measures

Subjective and physiological (HR only) measures were recorded continuously throughout the three exposure sessions. For each exposure task during each exposure session, Ps reported onset and offset SUDS, as well as SUDS at each minute, and average and peak HR were calculated. These data were used to examine emotion

Table 1

Thirteen available exposure items.

| | |
|-----------|---------------|
| Shoe | Stained cloth |
| Lotion | Crayon |
| Rag | Toothbrush |
| Pen | Comb |
| Windex | Money |
| Hairbrush | Glue stick |
| Sock | |

Note. Each participant selected six items from the 13 available items that s/he believed to be most contaminated, with which the participant subsequently completed exposure.

processing theory variables of initial fear activation (IFA), within session habituation (WSH), and between session habituation (BSH) (Foa & Kozak, 1986; Foa & McNally, 1996). IFA was operationalized as the peak SUDS or HR for each exposure session, averaged across the three exposure sessions. WSH was operationalized as the difference between peak SUDS or HR and final SUDS or HR for each exposure session, averaged across the three exposure sessions. BSH was operationalized as the average of the change in peak SUDS or HR from the first exposure session to the second exposure session and from the second session to the third session. Additional process measures included final fear (FINAL), as a measure of ending SUDS or HR at completion of the final exposure session. Also, fear variability (VAR) was calculated to evaluate the degree to which variability in emotional responding throughout exposure was a predictor of outcome. VAR was operationalized as the standard deviation of SUDS or HR for each exposure session, averaged across the three exposure sessions.

2.4. Procedure

Data were collected over five sessions: baseline assessment (PRE); three weekly exposure sessions, with the last exposure session followed immediately by post-assessment (POST); and an assessment two weeks later (2WFU). For all Ps, the assessments and exposures were conducted in separate laboratory rooms.

At PRE, Ps completed informed consent, received instructions for using the SUDS scale, were fitted into the LifeShirt, and underwent a 5-min acclimation. Ps selected six items that they believed to be most contaminated among 13 total items (see Table 1).² Ps then placed these six items into categories based on fear level, with two items as the highest, two items as moderate, and two items as the lowest. These six items were subsequently used in each BAT, and three of these items (one from each category) were used in exposure. After instructions for the baseline BAT, Ps underwent a 2-min anticipatory period and completed anticipatory SUDS and self-efficacy ratings. Throughout the BAT, Ps completed SUDS at the onset and offset of holding each item, and HR and SCL were recorded continuously. After the BAT, Ps completed the Y-BOCS and Padua Inventory. Finally, Ps were randomized to one of the two exposure groups, and the experimenter read a statement to Ps including treatment rationale and group instructions.

Each exposure session was scheduled within seven days of the previous study session. At the start of each exposure session, Ps were fitted into the Lifeshirt and underwent a 5-min baseline recording period. In the blocked and constant (BC) group, exposure proceeded with one item during each exposure session, progressing from the lowest item, to the moderate item, to the highest item

¹ Given the nonclinical nature of the sample, the assumption that prior experience with lower level items on the fear hierarchy may serve to desensitize and therefore lower fear of higher level items, and to retain as much sensitivity as possible for measuring PRE to POST/2WFU change, we chose to proceed from the highest to the lowest item.

² The exposure items and tasks were selected as typical contaminant situations encountered in daily life. We piloted potential items and tasks prior to the start of the study, and the most aversive items and tasks were chosen.

Table 2
Descriptive statistics for self-report measures and BAT measures by group and occasion.

