2020

Enhanced mental reinstatement of exposure treatment to improve the generalization of learning in claustrophobia

BOSTON UNIVERSITY

GRADUATE SCHOOL OF ARTS AND SCIENCES

Dissertation

ENHANCED MENTAL REINSTATEMENT OF EXPOSURE TREATMENT TO IMPROVE THE GENERALIZATION OF LEARNING IN CLAUSTROPHOBIA

by

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Submitted in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

2020

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ACKNOWLEDGEMENTS

I feel fortunate to say that my journey through graduate school, culminating in this dissertation, has been supported by a wonderful community of friends, family, colleagues and mentors.

In particular I want to say thanks to my advisor Stefan Hofmann for your unwavering support of my work, and for always pushing me to think innovatively and creatively in my research endeavors. I am extremely grateful for all of the opportunities working with you has provided, and for creating a lab environment that has inspired me to work hard without forgetting the importance of having a good time.

My two other readers, Michael Otto and Bram Vervliet have also played an invaluable role in shaping my thinking and my research, within this dissertation and outside it. From Michael, I have learned an immense amount about how to think translationally, applying basic concepts related to learning and memory to the complex world of clinical research, and vice versa. And Bram, I owe you major credit for getting me excited about the world of fear conditioning and experimental research, and I am particularly appreciative of your gracious invitation to the CLEP retreat in Belgium, which helped shaped the ideas explored in this dissertation.

I also owe a sincere thanks to my final two committee members, Lisa Smith and Todd Farchione. I have had the good fortune to be supervised and shaped in my development as a clinician by both of you, and it feels very fitting that you would be a part of this final chapter of my graduate school experience.

To the many fellow graduate students and current and past lab members, I also

want to give a big thank you. In particular to Josh, my partner in crime through all our years at PERL, I can't imagine what grad school would have been like without you. To Barbara, who taught me so much clinically, and became such a wonderful friend. To Angelina, for always keeping me on my toes. To Megan, Abby and Danielle, for keeping me young yet making me feel old. And to Emma, Hannah and Rachel, three amazing friends that started out as wonderful colleagues and have become so much more.

Also deserving of a big thanks are my mom, dad and brother. I am lucky to have such a supportive and loving family. And, of course, how I could have gotten through this dissertation and graduate school without the love and support of my wonderful wife Elizabeth. You have put up with a lot, and I can't thank you enough.

I am also incredibly grateful to the funders of this dissertation: the American Psychological Foundation, particularly William and Dorothy Bevan who sponsored the grant I received, and the American Psychological Association. And I could not have completed this project without the good will of Ron Killiany and the BUMC Biomedical Imaging Center, who let me use their mock MRI scanner, as well as Kayla and Tory for their tireless work on data entry and cleaning, and Danielle for so enthusiastically helping me run participants.

And lastly, I have to thank the wonderful participants who took part in this study. Being willing to face your worst fears is no small feat, and the courage you showed in doing so is an inspiration for me to keep doing this work and never shy away from the challenges life brings.

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ABSTRACT

Exposure therapy is the gold standard treatment for anxiety disorders, but reductions in fear following exposure often do not generalize well outside the context in which they took place. This study tested a strategy for increasing generalization that involved revisiting the memory of a prior exposure experience in order to enhance the retrieval of the learning that occurred. Forty-five participants (29 females, 16 males) with claustrophobia received exposure training consisting of repeated 5-minute trials lying inside a narrow cabinet laid on its back. One week later, they were randomly assigned to either enhanced mental reinstatement (EMR) or control procedures.

Results of the exposure training showed significant decreases in subjective fear, heart rate and avoidance in the training context, as well as reduced claustrophobia symptoms. As expected, fear levels in the mock MRI scanner one week later increased relative to the exposure training context post-treatment. Compared to the control condition, the EMR intervention led to significantly reduced heart rate reactivity in the mock MRI scanner, but not to reduced self-reported fear or avoidance of the mock scanner, nor to differences in claustrophobia symptoms at one-month follow-up. Expectancy violations about coping self-efficacy, measured via participants' surprise

about their ability to effectively cope during exposure, predicted lower fear in the mock MRI regardless of condition. Fear-related expectancy violations, reflecting greater discrepancy in expected vs. actual fear levels during exposure, predicted greater fear in the mock MRI. Results highlight the potential for mental reinstatement of exposure to improve generalization of learning in claustrophobia, though effects may be limited. The impact of expectancy violations on exposure outcomes may depend on the type of expectancy that is violated.

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Introduction

Cognitive-behavioral therapy consisting of exposure therapy has been shown to be the gold-standard treatment for anxiety disorders, yet treatment outcomes remain suboptimal (Carpenter et al., 2018; Hofmann & Smits, 2008). One hypothesized reason for this is that the learning that occurs from the nonoccurrence of anticipated negative outcomes during exposure, known as extinction learning, is somewhat fragile. Basic experimental research has shown that when a fear response is extinguished, the original fear memory has not been erased, but rather a new memory of safety has formed that inhibits its activation (Bouton, 2002). As a result, the retrieval of such learning appears to be highly dependent on context, such that the presentation of an extinguished stimulus outside of the context in which extinction occurs can lead to the renewal of the original fear response (Vervliet, Baeyens, Van den Bergh, & Hermans, 2013).

An important consequence of such contextual fear renewal effects is that the learning that occurs during exposure therapy often does not completely generalize to new situations. For example, spider phobics who undergo successful exposure therapy to a spider in one context demonstrate a return of fear to the same spider when it is presented in another context, (Mineka, Mystkowski, Hladek, & Rodriguez, 1999), with studies showing between 30% and 50% of the fear reduction seen during treatment in one context returning after a context change (Dibbets, Moor, & Voncken, 2013; Mystkowski, Craske, & Echiverri, 2002). Similarly, changes in elements of the feared stimulus itself can lead to a return of fear after successful extinction (Vervliet, Vansteenwegen, Baeyens, Hermans, & Eelen, 2005; Vervliet, Vansteenwegen, & Eelen, 2006; Rowe &

Craske, 1998). The consequences of such a failure to generalize safety learning can be significant for exposure therapy outcomes, as successful exposures conducted with a therapist may not translate to reduced anxiety outside of the treatment context, or improvements may be restricted to the specific feared situation confronted in the exposure. Individuals with anxiety disorders tend to experience anxiety in a wide variety of scenarios, but it is usually not feasible to conduct exposures to all possible feared stimuli in all contexts. Therefore, some amount of generalization is needed for successful treatment outcome. In addition, enhancing generalization could result in a need for fewer in-session exposures, and could increase the likelihood of patients confronting feared situations outside of session, which would contribute to further improvements.

Extinction Generalization Techniques

A number of different techniques designed to enhance the generalization of extinction learning have been tested in both laboratory and clinical research. For instance, conducting training in multiple contexts has been shown to attenuate renewal in experimental studies (Bandarian-Balooch, Neumann, & Boschen, 2012; Krisch, Bandarian-Balooch, & Neumann, 2018) and lead to reduced fear to a novel feared stimulus in clinical studies (Bandarian-Balooch et al., 2015; Shiban, Pauli, & Mühlberger, 2013; Shiban, Schelhorn, Pauli, & Mühlberger, 2015). Other methods of reducing contextual renewal that have shown promise in laboratory research, include extinguishing the original conditioned stimulus (CS; Vervliet, Vansteenwegen, & Eelen, 2004), directing attention to shared elements of an extinction stimulus and the original CS (Barry, Verliet & Hermans, 2017), increasing the number of extinction trials (Krisch et

al., 2018), and post-extinction sleep (Pace-Schott et al., 2009; Pace-Schott, Verga, Bennett, & Spencer, 2012). In addition, several different methods of decreasing the perceived aversiveness of an unconditioned stimulus in experimental extinction paradigms have also been shown to attenuate renewal (Dibbets, Poort, & Arntz, 2012; Haesen & Vervliet, 2015; Leer, Haesen, & Vervliet, 2018).

The techniques used in the studies above largely focus on manipulations of the extinction or exposure training itself, rather than procedures that occur in the context of a test of renewal. Identifying techniques that can help patients to apply prior learning to novel exposure situations as they come up, however, could be particularly helpful for fostering long-term treatment gains. One technique that fits with this approach is the use of a retrieval cue, which is a neutral stimulus present during extinction training that becomes associated with the learning that occurred during training. The presence of such a cue across different contexts can then help to retrieve the extinction memory and attenuate renewal of fear. Despite promising results seen in the laboratory (Dibbets, Havermans, & Artnz, 2008; Dibbets & Maes, 2011), only one of four trials has shown meaningful benefits of a retrieval cue for reducing return of fear (Culver, Stoyanova, & Craske, 2011; Dibbets, Moor, & Voncken, 2013; Laborda et al., 2016). The exception was a study by Shin and Newman (2018), which found reduced recovery of behavioral and physiological indicators of anxiety (though not subjective fear) when using a scented, neon-green puffer ball as a retrieval cue during public speaking exposure. Notably, this study differed from prior retrieval cue manipulations by increasing the sensory modalities the cue targeted (i.e. smell, touch, sight, and sound), suggesting that increasing the

salience of safety cue may be important for seeing beneficial effects.

One potential risk of a retrieval cue is that safety during exposure becomes attributed to the presence of the cue rather than the actual exposure situation (Dibbets & Maes, 2011; Salkovskis, 1991). If non-occurrence of feared outcomes only occurs in the context of a particular physical cue, then the retrieval of safety learning may depend on the presence of that cue, and fear is likely to return in the cue's absence. Therefore, the development of generalized safety learning about a feared situation could theoretically be impaired by the retrieval cue (i.e. protection from extinction; Lovibond, Davis, & O'Flaherty, 2000), similar to the way reliance of safety behaviors can maintain anxiety and slow progress during exposure therapy (see Blakey & Abramowitz, 2016 for a review).

Mental Reinstatement

Another generalization technique that attempts to enhance retrieval of the safety memory formed during extinction is mental reinstatement. Rather than using an arbitrary cue, however, participants are instructed to mentally revisit what happened during exposure training, as well as the context in which it occurred. Mental reinstatement of the context in which information was encoded has been shown to reduce the decrement in memory seen after a context change (Smith & Vela, 2001), and could plausibly bolster the retrievability of memories formed during extinction learning after a context change as well. While physical cues of a learning context may not necessarily be sufficient to counteract context-dependent memory effects, mental imagery of the learning environment and what occurred in it has been should to have more significant impact

(Smith, 1979). Furthermore, such a technique would appear less susceptible to protection from extinction than a retrieval cue given that it explicitly involves recall of prior safety learning memory rather than introducing a new contextual stimulus to which safety may be attributed.

Similar to the clinical findings on retrieval cues, mental reinstatement procedures show promise for enhancing generalization, but effects are somewhat inconsistent and are limited to particular outcomes. In the most successful application to date, Mystkowski, Craske, Echiverri, and Labus (2006) showed that in spider phobics, mental reinstatement of exposure treatment led to reduced recovery of subjective fear after a context change compared to reinstatement of a neutral memory, though they elected not to test effects on heart rate or behavioral avoidance given that no return of fear was seen in those measures. Elsesser and colleagues (2013) found that mental reinstatement led to shorter approach latencies to one of three phobic stimuli a week after exposure treatment for dental phobia, but no effects on subjective fear or heart rate to the phobic stimuli, or likelihood of going through with a dental procedure (Elsesser, Wannemüller, Lohrmann, Jöhren, & Sartory, 2013). Finally, in a study by Laborda and colleagues (2016) on public speaking anxiety, there was no effect of mental reinstatement on renewal of subjective fear ratings.

One limitation of the techniques used to enhance generalization to date is that they neglect to fully harness the benefits that could be seen by explicitly engaging top-down cognitive processes, and often rely on implicit methods of increasing the likelihood of extinction memory retrieval across different contexts. Participants undergoing

manipulations like training in multiple contexts (e.g., Bandarian-Balooch et al., 2015), attentional manipulations (Barry et al., 2017), or the use of retrieval cues (e.g. Shin & Newman, 2017) are largely passive recipients of training manipulations designed to enhance the likelihood of retrieving a memory of safety. Absent from these techniques is any explicit encouragement of reasoning processes or the generation of propositional beliefs about how such a safety memory might be relevant to a feared situation they are about to encounter. For example, although associating the scented neon green puffer ball used as a retrieval cue in Shin and Newman (2017) with a memory of safety may increase the likelihood of retrieving that safety memory when the puffer ball is present, its effects could be limited if its presence does not provide a clear reason for an individual to feel more safe.

The meaning of such a cue is relevant because feared stimuli are embedded with meaning that goes beyond their associative strength with an aversive experience (DeHouwer, 2009; Lovibond, 2004), and top-down cognitive processes can influence associative learning processes such as extinction (Delgado, Nearing, LeDoux, & Phelps, 2008; Hofmann, 2008). For example, extinction learning with a stimulus that is believed to be highly typical of a category has been shown to generalize to other members of that category more than an atypical member (Scheveneels, Boddez, Bennett, & Hermans, 2017), showing that the appraisal of an extinction experience impacts the extent to which extinction generalization occurs. Furthermore, reappraisal of conditioned stimuli has been shown to reduce conditioned fear responses when applied during extinction training (Blechert et al., 2015) as well as without it (Shurick et al., 2012). Accordingly, targeting

top-down reappraisal processes in order to strengthen beliefs about the relevance of prior learning to diverse contexts offers a promising direction for enhancing generalization.

The mental reinstatement technique offers some potential in this regard, as revisiting the outcome of prior exposure training in one's mind could provide a meaningful reason to feel safe in a new exposure context at the propositional level, as well as enhance the automatic retrieval of the safety memory developed during extinction. The instructions used in the studies employing mental reinstatement, however, provided minimal guidance for what exactly participants should recall. Specifically, participants in the different studies were told to: "Remember what happened and what you learned last time, and where all of that took place" (Mystkowski et al., 2006; p. 52), "mentally retrieve the treatment session" (Elsesser et al., 2013, p. 7), or "carefully re-imagine the sequence of events that took place last time, including what you learned and where all of that took place (Laborda et al., 2016, p. 906). Given such instructions, it is possible that participants widely varied in what exactly they recalled (no such information was reported in the studies), ranging from how anxious they were during the exposures to how accomplished they felt afterward for overcoming their fear. Such varying responses could have led to dramatically different expectations, anxiety levels, and avoidance behavior in the subsequent exposure, thereby altering effects of the manipulation. In addition, participants were not explicitly encouraged to reflect on or articulate the extent to which the learning they recalled *applies* to the exposure situation they are about to encounter. If participants were to reason about or focus their attention on similarities between the new and old exposure contexts, that may influence their level

of fear and willingness to approach the new exposure situation.

One illustration of how a memory of an exposure experience can be shaped to target beliefs about future feared situations, and consequently improve outcomes, comes from a recent study by Raeder and colleagues (2019). Immediately after virtual reality exposure for height phobia, participants were instructed to reactivate the memory of exposure treatment, identify how the exposure experience could help them take on other challenges, and identify prior mastery experiences from their life that they could relate to the exposure treatment process. Relative to control conditions, this memory reactivation manipulation led to reduced subjective fear and behavioral avoidance two to three days later and at one-month follow-up. Although the tests of fear in this study did not involve a change in context or feared stimuli, thereby not speaking directly to generalization, the results do show how the meaning of an exposure memory can be targeted in order to influence return of fear. Accordingly, shaping what participants recall from a prior exposure and guiding them to reason about what that learning means for an exposure in a new context could be a meaningful way to use reinstatement techniques in order to maximize generalization of learning.

Enhancing Mental Reinstatement

Following from the above discussion, the present study sought to test an enhanced version of mental reinstatement procedures which involved the following modifications. First, while recalling their exposure memory participants were explicitly instructed to recall the extent to which feared levels changed and feared outcomes did not occur during the course of exposure training. This was done to more tightly control what participants

were recalling, and specifically to have them identify the aspects of prior learning that are theorized to be most important for long-term gains resulting from exposure therapy. Inhibitory learning theory posits that a mismatch between expectancies and outcome drives the development and retention of new non-fearful associations during exposure therapy (Craske et al., 2008; Craske, Treanor, Conway, Zbozinek, & Verlivet, 2014), and evidence suggests that altering the delivery of treatment to maximize such expectancy violations leads to improved outcomes (Deacon et al., 2013). Therefore, highlighting the extent to which expectancies were violated in a prior exposure could help to more effectively recall the non-threat associations previously developed, thereby decreasing expectations of danger and increasing confidence in coping ability in a new exposure situation.

A second modification was to have participants revisit the memory of their exposure training while listening to audio recording of themselves (created immediately after training) articulating what happened during the exposure and what they learned. This was done firstly to further control what participants were recalling from exposure and to ensure they would recall the memory in an accurate and detailed manner. Furthermore, the audio-recording was used to enhance the believability of what participants learned at an affective level. Hearing their own words and expressions about what they took away from the training and how they felt about it, while simultaneously replaying that experience in their imagination, could help to more effectively reinstate the emotional learning associated with the training, thereby enhancing the extent to which the intervention targets both bottom-up and top-down processes.

The final modification was to have participants articulate how the learning recalled from the prior exposure is relevant to a subsequent exposure. This was done to more effectively harness top-down cognitive processes by fostering the generation of propositional beliefs about the likelihood of safety and one's ability to cope. Threat expectancies and coping beliefs have been shown to impact acute anxiety levels during singular exposures (Valentiner, Telch, Petruzzi, Bolte, 1996) and throughout exposure-based therapy (Fentz et al., 2013; Gallagher et al., 2013). Therefore, being encouraged to reason how prior learning about the absence of expected danger applies to a novel feared situation was expected to help participants to realize that feared consequences related to the new exposure situation are unlikely to occur.

It should be noted that the purpose of these procedures was to maximize the effect that could be achieved through mental reinstatement in order to better understand this method's potential for improving generalization after exposure. Including several different elements to this procedure necessarily reduces the level of mechanistic specificity that could be achieved if the intervention were to have an effect. However, research on exposure augmentation techniques frequently is unable to detect improved outcomes, and when improved outcomes are seen effects tend to be relatively modest (Weisman & Rodebaugh, 2018). Accordingly, this design was used based on the idea that it is more fruitful to focus on identifying specific mechanisms of augmentation techniques when it has been more firmly established that they work.

Application to Claustrophobia

A wide body of research has utilized samples with specific phobias or analogue clinical samples with discrete fears (e.g., public speaking) to investigate augmentation strategies of exposure therapy such as the one currently proposed. Such clinical research paradigms are particularly useful from a translational perspective, enabling findings from basic research paradigms (e.g. fear conditioning and extinction) to be tested in a fairly controlled setting with relatively straightforward clinical fears that typically respond quickly to exposure (Carpenter, Pinaire, & Hofmann, 2019; Scheveneels, Boddez, Vervliet, & Hermans, 2016).

Claustrophobia is one of the more common specific phobias, with prevalence rates around 4% (Curtis, Magee, Eaton, Wittchen, & Kessler, 1998). It is defined by a fear of being trapped or suffocated in enclosed spaces, and has been shown to be highly responsive to exposure treatment in a single session (Öst, Alm, Brandberg, & Breitholtz, 2001). Claustrophobia offers a particularly well-suited model to exposure treatment-related processes given the ease of creating highly controlled exposure contexts and the existence of established single-session exposure protocols that have been widely used in clinical research (Deacon, Su, Lickel, & Nelson, 2010; Sy, Dixon, Lickel, Nelson, & Deacon, 2011; Telch et al., 2014; Telch, Valentiner, Ilai, Petruzzi, & Hehmsoth, 2000). Furthermore, unlike other phobias often tested in exposure analogue studies (e.g., spider phobia, contamination fears), it does not involve a significant disgust component, which is influenced more by evaluative conditioning processes and responds more slowly to exposure (Olatunji et al., 2009). A common claustrophobic situation that has significant

public health relevance is the fear of magnetic resonance imaging (MRI scans). Approximately 1% of patients in need of an MRI refuse or prematurely terminate a scan due to claustrophobia, posing a significant problem for accurate detection of many serious medical issues (Munn, Moola, Lisy, Ritano & Murphy, 2015). Although exposure therapy has major potential for helping to alleviate this problem, poor generalization from exposure training in a separate context to an actual MRI could limit its utility. Accordingly, MRI-related claustrophobia offers a target for investigating generalization that both has ecologically validity and relates to an important public health issue.

Study Aims

Primary Aim

The primary aim of the this study was to conduct a randomized control trial comparing the effect of an enhanced mental reinstatement (EMR) procedure with standard exposure (SE) on recovery of subjective, behavioral and physiological indices of claustrophobic fear during exposure to a novel feared situation one week after exposure training for claustrophobia. Exposure training involved repeated exposure trials lying inside a metal cabinet laid on the ground, and then fear-related outcomes were measured one week later in a mock MRI scanner following EMR or SE procedures. EMR consisted of 1) mentally retrieving the memory of prior exposure training, including the extent to which feared outcomes did not occur; 2) listening to an audio recording made by participants after exposure training that includes them discussing their expectancy violations and biggest "take-away" from the exposure training; 3) identifying the similarities between the two feared situations and the relevance of what they learned from

the prior training for the exposure they were about to undergo. EMR was compared to a standard exposure (SE) condition, which included equivalent exposure training procedures. Prior to approaching the novel claustrophobia exposure, however, SE participants 1) recalled a neutral memory, 2) listened to an audio recording of themselves narrating this memory, and 3) answered a filler question connecting the memory to events that happened earlier that day. It was hypothesized that EMR would lead to reduced subjective fear, behavioral avoidance, and heart rate reactivity during exposure

Secondary Aims

Aim 2A. A number of secondary outcomes were investigated in this study. For one, the effect of EMR vs SE on self-reported claustrophobia symptoms was examined at one-month follow-up. Although self-reported ratings provide less specificity for measuring intervention effects, symptom measures of claustrophobia can assess anticipated anxiety and avoidance to a wider number of situations, thereby offering an alternative assessment of generalization. In addition, given that claustrophobia prevents many patients from receiving medically indicated MRI scans, participant ratings of expected anxiety and likelihood of getting a real MRI scan at Visit 2 and follow-up was examined across conditions. It was hypothesized that the benefits of EMR compared to SE would extend to improved claustrophobia symptoms, expected anxiety, and likelihood of getting an MRI.

Aim 2B. This study also sought to compare the effect of EMR and SE on the strength of feared outcomes reported immediately prior to the novel exposure context one week post-training. Given that participants in the EMR condition listened to an audio-

recording of themselves describing the extent to which their feared outcomes did not occur during exposure training, and were explicitly instructed to identify how their prior experience applied to the novel feared situation, it was expected that EMR would specifically decrease negative outcome expectancies regarding that novel feared situation. Furthermore, it was hypothesized that increased reductions in feared outcomes resulting from the EMR manipulation would mediate intervention effects. In addition, this study investigated the effect of condition on participants' feared outcomes if they were to receive a real MRI scan, assessed at the end of Visit 2 and at one-month follow-up, to assess the durability of intervention effects.

Aim 3A. Building on research showing the influence that top-down cognitive processes can have on extinction learning (Blechert et al., 2015; DeHouwer, 2009; Hofmann, 2008), another aim of this study was to investigate how participants' beliefs about what they learned from exposure training (i.e. their biggest "takeaway") impacted generalization to a novel feared situation. Investigating the relationship between the learning participants articulate about exposure training and subsequent outcomes can provide valuable information about the mechanisms driving change in exposure. In addition, understanding what participants take away from their exposure experience is particularly important for understanding the effects of any technique that attempts to enhance retrieval of an exposure memory, given that the effects of such retrieval may vary depending on the meaning associated with that memory. For instance, the retrieval cue study by Shin & Newman (2017) mentioned earlier found that participants who viewed the cue as a reminder of their anxiety during the exposure exhibited the least

return of fear, possibly because it reminded them that they were able to tolerate the anxiety that occurred in a prior exposure.