| | BC group | | | RV group | | | Effect size <i>d</i> at 2WFU |
|-----------------------------|-------------|-------------|-------------|-------------|-------------|-------------|------------------------------|
| | PRE | POST | 2WFU | PRE | POST | 2WFU | |
| Self-report measures | | | | | | | |
| Padua COWC | 24.4 (5.9) | 20.9 (6.5) | 19.5 (7.7) | 24.8 (5.4) | 19.5 (5.6) | 18.3 (6.6) | .17 |
| Y-BOCS obsessions | 7.0 (2.6) | 5.8 (3.0) | 6.0 (3.0) | 7.0 (3.5) | 6.0 (3.0) | 5.4 (3.6) | .18 |
| Y-BOCS compulsions | 7.3 (3.6) | 6.2 (3.6) | 5.9 (3.5) | 8.1 (3.0) | 7.1 (2.8) | 6.2 (3.8) | -.08 |
| BAT measures | | | | | | | |
| Behavioral | | | | | | | |
| No. sec high item | 30.0 (0.0) | 30.0 (0.0) | 30.0 (0.0) | 30.0 (0.0) | 30.0 (0.0) | 30.0 (0.0) | .00 |
| No. sec moderate item | 30.0 (0.0) | 30.0 (0.0) | 30.0 (0.0) | 30.0 (0.0) | 30.0 (0.0) | 30.0 (0.0) | .00 |
| No. sec low item | 30.0 (0.0) | 30.0 (0.0) | 30.0 (0.0) | 30.0 (0.0) | 30.0 (0.0) | 30.0 (0.0) | .00 |
| Subjective | | | | | | | |
| Anticipatory SUDS | 55.8 (23.1) | 38.3 (26.4) | 29.0 (22.2) | 55.5 (17.3) | 34.8 (24.8) | 27.9 (16.9) | .06 |
| Self-efficacy | 78.5 (23.5) | 89.1 (22.8) | 88.7 (22.9) | 81.4 (27.8) | 96.7 (5.6) | 96.2 (11.2) | -.41 |
| BAT SUDS high item | 61.3 (18.2) | 42.7 (30.6) | 35.2 (24.8) | 52.1 (23.3) | 37.5 (25.6) | 28.8 (24.0) | .26 |
| BAT SUDS moderate item | 44.4 (20.2) | 28.8 (23.6) | 25.2 (22.5) | 48.4 (21.2) | 31.3 (24.5) | 21.6 (17.9) | .18 |
| BAT SUDS low item | 37.0 (27.5) | 25.0 (23.4) | 23.0 (23.7) | 33.4 (20.4) | 21.4 (20.7) | 14.2 (16.3) | .43 |
| Psychophysiological | | | | | | | |
| Baseline HR | 80.2 (9.0) | 80.0 (11.3) | 81.4 (12.7) | 79.8 (9.8) | 80.3 (11.0) | 77.6 (11.7) | .31 |
| Anticipatory HR | 77.3 (9.5) | 74.6 (9.0) | 79.4 (13.0) | 78.6 (9.5) | 73.1 (8.5) | 74.5 (10.6) | .41 |
| BAT HR high item | 78.2 (10.3) | 74.3 (9.6) | 79.4 (13.1) | 79.2 (12.7) | 73.5 (9.0) | 75.1 (10.5) | .36 |
| BAT HR moderate item | 77.2 (10.6) | 76.5 (12.3) | 78.8 (13.1) | 78.8 (9.4) | 74.0 (9.0) | 75.4 (9.6) | .30 |
| BAT HR low item | 76.4 (9.0) | 74.2 (10.3) | 78.8 (12.6) | 78.2 (9.3) | 74.0 (8.7) | 73.9 (10.2) | .43 |
| Baseline SCL | 3.0 (2.8) | 3.3 (2.2) | 2.9 (1.5) | 3.0 (2.5) | 3.5 (2.3) | 3.8 (2.8) | -.40 |
| BAT SCL high item | 4.6 (4.6) | 5.8 (3.3) | 4.7 (2.4) | 5.7 (4.4) | 4.8 (3.6) | 4.5 (3.9) | .06 |
| BAT SCL moderate item | 4.4 (4.6) | 5.7 (3.1) | 4.4 (2.1) | 5.6 (4.5) | 4.9 (3.7) | 4.5 (3.8) | -.03 |
| BAT SCL low item | 4.4 (4.7) | 5.7 (3.2) | 4.4 (2.3) | 5.8 (4.8) | 5.0 (4.0) | 4.7 (3.9) | -.09 |

Note. Descriptive statistics for three BAT items not used during exposure. Effect sizes correspond to group differences at 2WFU. BAT = Behavioral Approach Task; BC Group = Blocked and Constant Exposure Group; HR = Heart rate (bpm); Padua COWC = Padua Inventory Contamination Obsessions and Washing Compulsions subscale (range = 0–40); RV Group = Random and Variable Exposure Group; SCL = Skin conductance level (μ S); SUDS = Subjective Units of Distress Scale (range = 0–100); Y-BOCS = Yale-Brown Obsessive Compulsive Scale (range = 0–20 for each subscale).

across the three exposure sessions. Within each exposure session, specific exposure tasks progressed from those rated as less difficult to those rated as more difficult (e.g., looking at an item at close proximity, spreading item over body). Finally, all exposure tasks were performed for 7 min.