Research on mechanisms of change in exposure therapy offers several different possibilities for the types of learning that can drive symptom improvement. These include changes in threat appraisals (Smits, Julian, Rosenfield, & Powers, 2012), improved fear tolerance (Deacon et al., 2013), improved coping self-efficacy (Fentz et al., 2013; Gallagher et al., 2013) and fear reductions between exposures (de Kleine et al., 2017). This study examined the extent to which themes related to such exposure mechanisms were present when participants verbalized what they learned from exposure training, as well as when they recalled what occurred during exposure a week later during EMR procedures. Exploratory analyses were conducted to examine the presence of each of these themes as a predictor of generalization to a novel feared situation. Treatment condition was then examined as a moderator of the relationship between post-exposure takeaway and fear outcomes, since listening to such takeaways via audio-recording right before entering a feared situation could enhance their impact.

Aim 3B. To further investigate the types of fear-related beliefs that impact generalization, this study also examined the impact of changes in different types of feared outcomes over the course of exposure training. Although changes in the threat appraisals, fear tolerance, and coping self-efficacy have each been shown to function as mediators or predictors of symptom improvement over the course of treatment (Smits, Julian, Rosenfield, & Powers, 2012; Deacon et al., 2013; Fentz et al., 2013; Gallagher et al., 2013), such analyses provide less specificity about the aspects of a single exposure most

important for subsequent gains. In a study examining fear-related outcomes in a single claustrophobia exposure, greater coping self-efficacy, but not threat expectancies related to suffocation and entrapment concerns, predicted lower subjective fear and heart rate (Valentiner et al., 1996), but this study did not examine belief change. To examine the specific belief changes that are the most impactful for maintaining and generalizing reduced fear outcomes, the present study explored the relative effects of changes in threat expectancies, coping self-efficacy and fear tolerance during exposure training on subsequent fear-related outcomes.

Aim 3C. A final aim of this study was to examine whether the strength of expectancy violations (i.e. prediction error; Rescorla & Wagner, 1972) during exposure training predicts fear-related outcomes in novel and familiar exposure contexts one week post-training, as well as self-reported outcomes at one-month follow-up. Although changes in threat expectancies are widely thought to be a fundamental mechanism of learning during exposure (Craske et al., 2008; Hofmann, 2008), and modifying treatment to maximize expectancy violations has been shown to fruitful (Deacon et al., 2013), explicit tests of the impact of expectancy violation strength on subsequent outcomes have only begun to emerge and have not consistently shown predicted effects. For instance, a study by de Kleine and colleagues (2017) found that the extent to which specific harm expectancies were violated during imaginal exposures was not related to PTSD symptom change, though measures of fear habituation were significant predictors. Two studies in pediatric OCD investigated discrepancy between expected and actual fear ratings during exposure, with one showing that fear being less than expected predicted (i.e. over-

predictions) worse outcomes at mid-treatment, though not post-treatment (Kircanski & Peris, 2015), and a second showing that more variability in expected vs. actual fear, as well as a higher proportion of over-predictions, were associated with predicted superior outcomes (Guzick, Reid, Balkhi, Geffken & McNamara., 2018). To help further clarify the role of expectancy violations in exposure outcomes, the present study measured expected vs. actual fear, discrepancy between likelihood of greatest feared outcomes and their occurrence, and surprise about feared outcome occurrence throughout exposure training, and these variable were examined as predictors of fear-related outcomes in a novel exposure context.

Methods

Experimental Design

A schematic of the experimental design can be seen in Figure 2. During the initial visit participants in both conditions completed a pre-training behavioral approach test (BAT; which also served as the final assessment of eligibility), exposure training, and a post-training BAT all in context 1 (a horizontal metal cabinet). Prior to the pre-training BAT (BAT 1A), baseline heart rate data and state anxiety were measured. Following BAT 1A, participants completed a battery of self-report questionnaires and audio recorded a neutral memory. After exposure training, an audio recording was made of participants orally reviewing their change in fear and feared outcomes and verbalizing their biggest "takeaway" from the training. At Visit 2, one week after exposure training, baseline heart rate, state anxiety and self-reported claustrophobia symptoms were measured again. Participants were then block-randomized to either Standard Exposure

(SE) or Enhanced Mental Reinstatement (EMR), and underwent condition-specific procedures prior to a BAT conducted in a mock MRI scanner (BAT 2) in a different location from Visit 1. Randomization was done in blocks of 4 and 6 and stratified by participant type (university student vs. community) using the web-based service Sealed Envelope, with condition revealed only when participants arrived at Visit 2. Primary outcomes included subjective fear, behavioral approach (i.e. time spent in mock MRI) and heart rate during BAT 2. Secondary outcomes included self-reported claustrophobia symptoms, feared outcomes, and expected fear of a real MRI scan at Visit 2 and one-month follow-up.

Participants

Participants consisted of adults (n = 45) recruited through postings on university student job sites, Craigslist and email list-serves of local hospitals. In addition, patients at BU's Center for Anxiety and Related Disorders who received a diagnostic assessment indicating clinical levels of claustrophobia and reported interest in research were contacted about the study. Participants received $75 for their participation. The CONSORT diagram outline participant screening, randomization and study completion can be seen in Figure 1.

Inclusion criteria included: 1) being 18–75 years of age; 2) self-reported fear of enclosed spaces at a moderate or greater level (≥2 on a 0–4 Likert scale); 3) expected fear of being in an MRI machine at a moderate or greater level (≥2 on a 0–4 Likert scale); 4) peak self-reported fear during a behavioral approach test (BAT) in a claustrophobia chamber (i.e. a horizontal metal cabinet) of ≥50 of 100. Participants with peak fear <50

who exited the cabinet before for the end of the two-minute BAT for fear-related reasons were also deemed eligible. See the Procedure section for further details on the screening process.

Exclusion criteria included: 1) presence of a medical condition (i.e., pregnancy, cerebrovascular disease, cardiovascular disease) that contraindicated participation in claustrophobia exposures; 2) physical condition preventing individuals from being able to safely enter the claustrophobia chamber, including individuals weighing >350 lbs (the weight limit for the mock MRI used in this study), and 6'4" (the length of the inside of the claustrophobia chamber); 3) prior exposure therapy for claustrophobia-related concerns; 4) presence of bipolar disorder, psychotic disorder, or cognitive dysfunction likely to impair participation in study activities; 5) refusal to enter the claustrophobia chamber during the initial BAT. In addition, participants who took as-needed medication (e.g. benzodiazepines, beta blockers) for anxiety were asked to refrain from taking medication the day of the study visit until after study procedures had been completed.

The sample was racially/ethnically diverse, with 40% identifying as Asian, 36% White/Caucasian, 18% Black/African-American, 4% Latinx and 2 % multiracial. Females made up 64% of the sample, mean age was 29.2 (*SD* = 12.3), and 58% of participants were students (graduates or undergraduates). Demographics for each study condition can be seen in Table 1, and baseline clinical variables are in Table 2. Thirteen percent of the sample was taking psychiatric medication and 84% met DSM-5 diagnostic criteria for Specific Phobia with claustrophobia at the time of the study.

Procedures

Screening Process. The screening procedure in this study was based on that of previous studies examining exposure training for claustrophobia (Kamphuis & Telch, 2000; Powers et al., 2008; Sloan & Telch, 2002; Telch et al., 2004; Telch et al., 2014). Potential participants were first screened on the phone for eligibility, which included being asked to rate on their overall fear of enclosed spaces on a 5-point Likert scale (0 = no fear, 1 = mild fear, 2 = moderate fear, 3 = severe fear, 4 = extreme fear). They also were provided a description of the mock MRI scanner used during BAT 2 and asked how much fear they would experience if they were to enter the scanner using the same scale. Those who reported a 2 or above on both questions and did not meet any exclusion criteria were invited in to the laboratory. Following the consent process, state anxiety was measured so ratings would not be affected by having entered the cabinet during BAT 1. Next, participants were outfitted with a heart rate monitor and baseline heart rate data was collected while resting in seated position for a five-minute period. Participants were then instructed to complete BAT 1. Those who experienced a peak fear level of 50 or greater (out of 100) were eligible to participate in the rest of the study. In addition, participants who requested to leave the cabinet prior to the 2-minute time limit for any fear-related reason (e.g., couldn't tolerate their anxiety, felt like they couldn't breathe, etc.) were also deemed eligible.

Behavioral Approach Test 1 (BAT 1). For BAT 1, participants were first shown the claustrophobia chamber, which consists of a metal cabinet measuring 6.5' x 4' x 1.5' laid on the ground (see Figure 2). The surface participants laid on was lined with foam

padding, and one side of the cabinet was lined with boxes so that the open space was three feet wide. Participants were told they would be asked to lie down inside the cabinet on their backs, at which point the experimenter would shut the cabinet doors. They were also instructed that the goal of the task was to remain inside the cabinet for as long as they could, but if they wanted to leave they could tell the experimenter, who would remain in the room, and would be let out immediately. Participants were made aware that when the task was over the experimenter would open the doors and let them out, but were not told the maximum length of the task, which was 2 minutes. After these instructions were given, participants completed a series of questions about their fears and expectations for the task, and then instructions were reiterated prior to entering the cabinet. BAT 1 was conducted prior to exposure training (BAT 1A) and after the training was completed (BAT 1B).

Pre-Exposure Procedures. Following BAT 1A, participants underwent a diagnostic interview assessing DSM-5 criteria for specific phobia of claustrophobia, and completed the remainder of the self-report questionnaires, and then created an audio recording of a neutral memory. Specifically they were asked to recall what they did for the first 30 minutes when they got out of bed that morning, and rate the degree of negative and positive emotion associated with this memory on a 5-point Likert scale (0 = none, 1 = a little , 2 = moderate, 3 = quite a bit, 4 = extreme). Participants with a rating of 0 or 1 for both emotions were then asked to recount the memory out loud step by step while being audio-recorded. Participants whose memory elicited a rating of >1 for either negative or positive emotion were then instructed to identify a different memory from the

previous 24 hours that met the positive and negative emotion criteria, and was also something they did on a daily basis (e.g. what they did before going to bed). An audio-recording was made while they recited the detail of this memory.

Exposure Training. Participants first viewed an eight-minute video of a clinician who was not an experimenter for the study describing the rationale for exposure as a method for overcoming claustrophobia (see Appendix A for text of rationale). The video began with psychoeducation about the role of avoidance and threat-related beliefs in the maintenance of claustrophobia, and how phobias act like a false alarm, making a person feel like there is danger present when in fact they are safe. It was then explained how repeatedly remaining in the situation for an extended period of time provides the opportunity to see that the situation is safe and tolerable, that one's expectations of danger are exaggerated, and that anxiety tends to go down over time. The video also explained the procedures of exposure training conducted in this study, emphasizing the importance of remaining in claustrophobia chamber for the duration specified by the experimenter in order to successfully overcome one's fear.

Following the procedures by Telch and colleagues (Kamphuis & Telch, 2000; Powers et al., 2008; Sloan & Telch, 2002; Telch et al., 2004; Telch et al., 2014), the exposure training itself consisted of six 5-minute exposure trials. During these trials, participants lay on their backs in the cabinet with the doors closed in the same manner as during BAT 1, except they were asked to stay in the cabinet for 5-minute intervals. They were also instructed to not engage in any avoidance behaviors like closing their eyes or pretending they were somewhere else, and instead try to simply observe the situation

around them and attend to whether their feared outcomes were actually occurring. If participants were unwilling to stay in the cabinet for the full 5-minute period initially, the time during later exposures when participants were more comfortable was increased so that each participant spent a full 30 minutes in the closet. This occurred for just three participants.

Prior to each trial, participants rated their degree of concern about various feared outcomes, as well as the predicted likelihood that their three greatest feared outcomes will occur (see details in Measures section). They also rated their current and expected fear levels. After each trial, participants rated their peak and end fear levels, as well as the extent to which their feared outcomes occurred and how surprised they were about each outcome. The experimenter also checked in about any avoidance behaviors the participant may have been engaging in, and provided coaching on how to act counter to such urges to avoid. Participants then rated their feared outcomes and expected fear levels for the next exposure trial.

Post-Exposure Training. After the final exposure trial, the experimenter helped the participant complete the Post-Exposure Review form (see Appendix C), in which they reviewed 1) what happened during the exposure training, including how their fear levels and concern and expectancy ratings for their three most feared outcomes changed, and 2) their biggest "take-away" from the training (i.e. the most important thing they learned). Then, participants made an audio recording of themselves verbalizing what they had just reviewed on the form. After this exercise, participants entered the cabinet one final time for BAT 1B.

Visit 2 Procedures. Visit 2 occurred one week after the first visit, plus or minus one day, at the Boston University Medical Campus's Center for Biomedical Imaging, which was in a different campus compared to Visit 1. Participants completed measures of state anxiety and claustrophobia symptoms, and baseline heartrate data were recorded while seated over the same 5-minute period as Visit 1. The experimenter then showed participants the mock MRI scanner they would be entering, explained the nature of BAT 2, and then took participants to a separate room for condition-specific procedures. After BAT 2, participants answered a final set of questionnaires.

Enhanced Mental Reinstatement (EMR). Following the introduction of the BAT 2, EMR participants were be taken to another room and asked to close their eyes and re-imagine what took place during their exposure training one week before. Specifically they were told to recall out loud 1) where they were, 2) how their fear levels and feared outcomes changed and why, and 3) what they learned from the training. Next, participants were instructed to continue to keep their eyes closed and keep the memory of the training in mind while listening to the audio recording they made the prior week about what happened and what they learned through exposure training at the first visit. Following this, participants completed vividness, perspective, affect ratings. Finally, the experimenter assisted participants in completing a worksheet in which they write down all the ways in which the situation they just recalled in their memory was similar to the mock MRI scanner they were about to enter, including similarities about the space itself as well as the types of fears elicited. They were explicitly instructed to focus only similarities. Next, participants were instructed to identify how what they learned in the

prior exposure training was relevant to the situation they were about to enter. They then spoke out loud what they had written on the worksheet. All participant responses during this time were audio-recorded for further analysis.

Standard Exposure (SE). The pre-BAT 2 procedures of the SE group were designed to mimic those of the EMR group as much as possible. After the introduction of the BAT 2 procedures, participants in the SE condition were taken to another room and reminded of the neutral memory they recorded at Visit 1. They were asked to close their eyes and imagine what took place during that memory in as much detail as possible, saying out loud exactly what they remembered. Next, they listened to the audio recording made the week before of them recalling this event while continuing to hold their memory in mind, and afterward completed the same vividness and affect questions as the EMR group. Following this, participants wrote down and then verbalized all the ways in which what happened the morning of the experiment (or whatever neutral memory had been recalled) was similar to what had happened the morning of Visit 2 (or equivalent, if a different memory). As in EMR, participant responses during SE procedures were audio-recorded.

Behavioral Approach Test 2 (BAT 2). BAT 2 took place in a decommissioned 3T MRI scanner used to accustom individuals to an MRI machine prior to a real scan (see Figure 2). Participants lay on a stretcher with their head held in place by plastic siding, and the experimenter slid the stretcher in to the tube of the mock scanner until the participant's entire upper body was inside enclosed. The opening of the scanner had a diameter of 60 cm, and the back side was covered with opaque plastic so the only light

coming in to the tube was from the direction of the participants' feet. Following the same procedures as BAT 1, participants answered questions about their feared outcomes and current fear levels prior to entering the scanner. They were given the same instructions as BAT 1A and BAT 1B about remaining in the tube for as long as they were willing, but if they became too uncomfortable, the experimenter would remove them from the scanner immediately. In order to reduce the likelihood of ceiling effects for time spent in the mock scanner, the maximum time before participants were removed was increased to 10 minutes (compared to two minutes during BAT 1). In addition, every two minutes participants were asked their current fear level, and then told that if they remained in the willing to stay they will be moved another 6 inches in to the scanner. After participants exited the tube, they completed a rating of their maximum and end fear levels.

One-month Follow-up. One month after visit 2, participants were sent a series of questionnaires via email that assessed claustrophobia symptoms, severity of feared outcomes if they were to undergo an MRI scan, and likelihood and expected fear of receiving an MRI scan.

Outcome Measures

Subjective Fear. Participants rated their subjective fear on a scale from 0 to 100, with anchors of 0 (no fear), 25 (mild fear), 50 (moderate fear), 75 (strong fear), and 100 (extreme fear/panic). Immediately upon exiting the claustrophobia chamber during BATs and exposure trials, participants rated their maximum level of fear while in the chamber, and their fear at the end of the trial (before knowing they were about to exit). Peak and end fear were highly correlated and initial analyses examining the two measures

separately were consistently similar, so analyses focused on peak fear. Prior to each BAT and exposure trial, participants also rated their current fear and expected fear for entering the enclosed space.

Behavioral Avoidance. Time until each participant requested to exit each of the BAT tasks, if relevant, was also recorded an indicator of behavioral avoidance.

Heart Rate Reactivity. Heart rate was measured continuously throughout the experiment via the Zephyr BioModule™ (Zephyr Technology Corp, Annapolis, MD, US), an ambulatory heart rate monitor that attaches to the chest via skin conductive electrodes. The device measures heart rate via electrocardiography (ECG) and has been shown to produce reliable and valid measurements of heart rate across a variety of contexts (Nazari et al., 2018). Sampling rate for ECG data was 1000 Hz. Artifact detection was conducted automatically using Kubios Version 3.1 Premium (Tarvainen, Niskanen, Lipponen, Ranta-Aho, & Karjalainen, 2014), and then was inspected manually and any additional corrections necessary were made. Mean heart rate data were extracted for baseline and BAT periods from Visits 1 and 2. Heart rate during BATs was adjusted for baseline by calculating the difference between mean heart rate during each BAT and the corresponding baseline period, and then adding that value to the mean baseline heart rate for the sample. This baseline-adjusted heart rate variable was used in analyses.

The Claustrophobia Questionnaire (CLQ). The CLQ (Radomsky, Rachman, Thordarson, McIsaac, & Teachman,, 2001) is a 26-item assessment of claustrophobia symptoms. Participants are asked to rate how anxious they would feel on a 5-point Likert scale (0 = not at all anxious, 4 = extremely anxious) in situations eliciting concerns about

suffocation (e.g. “Using an oxygen mask”) and restriction (e.g. “Locked in a small dark room without windows for 15 minutes”), the two components of fear thought to underlie claustrophobia (Rachman & Taylor, 1993). The CLQ has demonstrated strong predictive and discriminant validity, along with good internal consistency and test-retest reliability (Radomsky et al., 2001). Given the importance of avoidance of feared situations in anxiety psychopathology, participants were also asked how much they would want to avoid each of the 26 situations listed in the CLQ from 0 (no desire to avoid) to 4 (avoid at all costs). The CLQ was administered at after eligibility screening, the beginning of Visit 2 prior to randomization, and at one-month follow-up. Internal consistency in the present study was excellent at all three time points, both for fear and avoidance subscales separately and combined (α = .92 – .96).

Claustrophobic Expectancies Questionnaire (CLEQ). The CLEQ (see Appendix B) is a measure adapted for this study assessing respondents concern about 20 possible feared outcomes for a claustrophobic situation. It consisted of four items regarding concerns about *suffocation* (e.g. “I might start to choke”), four items regarding *entrapment* concerns (e.g. “I might not be able to escape if I had to”), and four items regarding *coping self-efficacy* (e.g. “I won’t be able to tolerate to my fear”), all of which were adapted from the Claustrophobic Concerns Questionnaire (Valentiner, Telch, Petruzzie, & Bolte, 1996). Also included were four items regarding *loss of control* (e.g. “I might lose control”) adapted from the Claustrophobia General Cognitions Questionnaire (Febbraro & Clum, 1995), and four items regarding *fear tolerance* (e.g. “The feelings of fear might be unbearable to me”) adapted from the Distress Tolerance Scale (Simons &

Gaher, 2005). The intent in creating this questionnaire was to generate a wide variety of possible feared outcomes for individuals with claustrophobia in order to increase the likelihood of accurately capturing participants' greatest specific concerns, and enable them to be tracked throughout the exposure training. From this scale, three subscale scores were created based on item averages: 1*) threat expectancies* (based on *suffocation, entrapment,* and *loss of control* items), 2) *coping self-efficacy,* and 3) *fear tolerance*.

Items were rated on a scale from 0 (no concern) to 100 (extreme concern). In addition, the highest-rated feared outcome from each CLEQ subscale was selected, and participants indicated how likely they believed each outcome was to occur (0% to 100% likelihood). The CLEQ was administered prior to all BATs and prior to the first and last trials of exposure training. Also before exposure trials 2 through 5, participants tracked their top-rated feared outcomes from the initial exposure by continuing to complete concern and likelihood ratings with regards to the next exposure. Internal consistency for the full scale was excellent across time points (α = .92 – .96), with subscale reliability being strong as well: *Threat Expectancies:* (α = .86 – .91), *Coping Self-Efficacy,* (α = .78 – .90), and *Fear Tolerance* (α = .83 – .94).

MRI Expectancies, Fear and Likelihood. After BAT 2 and at one-month follow-up, participants were asked how likely they would be to get a medically indicated MRI from 0 (definitely would NOT get it) to 100 (definitely WOULD get it). They were then asked to imagine they were to undergo a real MRI scan. They were told this would involve being in the same type of scanner they were in during the study, but that it would last 30–40 minutes and there would be no one in the room with them, though they could

press a button to tell the MRI technician they wanted to leave. Participants then rated their maximum expected fear while in the scanner with the same 0–100 scale used during BATs, as well as the feared outcome items from the CLEQ (CLEQ-MRI). Participants also rated fear and likelihood of getting a medically indicated MRI scan at baseline.

Claustrophobic Expectancy Violations. After each exposure, participants rated the extent to which their top feared outcomes occurred on a scale from 0 (not at all) to 100 (completely), and how surprised they were at the extent to which it occurred from 0 (not at all surprised) to 100 (completely surprised) (see Appendix B). For surprise ratings, the experimenter asked participants whether they were surprised that their feared outcome occurred more or less than expected, and if participants reported it happened more than expected, ratings were given a negative value. Surprise ratings, the difference between likelihood and occurrence scores, and the difference between concern and occurrence scores (see De Kleine, et al., 2017) were initially investigated as indicators of expectancy violations. In addition, the difference between expected and actual fear was examined as an additional possible indicator, as has been done in previous literature (Guzick et al., 2018; Kircanski & Paris, 2015). Because correlations between likelihood and concern rating at each exposure were quite high ($r > .60$), however, concern-occurrence discrepancies were not included in the analysis. Values for each feared outcome from the CLEQ (Threat Expectancies, Coping Self-Efficacy, and Fear Tolerance) over the course of six exposure trials were averaged in an attempt to capture the total expectancy violation throughout training. Because the exposure scenarios were identical throughout training and the potential for surprise at the outcome of repeated

exposures was likely to decline, expectancy violations during the first exposure were also examined. Expectancy violations for each type of feared outcome were not combined for analysis in order to comparatively examine violation of different beliefs, and also because internal consistency for discrepancy scores was in the questionable range (α = .62–.63).

Additional Measures

Composite International Diagnostic Interview (CIDI). The CIDI is a structured clinical interview commonly used in clinical and research settings to efficiently assess diagnostic criteria of psychological disorders (World Health Organization, 1997). The experimenter administered only the specific phobia module in this study to assess claustrophobia. Although designed for assessment of DSM-IV criteria, criteria for specific phobia in DSM-5 were essentially unchanged, and responses were evaluated with regard to DSM-5 criteria. The anxiety disorder module of the CIDI has demonstrated good psychometric properties, including good sensitivity (.86) and acceptable specificity (.52) (World Health Organization, 1997).

State-Trait Anxiety Inventory (STAI). The 6-item version of the STAI-state (Marteau & Bekker, 1992) was used as a brief measure of state anxiety at the beginning of Visits 1 and 2, whereas the 20-item version of the STAI-trait (Spielberger, Gorsuch, & Lushene, 1970) was used to characterize the degree of trait anxiety present in the sample. Internal consistency in this study was strong for the STAI-trait (α = 0.92), as well as for the STAI-state at Visit 1 (α = 0.83) and Visit 2 (α = 0.86).

Anxiety Sensitivity Inventory-3 (ASI-3). The ASI-3 (Taylor et al., 2007) measures the extent to which respondents are afraid of anxiety-related sensations, and

contains three subscales: physical concerns, social concerns, and cognitive concerns. The ASI-3 was administered at baseline only. Internal consistency in this sample was high (α = 0.89).