In contrast, in the random and variable (RV) group, exposure proceeded with all three contamination items during each exposure session, with exposure items and tasks in random order of difficulty both within and across the three sessions. Finally, the exposure tasks were performed for varying amounts of time (range = 2–12 min).

The total number of exposure tasks ($N = 18$), total minutes of exposure (126 min), and total number of exposure trials with each high, moderate, and low item (6 tasks each) were equivalent across the two groups. Throughout each exposure session, Ps completed SUDS ratings at the onset of each exposure task and at every minute of the task thereafter, and HR and SCL were recorded continuously. Experimenters were positioned to the side of the Ps and provided no support during the exposure tasks. Following each exposure session, Ps were instructed to not wash their hands for 2 h in order to prolong the exposure in their natural environment.

At POST and 2WFU, Ps completed the BAT, Y-BOCS, and Padua in the same manner as at PRE.

2.5. Data reduction

Ps who dropped out following the first study session ($n = 12$) were removed from subsequent analyses of self-report and psychophysiological variables. The RV and BC groups did not differ in the number of Ps removed due to study attrition, $\chi^2(1) = .00$, ns. In addition, Ps with an insufficiently strong initial fear level (SUDS < 40 on the 100-point scale; $n = 22$) throughout the baseline BAT were removed from subsequent analyses of self-report and psychophysiological variables. The RV and BC groups did not differ

in the number of Ps removed due to insufficiently strong pre-assessment fear level, $\chi^2(1) = .10$, ns, or errors in psychophysiological recording, $\chi^2(1) = 1.04$, ns.

3. Results

3.1. Group comparisons

Table 2 presents descriptive statistics for the various dependent measures along with effect sizes for between-group comparisons at 2WFU. Group effects were evaluated using separate repeated measures analyses of variance (ANOVAs). For all analyses, the between-subjects factor was Group (RV, BC) and the within-subjects factor was Occasion (PRE, POST, 2WFU). The analysis of the Y-BOCS included the within-subjects factor of Y-BOCS Subscale (obsessions, compulsions). The analyses of number of seconds of handling, SUDS, HR, and SCL included those three BAT items that were not used during exposure and the within-subjects factor of Item Level (high, moderate, low).³ Only significant main and interaction effects are reported.

3.1.1. Self-report measures

A 2 (Group) \times 3 (Occasion) repeated measures ANOVA was conducted for Padua Inventory Contamination Obsessions and Washing Compulsions subscale score. A significant main effect was found for Occasion, $F(1.46, 61.46) = 26.82$, $p < .001$, and series of paired-samples t -tests indicated, across groups, significant decreases in Padua score from PRE to POST, $t(48) = 6.04$, $p < .001$, $d = .86$, and from POST to 2WFU, $t(43) = 2.55$, $p < .05$, $d = .40$.

³ Results for the three BAT items used during exposure were the same with regard to significance as the results presented here for three items not used during exposure. Here we elected to focus on the items not used during exposure as the more independent measure of outcome.

A 2 (Group) \times 3 (Occasion) \times 2 (Subscale) repeated measures ANOVA was conducted for Y-BOCS score. A significant main effect was found for Occasion, $F(1.53, 82.79) = 6.25, p < .005$, and a series of paired-samples t -tests indicated, across groups, a significant decrease in Y-BOCS score from PRE to POST, $t(48) = 2.17, p < .05, d = .31$, and a marginally significant decrease in Y-BOCS score from POST to 2WFU, $t(44) = 1.97, p = .06, d = .30$.

3.1.2. BAT measures

3.1.2.1. Behavioral. A 2 (Group) \times 3 (Occasion) \times 3 (Item Level) repeated measures ANOVA was conducted for number of seconds of handling. No main or interaction effects were significant.