Distress Tolerance Scale (DTS). The DTS (Simons & Gaher, 2005) is a 15-item scale measuring respondents' perceived ability to tolerate emotional distress, administered at baseline in this study. Internal consistency in this study high (α = 0.90).

Vividness of Visual Imagery Questionnaire (VVIQ). The VVIQ (Marks, 1973) measures the strength of respondents' mental imagery. Respondents are asked to close their eyes and form an image of sixteen different scenes, and then rate the vividness of the mental image on a scale from 0 (no image at all, you only "know" that you are thinking of the object) to 4 (perfectly clear and as vivid as normal vision). Internal consistency in this study was high (α = 0.89). This same scale was used for participant ratings of vividness of the exposure or neutral memory recalled during EMR or SE.

Memory Perspective Rating. After revisiting either the neutral or exposure memory, participants were asked to rate the extent to which they recalled the memory from an 'observer' perspective (i.e. viewing from the outside) or 'field' perspective (i.e. viewing through one's own eyes) on a Likert scale from -3 (strong field perspective) to 3 (strong observer perspective) (Wells, Clark, & Ahmad, 1998).

Credibility and Expectancy Questionnaire (CEQ). The CEQ (Devilly & Borkovec, 2000) is a 6-item instrument designed to assess respondent's assessment of the credibility of a treatment they are about to receive, as well as their expectations for success. Participants completed the CEQ after watching the video explaining the rationale

for exposure treatment, before the first exposure. Internal consistency in this study was high ($\alpha = 0.91$).

Positive and Negative Affect Scale – Short Form (PANAS-SF). The PANAS-SF (Kercher, 1992) is a commonly used scale consisting of five items measuring positive affect and five items assessing negative affect. The scale was administered immediately after the participants went through EMR or SE procedures to determine whether the memory recall procedures led to any immediate differences in affect across condition. Internal consistency was adequate for both the positive ($\alpha = 0.76$) and negative scales ($\alpha = 0.80$).

Exposure Training Thinking. After participants completed BAT 2, they answered questions about how much they thought about the exposure training when approaching the mock MRI and when inside on a scale from 0 (not at all) to 100 (the entire time). If they answered a response other than 0, they were prompted to write a sentence or two about what specifically they thought about. Responses were coded yes/no for whether the participant described either something they learned from the exposure training or reported using the memory to help them feel less anxious.

Coding of Audio-recordings

Audio-recordings made after exposure training and during EMR procedures were transcribed and then coded for the presence of statements related to possible mechanisms driving change in exposure therapy. Specifically, transcriptions from both post-exposure audio-recordings and the portion of EMR audio-recordings in which they recalled prior exposure training (i.e. exposure recall) were coded for statements pertaining to: 1)

Coping Self-Efficacy, 2) Fear Tolerance, 3) Threat Reappraisal/Safety, 4) Fear Reduction, and 5) Generalization. For EMR audio-recordings only, a dimensional Fear Recall rating was also made, which assessed the amount of attention paid to experience of fear during recounting of exposure experience. This was done given evidence that mental rehearsal of feared stimuli can lead to sustained fear responses (Dadds, Bovbjerg, Redd & Cutmore, 1997; Joos, Vansteenwegen, & Hermans 2012), which could negate the effects of the EMR manipulation in this study. Definitions, example statements and interrater reliability ratings for the coding categories can be seen in Table 3, with full coding guidelines in Appendix D. Two independent raters were trained on the coding procedures using five transcriptions, and then the remaining transcriptions were rated separately. Discrepancies were resolved by consensus of the two raters.

Data Analytic Approach

Data were analyzed using SPSS 26.0. Prior to running the primary analyses, EMR and SE groups were compared on baseline clinical and demographic variables using Chi-Square for categorical variables and independent-samples t-test for continuous measures. A series of 2 x 2 mixed effects ANOVAs with time as a within-subject factor and condition as a between-subject factor were then used to examine equivalence of treatment effects across condition (pre-randomization) on subjective fear, behavioral avoidance, and heart rate during pre- and post-exposure training BATs, as well as Visit 1 and Visit 2 CLQ scores. One-way ANOVAs were also used to test for differences in main outcome variables between BATs (collapsing across condition), in order to test for return of fear after exposure training. Partial-eta squared (η_p^2), which represents the portion of variance

explained by the predictor after excluding other predictors, was reported as an effect size for ANOVAs.

For the study's primary aim, the effect of condition (EMR vs. SE) on peak fear and heart rate during BAT 2 was tested using hierarchical linear regression, entering each at outcome at BAT 1B and Visit 2 STAI-S as predictors in the first step, and condition at the second step (SE coded as 0, EMR coded as 1). For behavioral avoidance, a survival analysis was performed using Cox regression to predict the relatively likelihood of exit from the mock MRI scanner for EMR vs. SE (i.e. the hazard ratio [HR]) over the course of the 10 minutes of the BAT, while controlling for relevant covariates. Because no participants exited early from BAT 1B, a categorical variable was created to indicate whether a participant exited early from BAT 1A, and was used to control for baseline behavioral avoidance.

For secondary outcomes (Aims 2A and 2B), linear regression was used to examine the effect of condition on CLQ scores at one-month follow-up, controlling for CLQ at Visit 2 (pre-randomization). The effect of condition was also examined on Visit 2 (post-BAT 2) and one-month follow-up CLEQ-MRI scores, controlling for CLEQ at BAT 1B (as CLEQ-MRI was not administered pre-randomization), and MRI fear and likelihood ratings, controlling for at baseline (as these ratings were not made post-exposure training). Furthermore, the effect of EMR vs. SE was investigated on CLEQ scores (concern and likelihood ratings) prior to BAT 2, controlling for CLEQ at BAT 1B.

A number of exploratory analyses were conducted in this study as part of Aims 3A–3C, so the analytic approach for these aims attempted to balance the Type I error

risks inherent to running a large number of tests, while still thoroughly examining possible relationships impacting exposure outcomes. To do so, predictions of BAT 2 outcomes by exposure takeaways and their interaction with treatment condition (Aim 3A) as well as expectancy violation variables (Aim 3C) were entered in to a stepwise linear regression set to retain all predictors at $p < .05$ and exclude predictors at $p > .10$. Stepwise regression uses an automatic model-building process that adds predictors one at a time based on the amount of additional variance explained, and thus offers an efficient method of balancing parsimony and model fit. Given that such an approach has received some criticism for producing findings that are generalizable across samples (Mundry & Nunn, 2009; Thompson, 1995), simultaneous regression was used as a secondary approach, with results presented in the text when they substantially differed, or footnoted when they were similar. For the stepwise regression, moderator analyses for post-exposure takeaways were run with all main effects entered first, and then all interactions with treatment condition were added in a stepwise manner. Because using so many predictors compromises degrees of freedom, interaction terms with $p < .10$ were re-run in a model without the other main effects to get a more accurate assessment of effect size and significance. For expectancy violation variables (Aim 3C), predictors were grouped and entered into stepwise regression based on measure time-point (i.e., initial exposure or all exposures). Significant predictors of BAT 2 fear outcomes were then tested in a separate model to examine whether effects extended to CLQ scores at Visit 2 and one-month follow-up.

When analyzing exposure recall themes among participants randomized to EMR,

point bi-serial partial correlations accounting for BAT 1B variables were used to preliminarily examine relations with fear outcomes. For simplicity of presentation, relationships between change in CLEQ scores and fear outcomes at Visit 2 (Aim 3B) were also analyzed using partial correlations, controlling for outcomes at BAT 1B.

Throughout analysis assumptions of linear regression were tested, including normality, homoscedasticity and independence of residuals, absence of multicollinearity, and the presence of outliers. Data were consistently suitable for linear regression. The squared semi-partial correlation coefficient (sr^2), which represents the unique portion of variance explained by the predictor, was used as an indicator of effect size for regression analyses.

Missing data. No data were missing for self-report or behavioral variables. Due to equipment failure, heart rate data was not collected for two participants (one SE, one EMR), and 10 participants had one or two baseline or BAT periods with unusable data resulting from a poor-quality ECG signal. Across participants with any heart rate data, 9.7% of values were missing. To address this, first Little's missing completely at random test (Little, 1988) was used to determine whether missingness of data was related to any variables being examined in the study. Although this test was not significant, $\chi^2(24) = 23.65$, $p = .48$, indicating that were missing completely at random, multiple imputation was used to generate plausible values for the missing heart rate data and preserve power. The model used to generate such values included the mean, maximum and standard deviation of heart rate at each BAT and baseline period, as well as several additional periods of heart rate data not directly analyzed in this study, specifically the first and last

exposure in the closet and a two-minute period for and after each BAT. In addition, fear ratings and duration of BATs, state anxiety and experimental condition were included as predictors given their potential relationships with heart rate during a BAT. Fully conditional specification (van Buunen, 2007) was used to handle instances of multiple missing variables, and twenty iterations of complete data sets were generated and analyzed, with effects pooled to create a single set of results. As recommended by Sterne et al., (2009), we conducted sensitivity analyses to compare results of the imputed data set with the original data, and report results in a footnote below.

Power Analyses: The mental reinstatement procedure by Mystkowski and colleagues (2006), which led to significantly reduced subjective fear levels after a context change compared to a control condition, resulted in a partial eta squared of 0.15, indicative of a large effect (Cohen, 1988). Conservatively assuming a medium-to-large effect size ($f^2 = 0.25$) and power = 0.80, a power analysis conducted with G*Power indicated that a sample size of 34 would be sufficient to detect a significant effect. A minimum sample size of 40 was planned for in order to increase power to detect a smaller effect and investigate potential moderators, and data collection was continued until no longer feasible. A post-hoc sensitivity analysis indicated that with the current sample size, controlling for an additional covariate (STAI-S), the study had power = .80 to detect a medium effect size of $f^2 = 0.18$.

Results

Baseline Characteristics and Overall Response to Exposure Training

Demographics across condition can be seen in Table 1, with baseline clinical characteristics seen in Table 2. No baseline differences were found for any demographic or clinical variables.

With regard to effects of exposure training, means and standard errors of BAT Fear across Time and Condition can be seen in Figure 3. A 2 x 2 mixed-effects ANOVA showed a main effect of Time on BAT Fear during Visit 1, $F(1,43) = 598.78$, $p < .001$, $\eta_p^2 = .93$, such that fear at BAT 1B ($M = 8.18$, SE = 1.78) was significantly reduced compared to BAT 1A ($M = 73.59$, $SE = 2.18$), with no significant effect of Condition, $F(1,43) = 2.94$, $p = 0.10$, $\eta_p^2 = .06$, or Time by Condition interaction, $F(1,43) = 0.35$, $p = 0.85$, $\eta_p^2 = .00$. Similarly, there was a significant main effect of Time on heart rate, $F(1,41) = 55.23$, $p < .001$, $\eta_p^2 = .57$, showing a decrease from BAT 1A ($M = 77.01$, $SE = 1.36$) to BAT 1B ($M = 68.80$, $SE = 1.29$), but no significant effect of Condition, $F(1,41) = 1.17$, $p = .29$, $\eta_p^2 = .02$, or Time by Condition interaction, $F(1,41) = 1.52$, $p = .22$, $\eta_p^2 = .04$. For behavioral avoidance, all participants remained in the closet for the full two minutes at BAT 1B, in contrast to BAT 1A in which eight SE participants (35%) and three EMR participants (14%) exited early (not significantly different, Fisher's Exact Test, $p = 0.17$). There was a significant main effect of Time on BAT duration, $F(1,43) = 8.72$, $p = .005$, $\eta_p^2 = .17$, but again no effect of Condition, $F(1,43) = 0.21$, $p = .89$, $\eta_p^2 = .00$, or Time by Condition interaction, $F(1,43) = 0.21$, $p = .89$, $\eta_p^2 = .00$. In sum, exposure training led to significant and large improvements in subjective fear, heart rate and

behavioral avoidance, with no differences in response to exposure across conditions.

At Visit 2, CLQ scores (M = 95.18, SE = 5.60) from prior to randomization showed a similarly large and significant reduction compared to scores pre-exposure training from Visit 1 (M = 120.33, SE = 5.23; F[1,43] = 23.06, p < .001, η_p^2 = .35). No main effect of Condition, F(1,43) = 0.02, p = .89, η_p^2 = .00, or Time by Condition interaction, F(1,43) = 0.93, p = .34, η_p^2 = .02, was found. However, there was a significant difference in state on the STAI-S at the beginning of Visit 2, t(43) = -2.11, p = .04, d = 0.63, indicating that at the beginning of Visit 2 (prior to all other Visit 2 procedures other than baseline heart rate measurement), EMR participants (M = 42.58, SE = 2.75) endorsed greater levels of state anxiety than SE participants (M = 34.93, SE = 2.36). Accordingly, STAI-S was controlled for in subsequent analyses examining the effect of condition.[1] There was no significant difference in baseline heart rate at visit 2, t(41) = 1.82, p = .55, d = 0.05.

Return of Fear. To examine the extent to which the change in context from BAT 1 to BAT 2 led to a return of fear across conditions, one-way ANOVAs were conducted on fear ratings and heart rate across all three BATs. Results showed significant differences across time-points in fear, F(1.54, 67.78) = 140.69, p = <.001, η_p^2 = .76, and heart rate F(1.51, 66.20) = 27.68, p = <.001, η_p^2 = .40. Paired-samples t-tests indicated

[1] Although controlling for baseline differences in randomized trials is a common practice (Austin, Manca, Zwarenstein, Juurlinnk, & Stanbrook), it is not without its critics (e.g., de Boer et al., 2015). Given the relatively limited power in this study and the potential for an additional covariate to reduce significance by removing degrees of freedom, analyses were also run without controlling for STAI-S at Visit 2. Except as noted in the text, results did not differ in statistical significance, and in most cases, effect sizes were larger when including STAI-S as a covariate, so it was retained in the analyses reported.

fear rating at BAT 2 (M = 44.04, SE = 4.29) was significantly greater than at BAT 1B, $t(44) = 8.35$, $p < .001$, $d = 1.25$, and significantly lesser than at BAT 1A, $t(44) = 8.35$, $p < .001$, $d = 0.98$. Similarly, heart rate at BAT 2 (M =72.21, SE = 1.27) was significantly greater than BAT 1B (M = 68.80, SE = 0.92; $t(42) = 2.21$, $p = .03$, $d = 0.34$), and significantly lower than BAT 1A (M = 77.01, SE =0.97; $t(42) = 3.96$, $p < .001$, $d = 0.61$).

Primary Aim: Effects of Treatment Condition on Fear Outcomes at BAT 2

Results of the full regression models predicting fear rating and heart rate can be seen in Table 4. Controlling for BAT 1B Fear[2] and STAI-S, the effect of treatment condition (EMR vs. SE) on Fear at BAT 2 was not significant, B = -9.79, SE = 8.41, p = .25, $sr^2 = .03$.

For heart rate data, after controlling for STAI-S and heart rate at BAT 1B, the effect of condition was significant, B = -6.73, SE = 2.64, p = .01, $sr^2 = .14$, indicating that EMR participants had a lower heart rate during BAT 2 relative to baseline than participants in SE. To ensure that such an effect was not confounded by the variable length of time participants spent in BAT 2, heart rate data during the first minute of BAT 2 was compared to the full duration of the BAT (among participants who stayed more than one minute, 95% of the sample), and a paired t-test showed no significant difference, $t(40) = -0.44$, $p = .66$, $d = .07$. Nonetheless, the effect of condition was also examined on

[2] Because fear ratings at BAT 1B were so consistently low (≤ 10 of 100 for 78% of the sample) and were unrelated to fear ratings at BAT 2, variability among ratings may not have been the most meaningful indicator of claustrophobic fear following exposure training. In an attempt to better capture claustrophobia levels prior to randomization, the analysis was also run with post-exposure CLQ scores as a predictor at Step 1. Although CLQ significantly predicted BAT 2 fear, B = 0.55, SE = 0.18, p = .004, $sr^2 = .19$, the effect of condition was still not significant, B = -9.81, SE = 7.67, p = .21, $sr^2 = .04$, so the original planned analysis was retained.

heart rate during the first minute of BAT 2. Results again show a significant effect of condition, B = -5.35, *SE* = 2.67, *p* = .04, sr^2 = .09, with lower heart rate relative to baseline in EMR vs. SE.[3]

Regarding behavioral avoidance, Figure 5 graphically depicts the portion of participants in EMR vs. SE groups exiting early across the 10 minutes of BAT 2, including when they exited. One participant asked to exit the scanner before entering entirely, so time was recorded as 0. When entered together in a Cox regression, exiting BAT 1A early was a significant predictor of exiting early during BAT 2, *Hazard Ratio (HR)* = 5.79, 95% CI [1.45, 37.10], *p* = .02, but treatment condition, *HR* = 0.60, 95% CI [0.12, 3.38], *p* = .60, and STAI-S, *HR* = 1.05, 95% CI [0.99, 1.12], *p* = .13) were not. Given that only seven of 45 participants (16%) exited the MRI scanner early (*n* = 4 in SE, *n* = 3 in EMR), results should be interpreted in the context of possible ceiling effects. Accordingly, BAT 2 duration was not used as a dependent variable in subsequent analyses.

Exposure Thinking Manipulation Check. When asked after BAT 2, all but 3 participants endorsed thinking about the prior exposure training while in the mock MRI scanner. EMR participants' ratings of how much they thought about the prior exposure training while in the scanner (*M* = 63.73, *SD* = 27.17) were not significantly different from SE participants (*M* = 50.91, *SD* = 30.52; *t*(43) = 1.49, *p* = .15, *d* = 0.44), though

[3] Following recommendations by Sterne et al., (2009), a sensitivity analysis was conducted examining only participants with complete data and compared to the analysis using multiple imputation. The significant effect of condition remained, and effect sizes were slightly larger when examining heart rate during the full duration of BAT 2, B = -8.89, *SE* = 3.30, *p* = .01, sr^2 = .20, and the first minute only, B = -7.42, *SE* = 3.53, *p* = .04, sr^2 = .14.

means were in the expected direction. When comparing the portion of participants from each group who described thinking about what they learned from exposure training or used the memory to help them feel less anxious (i.e. safety retrieval), the difference approached significance, (EMR = 81%; SE = 56%; $\chi^2 = 3.02$, $p = .08$). After controlling for BAT 1B outcomes and STAI-S, safety retrieval did not significantly predict BAT 2 fear, B = -9.04, $SE = 9.66$, $p = .36$, $sr^2 = .02$, or heart rate, B = -1.38, $SE = 2.99$, $p = .65$, $sr^2 = .01$, nor did it its interaction with treatment condition, (fear: B = 13.74, $SE = 21.66$, $p = .53$, $sr^2 = .01$; heart rate: B = 5.49, $SE = 5.72$, $p = .34$, $sr^2 = .02$).

When asked at the conclusion of Visit 2 whether they thought revisiting the memory of prior training was helpful, 14 of 18 (78%) EMR participants (4 missing responses) responded affirmatively, with 2 participants being unsure and 2 participants saying it was not. A partial point bi-serial correlation with BAT 2 fear outcomes, controlling for outcomes at BAT 1B, showed responding yes was associated with lower fear ratings ($r = -.43$, $p = .07$) and heart rate ($r = -.54$, $p = .04$).

Aim 2: Effects of Treatment Condition on Secondary Outcomes

Visit 2. There was no significant effect of condition on pre-BAT 2 outcome expectancies (i.e. CLEQ scores) as measured by concern ratings, B = -3.06, $SE = 5.79$, $p = .60$, $sr^2 = .01$, and likelihood ratings, B = -10.00, $SE = 6.91$, $p = .16$, $sr^2 = .05$, nor on expected fear, B = -8.84, $SE = 7.21$, $p = .23$, $sr^2 = .04$, controlling for each variable at BAT 1B as well as STAI-S at the beginning of Visit 2. Accordingly, planned analyses of claustrophobic expectancies as a mediator of the effect of EMR vs. SE were not conducted. There was also no significant difference between conditions on MRI-related

variables at the end of Visit 2, including negative outcome expectancies (i.e. CLEQ-MRI score) as measured by concern ratings, B = -2.00, *SE* = 5.92, *p* = .74, sr^2 = .003, and likelihood ratings, B = 1.99, *SE* = 8.19, *p* = .81, sr^2 = .002, expected fear, B = 5.21, *SE* = 8.23, *p* = .53, sr^2 = .01, or likelihood of getting a medically indicated MRI scan, B = 7.37, *SE* = 5.07, *p* = .15, sr^2 = .05, controlling for baseline ratings, or in the case of the CLEQ-MRI, controlling for BAT 1B CLEQ scores.

Follow-up. Effects at follow-up mirrored those at Visit 2. Controlling for CLQ scores at Visit 2 (pre-randomization), there was no significant effect of treatment condition on CLQ at one-month follow-up, B = -11.71, *SE* = 9.25, *p* = .21, sr^2 = .04. Similarly, there was no significant effect of condition on MRI fear, B = -2.20, *SE* = 9.25, *p* = .81, sr^2 = .001, MRI likelihood, B = 8.75, *SE* = 5.63, *p* = .13, sr^2 = .05, or CLEQ-MRI concern, B = -2.92, *SE* = 7.61, *p* = .70, sr^2 = .01, or likelihood, B = -3.86, *SE* = 6.05, *p* = .53, sr^2 = .004, controlling for baseline ratings, or in the case of the CLEQ-MRI, controlling for BAT 1B CLEQ.

Table 5 shows means of the CLQ and MRI-related variables across study time-points, along with the results of one-way ANOVAs examining differences in each variable across time when collapsing across condition. Significant decreases in CLQ scores, MRI fear, and MRI outcome expectancies were seen between all time-points, as were significant increases in likelihood of getting an MRI (all *p*s < .001).

Aim 3A: Exposure Takeaways

The frequency of post-exposure audio-recording themes can be seen in Table 3. The most frequent theme was Threat Reappraisal/Safety, present in 56% of the

recordings, whereas Fear Tolerance was relatively infrequent, present in just 18% of recordings. When entering each exposure takeaway variable in to stepwise regression, controlling for BAT 1B fear, condition, and STAI-S, only Generalized emerged as a significant predictor of BAT 2 fear, B = 16.51, *SE* = 7.93, *p* = .04, sr^2 = .10.[4] The direction of this effect indicated that participants who described their takeaway from exposure training in generalized terms had higher fear ratings at BAT 2 compared to than those who did not. When entering the interaction terms for each exposure takeaway with treatment condition in to the model (after re-entering each main effect), the Generalized variable approached significance as a moderator (*p* = .08), though when examined without the other exposure takeaway main effects, this effect fell outside of even marginal significance, B = -25.04, *SE* = 15.18, *p* = .11, sr^2 = .07. Nonetheless, graphical inspection of the results (see Figure 6) split by condition showed that those with Generalized takeaways in SE appeared to have greater fear during at BAT 2 compared to EMR participants, which may have been driving the main effect.

When examining heart rate as the dependent variable, a stepwise regression with all exposure takeaway predictors, controlling for BAT 1B heart rate and STAI-S, did not produce any significant effects (*p*s > 0.10). When examining exposure takeaways as moderators, however, both the interaction for Fear Reduction × Condition, B = 12.80, *SE*

[4] Results when entering predictors simultaneously showed similar patterns. Although Generalized was not initially significant with all other predictors present, B = 14.75, *SE* = 9.06, *p* = .11, sr^2 = .07, it was associated with a similar small to medium effect size, and became significant when other predictors were removed B = 16.51, *SE* = 7.93, p = .04, sr^2 = .10. Also similar to the stepwise results, the Generalized x Condition interaction was marginally significant when entered with other predictors, B = 39.74, *SE* = 20.35, *p* = .06, sr^2 = .10. (*p* = .06), but not significant with other predictors removed, B = 16.51, *SE* = 7.93, p = .04, sr^2 = .10.

= 6.12, p = .04, sr^2 = .12, and Generalized × Condition , B = -8.22, SE = 3.98, p = .03, sr^2 = .12, were significant. After removing other exposure takeaway variables, Fear Reduction remained a significant moderator, B = 14.36, SE = 6.40, p = .02, sr^2 = .12, whereas Generalized did not, B = 5.74, SE = 5.03, p = .25, sr^2 = .03, though the direction of moderation effect for Generalized was the same that it had been when predicting fear rating.[5] Figure 7 illustrates that the effect of EMR on reduced heart rate compared to SE appears to be driven by participants who did not have a fear reduction takeaway from their exposure. The effect of condition appears to be in the opposite direction for those with a Fear Reduction takeaway, but there were only three participants in SE with fear reduction takeaways, so this pattern may be spurious. A post-hoc examination of the EMR sample found there was a trend toward the presence of a Fear Reduction takeaway predicting greater heart rate reactivity, controlling for post-exposure training levels, B = 4.83, SE = 2.87, p = .09, sr^2 = .14.

Effects of Mental Reinstatement Variables. Table 3 shows the frequency by which different exposure takeaway themes were recalled during EMR procedures at Visit 2, when participants revisited the memory of exposure training. Notably, only one participant recalled a Fear Tolerance takeaway, whereas all but two participants recalled a Fear Reduction takeaway. In Table 6, partial point bi-serial correlations of the presence of each exposure recall theme with BAT 2 fear ratings and heart rate reactivity,

[5] Again, results of a simultaneous regression analysis were highly similar as the stepwise approach. There were no significant main effects, but the Fear Reduction x Condition interaction was significant both when entered with other interactions terms as predictors, B = 19.97, SE = 7.70, p = .009, sr^2 = .18, and without, B = 14.36, SE = 6.40, p = .02, sr^2 = .12.

controlling for each variable at BAT 1B, are reported. Given that these correlations were conducted on just half the sample, results should be interpreted with caution.

Table 6 also presents partial correlations between outcome variables and several ratings made immediately after recalling their exposure training and listening to their audio-recording. Post-reinstatement negative affect demonstrated a positive association with BAT 2 fear that approached significance, though in a separate analysis this did not hold when also controlling for STAI-S rated at the beginning of Visit 2 ($r(18) = .33$, $p = .15$). Positive affect, however, remained significantly negatively associated with BAT 2 fear rating when controlling for STAI-S and BAT 1B fear ($r(18) = -.45$, $p = .047$). Since affect ratings were also made after the memory recall procedure in the SE condition, positive affect and its interaction with condition were then examined as predictor in the full sample. After controlling for STAI-S and Post BAT 1B fear, neither the main effect, B = -.325, $SE = 1.06$, $p = .76$, $sr^2 = .002$, nor the interaction term with condition were significant, B = -3.71, $SE = 2.29$, $p = .11$, $sr^2 = .06$. When removing STAI-S as a covariate, however, the interaction effect was significant, B = -5.07, $SE = 2.34$, $p = .04$, $sr^2 = .10$, indicating that EMR was more predictive of reduced fear levels during BAT 2 for those who reported greater positive affect after reinstatement of the exposure memory.

Although vividness of the exposure memory was not significantly associated with BAT 2 outcomes, greater imagery ability as assessed by the VVIQ was a strong predictor of increased fear, so VVIQ and their interaction with condition were examined in the whole sample to determine whether this relationship was specific to EMR. Controlling

for STAI-S and Post BAT 1B fear, VVIQ had a significant main effect on BAT 2 fear, B = 1.36, *SE* = 0.38, *p* = .001, sr^2 = .11, and the VVIQ × Condition interaction approached significance, B = 1.31, *SE* = 0.73, *p* = .08, sr^2 = .06, with the direction of this effect trending toward a stronger relationship for participants in EMR. However, when removing STAI-S as a covariate, the effect weakened, B = 1.04, *SE* = 0.86, *p* = .23, sr^2 = .04.

Exploratory Moderator Analysis. Given that a sizable portion of the sample experienced only mild fear levels during BAT 2 (median peak fear = 40, median end fear = 20) and may have experienced minimal benefit from additional intervention to help generalize learning, exploratory moderator analyses were run to investigate whether an effect of treatment condition on subjective fear may emerge for those more likely to be fearful in the mock scanner. Specifically, post-exposure CLQ scores and their interaction with treatment condition were entered in to the regression model. However, the effect of the interaction term was not significant, B = -0.19, *SE* = 0.21, *p* = .38, sr^2 = .02. The same test of moderation was run with the STAI-S to explore whether those with greater state anxiety at the beginning of Visit 2 may have benefited more from MRE. Again, the effect of the interaction term was non-significant, B = -1.03, *SE* = 0.66, *p* = .13, sr^2 = .06, though the direction of both of these effects were such that EMR was associated with lower fear ratings relative to SE among those with higher CLQ and STAI-S scores at the beginning of Visit 2. The same non-significance was seen when examining heart rate as the dependent variable (CLQ by condition interaction: B = 0.04, *SE* = 0.07, *p* = .54, sr^2 = .001; STAI-S by condition interaction, B = -0.11, *SE* = 0.21, *p* = .60, sr^2 = .001).

Aim 3B: Changes in Feared Outcomes

Following planned analysis, the relative effects of changes in feared outcomes related to threat expectancies, fear tolerance, and coping self-efficacy on the CLEQ during exposure training were examined as predictors of outcomes at BAT 2. Means and SDs of CLEQ subscales across BATs are reported in Table 7. Partial correlations controlling for BAT 1B outcomes showed that neither the CLEQ subscales or total scale were associated with fear ratings or heart rate at BAT 2 (Table 7). CLEQ changes from BAT 1B to BAT 2 showed strong positive correlations with fear and small positive correlations (approaching significance) with heart rate at BAT 2, controlling for outcomes at BAT 1B, though the magnitude of these associations did not meaningfully differ across CLEQ subscales.

One-way ANOVAs were examined to evaluate differences across changes scores in CLEQ subscales. Significant differences emerges across subscales from BAT 1A to BAT 1B, $F(2,88) = 9.28$, $p < .001$, $\eta_p^2 = .17$, with greater reduction in fear tolerance than threat expectancies, $t(44) = 3.50$, $p = .001$, and coping self-efficacy, $t(44) = 3.77$, $p < .001$. Change scores for the CLEQ from BAT 1B to BAT 2 also varied significantly, $F(2,88) = 14.27$, $p < .001$, $\eta_p^2 = .25$, with smaller increases in threat expectancies compared to fear tolerance, $t(44) = -4.38$, $p < .001$, and coping self-efficacy, $t(44) = -3.81$, $p < .001$.

Aim 3C: Expectancy Violations

Means and standard deviations of expectancy violation variables during the initial exposure and across all exposures are reported in Table 8. Values reflecting surprise

regarding feared outcome occurrence were consistently higher than likelihood-occurrence discrepancies, though standard deviations reflect significant variability across participants for both measures. Values were also greater during the initial exposure than when averaged across all six exposures. For prediction analyses, expectancy violation variables were grouped according to time-point (initial exposure vs. mean across all six exposures), and then each type of expectancy violation (threat expectancy, coping self-efficacy, fear tolerance, and fear level) as measured by both surprise ratings and likelihood-occurrence discrepancy was entered in a stepwise regression model predicting BAT 2 fear and heart rate reactivity, controlling for condition and the relevant outcome at BAT 1B.

Prediction of BAT 2 Fear. When examining initial exposure predictors of fear at BAT 2, surprise ratings regarding coping self-efficacy, B = -0.33, *SE* = 0.14, $p = .02$, $sr^2 = .10$, and discrepancy between expected vs. actual fear levels, B = 0.45, *SE* = 0.21, $p = .04$, $sr^2 = .10$, emerged as significant, though effects were in opposite directions. Whereas greater coping self-efficacy surprise predicted lower fear, expecting greater fear than actually occurred (i.e., over-predicting fear) during the first exposure was associated with higher fear ratings at BAT 2. Of note, likelihood-occurrence discrepancy for coping self-efficacy approached significance, B = -0.38, *SE* = 0.20, $p = .06$, $sr^2 = .09$, with its effect in same direction as coping self-efficacy surprise (i.e., greater expectancy violation predicting reduced fear). Expectancy violations related to threat expectancies and fear tolerance from the initial exposure were not significant predictors of BAT 2 fear, regardless of whether they were measured by surprise ratings or likelihood-occurrence discrepancies (all *p*s > .22). When examining expectancy violation variables averaged

across all exposure trials, no individual predictor showed significant effects on BAT 2 fear (all *p*s > .11).[6]

Prediction of BAT 2 Heart Rate. When examining heart rate at BAT 2, the only initial exposure predictor that emerged as significant in the stepwise regression was fear level expectancy violations, with greater over-predictions of fear associated with greater BAT 2 heart rate, B = -0.38, *SE* = 0.20, *p* = .06, sr^2 = .09 (all other *p*s > .15). No expectancy violation measure averaged across all exposures significantly predicted BAT 2 heart rate (all *p*s > .11).

Unlike BAT 2 fear, testing predictors of heart rate reactivity simultaneously led to substantially different results, which can be seen in Appendix E, Table E.2. Regardless of whether ratings were from the initial exposure or averaged across all six exposures, greater self-efficacy expectancy violations (measured by likelihood-occurrence discrepancies) predicted lower heart rate at BAT 2, whereas greater discrepancy between predicted vs. actual fear levels during the initial exposure was associated with higher heart rate at BAT 2. Greater fear tolerance expectancy violations through all six exposures, measured by likelihood-occurrence discrepancies, also predicted higher heart rate at BAT 2. The emergence of a larger number of significant predictors in the simultaneous regression could suggest the presence of suppressor effects. Specifically, if

[6] Results from a separate analysis regressing BAT 2 fear on expectancy violation variables simultaneously, which can be seen in Appendix E, Table E.1, showed a similar pattern to stepwise analysis. Coping self-efficacy surprise and fear level expectancy violations again emerged as significant predictors, with the one difference being that the effect of the other coping self-efficacy expectancy violation measure from the initial exposure, likelihood-occurrence discrepancy, reached significance. Of note, predictors in the simultaneous regression were also grouped by expectancy violation measurement type (i.e. surprise ratings vs. likelihood-occurrence discrepancy), with separate tests for each group of variables.

shared variance in a group of predictors is uncorrelated with the dependent variable, entering the predictors simultaneously will lead that portion of the variance to be partialled out. In turn, this can cause the unique variance in each predictor to be more likely to account for variance in the dependent variable, thereby emerging as significant when no effect of the predictor was evident when tested by itself (Ludlow & Klein, 2014). Expectancy violation predictors were modestly correlated (most *r*s between 0.3 and 0.4), making such an explanation plausible. However, the lack of consistency in the relation between expectancy violations and BAT 2 heart rate changes across analytic approaches suggests significant caution with interpretation is warranted.

Prediction of Claustrophobia Symptoms. Based on results from the stepwise approach, a separate regression model was then tested that included just the significant predictors from the previous analyses, coping self-efficacy surprise and fear level expectancy violation during the initial exposure, and examined effects on CLQ scores at Visit 2 and follow-up, controlling for Visit 1 CLQ scores and treatment condition. No significant effects were seen for CLQ at Visit 2 (coping self-efficacy: B = -0.23, *SE* = 0.16, $p = .17$, $sr^2 = .05$; fear level: B = 0.34, *SE* = 0.17, $p = .22$, $sr^2 = .03$), but coping self-efficacy surprise significantly predicted CLQ scores at follow-up, B = -0.40, *SE* = 0.19, $p = .04$, $sr^2 = .10$, with greater surprise about coping self-efficacy during the initial exposure being associated with reduced claustrophobia symptoms on the CLQ. For initial exposure fear level expectancy violations, there was a trend for greater over-predictions of fear to be associated with higher CLQ scores, but it did not reach significance, B = .56, *SE* = 0.32, $p = .09$, $sr^2 = .10$.

Discussion

The primary aim of this study was to examine a method of overcoming one of the primary limitations of exposure therapy, namely that the learning of safety resulting from exposure to a feared situation may not adequately generalize beyond the context in which that learning occurs. To accomplish this aim, I conducted a randomized clinical trial testing the effect of mentally reinstating the memory of previous exposure training for claustrophobia prior to approaching a novel feared situation, specifically a mock MRI scanner. Building upon limitations of previous studies examining such a procedure (Elsesser et al., 2013; Mystkowski et al., 2006; Laborda et al., 2016), which showed limited effects, the mental reinstatement procedure in this study was (putatively) enhanced by having participants listen to an audio-recording of themselves verbalizing what they had learned in their prior exposure training, and then explicitly identify how this previous learning applied to the novel exposure context they were about to encounter.

This study examined the effects of such a manipulation on 45 participants endorsing significant fear of enclosed spaces generally and MRIs specifically, 84% of whom met DSM-5 criteria for specific phobia. Across conditions, results showed that the exposure training resulted in significant reductions in fear ratings, heart rate and avoidance during a behavioral approach test (BAT) in the exposure training context, as well as self-reported claustrophobic symptoms and MRI fear one week later and at one-month follow-up. Fear responses one week later during a BAT in the mock MRI scanner (i.e. BAT 2) were significantly lower compared to baseline, but fear ratings and heart rate were significantly higher compared to BAT 1B, which occurred at the end of exposure

training in the exposure context. Therefore, a partial return of fear of fear effect was seen, enabling this study to meaningfully investigate the effect of EMR on generalization of gains following exposure training. For behavioral avoidance, however, only 7 of the 45 participants exited BAT 2 before the maximum time elapsed, limiting investigation of behavioral outcomes.

Results of the primary analyses showed that compared to SE, EMR led to significantly reduced heart rate reactivity during BAT 2, reflective of a medium-sized effect ($sr^2 = .14$). The impact of EMR vs. SE on subjective fear was in the expected direction (i.e., reduced fear in EMR compared to SE), but the effect was small ($sr^2 = .03$) and not significant. Furthermore, no differences were seen on behavioral avoidance, though low avoidance rates across conditions indicate a likely ceiling effect. With regard to secondary outcomes, no effect of treatment condition was seen on negative outcome expectancies prior to BAT 2, self-reported claustrophobia symptoms at one-month follow-up, or MRI fear-related outcomes (i.e. negative outcome expectancies, expected fear, likelihood of getting an MRI) after BAT 2 or at one-month follow-up. As with the fear rating outcome, results for nearly all secondary outcomes were in the expected direction of greater improvement in EMR, but effect sizes were small ($sr^2 = .01$ to $.05$) and not statistically significant.

The absence of effect on subjective fear ratings in this study is in contrast to the findings of Mystkowski and colleagues (2006), who found mental reinstatement to lead to decreased subjective fear during a BAT with spider phobics, but consistent with findings of Elsesser et al. (2013) in dental phobia and Laborda et al. (2016) in social

phobia. A notable difference between the study by Mystkowski et al. (2006) and the present research, beyond the type of phobia treated, is that generalization was examined with the same exposure stimulus (a spider) across distinct contexts, whereas in the current study the context and stimulus differed, potentially leading to more difficulty generalizing.

With regard to heart rate outcomes, this is the first study to show effects of mental reinstatement on heart rate reactivity during exposure following a context change, though it should be noted that only one (Elsesser et al., 2013) of the three prior mental reinstatement studies examined effects on heart rate. That effects were specific to heart rate is somewhat surprising given that the "enhanced" aspects of the procedure were in large part designed to target top-down reasoning processes about the relevance of prior learning to a new feared situation, and therefore might be more likely to impact subjective fear ratings and threat expectancies. In particular it was hypothesized that the advantage of EMR over the control condition would be mediated by superior impacts on negative outcome expectancies, but no difference in expectancies was found across conditions. Nonetheless, despite equivalent subjective ratings of fear and outcome expectancies, the EMR intervention led to decreased physiological reactivity compared to SE when entering a novel feared situation, with heart rate levels essentially equivalent to post-exposure training in a familiar claustrophobic context.

The discordance between subjective and physiological outcomes in this study is noteworthy in that it highlights the distinct response systems of fear originally delineated by Lang (1968). De-synchrony between these response systems has been shown to be

greatest under conditions of less severe emotional arousal (Calvo & Miguel-Tobal, 1998; Hodgson & Rachman, 1974), which appears to have been reflected in this study in the relatively moderate levels of fear experienced on average during BAT 2. Although researchers are frequently drawn to prioritize physiological outcomes as more objective indicators of emotional states directly linked to underlying brain circuitry (e.g., Perusini & Fanselow, 2015), others have argued that the subjective, conscious report of fear reflects a valid and reliable measurement that is particularly important since subjective distress tends to be what drives people to seek treatment (LeDoux, 2014; LeDoux and Hofmann, 2018). In this account, physiological responses reflect defensive survival circuits that can contribute to the conscious experience of fear, but do not determine it. Thus in this study, the EMR intervention appeared to have an effect on reducing a measure of autonomic arousal (heart rate) reflective of underlying defensive circuitry (Friedman, 2007), However, this reduced autonomic arousal did not appear to impact the conscious experience fear enough to lead to a concordant reduction in subjective fear ratings.

A number of possible explanations exist for the non-significant findings of EMR on self-reported variables. For one, results of the manipulation check applied after BAT 2 showed that a sizable portion (56%) of the participants in the SE condition reported thinking about their prior exposure training during BAT 2 *and* specifically described thinking about what they learned or used the memory to help them feel less afraid. There was a trend toward more MRE participants (81%) revisiting their exposure training in this way, but such a pattern suggests that not everyone in the MRE condition explicitly

recalled the more helpful aspects of their prior exposure training while going in the mock MRI canner, and that numerous participants revisited their exposure training without going through those procedures. It should be noted that there were substantial limitations to this manipulation check given that it was done retrospectively, ratings did now a significant relationship with fear during BAT 2, and there may have been a social desirability bias impacting participants from both conditions. Furthermore, MRE procedures still could have had an effect without leading to explicit memory retrieval (e.g. see Shin & Newman, 2018). Nonetheless, such a pattern reflects the likelihood that prior learning was likely fairly salient for all participants in the study. Although BAT 2 occurred one week after initial training and occurred in a location, the novelty of coming in for a research study visit on claustrophobia could made reinstatement of prior safety memories easily occur, as could have the SE procedure in which participants recalled a neutral memory from around the same time as the first study visit.

Also potentially contributing to the high salience of prior learning for all participants, and consequently to the limited impact of EMR, is the creation of the audio-recording after exposure training, in which participants reviewed what happened during the exposure training and what they learned about their fear. Expression of fear and safety memories are influenced by consolidation processes as well as retrieval (Quirk & Mueller, 2011), and the elaborated review of exposure training may have functioned as a strong extinction memory consolidation intervention, reducing possible effects of a later retrieval-based manipulation. In fact, Raeder and colleagues (2019) showed that reactivating the memory of exposure training and evaluating one's success in facing

feared scenarios immediately after a single session of exposure training for height phobia led to reduced recovery of fear and increased self-efficacy during BATs done two to three days later and at one-month follow-up. After using a similar intervention across all participants in the present study, a large return of fear effect (d = 1.25) was still present, suggesting there was still substantial room for improvement from the EMR intervention. However, the median peak fear level across conditions was 40 out of 100, meaning that many participants did not experience substantial fear levels after a change in context. Moderator analyses did not show the effect of treatment condition to be significantly impacted by claustrophobia severity or state anxiety prior to the manipulation, which might be expected if ceiling effects were present, though such tests were limited by the small sample size.

Exposure Takeaways

In order to better understand the role of higher-order reasoning processes on generalization of learning following exposure, this study examined what participants reported learning and remembering from their exposure training. Doing so enabled an investigation of the meaning participants made of their exposure experience immediately after the training concluded, and how this meaning related to subsequent fear outcomes. It also provided insight in to what participants in the EMR condition remembered prior to entering to entering the mock MRI scanner.

Results showed that despite the standardized exposure training, there was substantial variability in the participants' biggest takeaways. The most common theme immediately after exposure training was Threat Reappraisal/Safety, suggesting that the

realization that fears did not come true and they were actually safe in an enclosed space was particularly salient for participants. When recalling the exposure memory during EMR procedures one week later, however, almost all participants emphasized fear reduction, suggesting this was one of the most memorable elements of the exposure training. Fear tolerance takeaways, on the other hand, were described by only a small proportion of participants in both the post-exposure recording at Visit 1 and exposure recall at Visit 2, which is notable given the theoretical importance of learning to tolerate fear for long-term exposure outcomes (Arch & Abramowitz, 2015; Craske et al., 2008). Of note, fear tolerance was not emphasized during the rationale for exposure (whereas threat reappraisal and fear reduction were), fear tolerance beliefs were tracked through exposure training. Nonetheless fear tolerance did not appear to be a particularly salient takeaway point for participants in this study.

In regards to relationships with outcome, the presence of a fear reduction takeaway during the post-exposure recording was associated with increased heart rate reactivity at BAT 2. Although interaction effects should be interpreted with caution given the small sample size, it appears that this effect was specific to the EMR condition, suggesting that the impact of a fear reduction takeaway may have had more to do with hearing fear reduction being highlighted on the audio-recording during EMR procedures than it being a point of emphasis at the end of exposure. It is possible that hearing oneself describe how fear reduced over the course of exposure led to an expectation or hope for reduced fear during BAT, consequently leading to a greater physiological fear response when inside the mock MRI and experiencing significant fear. Alternatively, audio-

recordings emphasizing fear reduction may have also elicited stronger memories of the fear initially experienced during exposure training, thereby strengthening the salience of the fear memory prior to BAT 2.

A somewhat surprising result from the analysis of exposure recording themes was that takeaways that included a generalized component to them were predictive of greater fear ratings during BAT 2. Associating safety with a specific context rather than abstracting a rule that can be applied across contexts is thought to be one of major determinants of fear renewal (Gawronski, Rydell, Vervliet, & De Houwer, 2010), so it was expected that a generalized element of exposure takeaway recordings would help to reduce return of fear. Closer inspection of the generalized statements present, however, shows that many of them described what occurred in a somewhat simplistic way (e.g. "fear is all in my head," "exposure shows you nothing bad will happen, even if at first you imagine it will"), absent of specific details about why this generalized statement is true. Such statements may reflect a lack of memory specificity about the exposure experience, which could be associated with poorer outcomes given evidence that low autobiographical memory specificity has been shown to be associated with more generalized fear responding (Lenaert et al., 2012) and poor discrimination learning (Lenaert, Boddez, Vervliet, Schruers, & Hermans, 2015). Based on such findings, investigating whether memory specificity for exposure experiences or extinction training is helpful for the retention or generalization of safety learning would be an intriguing direction for future research.

Expectancy Violations

By tracking feared expectations and outcomes at each trial of exposure training, this study enabled the investigation of a number of different types of expectancy violations as predictors of generalization outcomes. Results showed that expectancy violations pertaining to coping self-efficacy and expected fear levels during participants' initial exposure were significantly related to self-reported fear outcomes, though in opposite directions. Specifically, greater surprise about coping self-efficacy outcomes (i.e. surprise about coping better than expected) predicted lower fear ratings at BAT 2, as well as self-reported claustrophobia symptoms at one-month follow-up. There was also some indication that likelihood-outcome discrepancies related to coping-self efficacy concerns predicted fear and heart rate reactivity during BAT 2, though this result was not consistent across analytic approaches. The finding that learning related to coping self-efficacy, i.e. the ability to actively manage fearful thoughts, feelings and behaviors, was associated with outcomes is consistent with previous literature showing improvements in coping self-efficacy to mediate subsequent symptom reduction during exposure therapy (Fentz et al., 2013; Gallagher et al., 2014). Furthermore, experimentally manipulating self-efficacy prior to an extinction learning task has been shown to lead to reduced physiological responding and negative evaluations of a conditioned stimulus (Zlomuzica, Preusser, Schneider, & Margraf, 2015). The present study extends these findings by showing that a strong expectation of poor coping self-efficacy, followed by the realization that one can effectively cope, is predictive of reduced fear in a new feared context.