3.1.2.2. Subjective. A 2 (Group) \times 3 (Occasion) repeated measures ANOVA was conducted for anticipatory SUDS score. A significant main effect was found for Occasion, $F(1.43, 59.84) = 19.19, p < .001$, and a series of paired-samples t -tests indicated, across groups, significant decreases in anticipatory SUDS score from PRE to POST, $t(48) = 3.57, p = .001, d = .51$, and from POST to 2WFU, $t(43) = 2.97, p = .005, d = .47$.

A 2 (Group) \times 3 (Occasion) repeated measures ANOVA was conducted for self-efficacy score. A significant main effect was found for Occasion, $F(1.23, 51.70) = 9.20, p < .005$, and a series of paired-samples t -tests indicated, across groups, a significant increase in self-efficacy from PRE to POST, $t(48) = -3.17, p < .005, d = -.47$.

A 2 (Group) \times 3 (Occasion) \times 3 (Item Level) repeated measures ANOVA was conducted for BAT SUDS score, averaged across onset and offset ratings. A significant main effect was found for Occasion, $F(1.76, 75.84) = 30.38, p < .001$, and a series of paired-samples t -tests indicated, across groups, significant decreases in SUDS score from PRE to POST, $t(48) = 5.50, p < .001, d = .79$, and from POST to 2WFU, $t(44) = 2.84, p < .01, d = .43$.

3.1.2.3. Psychophysiological. A 2 (Group) \times 3 (Occasion) repeated measures ANOVA was conducted for anticipatory HR, entering baseline HR and baseline HR² as covariates. No main or interaction effects were significant.

A 2 (Group) \times 3 (Occasion) \times 3 (Item Level) repeated measures ANOVA was conducted for BAT HR, entering baseline HR and baseline HR² as covariates. No main or interaction effects were significant.

A 2 (Group) \times 3 (Occasion) \times 3 (Item Level) repeated measures ANOVA was conducted for BAT SCL, entering baseline SCL as a covariate. A significant main effect was found for Occasion, $F(2, 66) = 6.30, p < .005$, and a series of paired-samples t -tests indicated, across groups, a marginally significant decrease in SCL from POST to 2WFU, $t(35) = 1.88, p = .06, d = .24$.

3.2. Exposure process

Table 3 presents descriptive statistics for the exposure process variables. The only variable on which the two treatment groups differed was SUDS WSH, $t(53) = 3.19, p < .01$, with higher values in the RV Group than the BC Group.

The relationship between exposure process variables and dependent measures at 2WFU was examined using a stepwise multiple regression model, again using only those three BAT items that were not used during exposure. The first step entered the baseline value of each dependent measure. The second step entered Group (enter selection). The third step contained IFA, WSH, BSH, FINAL, and VAR for SUDS and HR (forward selection). Only significant results are reported.

3.2.1. Self-report measures

For Y-BOCS Obsessions subscale at 2WFU, greater SUDS WSH predicted lower scores, $R^{2\text{change}} = .06$, standardized $\beta = -.24$,

Table 3
Descriptive statistics for exposure process variables.

| | Mean (SD) |
|---------------------|-------------|
| Subjective measures | |
| SUDS IFA | 67.0 (21.2) |
| SUDS WSH | 32.8 (22.1) |
| SUDS BSH | .2 (15.4) |
| SUDS VAR | 22.8 (8.1) |
| SUDS FINAL | 38.3 (31.5) |
| Heart rate measures | |
| HR IFA | 99.6 (9.2) |
| HR WSH | 24.5 (5.3) |
| HR BSH | -2.5 (5.3) |
| HR VAR | 77.1 (39.8) |
| HR FINAL | 77.0 (9.1) |

Note. BSH = Between Session Habituation; FINAL = Final SUDS or HR during exposure; HR = Heart Rate; IFA = Initial Fear Activation; SUDS = Subjective Units of Distress Scale (range = 0–100); WSH = Within Session Habituation; VAR = Standard deviation in SUDS or HR during exposure.

$p < .05$, as did greater HR BSH, $R^{2\text{change}} = .08$, standardized $\beta = -.28, p < .05$.