Although it was based on a small sample, there was also a non-significant trend (r_{part} = .40) toward recall of a coping self-efficacy takeaway during EMR predicting reduced heart rate reactivity at BAT 2, which is consistent with the idea that coping beliefs are central to fear outcomes. Also notable is the finding that positive affect after the memory recall procedure for EMR participants was associated with lower fear during BAT 2, as positive affect and self-efficacy are often linked (Schutte, 2014). Thus during exposure training, particularly at the first exposure, surprise about one's ability to cope during exposure was predictive of later fear outcomes, whereas after having gone through exposure training, recalling that one can cope and feeling positive immediately prior to entering a feared situation was associated with reduced fear.

With regard to fear level expectancy violations, discrepancy between expected and actual fear (i.e. expected minus actual fear levels, or over-prediction of fear) at the initial exposure was significantly positively associated with greater fear ratings and heart rate reactivity during BAT 2. There were also positive associations between over-prediction of fear and fear intolerance outcomes (i.e. believing fear would be more intolerable than it was) across all exposures and fear outcomes at BAT 2, though this result was not consistent across analytic approaches. Although realizing that fear was consistently lower and more tolerable than expected should theoretically help facilitate therapeutic learning (Craske, Vervliet, & Hermans, 2018), it is important to note that in the present study attention was not explicitly drawn to expected vs. actual fear discrepancies like it was for specific feared outcomes, as surprise about fear levels was not rated. Over-predictions of fear levels and consistent expectations that fear would be

intolerable may have instead reflected an inability to update expectations based on actual experience, suggestive of a more rigid cognitive style. The finding that expectancy violations related to fear tolerance and coping self-efficacy showed opposite associations with fear outcomes is somewhat surprising given that both belief domains reflect concerns about the consequences of fear. However, coping self-efficacy beliefs are specific to one's ability to actively cope with or reduce fear rather than tolerate it, suggesting that learning one can exert control over one's response in a feared situation is particularly beneficial. Notably, fear tolerance expectancy violations were predictive only of BAT 2 heart rate outcomes and not fear ratings, further highlighting the discordance between subjective and physiological outcomes seen in the present study.

The direction of these effects is consistent with the findings of Kircanski & Peris (2015), who found that over-predictions of fear early in exposure treatment predicted worse mid-treatment outcome. A study by Guzick et al. (2018), on the other hand, found that greater variability in expected vs. actual fear over the full course of treatment, which meant a higher proportion of over-predictions, was associated with improved outcome. Of note, expectancy violations in the current study were based on a massed set of identical exposures, in contrast to the studies mentioned above which included a full course of treatment with varying types of exposures. It may be that over-predictions of fear are related to outcome when a limited number of exposure situations have been encountered, but as more situations are approached this no longer is the case.

This is the first study to show that expectancy violations about specific feared outcomes (rather than expected fear levels) are predictive of subsequent fear levels.

However conclusions about the belief domains used in this study (coping self-efficacy, fear tolerance, and threat expectancies) should be considered as tentative. The categories of beliefs used in the CLEQ, which were subsequently used to distinguish expectancy violation beliefs, were based on items selected from prior measures as well as distinctions between theorized mechanisms of exposure. Although internal consistency within belief domains was strong, sample size limitations prevented full psychometric analysis. Given that expectancy violations related to different types of beliefs can have divergent effects on future outcomes, better delineating the types of beliefs related to exposure outcomes is an important direction for future research. It is also worth noting that the associations between .

Limitations

Results of this study should be considered within the context of a number of limitations. For one, administration of BATs was not blinded, making it impossible to rule out that knowledge of experimental condition subtly impacted experimenter behavior. Although a standardized script was followed for each BAT, having a separate experimenter conduct outcome assessment served as a stronger control. Relatedly, although SE procedures were designed to mimic EMR procedures in terms of memory reinstatement, it was not designed to be an equally plausible alternative in terms of helping reduce fear outcomes, so participant expectancy effects may have played a role in EMR.

Another limitation is that the results of the present study cannot speak to whether effects on fear outcomes during BAT 2 are specific to generalization processes, or rather

impacted return of fear due to the passage of time, which could only be determined if there was a comparison group that went through BAT 2 in the same context as BAT 1. Furthermore, without counterbalancing the order of contexts, it is possible that effects are restricted to the specific order of exposure situations that participants encountered. The decision to test the return of fear exclusively in a mock MRI explicitly was made with maximizing clinical applicability in mind, as generalization to an MRI scanner is a real-life scenario claustrophobic individuals may need to encounter, and given the wide variety of situations anxious patients encounter, the failure to generalize is a more common limitation of treatment effects than return of fear due to passage of time. Nonetheless, these limitations are relevant when considering the specific mechanisms preventing or leading to the return of fear

Regarding the EMR intervention itself, another limitation is that because it included multiple ingredients (i.e. recall of exposure memory, listening to audio recording, and identifying relevance of exposure memory), it is difficult to know whether certain elements may have been driving or impeding effects. Multiple components were used in order to maximize likelihood of improving outcomes given that exposure is already a fairly robust intervention, but it is also possible that certain elements of the procedure ended up increasing fear levels, particularly for certain participants like those who emphasized fear reduction in their exposure recordings. Unlike previous research examining mental reinstatement, however, we assessed and analyzed a number of different components of the memory recall procedures, enabling more specific understanding of the factors potentially influencing mental reinstatement.

It should also be noted that even though the study was adequately powered to detect a medium-sized effect for the main outcomes, sample size is still a limitation, particularly for secondary analyses involving moderation. Even for main outcomes, non-significant effects were consistently in the direction of superior outcomes for EMR, but may have been too small to detect in the present study. This may be especially true given the modest return of fear seen for the majority of the sample, and particularly for behavioral avoidance as an outcome, which showed a clear ceiling effect. Relatedly, the control procedures in the SE condition may have inadvertently elicited reinstatement of the exposure memory in a way that reduced differences seen between conditions. Specifically, vividly imagining a neutral memory that occurred close in proximity to the initial study visit as well as listening to an audio-recording made during that visit may have prompted SE participants to implicitly or explicitly recall the memory of exposure training more than they otherwise would have. Although the elaborated procedures of the EMR condition would still be expected to lead to a stronger reinstatement of prior learning, overlap between conditions could have reduced the magnitude of effects to a level not detectable given the present sample size. This idea is also supported by the results of the manipulation check mentioned previously, in which the difference in proportion of EMR vs SE participants who explicitly revisited the memory of exposure training prior to or during BAT 2 compared only approached significance.

Implications and Future Directions

Based on findings from this study and other investigations of mental reinstatement techniques (Elsesser et al., 2013; Laborda et al., 2016; Mystkowski et al.,

2006), effects of revisiting a prior exposure memory in order to enhance generalization appear to be limited, and it is difficult to make definitive conclusions about the clinical utility of such an exposure augmentation strategy as it has been applied to date. Nonetheless, the presence of significant effects on psychophysiological reactivity, possible moderators (e.g. post-reinstatement positive affect) and sample size limitations of this study suggests that further investigation of mental reinstatement and related techniques could be beneficial.

In order to better understand the processes in play in extant findings on mental reinstatement, one future direction would be to experimentally manipulate the manner in which the memory is recalled, as well as the formation of the memory itself. For instance, Raeder and colleagues (2019) found that immediately after exposure treatment, having participants reactivate the memory of the exposure experience and connect it to other mastery experiences led to improved fear outcomes compared to reactivating the memory and comparing it to other stressful experiences. An extension of this research would be to examine whether mental reinstatement of exposure after such a self-mastery reactivation exercise could amplify its effects, and potentially extend benefits to a novel situation. Given the challenges of experimentally manipulating complex memories like that of an exposure, laboratory fear conditioning and extinction paradigms also offer a way to more specifically influence and evaluate what is remembered. For instance, in a study using a contextual renewal extinction paradigm, neural reinstatement of a safe context was associated with reduced feelings of threat to a conditioned stimulus (Hennings, McClay, Lewis-Peacock, & Dunsmoor, 2020), so future research could examine memory retrieval

techniques (e.g., mental rehearsal; Joos et al., 2012) designed to help facilitate such neural reinstatement.

Another meaningful direction for this research would be to examine the potential of utilizing mental reinstatement procedures to enhance generalization of learning to a person's day to day life. One of the most significant context shifts that patients experience during exposure therapy is going from an exposure completed during a treatment session in the presence of a therapist to encountering feared situations one their own outside of the clinic. Unlike the present study, in which the context of being a research participant and the presence of the experimenter likely made the memory of previous exposure highly salient, day to day feared situations are likely to contain fewer contextual cues and reminders of prior learning. Therefore there may be a stronger need for, and therefore benefit of, reinstatement of previous exposure success. Mobile technology could be particularly useful in this regard, delivering reminders of prior exposure success, potentially through self-generated statements capturing the most important learning points from earlier exposures, as well as visual or other sensory cues that serve as a reminder of therapeutic learning (e.g. Rosenthal & Kutlu, 2014). In doing so, such an approach could utilize mental reinstatement as well as retrieval cues strategies, both of which have shown potential for clinical utility (e.g. Shin & Newman, 2018) but by themselves may be more limited in impact.

Another consideration for future research is the limitations of examining exposure augmentation strategies over the course of a single session. For instance, effects that are useful over multiple sessions of exposure may be too small to detect after a single

session. In addition, single session protocols like the one in the present study inherently limit variability in exposure contexts, and the facilitation of generalized therapeutic learning or beliefs about coping self-efficacy may be more limited with only a single context from which to learn from. Multiple sessions of exposures in different contexts may enable more generalized safety learning to occur, and thus more effectively be retrieved through reinstatement procedures. Furthermore, early in treatment it may be important to emphasize the creation of strong expectancy violations in order to enhance the formation of new learning, whereas overemphasizing safety and low fear levels carries risks of relapse if an exposure goes poorly (Abramowitz & Arch, 2014).

Regarding expectancy violations, findings from this study are certainly in need of replication given the exploratory nature of the analyses and small sample size. However, they suggest that the experience of coping more effectively than one expected during an exposure helps to facilitate durable reductions in fear. Such a finding offers important evidence in a clinical context for a central tenet of inhibitory learning theory, which is that therapeutic learning is facilitated through maximizing of expectancy violations (Craske et al., 2008; Rescorla-Wagner, 1972). This is particularly notable given a number of recent studies that failed to find evidence in support of expected associations between expectancy violations and outcomes (de Kleine et al., 2017; Scheveneels, Boddez, Van Daele, & Hermans, 2019; Scheveneels, Boddez, Vervliet, & Hermans, 2019). This study also demonstrated the value of investigating the different types of expectancies that may be violated during exposure, as previous research has largely focused on a single indicator of expectancies, most frequently expected fear levels. The types of beliefs that

drive fear can vary widely both across and within different types of anxiety presentations, and the present results show that examining expectancy violations with greater specificity in regards to belief domains may help to clarify inconsistent findings. Further research investigating the types of expectancy violations that are most predictive of outcomes, both within and across individuals, will be important to continue refine inhibitory learning theory and elucidate the cognitive mechanisms driving change during exposure. In addition, in order to demonstrate that expectancy violations function as mechanism of change, future research will need to manipulate treatment in such a way that facilitates greater expectancy-outcome mismatches (e.g. Deacon et al., 2013), and demonstrate that this in turn leads to improved outcomes.

Lastly, although the current study was not specifically designed as an intervention for treatment of MRI-related claustrophobia, it illustrates the utility of exposure therapy for decreasing MRI-related fear when access to a real scanner is limited. Specifically, MRI-related fear and expected likelihood of getting a medically-indicated MRI substantially improved as a result of two visits involving exposure to feared spaces. Given the major public health implications of MRI avoidance due to claustrophobia (Munn et al., 2015), this study could serve as the basis for future research investigating an efficient exposure-based intervention for fear of MRI scans.

Conclusion

Results of the present study showed that an intervention involving mental reinstatement of prior exposure training for claustrophobia led to reduced heart rate reactivity when entering a new feared situation, but effects on subjective fear rating or

feared outcome expectancies were not significant. In addition, no impact of intervention was seen on self-reported claustrophobia symptoms or MRI fear-related variables at one-month follow-up. Compared to results of prior studies examining a similar manipulation, the elements added to the procedure, including listening to an audio-recording of what participants learned from prior exposure training, did not appear to meaningfully improve outcomes. Analysis of exposure training processes showed that expectancy violations related to coping self-efficacy, particularly during participants' first exposure, led to less fear in a novel exposure situation one week later, as well as less self-reported claustrophobia symptoms at one-month follow-up. Over-predictions of fear levels, however, were associated with greater fear levels in the novel feared situation. More research is needed to understand how to most effectively facilitate the formation and retrieval of safety memories in order to enhance generalization of learning from exposure.

Table 1

Demographics

	EMR (n = 22) *M (SD) or n (%)*	SE (n = 23) *M (SD) or n (%)*	p value for T, χ^2 or Fisher's Exact Test
Age	30.8 (13.3)	27.7 (11.4)	0.40
Participant Type			0.30
Student	13 (55%)	13 (57%)	
Community	9 (45%)	10 (43%)	
Gender			0.29
Male	9 (41%)	6 (26%)	
Female	12 (54%)	17 (74%)	
Other	1 (5%)	0 (0%)	
Race/Ethnicity			0.19
Asian	7 (31%)	11 (48%)	
Black	6 (27%)	2 (9%)	
White	9 (41%)	7 (30%)	
Latinx	0	1 (4%)	
Multiple	0	2 (9%)	
Education			0.47
High school	3 (14%)	1 (4%)	
Some college	5 (23%)	9 (39%)	
4-yr college deg.	7 (31%)	8 (34%)	
Postgrad deg.	7 (31%)	5 (22 %)	

Note: EMR = Enhanced Mental Reinstatement; SE = Standard Exposure.

Table 2

Baseline Clinical Characteristics

	EMR (n = 22) *M (SD) or n (%)*	SE (n = 23) *M (SD) or n (%)*	p value for T, χ^2 or Fisher's Exact Test
Specific Phobia Diagnosis (Claustrophobia)			0.15
Currently meets	19 (86%)	19 (82%)	
Past only	2 (9%)	0 (0%)	
Does not meet	1 (5%)	4 (17%)	
Psychiatric medication	2 (9%)	4 (17%)	0.67
MRI Variables			
Prior MRI Experience	13 (59%)	12 (52%)	0.64
MRI Fear (0–100)	75.4 (19.1)	71.5 (18.9)	0.49
MRI Likelihood (0–100)	56.5 (27.4)	67.0 (34.7)	0.27
Questionnaire Scores			
CLQ-fear	58.6 (17.4)	59.4 (17.7)	0.87
CLQ-avoidance	59.6 (19.2)	62.8 (16.8)	0.59
STAI-T	44.0 (11.7)	42.6 (11.4)	0.68
STAI-S	43.8 (10.7)	40.9 (11.3)	0.38
DTS	45.1 (13.6)	44.1 (11.4)	0.78
ASI-3	29.0 (13.0)	31.7 (14.0)	0.51
VVIQ	44.0 (9.3)	44.7 (9.8)	0.81
CEQ	5.5 (1.5)	5.9 (1.4)	0.35
BAT 1A Variables			
Peak Fear (0–100)	76.3 (14.0)	70.9 (15.1)	0.22
End Fear (0–100)	63.4 (22.6)	59.1 (22.9)	0.54
Exited early	8 (36%)	3 (14%)	0.10
CLEQ – concern	48.6 (16.1)	51.9 (20.6)	0.56
CLEQ – likelihood	56.4 (15.7)	56.4 (24.4)	0.87

Note: EMR = Enhanced Mental Reinstatement; SE = Standard Exposure; CLQ = Claustrophobia Questionnaire; STAI-T = State-Trait Anxiety Inventory – trait; STAI-S = State-Trait Anxiety Inventory – state; DTS = Distress Tolerance Scale; ASI-3 = Anxiety Sensitivity Inventory; VVIQ = Vividness of Imagery Questionnaire; CLEQ = Claustrophobia Expectancies Questionnaires.

Table 3

Post-Exposure and EMR Audio-recording Themes, Interrater Reliabilities and Frequencies

Theme	Definition	Example	Interrater reliability (κ)	Frequency of theme (*n*)	
				Post-Exposure Recording	Exposure Recall
Coping Self-Efficacy	Learns they have control over how they react, think or feel in a feared situation	*I can reduce my fear by staying in the situation and accepting it*	0.60	Total: 17 EMR: 9 SE: 8	5
Fear Tolerance	Learns that fear can be tolerated	*My fear wasn't as unbearable as I thought*	0.57	Total: 8 EMR: 7 SE: 1	1
Threat Reappraisal/ Safety	Learns their fears were not accurate and/or they were actually safe	*What I was anxious about did not happen*	0.73	Total: 25 EMR: 11 SE: 14	14
Fear Reduction	Describes how their fear or distress level decreased	*My anxiety eventually reduced*	0.70	Total: 14 EMR: 11 SE: 3	20
Generalized	Describes what they learned in a general manner, rather than speaking just about the exposure training experience/ context itself	*Fear is not a reliable source of information* (Yes) vs. *My fears about the closet were not accurate* (No)	0.66	Total: 19 EMR: 9 SE: 10	11

Exposure Recall Recording only			Intra-class Correlation		
Fear Recall	Indicates amount of attention placed on experience of fear	0 – No mention of fear 1 – Mentions fear w/o elaboration, or in context of fear not coming true 2 – Describes fear in detail, multiple times, or mentions how fear has persisted/is still present	0.59	NA	(0) = 0 (1) = 13 (2) = 9

Table 4

Results from regression models examining effect of condition on primary outcomes during BAT 2

Outcome	**Step**	**Predictor**	**ΔR^2**	**B**	***SE* B**	***β***	***sr*²**
Fear Rating	1.	BAT 1B Fear	.19*	0.42	0.35	.17	.04
		STAI-S		0.87	0.32	.38**	.15
	2.	Condition	.03	-9.79	8.41	-.17	.03
Heart Rate	1.	BAT 1B HR	.01	0.03	0.22	0.03	.00
		STAI-S		-0.02	0.11	-0.04	.00
	2.	Condition	.14*	-6.73	2.64	-0.33*	.14
Outcome	**Step**	**Predictor**	**$\Delta\chi^2$**	**Hazard Ratio**	**95% CI for Hazard Ratio**		***p***
Avoidance (Time to exit)	1.	STAI-S	6.62*	1.04	0.98 to 1.10		.15
		BAT 1A Exited		7.55*	1.52 to 37.44		.01
	2.	Condition	0.28	0.64	0.12 to 3.38		.60

Note: * = $p < .05$; ** = $p < .01$; BAT = Behavioral Approach Test; BAT 1A Exited coded; Condition coded 0 = Standard Exposure, 1 = Enhanced Mental Reinstatement; 0 = no, 1 = yes; STAI-S = State Trait Anxiety inventory – State, measured at the beginning of Visit 2; HR = Heart rate.

Table 5

Claustrophobia symptom scores and MRI fear variables across study time-points.

	Condition	Visit 1: Baseline *M (SD)*	Visit 2: Post-Treatment[a] *M (SD)*	One-mo. follow-up *M (SD)*	Effect of Time (*F*-test)[b]	η_p^2
CLQ	EMR	118.4 (36.1)	98.4 (38.1)	72.0 (34.0)	31.70**	0.42
	SE	122.2 (34.1)	92.0 (37.0)	79.2 (46.3)		
MRI Fear	EMR	75.5 (19.1)	52.7 (24.1)	39.6 (31.0)	36.46**	0.46
	SE	71.5 (18.9)	46.3 (30.8)	39.4 (34.4)		
MRI Likelihood	EMR	56.6 (27.4)	74.1 (25.3)	84.4 (17.6)	21.57**	0.33
	SE	67.0 (34.7)	74.3 (30.6)	80.7 (28.4)		
CLEQ-MRI concern	EMR	-	24.5 (19.6)	15.7 (17.6)	9.91*	0.19
	SE	-	23.9 (22.1)	18.1 (22.5)		
CLEQ-MRI likelihood	EMR	-	40.7 (25.5)	26.4 (28.2)	18.92**	0.31
	SE	-	36.1 (29.8)	24.3 (21.0)		

Note: *$p < .01$; **$p < .001$; [a]CLQ administered pre-BAT 2 at Visit 2, whereas other variables captures after BAT 2. [b]Follow-up paired samples t-tests (collapsed across condition) indicated significant differences between all Visit 1 and Visit 2 variables, and between Visit 2 and follow-up (all p's < .001); EMR = Enhanced Mental Reinstatement; SE = Standard Exposure; CLQ = Claustrophobia Questionnaire; CLEQ-MRI – Claustrophobic Expectancies Questionnaire for an MRI scan.

Table 6

Partial correlations of EMR process variables with BAT 2 Fear and Heart Rate Reactivity

	Measure	Fear Rating (n = 22)	Heart Rate (*n* = 21)
Exposure Recall	Fear Recall	.23	.20
Themes	Coping Self-Efficacy	.30	-.40^{+}
	Threat Reappraisal	-.15	.13
	Generalized	-.18	-.09
Post-Reinstatement	Vividness	.13	.13
Ratings	Perspective[a]	-.01	-.05
	Positive affect	-.50*	-.18
	Negative affect	.40^{+}	.14
Baseline	VVIQ	.64**	.21

Note: $^{+}p < .01$; $*p < .05$; $**p < .01$; Correlations with BAT 2 Fear Rating and Heart Rate are controlling for the respective outcome variable (i.e. fear or heart rate) at BAT1B. Fear tolerance theme not included due it being present for only one participant, and fear reduction theme not included due to it being present for all but two participants. [a] For Perspective rating, larger values indicate taking more of an observer perspective, whereas smaller values indicate a 'field' perspective (i.e. through one's own eyes); VVIQ = Vividness of Visual Imagery Questionnaire.

Table 7

Claustrophobia-related feared outcomes prior to each BAT, and relationship with BAT 2 outcomes

CLEQ Scale (concern ratings)	BAT 1A *M (SD)*	BAT 1B *M (SD)*	BAT 2 *M (SD)*	r_{part} with BAT 2 Outcomes			
				Δ BAT 1A to 1B		Δ BAT 1B to 2	
				Fear	*HR*	*Fear*	*HR*
Total	50.3(18.4)	6.0 (7.9)	23.6 (19.3)	-.05	.14	.70**	.28^{+}
Threat Expectancies	47.5 (19.1)	5.4 (7.6)	19.6 (17.8)	.03	.15	.67**	.21
Coping Self-Efficacy	50.3 (22.4)	6.8 (9.5)	28.1 (22.8)	-.07	.01	.65**	.25^{+}
Fear Tolerance	58.5 (23.0)	6.7 (10.0)	30.9 (26.4)	-.07	.16	.64**	.30^{+}
Diff. across subscales (*F*)	10.18**	1.50	15.48**	-	-	-	-
η_p^2	.19	.03	.26	-	-	-	-

Note: $^{+}p < .10$; **$p < .001$; CLEQ = Claustrophobic Expectancies Questionnaire; HR = heart rate; Degrees of freedom for *F*-tests = 2,88. Partial correlations control for outcomes at BAT 1B.

Table 8

Means and SDs of expectancy violation variables

	Feared Outcome	Outcome Likelihood/ Expected Fear	Outcome Occurrence/ Actual Fear	Likelihood-Occurrence Discrepancy	Surprise
Initial Exposure	Coping Self-Efficacy	54.8 (19.5)	35.6 (23.7)	19.2 (22.1)	44.8 (32.0)
	Fear Tolerance	52.5 (21.6)	39.8 (24.2)	12.7 (25.8)	49.1 (29.0)
	Threat Expectancy	50.3 (26.0)	41.3 (27.1)	9.02 (31.9)	42.7 (35.0)
	Fear Level	63.7 (17.2)	45.2 (24.9)	18.4 (19.9)	-
All Exposures	Coping Self-Efficacy	29.2 (18.1)	17.9 (14.8)	11.3 (8.1)	27.2 (17.3)
	Fear Tolerance	27.3 (15.9)	18.4 (16.0)	8.9 (8.1)	29.7 (15.8)
	Threat Expectancy	26.3 (18.2)	19.8 (16.9)	6.4 (11.1)	27.2 (17.3)
	Fear Level	35.1 (17.7)	21.8 (16.9)	13.4 (8.9)	-

Note: All ratings made on a scale from 0 to 100 with the following anchors: Likelihood: 0 (will not happen) to 100 (certainly will happen); Fear: 0 (No fear) to 100 (Extreme fear/panic); Occurrence: 0 (not at all) to 100 (completely); Surprise: 0 (not at all surprised) to 100 (completely surprised). If participants were surprised because the feared outcome occurred more than they expected, a negative value for the rating was used. Surprise regarding fear levels was not assessed.

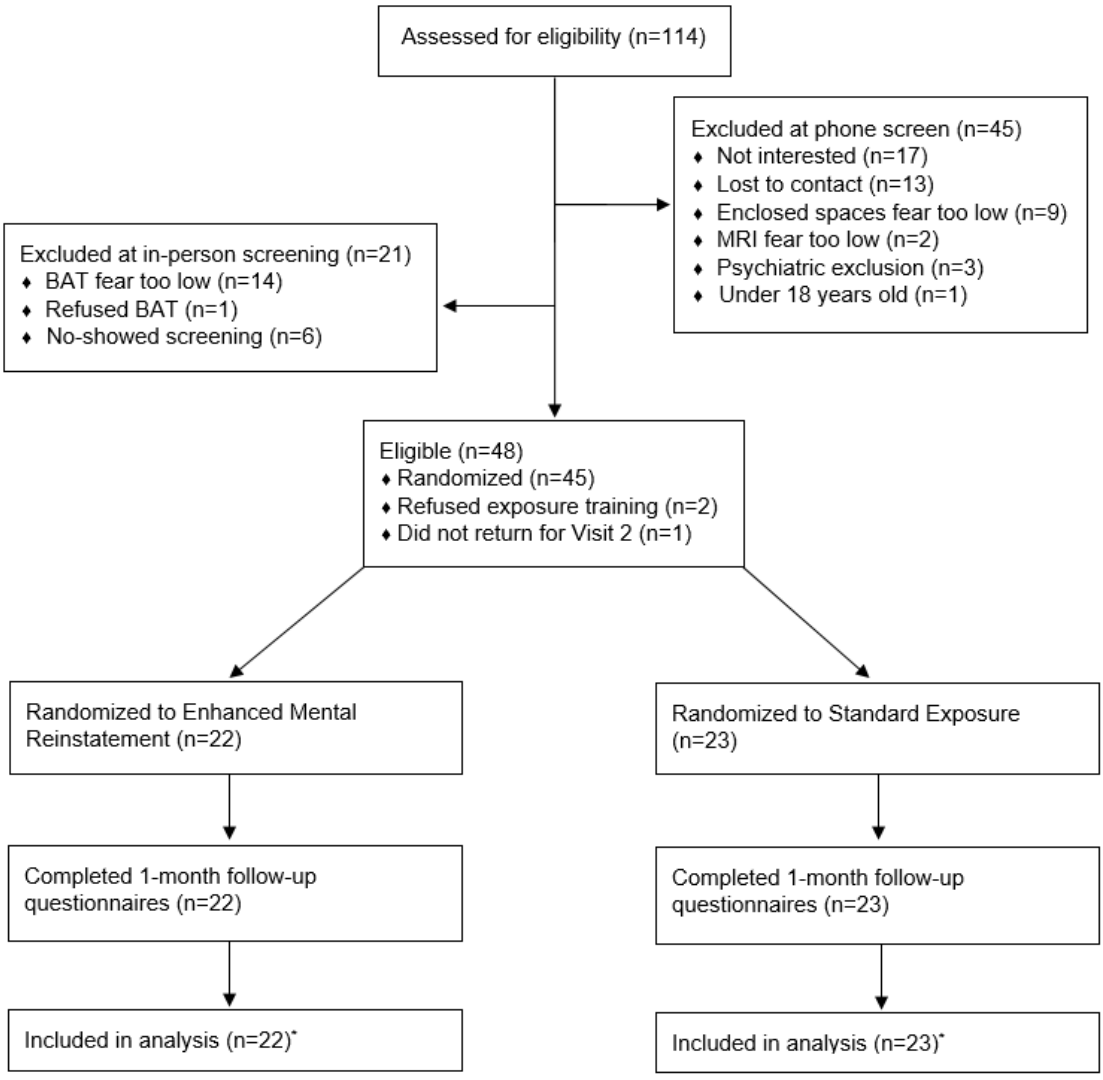

Figure 1. CONSORT diagram of participant screening, randomization, and study completion. Randomization occurred at Visit 2, following completion of exposure training at Visit 1. *For heart rate analysis, $n = 21$ for enhanced mental reinstatement and $n = 22$ for standard exposure, as data for two participants were lost due to equipment failure.

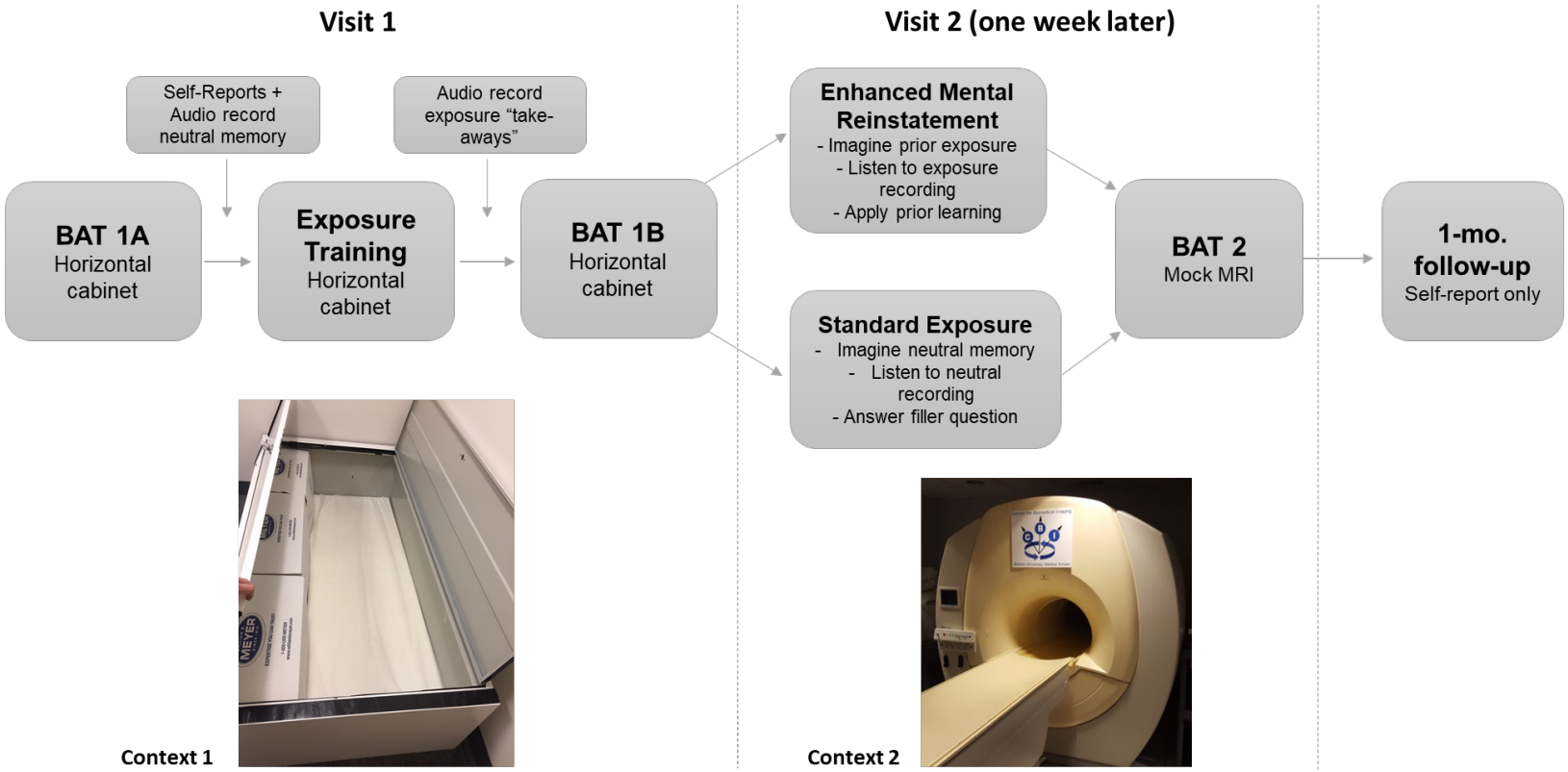

Figure 2. Schematic of study design and contexts for Behavioral Approach Tests (BAT). Open space in cabinet (Context 1) is 6' x 3' x 1.5', and doors were closed on top of participants. Diameter of tube in mock MRI scanner (Context 2) is 2'. Participants were slid in to tube headfirst until their entire upper body was enclosed, and then were moved an additional 6" back in the scanner at two-minute intervals. Back of the scanner was covered in opaque plastic to increase sense of enclosure.

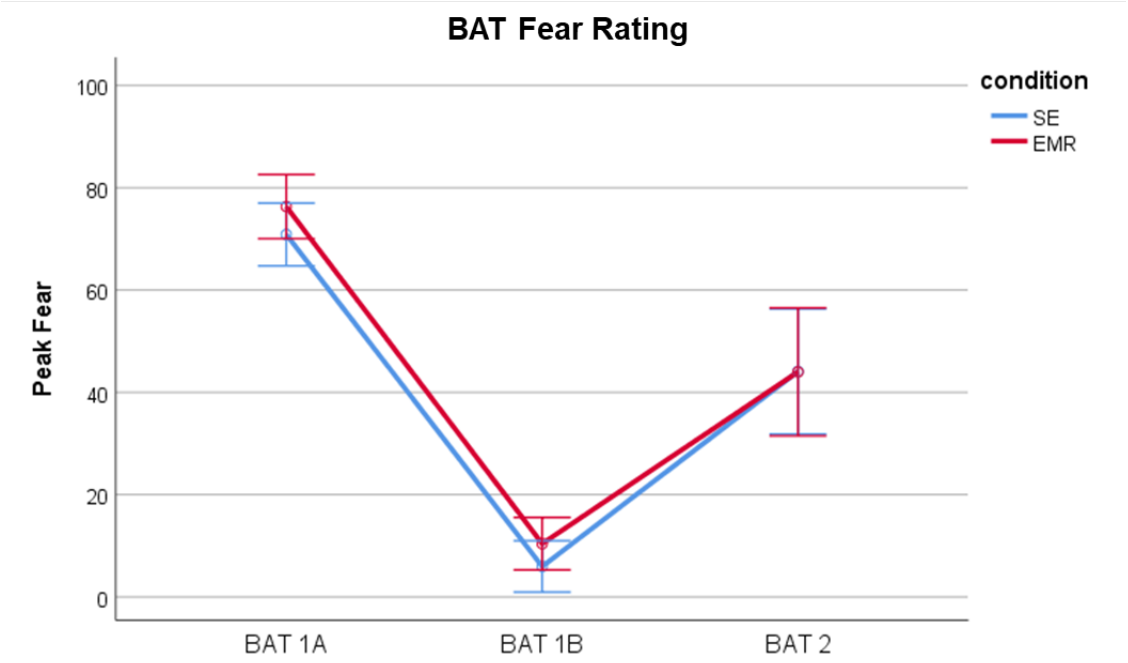

Figure 3. Peak fear rating during Behavioral Approach Tests (BAT) across conditions. Error bars reflect 95% confidence intervals. SE = Standard Exposure; EMR = Enhanced Mental Reinstatement.

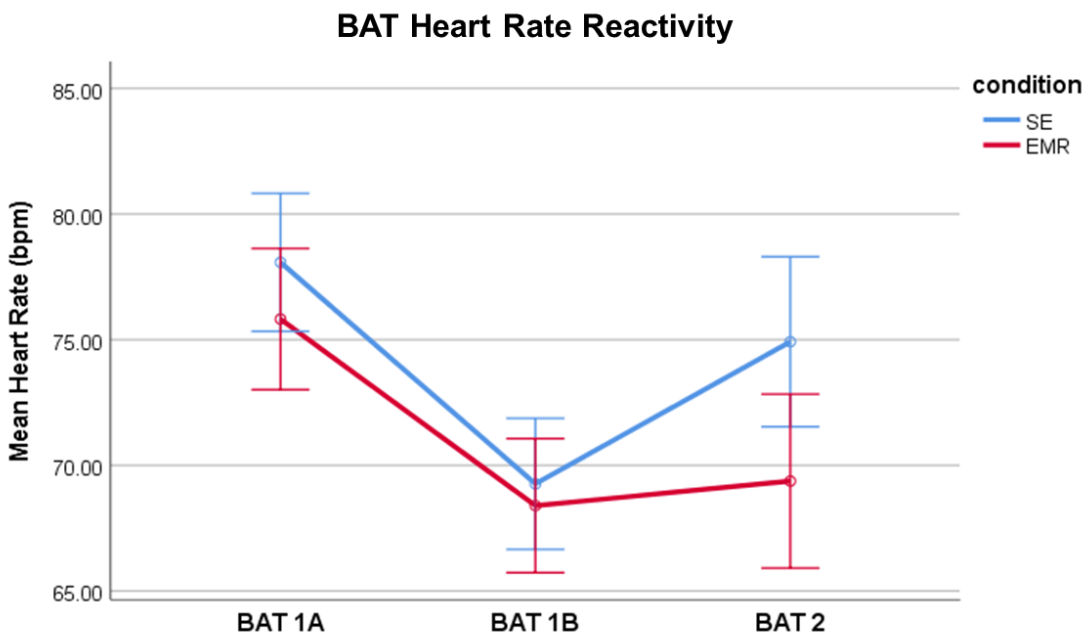

Figure 4. Heart rate during behavioral approach tests (BATs) across conditions. Error bars reflect 95% confidence intervals. Heart rate values are adjusted for baseline. SE = Standard Exposure; EMR = Enhanced Mental Reinstatement; bpm = beats per minute.

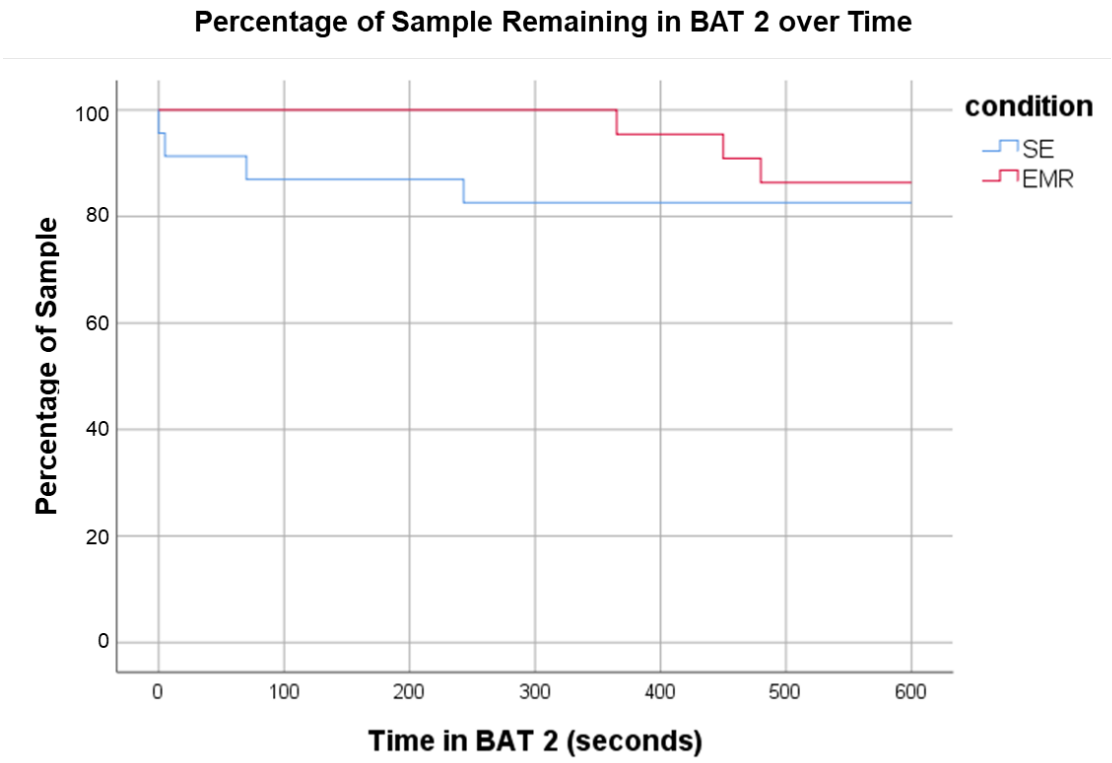

Figure 5. Percentage of Enhanced Mental Reinstatement (EMR) vs. Standard Exposure (SE) sample that exited BAT 2 across time

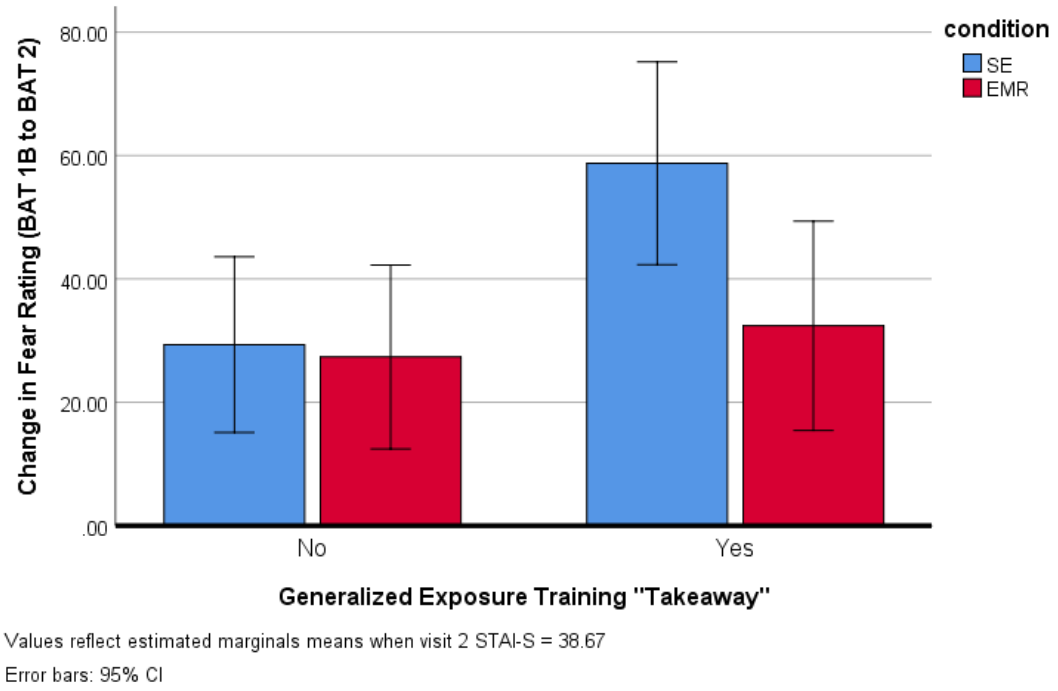

Figure 6. Change in Fear Rating from BAT 1B to BAT 2 across condition and presence of generalized takeaway post-exposure training.

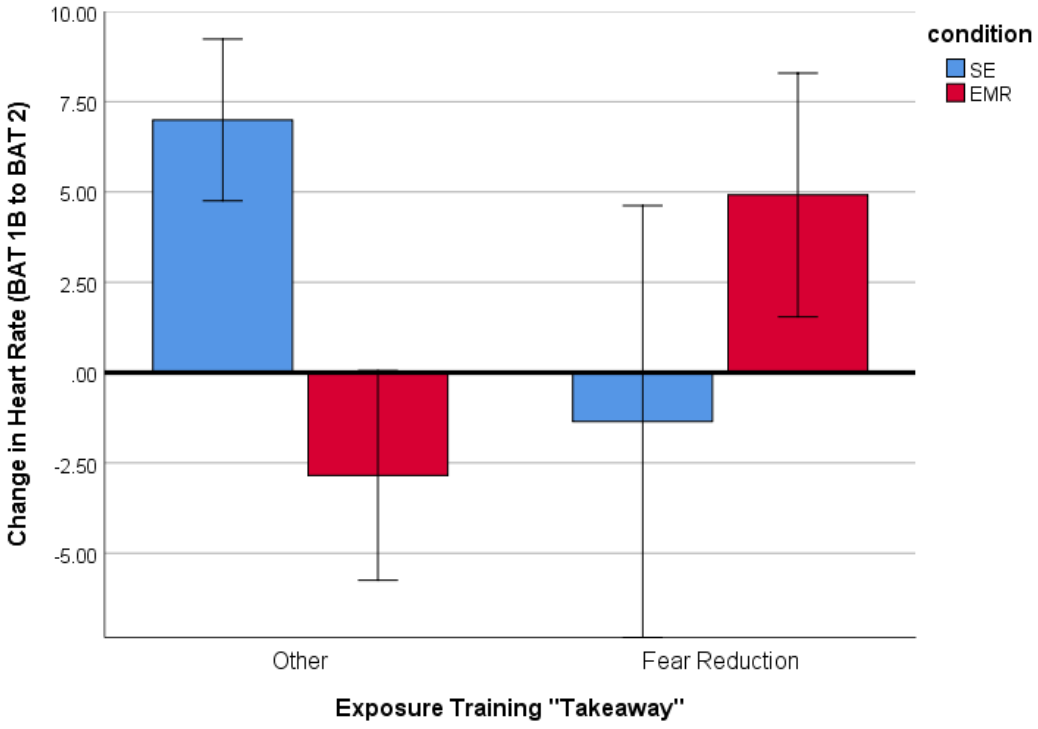

Figure 7. Change in Heart Rate from BAT 1B to BAT 2 across Condition and Exposure Takeaway. Error bars reflect standard errors. Heart rate values reflect estimated marginal means at mean of Visit 2 STAI-S.

Appendix A: Script for Exposure Rationale

(Delivered via video)

Hi there. I'm a therapist at the anxiety clinic here at Boston University. I'm going to be talking to you for the next few minutes about the most effective way to overcome fears like claustrophobia. To start, it can be helpful to have a basic understanding of how fear works, and what is happening when someone has a phobia. Fear is our body's alarm system, meaning that its purpose is to alert us to possible danger. When we're afraid, our nervous system kicks in to gear, and prepares us to fight or flee. In some situations that's useful, for instance when a car is coming right at you as you're crossing the street, fear drives you to get out of the way. In the case of phobias, however, fear is acting as a false alarm, telling us there is danger when in reality there is not. In claustrophobia, for example, fear is sending the message that some possible harm, usually related to suffocation or being trapped, could occur as a result of being in an enclosed space. While there are a few rare situations where this danger may be a reality, most of the time it's not. Nonetheless, the false alarm signal of a phobia tries to convince us otherwise by flooding our body and minds with fear.

Now one of the reasons why phobias tend to persist is that people who are afraid of something tend to avoid it as much as they can. As someone with a fear of enclosed spaces, for example, you probably tend to avoid such spaces whenever possible. This makes a lot of sense, as feeling fear isn't much fun. However, one result of such avoidance is that it prevents you from getting a chance to see that the situations you're afraid of aren't actually as dangerous as they feel. Or in other words, you don't get the chance to learn that the fear you experience in tight spaces is a false alarm.

So what can we do instead? Well, the most effective strategy for reducing fear is to confront the feared situation repeatedly until the anxiety decreases. Or in other words, face your fears. We call this treatment strategy exposure. To see how exposure works, let's look at the following graph, where we have fear level on the vertical axis, and time on the horizontal axis. When you enter an enclosed space, your fear probably spikes, so you leave the situation as quickly as you can, and then your fear comes back down. By itself that's not so bad, but what happens the next time you're in an enclosed space? The fear spikes right back up again. You can continue to avoid, but the fear will come back every time you encounter the situation. In fact, avoiding tends to make the fear get even worse. This is because by avoiding, you are basically telling your brain that the situation is in fact dangerous. You're reinforcing the false alarm.