3.2.2. BAT measures

3.2.2.1. Subjective. For anticipatory SUDS score at 2WFU, greater SUDS IFA predicted higher scores, $R^{2\text{change}} = .29$, standardized $\beta = .86, p < .001$, whereas greater SUDS VAR predicted lower scores, $R^{2\text{change}} = .15$, standardized $\beta = -.51, p < .005$. For self-efficacy ratings at 2WFU, lower SUDS FINAL predicted higher scores, $R^{2\text{change}} = .10$, standardized $\beta = -.32, p < .02$.

For BAT SUDS score at 2WFU, greater SUDS IFA predicted higher scores, $R^{2\text{change}} = .15$, standardized $\beta = .60, p = .001$, as did greater SUDS FINAL, $R^{2\text{change}} = .17$, standardized $\beta = .31, p = .01$. In contrast, greater SUDS VAR predicted lower scores, $R^{2\text{change}} = .06$, standardized $\beta = -.59, p < .001$. Also, greater HR IFA predicted higher scores, $R^{2\text{change}} = .08$, standardized $\beta = .29, p < .05$, whereas greater HR BSH predicted lower scores, $R^{2\text{change}} = .09$, standardized $\beta = -.30, p < .05$.

3.2.2.2. Psychophysiological. For anticipatory HR at 2WFU, greater HR IFA predicted higher values, $R^{2\text{change}} = .15$, standardized $\beta = .45, p < .005$. For BAT HR at 2WFU, greater HR IFA predicted higher values, $R^{2\text{change}} = .10$, standardized $\beta = .40, p = .005$.

4. Discussion

The present results support the notion that the traditional exposure paradigm is sufficient, but not necessary, to produce clinical improvement in contamination-related fears. Whereas blocked and constant exposure did not differ significantly from random and variable exposure in its effects at POST and 2WFU, after partialing the effect of group to arrive at more idiosyncratic measures of exposure process, greater variability in subjective fear during exposure predicted lower subjective fear at 2WFU. In the comments below, implications and limitations of the data are discussed along with directions for future research.

4.1. Stimulus variability

Results of the experimental manipulation suggest that at the very least, random and variable exposure produces outcomes similar to traditional blocked and constant exposure procedures in this population. Across multiple subjective measures, including the Padua Inventory Contamination Obsessions and Washing

Compulsions Subscale, Y-BOCS, self-efficacy, and SUDS scores, both the BC Group and RV Group exhibited significant improvements from PRE to POST. Changes from POST to 2WFU were slightly less reliable, perhaps due to the fact that explicit relapse prevention instructions, typically provided after a full course of exposure treatment, were not given to participants in this study. Although group means did not significantly differ at 2WFU, the effect sizes on most measures, albeit small, indicated lower levels of subjective fear in the RV Group than the BC Group, and such effects may expand within a clinical group. Importantly, as encounters with feared objects and situations in the real world do not naturally occur in a graduated and hierarchical manner, random and variable exposure may more closely link with patients' experiences outside of therapy.

4.2. Emotion variability

Results for the exposure process data suggest that variability in the emotional experience of individuals with contamination fears during exposure, as a subjective rather than objective measure of variability, may be even more important to their long-term learning. Specifically, greater SUDS variability during exposure predicted lower anticipatory SUDS score and lower BAT SUDS score at 2WFU. Several possible mechanisms may play a role. First, emotional state (i.e., fear level) may serve as a retrieval cue; variability in fear level during exposure would be expected to enhance retrievability of learning, as varying levels of fear are likely to be elicited in situations following exposure therapy where retrieval is required (Bjork & Bjork, 1992, 2006). More generally, variability in subjective fear during exposure may aid in generalization of learning, such as the understanding that one can tolerate exposure to a stimulus across a variety of emotional states. However, the results did not extend to variability in psychophysiological response throughout exposure.