Now let's look at the alternative to avoidance on this graph, which is what happens in exposure. In this case, you encounter the enclosed space, and your anxiety goes up, but you don't leave. What do you think will happen? Well, the anxiety will continue to go up, but it doesn't go up indefinitely. Eventually it will level off, and then even begin to go down. By itself, this might not look that much better than avoiding. However, if you approach that feared situation a second time, things get better. Specifically, the peak of the fear is lower, and the anxiety reduces more over the course of the exposure. Do it repeatedly, time and time again, and eventually the fear response

becomes minimal and you'll no longer feel the urge to avoid. Why does this happen? Well when you repeatedly confront a feared situation rather than avoiding it, you get the opportunity to see that the things you're most afraid of don't actually happen. Essentially, your brain realizes that the alarm system going off is a false alarm, and that you're not actually in danger. In addition, you get a chance to see that the anxiety you're experiencing is tolerable and harmless, rather than something to avoid at all costs. By experiencing these things, your automatic fear response tends to gradually subside.

To see how this works for yourself, you're going to be doing a series of exposures in the closet you entered before, with the purpose of helping you overcome fear of enclosed spaces. The experimenter is going to direct you to lie down in the closet with the doors closed as you did before, and your goal will be to try and remain in the closet for as long as you can. Understand that you can leave the chamber at any time if you get too uncomfortable, just let the experimenter know you want to exit. However, you should try and stay for at least five minutes. As mentioned before, it's important to do these exposures multiple times to fully benefit, so you'll be doing six separate exposures. In between exposures, you'll also be answering some questions about your fears and expectations about being in the closet, and how the prior exposure went.

One final note about the exposures is that when you're in the closet, it's important that you don't engage in subtle avoidance behaviors. This includes things like trying to suppress anxious thoughts or feelings, closing your eyes, or pretending you're somewhere else. Although these things might provide temporary relief, they get in the way of learning that you are safe in the situation. This is because similar to avoiding the situation entirely, avoiding anxious thoughts and feelings teaches your brain that the situation is in fact dangerous, and that you can only handle it if you avoid thinking about the scary parts. If you instead let yourself pay attention to whether your feared outcomes are occurring, you are more likely to learn that you are in fact safe, and your anxiety is more likely to go down.

If you have any further questions, let your experimenter know, and they will guide you through the rest of the treatment. Good luck!

Appendix B: Claustrophobia Expectancies Questionnaire (CLEQ)

Rate how concerned you are about the following outcomes occurring for the following exposure. Use the scale below (using any number 0–100), and enter your ratings in the unshaded boxes.

0 10 20 30 40 50 60 70 80 90 100
No Concern Mild Concern Moderate Concern Strong Concern Extreme Concern

	A	**B**	**C**
I might start to choke			
I might not be able to escape if I have to			
I might lose control			
I might not be able to reduce my fear to a tolerable level			
I might not be able to tolerate my discomfort			
I might run out of air			
I might not be able to get out			
I might be paralyzed by fear			
I might not be able to think clearly			
The feelings of fear might be unbearable to me			
I might have difficulty breathing			
I might be trapped			
I might act foolishly			
I might not be able to remain in control of my actions			
I might not be able to handle my fear			
I might not be able to get enough air			
I might not be able to move			
I might go crazy			
I might not be able to control fearful thoughts or images			
I might be so scared that I need to leave			

Select the highest rated concern from each column and write it below. Then rate **how likely you think it is that this concern will occur** when you are in the closet, using on the scale below (use any number 0–100)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Will not happen Maybe will happen Certainly will happen

Column A: _____ Likelihood:_____
Column B: _____ Likelihood:_____
Column C: _____ Likelihood:_____

Use the scale below for the final two questions (using any number 0–100):

0 10 20 30 40 50 60 70 80 90 100
No Fear Mild Fear Moderate Fear Strong Fear Extreme Fear (panic)

1. How fearful do you think you **will be** when you are in the closet (max fear)?_____
2. What is your **current** level of fear? _____

(Appendix B continued)

Post-Exp 1

Use the scale below for the next two questions (using any number 0–100):

0	10	20	30	40	50	60	70	80	90	100
No Fear		Mild Fear		Moderate Fear			Strong Fear		Extreme Fear (panic)	

1. What was the **HIGHEST** level of fear you experienced while in the closet? _____

2. What was the level of fear you experienced **IMMEDIATELY BEFORE** exiting the closet? _____

For the next sections, copy the 3 concerns selected from the previous sheet in the first column, and then answer the questions in the second and third columns using the rating scales below.

Rating Scale 1: How much did your concern/feared outcome happen?

0	10	20	30	40	50	60	70	80	90	100
Not at all		A little bit			Somewhat			Mostly		Completely

Rating Scale 2: How surprised were you about how much it happened?

0	10	20	30	40	50	60	70	80	90	100
No Surprise		Mildly Surprised			Moderately Surprised			Very Surprised		Completely Surprised

Concern/Feared outcome (from previous sheet)	**How much did your concern happen? (rating scale 1)**	**How surprised were you about how much it happened? (rating scale 2)**
A.		
B.		
C.		

[Not included in measure]
Column A = Threat Expectancies
Column B = Coping Self Efficacy
Column C = Fear Tolerance

(Appendix B continued)

Pre-Exp 2

For the next section, copy the 3 concerns from the prior sheets in to the first column, and then answer the questions in the second and third columns with regard to the next exposure. Use the rating scales below.

Rating Scale 1: How concerned are you about this outcome?

0 10 20 30 40 50 60 70 80 90 100
No Concern Mild Concern Moderate Concern Strong Concern Extreme Concern

Rating Scale 2: How likely is it that this outcome will occur?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Will not happen Maybe will happen Certainly will happen

Concern/Feared outcome (from previous sheet)	**How concerned are you about the outcome? (rating scale 1)**	**How likely is it that this outcome will occur? (use rating scale 2)**
A.		
B.		
C.		

Use the scale below for the final two questions (using any number 0–100):

0 10 20 30 40 50 60 70 80 90 100
No Fear Mild Fear Moderate Fear Strong Fear Extreme Fear (panic)

1. How fearful do you think you **will be** when you are in the closet (max fear)?_____
2. What is your **current** level of fear? _____

Appendix C: Exposure Training Review Form

Memory Prompt 2

1. ***Over the last 45 minutes, I went through exposure training for claustrophobia. This involved***...[describe what you did]

2. ***When I first entered the closet…*** [describe your level of fear]

   Beg. Fear
   ____ of 100

   By the end of the training… [describe your level of fear]

   End Fear
   ____ of 100

3. ***When I first entered the closet, I was really worried that…***

   Beginning
   Concern ____
   Likelihood____

   By the end of the training… [how much did it happen/was it a concern?]

   End
   Concern ____
   Occurrence____

4. ***I was also worried that…***

   Beginning
   Concern ____
   Likelihood____

   By the end of the training… [how much did it happen/was it a concern?]

   End
   Concern ____
   Occurrence____

5. ***I was also worried that…***

   Beginning
   Concern ____
   Likelihood____

   By the end of the training… [how much did it happen/was it a concern?]

   End
   Concern ____
   Occurrence____

6. ***By repeatedly going in to the closet for long periods of time and facing my fears by, I learned…*** [Describe your *biggest take-away* from the exposure training. Or in other words, what was the most important thing you learned?]

Appendix D: Post-Exposure and MRE Coding

Post-Exposure Recording Coding

Rate whether the participant stated a take-away from the exposure in each of the following categories. This take-away should come after they reviewed the changes in their ratings, typically starting where they said "By repeatedly going in to the closet…and facings my fears…"

1. Coping Self-Efficacy – Participant identified there is something they learned they can do to better handle the claustrophobic situation or reduce their fear. This is something indicating that they have some control over how they react, think or feel in the situation. This is different from other categories in that the participant describes something *active* they can do to cope rather than passively being able to tolerate their fear.

Examples:
If I set my mind to it *I can get through it*
I can ***control*** *my fear*
I tolerated my fear ***by telling my brain that everything is fine****, it's not a big deal*

2. Fear Tolerance – Participant identified learning that fear is tolerable or they can cope with fear *without* mentioning anything they did/can do to make it more tolerable (if they did mention a strategy to tolerate it, it would be coping self-efficacy). This can also include learning that fear isn't that bad, or isn't as bad as they thought.

Examples:
I can tolerate better than I thought
Fear is just fear, it's not that bad
I can get through fearful situations

3. Threat Reappraisal/Safety – Participant identified that their fears were misguided/did not come true, or that they were actually safe (i.e. their experience helped them reappraise the perceived threat in the situation). Can include realizing that fears were irrational or unrealistic, or realizing that nothing bad was going to happen. This *does not* apply to realizing fears about fear being intolerable or not being able to cope didn't come true, as those would fall under fear tolerance or coping self-efficacy.

Examples
My fears did not come true
What I'm anxious about is unlikely to happen
I realized I was safe

4. Fear Reduction – Participant identified that over the course of the exposure their fear, anxiety, distress, etc. went down. Of note, if they say they were able *to do something* that reduced their fears (e.g. not avoid), it counts as Coping Self-Efficacy, not Fear Reduction.

Examples:
I learned my fear will eventually go down
The more I went it in, the comfortable I got
My anxiety eventually reduced

5. Generalized – Participant describes an insight that refers to more than just the specific exposure situation they experienced. If they are saying something in the past tense ("I learned that it *was* tolerable") or something specific about the closet ("I know I can tolerate the closet") this does *not* count. Rather, it's something that could applies to other situations beyond what they experienced. It still needs to be a specific and meaningful takeaway (not vague).

Examples
Fear can't hurt you
I just need to face my fears
My fear is not an accurate predictor of reality

MRE Recording

Same categories as Post Exposure Recording, plus…

Fear Recall rating – Rate how much attention they were placing on their fears during the exposure and/or the extent to which they persisted:

0 Does not explicitly mention being afraid or having to be let out of closet early
1 Mentions their initial fear at but does not elaborate on it (i.e. no more than a sentence).
OR
Describes fear I n more detail, but mentions how those fears did not come true (e.g. *I was scared that I wouldn't be able to breathe, but realized that I my fear was exaggerated)*.

2 Describes their fear/urge to escape in some detail (i.e. more than a sentence describing specific thoughts, physical sensations, concerns etc.) w/o describing how those fears didn't come true.
OR
Mentions their fears on multiple instances throughout recording
OR
Describes a fear that they still have/that lasted throughout the exposure.

Note: Take in to account the general tone of their memory. If you're uncertain but it doesn't seem they are primarily focusing on improvement/fear reduction, okay to put 2.

Appendix E: Expectancy violation results for simultaneously tested predictors

Table E.1: Prediction of BAT 2 fear by expectancy violation variables

EV Variable	Expectancy Type	Mean (SD)	B	*SE* B	*β*	sr^2
Likelihood-occurrence discrepancy: Total	Coping Self-Efficacy	11.30 (8.07)	-0.07	0.70	-.02	.00
	Threat Expectancy	6.40 (11.08)	0.09	0.51	.03	.00
	Fear Tolerance	8.94 (8.12)	0.13	0.63	.04	.00
	Expected Fear	13.37 (8.90)	0.75	0.58	.23	.04
Likelihood-occurrence discrepancy: Exposure 1	**Coping Self-Efficacy**	**19.20 (22.10)**	**-0.53**	**0.20**	**-.42***	**.16**
	Threat Expectancy	9.02 (31.87)	0.15	0.15	.16	.02
	Fear Tolerance	12.68 (25.81)	0.03	0.19	.03	.00
	Expected Fear	**18.42 (19.89)**	**0.50**	**0.23**	**.36***	**.12**
Surprise Rating: Total	Coping Self-Efficacy	27.80 (18.43)	-0.03	0.53	-.02	.00
	Threat Expectancy	26.66 (17.12)	-0.56	0.50	-.33	.03
	Fear Tolerance	28.80 (16.15)	0.37	0.48	.21	.01
Surprise Rating: Exposure 1	**Coping Self-Efficacy**	**44.66 (31.63)**	**-0.36**	**-0.17**	**-.40***	**.10**
	Threat Expectancy	44.11 (35.04)	0.10	0.15	.12	.01
	Fear Tolerance	48.64 (28.82)	0.00	0.18	.00	.00

Note: * $p <$ .05; All values reflect results of linear regression controlling for condition and BAT 1B fear rating. Scale for Surprise Ratings is 0-100, though if participants described being surprised , a negative values was assigned. Likelihood and occurrence ratings also rated on scale from 0-100, with occurrence rating subtracted from likelihood rating (i.e. positive values = fears occurring less than expected)

Table E.2

Prediction of heart rate reactivity by expectancy violation variables

EV Variable	Expectancy Type	Mean (SD)	B	*SE* B	*β*	sr^2
Likelihood-occurrence discrepancy: Total	**Coping Self-Efficacy**	**11.30 (8.07)**	**-0.54**	**0.16**	**-.52****	**.25**
	Threat Expectancy	6.40 (11.08)	-0.16	0.12	-.17	.04
	Fear Tolerance	**8.94 (8.12)**	**0.60**	**0.18**	**.52****	**.25**
	Expected Fear	**13.37 (8.90)**	**0.27**	**0.13**	**.22***	**.10**
Likelihood-occurrence discrepancy: Exposure 1	Coping Self-Efficacy	19.20 (22.10)	-0.10	0.06	-.27	.08
	Threat Expectancy	9.02 (31.87)	-0.03	0.05	-.11	.01
	Fear Tolerance	12.68 (25.81)	0.05	0.05	.19	.03
	Expected Fear	**18.42 (19.89)**	**0.16**	**0.07**	**.37***	**.15**
Surprise Rating: Total	Coping Self-Efficacy	27.80 (18.43)	-0.03	0.15	-.13	.00
	Threat Expectancy	26.66 (17.12)	-0.03	0.15	-.16	.00
	Fear Tolerance	28.80 (16.15)	0.04	0.15	.29	.00
Surprise Rating: Exposure 1	Coping Self-Efficacy	44.66 (31.63)	0.05	0.05	.06	.03
	Threat Expectancy	44.11 (35.04)	-0.05	0.06	.08	.02
	Fear Tolerance	48.64 (28.82)	0.02	0.04	.05	.01

Note: * $p <$ .05; ** $p <$ .05; All values reflect results of linear regression controlling for condition and BAT 1B heart rate. Heart rate values are adjusted for baseline. Scale for Surprise Ratings is 0-100, though if participants described being surprised , a negative values was assigned. Likelihood and occurrence ratings also rated on scale from 0-100, with occurrence rating subtracted from likelihood rating (i.e. positive values = fears occurring less than expected)

Appendix F: Manuscript

Enhanced Mental Reinstatement of Expsosure to Improve Generallization of Extinction Learning in Claustrophobia Treatment Related to Fear of MRI Scans

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Abstract

Background: Reductions in fear following exposure therapy for anxiety often do not generalize well outside the context in which they took place. This study tested a strategy for increasing generalization that involved revisiting the memory of a prior exposure experience in order to enhance the retrieval of the learning that occurred.

Methods: Forty-five participants with claustrophobia received exposure training consisting of repeated 5-minute trials lying inside a narrow cabinet laid on the ground. One week later, they were randomly assigned to either enhanced mental reinstatement (EMR) or control procedures. Prior to entering a mock MRI scanner, participants in the EMR condition recalled the memory of exposure training and listened to an audio recording of themselves describing what they learned, while control participants recalled and then listened to an audio recording of themselves describing a neutral memory.

Results: Compared to the control condition, the EMR intervention led to significantly reduced heart rate reactivity in the mock MRI scanner, but not self-reported fear or avoidance of the mock scanner, nor were there any differences between conditions at one-month follow-up. Across conditions, greater expectancy violations related to coping self-efficacy during exposure training predicted lower fear ratings and heart rate one week later in the mock MRI. Conversely, greater over-predictions of fear levels throughout exposure training predicted greater fear in the mock MRI.

Conclusions: Results suggest relatively limited benefits of mental reinstatement of exposure training for improving generalization of learning in claustrophobia, with discordant outcomes between measures of subjective fear and physiological arousal.

Introduction

Exposure-based cognitive-behavioral therapy has been shown to be the gold-standard treatment for anxiety disorders, yet treatment outcomes remain suboptimal (Carpenter et al., 2018; Hofmann & Smits, 2008). One hypothesized reason for this is that the learning that occurs during exposure therapy often does not completely generalize to new situations (Mineka, Mystkowski, Hladek, & Rodriguez, 1999; Dibbets, Moor, & Voncken, 2013; Mystkowski, Craske, & Echiverri, 2002; Vervliet, Vansteenwegen, Baeyens, Hermans, & Eelen, 2005; Vervliet, Vansteenwegen, & Eelen, 2006; Rowe & Craske, 1998). The consequences of such a failure to generalize safety learning can be significant for exposure therapy outcomes, as successful exposures conducted with a therapist may not translate to reduced anxiety outside of the treatment context, or improvements may be restricted to the specific feared situation confronted in the exposure. Enhancing generalization, on the other hand, could lead to reduced vulnerability to return of fear and more efficient treatment as a result of fewer in-session exposures.

One commonly experienced feared situation in which improving generalization may be particularly relevant is MRI scans, which involve spending extended periods of time in an enclosed space, frequently leading to claustrophobic fear. Claustrophobia is one of the more common specific phobias, with prevalence rates around 4% (Curtis, Magee, Eaton, Wittchen, & Kessler, 1998), and approximately 1% of patients in need of an MRI refuse or prematurely terminate a scan due to claustrophobia, posing a significant problem for accurate detection of many serious medical issues (Munn, Moola, Lisy,

Ritano & Murphy, 2015). Although exposure therapy has major potential for helping to alleviate this problem, poor generalization from exposure training in a separate context to an actual MRI could limit its utility. Accordingly, MRI-related claustrophobia offers a target for investigating generalization that both has ecologically validity and relates to an important public health issue.

One technique for enhancing generalization after exposure treatment is called mental reinstatement, which involves mentally revisiting what happened during exposure treatment and the context in which it occurred prior to approaching a new feared situation. Mental reinstatement of the context in which information was encoded has been shown to reduce the decrement in memory seen after a context change (Smith & Vela, 2001), and could plausibly bolster the retrievability of memories formed during extinction learning after a context change as well. Applications of this technique have shown promise for enhancing generalization, but effects are somewhat inconsistent and are limited to particular outcomes. In the most successful application to date, Mystkowski, Craske, Echiverri, and Labus (2006) showed that in spider phobics, mental reinstatement of exposure treatment led to reduced recovery of subjective fear after a context change compared to reinstatement of a neutral memory, though they elected not to test effects on heart rate or behavioral avoidance given that no return of fear was seen in those measures. Elsesser and colleagues (2013) found that mental reinstatement led to shorter approach latencies to one of three phobic stimuli a week after exposure treatment for dental phobia, but no effects on subjective fear or heart rate to the phobic stimuli, or likelihood of going through with a dental procedure (Elsesser, Wannemüller, Lohrmann,

Jöhren, & Sartory, 2013). Finally, in a study by Laborda and colleagues (2016) on public speaking anxiety, there was no effect of mental reinstatement on renewal of subjective fear ratings.

One limitation of the way mental reinstatement has been implemented is these studies is that they have provided minimal guidance for what exactly participants should recall. The instructions in Mystkowski et al., (2006) and Laborda et al., (2016) stated that participants should remember what happened in the prior exposure, including what they learned and where it took place, and Elsesser et al., (2013) described only that participants were told to mentally retrieve the previous treatment session. Given such instructions, it is possible that participants widely varied in what exactly they recalled (no such information was reported in the studies), ranging from how anxious they were during the exposures to how accomplished they felt afterward for overcoming their fear. Such varying responses could have led to dramatically different expectations, anxiety levels, and avoidance behavior in the subsequent exposure, thereby altering effects of the manipulation. In addition, participants were not explicitly encouraged to reflect on or articulate the extent to which the learning they recalled *applies* to the exposure situation they are about to encounter. If participants were to reason about or focus their attention on similarities between the new and old exposure contexts, that may influence their level of fear and willingness to approach the new exposure situation.

The present study sought to test an enhanced version of mental reinstatement procedures, which involved the following modifications. First, while recalling their exposure memory participants were explicitly instructed to recall the extent to which

feared levels changed and feared outcomes did not occur during the course of exposure training. This was done to more tightly control what participants were recalling, and specifically to have them identify the aspects of prior learning that are theorized to be most important for long-term gains resulting from exposure therapy. Inhibitory learning theory posits that a mismatch between expectancies and outcome drives the development and retention of new non-fearful associations during exposure therapy (Craske et al., 2008; Craske, Treanor, Conway, Zbozinek, & Verlivet, 2014), and evidence suggests that altering the delivery of treatment to maximize such expectancy violations leads to improved outcomes (Deacon et al., 2013). Therefore, highlighting the extent to which expectancies were violated in a prior exposure could help to more effectively recall the non-threat associations previously developed, thereby decreasing expectations of danger and increasing confidence in coping ability in a new exposure situation. In support of this, a study by Raeder and colleagues (2019) showed that reactivating the memory of how one overcame their fears immediately after exposure training led to reduced return of fear and increased self-efficacy in the same exposure situation several days later.

A second modification was to have participants revisit the memory of their exposure training while listening to an audio recording of themselves (created immediately after training) articulating what happened during the exposure and what they learned. This was done firstly to further control what participants were recalling from exposure and to ensure they would recall the memory in an accurate and detailed manner. Furthermore, the audio-recording was used to enhance the believability of what participants learned at an affective level. Hearing their own words and expressions about

what they took away from the training and how they felt about it, while simultaneously replaying that experience in their imagination, could help to more effectively reinstate the emotional learning associated with the training, thereby enhancing the extent to which the intervention targets both bottom-up and top-down processes.

The final modification was to have participants articulate how the learning recalled from the prior exposure is relevant to a subsequent exposure. This was done to more effectively harness top-down cognitive processes by fostering the generation of propositional beliefs about the likelihood of safety and one's ability to cope. Threat expectancies and coping beliefs have been shown to impact acute anxiety levels during singular exposures (Valentiner, Telch, Petruzzi, Bolte, 1996) and throughout exposure-based therapy (Fentz et al., 2013; Gallagher et al., 2013). Therefore, being encouraged to reason how prior learning about the absence of expected danger applies to a novel feared situation was expected to help participants to realize that feared consequences related to the new exposure situation are unlikely to occur.

The primary aim of the this study was to conduct a randomized control trial comparing the effect of an enhanced mental reinstatement (EMR) procedure with standard exposure (SE) on recovery of subjective, behavioral and physiological indices of claustrophobic fear during exposure to a mock MRI one week after exposure training for claustrophobia in a different context. In addition, the effect of EMR vs SE was examined on several secondary outcomes, including and negative outcome expectancies prior to entering the mock MRI, self-reported claustrophobia symptoms at one-month follow-up, expected anxiety and likelihood of getting a real MRI scan. Given the emphasis on non-

occurrence of feared outcomes in the EMR intervention, it was hypothesized that superior reductions in negative outcome expectancies resulting from the EMR manipulation would mediate intervention effects.

A final aim of this study was to examine whether the strength of expectancy violations (i.e. prediction error; Rescorla & Wagner, 1972) during exposure training predicts fear-related outcomes in novel and familiar exposure contexts one week post-training, as well as self-reported outcomes at one-month follow-up. Although changes in threat expectancies are widely thought to be a fundamental mechanism of learning during exposure (Craske et al., 2008; Hofmann, 2008), and modifying treatment to maximize expectancy violations has been shown to fruitful (Deacon et al., 2013), explicit tests of the impact of expectancy violation strength on subsequent outcomes have only begun to emerge and have not consistently shown predicted effects. Specifically, a study by de Kleine and colleagues (2017) found no effect of harm expectancy violations on outcomes during exposure therapy for PTSD, whereas two studies in pediatric OCD showed divergent effects of fear level expectancy violations on exposure outcomes (Guzick, Reid, Balkhi, Geffken & McNamara., 2018; Kircanski & Peris, 2015). To help further clarify the role of expectancy violations in exposure outcomes, the present study measured expected vs. actual fear, discrepancy between likelihood of greatest feared outcomes and their occurrence, and surprise about feared outcome occurrence throughout exposure training, and these variable were examined as predictors of fear-related outcomes in a novel exposure context.