Results were mixed with regard to traditional indices of emotion processing theory (Foa & Kozak, 1986; Foa & McNally, 1996). On the one hand, greater SUDS WSH and greater HR BSH predicted lower follow-up scores on the Y-BOCS Obsessions scale, but not on the Padua scale or the Y-BOCS Compulsions score. Also, greater HR BSH predicted lower BAT SUDS score. On the other hand, indices of subjective and physiological initial fear activation predicted higher (instead of lower) levels of anticipatory and/or in vivo distress during the BAT at 2WFU. Also, no indices of WSH predicted BAT scores at 2WFU. Indeed, many participants ended exposure sessions with high levels of distress, even higher than their initial fear levels, and still exhibited clinical improvements at 2WFU. Emerging animal research on extinction, the laboratory analog of exposure therapy, may help to explain the lack of a reliable relationship between emotion processing theory variables and fear reduction in the long-term. Woods and Bouton (2008) demonstrated across several paradigms that immediate extinction (i.e., greater or more immediate habituation) was less durable than delayed extinction, in that it led to stronger spontaneous recovery at final test. Likewise, Plendl and Wotjak (2010) found that conditions leading to more immediate WSH were unrelated to BSH, and that BSH occurred in the total absence of WSH. These findings parallel the notion that real-world experiences with feared stimuli may not naturally end in a fear reduction state.

4.3. Study limitations

With regard to psychophysiological variables, across groups no significant effects were found for HR or SCL, although SCL decreased marginally from POST to 2WFU. The limited findings for HR and SCL relative to subjective measures align with a large body of research

indicating differential reactivities of these channels to fear stimuli and differential responsiveness to exposure treatment (e.g., Grey, Sartory, & Rachman, 1979; Lang, 1968). Specifically, reported fear tends to decrease more rapidly during exposure than autonomic activation, which may persist in the long-term despite changes in self-report or behavior (Craske et al., 2008). For example, in our prior work with panic disorder samples, normalization of psychophysiological variables did not occur until a nine-month follow-up assessment (Craske, Lang, Aikins, & Mystkowski, 2005). Furthermore, HR in particular showed almost no increase as a function of pre-BAT items, resulting in floor effects that likely mitigated treatment effects. This may be due to contaminant BAT items, as contamination fears have been associated with disgust reactions and HR deceleration rather than acceleration. Indeed, in addition to fear, disgust appears to characterize contamination-related OCD (e.g., Cogle, Wolitzky-Taylor, Lee, & Taylor, 2007; Deacon & Olatunji, 2007; reviewed in Cisler, Olatunji, & Lohr, 2009), just as fear and disgust have been implicated in specific phobias such as blood-injury-injection phobia and spider phobia (e.g., Woody & Teachman, 2000; reviewed in Cisler et al., 2009). Although fear and disgust are related (Rachman, 2004), these results speak more directly to exposure therapy for contamination-related OCD, and future studies should examine whether the results extend to exposure therapy for other anxiety disorders in which fear is more prominent. Also, the behavioral measure exhibited no change across groups. This appears due to a ceiling effect whereby nearly all participants were able to handle each contamination item for the full 30 s at baseline, resulting in little sensitivity of this measure to improvement.

Another limitation of the current study is its use of analog procedures, including a brief course of exposure therapy and follow-up within an undergraduate analog sample, albeit with self-reported contamination fears similar to the levels of clinical samples. Although drop-out rates were equivalent across the BC Group and RV Group, it will be critical to evaluate the feasibility of random and variable exposure with clinical populations. Anecdotally, in our own anxiety disorders treatment center, we have found that the provision of a rationale for the use of random and variable exposure (e.g., enhanced generalizability of learning) assists patients in understanding of and engagement in such procedures.

4.4. Conclusions

Exposure therapy is the most common behavioral treatment for anxiety disorders, and its traditional models and methods tend to rely on the graduated fear hierarchy and the premise of habituation as the index of corrective learning. However, there is a gap between advances made in learning and memory and the typical exposure therapy paradigm. The integration of new theoretical mechanisms and empirical developments from basic science may increase the efficacy of exposure, which is warranted as although exposure therapy has demonstrated effectiveness, it is not full-proof. These findings suggest that random and variable exposure produces outcomes similar to traditional exposure for contamination-related fears, and that greater emotion variability during exposure, which includes the ups and the downs of fear as opposed to pure habituation, may serve to enhance patient outcomes.

Conflict of interest

The authors have no potential conflicts of interest to declare.

Role of funding

This study received no external funding.

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