Methods

Experimental Design

A schematic of the experimental design can be seen in Figure 2. During the initial visit participants in both conditions completed a pre-training behavioral approach test (BAT; which also served as the final assessment of eligibility), exposure training, and a post-training BAT all in context 1 (a horizontal metal cabinet). Prior to the pre-training BAT (BAT 1A), baseline heart rate data and state anxiety were measured. Following BAT 1A, participants completed a battery of self-report questionnaires and audio recorded a neutral memory. After exposure training, an audio recording was made of participants orally reviewing their change in fear and feared outcomes and verbalizing their biggest "takeaway" from the training. At Visit 2, one week after exposure training, baseline heart rate, state anxiety and self-reported claustrophobia symptoms were measured again. Participants were then block-randomized to either Standard Exposure (SE) or Enhanced Mental Reinstatement (EMR), and underwent condition-specific procedures prior to a BAT conducted in a mock MRI scanner (BAT 2) in a different location from Visit 1. Randomization was done in blocks of 4 and 6 and stratified by participant type (university student vs. community) using the web-based service Sealed Envelope, with condition revealed only when participants arrived at Visit 2.

Participants

Participants consisted of adults (n = 45) recruited through postings on university student job sites, Craigslist and email list-serves of local hospitals. In addition, patients at BU's Center for Anxiety and Related Disorders who received a diagnostic assessment

indicating clinical levels of claustrophobia and reported interest in research were contacted about the study. Participants received $75 for their participation. The CONSORT diagram outline participant screening, randomization and study completion can be seen in Figure 1.

Inclusion criteria included: 1) being 18-75 years of age; 2) self-reported fear of enclosed spaces at a moderate or greater level (≥2 on a 0-4 Likert scale); 3) expected fear of being in an MRI machine at a moderate or greater level (≥2 on a 0-4 Likert scale); 4) peak self-reported fear during a behavioral approach test (BAT) in a claustrophobia chamber (i.e. a horizontal metal cabinet) of ≥50 of 100. Participants with peak fear <50 who exited the cabinet before for the end of the two-minute BAT for fear-related reasons were also deemed eligible. See the Procedure section for further details on the screening process.

Exclusion criteria included: 1) presence of a medical condition (i.e., pregnancy, cerebrovascular disease, cardiovascular disease) that contraindicated participation in claustrophobia exposures; 2) physical condition preventing individuals from being able to safely enter the claustrophobia chamber, including individuals weighing >350 lbs (the weight limit for the mock MRI used in this study), and 6’4” (the length of the inside of the claustrophobia chamber); 3) prior exposure therapy for claustrophobia-related concerns; 4) presence of bipolar disorder, psychotic disorder, or cognitive dysfunction likely to impair participation in study activities; 5) refusal to enter the claustrophobia chamber during the initial BAT. In addition, participants who took as-needed medication (e.g. benzodiazepines, beta blockers) for anxiety were asked to refrain from taking

medication the day of the study visit until after study procedures had been completed.

The sample was racially/ethnically diverse, with 40% identifying as Asian, 36% White/Caucasian, 18% Black/African-American, 4% Latinx and 2 % multiracial. Females made up 64% of the sample, mean age was 29.2 (*SD* = 12.3), and 58% of participants were students (graduates or undergraduates). Demographics for each study condition can be seen in Table 1, and baseline clinical variables are in Table 2. Thirteen percent of the sample was taking psychiatric medication and 84% met DSM-5 diagnostic criteria for Specific Phobia with claustrophobia at the time of the study.

Procedures

Screening Process. The screening procedure in this study was based on that of previous studies examining exposure training for claustrophobia (Kamphuis & Telch, 2000; Powers et al., 2008; Sloan & Telch, 2002; Telch et al., 2004; Telch et al., 2014). Potential participants were first screened on the phone for eligibility, which included being asked to rate on their overall fear of enclosed spaces on a 5-point Likert scale (0 = no fear, 1 = mild fear, 2 = moderate fear, 3 = severe fear, 4 = extreme fear). They also were provided a description of the mock MRI scanner used during BAT 2 and asked how much fear they would experience if they were to enter the scanner using the same scale. Those who reported a 2 or above on both questions and did not meet any exclusion criteria were invited in to the laboratory. Following the consent process, state anxiety was measured so ratings would not be affected by having entered the cabinet during BAT 1. Next, participants were outfitted with a heart rate monitor and baseline heart rate data was collected while resting in seated position for a five-minute period. Participants were

then instructed to complete BAT 1. Those who experienced a peak fear level of 50 or greater (out of 100) were eligible to participate in the rest of the study. In addition, participants who requested to leave the cabinet prior to the 2-minute time limit for any fear-related reason (e.g., couldn't tolerate their anxiety, felt like they couldn't breathe, etc.) were also deemed eligible.

Behavioral Approach Test 1 (BAT 1). For BAT 1, participants were first shown the claustrophobia chamber, which consists of a metal cabinet with internal dimensions of 6' x 3' x 1.5' laid on the ground (see Figure 2). Participants were told they would be asked to lie down inside the cabinet on their backs, at which point the experimenter would shut the cabinet doors. They were also instructed that the goal of the task was to remain inside the cabinet for as long as they could, but if they wanted to leave they could tell the experimenter, who would remain in the room, and would be let out immediately. Participants were made aware that when the task was over the experimenter would open the doors and let them out, but were not told the maximum length of the task, which was 2 minutes. After these instructions were given, participants completed a series of questions about their fears and expectations for the task, and then instructions were reiterated prior to entering the cabinet. BAT 1 was conducted prior to exposure training (BAT 1A) and after the training was completed (BAT 1B).

Pre-Exposure Procedures. Following BAT 1A, participants underwent a diagnostic interview assessing DSM-5 criteria for specific phobia of claustrophobia, and completed the remainder of the self-report questionnaires, and then created an audio recording of a neutral memory. Specifically they were asked to recall what they did for

the first 30 minutes when they got out of bed that morning, and rate the degree of negative and positive emotion associated with this memory on a 5-point Likert scale (0 = none, 4 = extreme). Participants with a rating of 0 or 1 for both emotions were then asked to recount the memory out loud step by step while being audio-recorded. Participants whose memory elicited a rating of >1 for either negative or positive emotion were then instructed to identify a different memory from the previous 24 hours that met the positive and negative emotion criteria, and was also something they did on a daily basis (e.g. what they did before going to bed). An audio-recording was made while they recited the detail of this memory.

Exposure Training. Participants first viewed an eight-minute video of a clinician who was not an experimenter for the study describing the rationale for exposure as a method for overcoming claustrophobia. The video began with psychoeducation about the role of avoidance in the maintenance of claustrophobia, and then explained how repeatedly remaining in a feared situation for an extended period of time provides the opportunity to see that the situation is safe and tolerable. The video also explained the procedures of exposure training conducted in this study.

Following the procedures by Telch and colleagues (Kamphuis & Telch, 2000; Powers et al., 2008; Sloan & Telch, 2002; Telch et al., 2004; Telch et al., 2014), the exposure training itself consisted of six 5-minute exposure trials. During these trials, participants lay on their backs in the cabinet with the doors closed in the same manner as during BAT 1, except they were asked to stay in the cabinet for 5-minute intervals. They were also instructed to not engage in any avoidance behaviors like closing their eyes or

pretending they were somewhere else, and instead try to simply observe the situation around them and attend to whether their feared outcomes were actually occurring. If participants were unwilling to stay in the cabinet for the full 5-minute period initially, the time during later exposures when participants were more comfortable was increased so that each participant spent a full 30 minutes in the closet. This occurred for just three participants.

Prior to each trial, participants rated their degree of concern about various feared outcomes, as well as the predicted likelihood that their three greatest feared outcomes will occur (see details in Measures section). They also rated their current and expected fear levels. After each trial, participants rated their peak and end fear levels, as well as the extent to which their feared outcomes occurred and how surprised they were about each outcome. The experimenter also checked in about any avoidance behaviors the participant may have been engaging in, and provided coaching on how to act counter to such urges to avoid. Participants then rated their feared outcomes and expected fear levels for the next exposure trial.

Post-Exposure Training. After the final exposure trial, the experimenter helped the participant to review 1) what happened during the exposure training, including how their fear levels and concern and expectancy ratings for their three most feared outcomes changed, and 2) their biggest "take-away" from the training (i.e. the most important thing they learned). Then, participants made an audio recording of themselves verbalizing what they had just reviewed on the form. After this exercise, participants entered the cabinet one final time for BAT 1B.

Visit 2 Procedures. Visit 2 occurred one week after the first visit, plus or minus one day, at the Boston University Medical Campus's Center for Biomedical Imaging, which was in a different campus compared to Visit 1. Participants completed measures of state anxiety and claustrophobia symptoms, and baseline heartrate data were recorded while seated over the same 5-minute period as Visit 1. The experimenter then showed participants the mock MRI scanner they would be entering, explained the nature of BAT 2, and then took participants to a separate room for condition-specific procedures. After BAT 2, participants answered a final set of questionnaires.

Enhanced Mental Reinstatement (EMR). Following the introduction of the BAT 2, EMR participants were be taken to another room and asked to close their eyes and re-imagine what took place during their exposure training one week before. Specifically they were told to recall out loud 1) where they were, 2) how their fear levels and feared outcomes changed and why, and 3) what they learned from the training. Next, participants were instructed to continue to keep their eyes closed and keep the memory of the training in mind while listening to the audio recording they made the prior week about what happened and what they learned through exposure training at the first visit. Following this, participants completed vividness, perspective, affect ratings. Finally, the experimenter assisted participants in completing a worksheet in which they write down all the ways in which the situation they just recalled in their memory was similar to the mock MRI scanner they were about to enter, including similarities about the space itself as well as the types of fears elicited. They were explicitly instructed to focus only similarities. Next, participants were instructed to identify how what they learned in the

prior exposure training was relevant to the situation they were about to enter. They then spoke out loud what they had written on the worksheet. All participant responses during this time were audio-recorded for further analysis.

Standard Exposure (SE). The pre-BAT 2 procedures of the SE group were designed to mimic those of the EMR group as much as possible. After the introduction of the BAT 2 procedures, participants in the SE condition were taken to another room and reminded of the neutral memory they recorded at Visit 1. They were asked to close their eyes and imagine what took place during that memory in as much detail as possible, saying out loud exactly what they remembered. Next, they listened to the audio recording made the week before of them recalling this event while continuing to hold their memory in mind, and afterward completed the same vividness and affect questions as the EMR group. Following this, participants wrote down and then verbalized all the ways in which what happened the morning of the experiment (or whatever neutral memory had been recalled) was similar to what had happened the morning of Visit 2 (or equivalent, if a different memory). As in EMR, participant responses during SE procedures were audio-recorded.

Behavioral Approach Test 2 (BAT 2). BAT 2 took place in a decommissioned 3T MRI scanner used to accustom individuals to an MRI machine prior to a real scan (see Figure 2). Participants lay on a stretcher with their head held in place by plastic siding, and the experimenter slid the stretcher in to the tube of the mock scanner until the participant's entire upper body was inside enclosed. The opening of the scanner had a diameter of 60 cm, and the back side was covered with opaque plastic so the only light

coming in to the tube was from the direction of the participants' feet. Following the same procedures as BAT 1, participants answered questions about their feared outcomes and current fear levels prior to entering the scanner. They were given the same instructions as BAT 1A and BAT 1B about remaining in the tube for as long as they were willing, but if they became too uncomfortable, the experimenter would remove them from the scanner immediately. In order to reduce the likelihood of ceiling effects for time spent in the mock scanner, the maximum time before participants were removed was increased to 10 minutes (compared to two minutes during BAT 1). In addition, every two minutes participants were asked their current fear level, and then told that if they remained in the willing to stay they will be moved another 6 inches in to the scanner. After participants exited the tube, they completed a rating of their maximum and end fear levels.

One-month Follow-up. One month after visit 2, participants were sent a series of questionnaires via email that assessed claustrophobia symptoms, severity of feared outcomes if they were to undergo an MRI scan, and likelihood and expected fear of receiving an MRI scan.

Outcome Measures

Subjective Fear. Participants rated their subjective fear on a scale from 0 to 100, with anchors of 0 (no fear), 25 (mild fear), 50 (moderate fear), 75 (strong fear), and 100 (extreme fear/panic). Immediately upon exiting the claustrophobia chamber during BATs and exposure trials, participants rated their maximum level of fear while in the chamber, and their fear at the end of the trial (before knowing they were about to exit). Peak and end fear were highly correlated and initial analyses examining the two measures

separately were consistently similar, so analyses focused on peak fear. Prior to each BAT and exposure trial, participants also rated their current fear and expected fear for entering the enclosed space.

Behavioral Avoidance. Time until each participant requested to exit each of the BAT tasks, if relevant, was also recorded an indicator of behavioral avoidance.

Heart Rate Reactivity. Heart rate was measured continuously throughout the experiment via the Zephyr BioModule™ (Zephyr Technology Corp, Annapolis, MD, US), an ambulatory heart rate monitor that attaches to the chest via skin conductive electrodes. The device measures heart rate via electrocardiography (ECG) and has been shown to produce reliable and valid measurements of heart rate across a variety of contexts (Nazari et al., 2018). Sampling rate for ECG data was 1000 Hz. Artifact detection was conducted automatically using Kubios Version 3.1 Premium (Tarvainen, Niskanen, Lipponen, Ranta-Aho, & Karjalainen, 2014), and then was inspected manually and any additional corrections necessary were made. Mean heart rate data were extracted for baseline and BAT periods from Visits 1 and 2. Heart rate during BATs was adjusted for baseline by calculating the difference between mean heart rate during each BAT and the corresponding baseline period, and then adding that value to the mean baseline heart rate for the sample. This baseline-adjusted heart rate variable was used in analyses.

The Claustrophobia Questionnaire (CLQ). The CLQ (Radomsky, Rachman, Thordarson, McIsaac, & Teachman,, 2001) is a 26-item assessment of claustrophobia symptoms. Participants are asked to rate how anxious they would feel on a 5-point Likert scale (0 = not at all anxious, 4 = extremely anxious) in situations eliciting concerns about

suffocation (e.g. “Using an oxygen mask”) and restriction (e.g. “Locked in a small dark room without windows for 15 minutes”), the two components of fear thought to underlie claustrophobia (Rachman & Taylor, 1993). The CLQ has demonstrated strong predictive and discriminant validity, along with good internal consistency and test-retest reliability (Radomsky et al., 2001). Given the importance of avoidance of feared situations in anxiety psychopathology, participants were also asked how much they would want to avoid each of the 26 situations listed in the CLQ from 0 (no desire to avoid) to 4 (avoid at all costs). The CLQ was administered at after eligibility screening, the beginning of Visit 2 prior to randomization, and at one-month follow-up. Internal consistency in the present study was excellent at all three time points, both for fear and avoidance subscales separately and combined (α = .92 - .96).

Claustrophobic Expectancies Questionnaire (CLEQ). The CLEQ (see Appendix B) is a measure adapted for this study assessing respondents concern about 20 possible feared outcomes for a claustrophobic situation. It consisted of four items regarding concerns about *suffocation* (e.g. “I might start to choke”), four items regarding *entrapment* concerns (e.g. “I might not be able to escape if I had to”), and four items regarding *coping self-efficacy* (e.g. “I won’t be able to tolerate to my fear”), all of which were adapted from the Claustrophobic Concerns Questionnaire (Valentiner, Telch, Petruzzie, & Bolte, 1996). Also included were four items regarding *loss of control* (e.g. “I might lose control”) adapted from the Claustrophobia General Cognitions Questionnaire (Febbraro & Clum, 1995), and four items regarding *fear tolerance* (e.g. “The feelings of fear might be unbearable to me”) adapted from the Distress Tolerance Scale (Simons &

Gaher, 2005). The intent in creating this questionnaire was to generate a wide variety of possible feared outcomes for individuals with claustrophobia in order to increase the likelihood of accurately capturing participants' greatest specific concerns, and enable them to be tracked throughout the exposure training. From this scale, three subscale scores were created based on item averages: 1*) threat expectancies* (based on *suffocation, entrapment,* and *loss of control* items), 2) *coping self-efficacy,* and 3) *fear tolerance*.

Items were rated on a scale from 0 (no concern) to 100 (extreme concern). In addition, the highest-rated feared outcome from each CLEQ subscale was selected, and participants indicated how likely they believed each outcome was to occur (0% to 100% likelihood). The CLEQ was administered prior to all BATs and prior to the first and last trials of exposure training. Also before exposure trials 2 through 5, participants tracked their top-rated feared outcomes from the initial exposure by continuing to complete concern and likelihood ratings with regards to the next exposure. Internal consistency for the full scale was excellent across time points (α = .92 - .96), with subscale reliability being strong as well: *Threat Expectancies:* (α = .86 - .91), *Coping Self-Efficacy,* (α = .78 - .90), and *Fear Tolerance* (α = .83 - .94).

MRI Expectancies, Fear and Likelihood. After BAT 2 and at one-month follow-up, participants were asked how likely they would be to get a medically indicated MRI from 0 (definitely would NOT get it) to 100 (definitely WOULD get it). They were then asked to imagine they were to undergo a real MRI scan. They were told this would involve being in the same type of scanner they were in during the study, but that it would last 30-40 minutes and there would be no one in the room with them, though they could

press a button to tell the MRI technician they wanted to leave. Participants then rated their maximum expected fear while in the scanner with the same 0-100 scale used during BATs, as well as the feared outcome items from the CLEQ (CLEQ-MRI). Participants also rated fear and likelihood of getting a medically indicated MRI scan at baseline.

Claustrophobic Expectancy Violations. After each exposure, participants rated the extent to which their top feared outcomes occurred on a scale from 0 (not at all) to 100 (completely), and how surprised they were at the extent to which it occurred from 0 (not at all surprised) to 100 (completely surprised). For surprise ratings, the experimenter asked participants whether they were surprised that their feared outcome occurred more or less than expected, and if participants reported it happened more than expected, ratings were given a negative value. Surprise ratings, the difference between likelihood and occurrence scores, and the difference between concern and occurrence scores (see De Kleine, et al., 2017) were initially investigated as indicators of expectancy violations. In addition, the difference between expected and actual fear was examined as an additional possible indicator, as has been done in previous literature (Guzick et al., 2018; Kircanski & Paris, 2015). Because correlations between likelihood and concern rating at each exposure were quite high ($r > .60$), however, concern-occurrence discrepancies were not included in the analysis. Values for each feared outcome from the CLEQ (Threat Expectancies, Coping Self-Efficacy, and Fear Tolerance) over the course of six exposure trials were averaged in an attempt to capture the total expectancy violation throughout training. Because the exposure scenarios were identical throughout training and the potential for surprise at the outcome of repeated exposures was likely to decline,

expectancy violations during the first exposure were also examined. Expectancy violations for each type of feared outcome were not combined for analysis in order to comparatively examine violation of different beliefs, and also because internal consistency for discrepancy scores was in the questionable range (α = .62-.63)

Additional Measures

Composite International Diagnostic Interview (CIDI). The CIDI is a structured clinical interview commonly used in clinical and research settings to efficiently assess diagnostic criteria of psychological disorders (World Health Organization, 1997). The experimenter administered only the specific phobia module in this study to assess claustrophobia. Although designed for assessment of DSM-IV criteria, criteria for specific phobia in DSM-5 were essentially unchanged, and responses were evaluated with regard to DSM-5 criteria. The anxiety disorder module of the CIDI has demonstrated good psychometric properties, including good sensitivity (.86) and acceptable specificity (.52) (World Health Organizaiton, 1997).

State-Trait Anxiety Inventory (STAI). The 6-item version of the STAI-state (Marteau & Bekker, 1992) was used as a brief measure of state anxiety at the beginning of Visits 1 and 2, whereas the 20-item version of the STAI-trait (Spielberger, Gorsuch, & Lushene, 1970) was used to characterize the degree of trait anxiety present in the sample. Internal consistency in this study was strong for the STAI-trait (α = 0.92), as well as for the STAI-state at Visit 1 (α = 0.83) and Visit 2 (α = 0.86).

Exposure Training Thinking. After participants completed BAT 2, they answered questions about how much they thought about the exposure training when

approaching the mock MRI and when inside on a scale from 0 (not at all) to 100 (the entire time). If they answered a response other than 0, they were prompted to write a sentence or two about what specifically they thought about. Responses were coded yes/no for whether the participant described either something they learned from the exposure training or reported using the memory to help them feel less anxious.

Data Analytic Approach

Data were analyzed using SPSS 26.0. Prior to running the primary analyses, EMR and SE groups were compared on baseline clinical and demographic variables using Chi-Square for categorical variables and independent-samples t-test for continuous measures. A series of 2 x 2 mixed effects ANOVAs with time as a within-subject factor and condition as a between-subject factor were then used to examine equivalence of treatment effects across condition (pre-randomization) on subjective fear, behavioral avoidance, and heart rate during pre- and post-exposure training BATs, as well as Visit 1 and Visit 2 CLQ scores. One-way ANOVAs were also used to test for differences in main outcome variables between BATs (collapsing across condition), in order to test for return of fear after exposure training.

To analyze the effect of condition (EMR vs. SE) on primary fear outcome variables, hierarchical linear regression was used, entering each at outcome at BAT 1B and Visit 2 STAI-S as predictors in the first step, and condition at the second step (SE coded as 0, EMR coded as 1). For behavioral avoidance, a survival analysis was performed using Cox regression to predict the relatively likelihood of exit from the mock MRI scanner for EMR vs. SE (i.e. the hazard ratio [HR]) over the course of the 10

minutes of the BAT, while controlling for relevant covariates. Because no participants exited early from BAT 1B, a categorical variable was created to indicate whether a participant exited early from BAT 1A, and was used to control for baseline behavioral avoidance. For secondary outcomes linear regression was used to examine the effect of condition on CLQ scores at one-month follow-up, controlling for CLQ at Visit 2 (pre-randomization). The effect of condition was also examined on Visit 2 (post-BAT 2) and one-month follow-up CLEQ-MRI scores, controlling for CLEQ at BAT 1B (as CLEQ-MRI was not administered pre-randomization), and MRI fear and likelihood ratings, controlling for at baseline (as these ratings were not made post-exposure training). Furthermore, the effect of EMR vs. SE was investigated on CLEQ scores prior to BAT 2, controlling for CLEQ at BAT 1B. When examining the impact of as expectancy violation variables, predictors were entered in to a stepwise linear regression set to retain all predictors at $p < .05$ and exclude predictors at $p > .10$.

Throughout analysis assumptions of linear regression were tested, including normality, homoscedasticity and independence of residuals, absence of multicollinearity, and the presence of outliers. Data were consistently suitable for linear regression. The squared semi-partial correlation coefficient (sr^2), which represents the unique portion of variance explained by the predictor, was used as an indicator of effect size for regression analyses.

Missing data. No data were missing for self-report or behavioral variables. Due to equipment failure, heart rate data was not collected for two participants (one SE, one EMR), and 10 participants had one or two baseline or BAT periods with unusable data

resulting from a poor-quality ECG signal. Across participants with any heart rate data, 9.7% of values were missing. To address this, first Little's missing completely at random test (Little, 1988) was used to determine whether missingness of data was related to any variables being examined in the study. Although this test was not significant, χ^2 (24) = 23.65, p = .48, indicating that were missing completely at random, multiple imputation was used to generate plausible values for the missing heart rate data and preserve power. The model used to generate such values included the mean, maximum and standard deviation of heart rate at each BAT and baseline period, as well as several additional periods of heart rate data not directly analyzed in this study, specifically the first and last exposure in the closet and a two-minute period for and after each BAT. In addition, fear ratings and duration of BATs, state anxiety and experimental condition were included as predictors given their potential relationships with heart rate during a BAT. Fully conditional specification (van Buunen, 2007) was used to handle instances of multiple missing variables, and twenty iterations of complete data sets were generated and analyzed, with effects pooled to create a single set of results. As recommended by Sterne et al., (2009), we conducted sensitivity analyses to compare results of the imputed data set with the original data, and report results in a footnote below.

Power Analyses: The mental reinstatement procedure by Mystkowski and colleagues (2006), which led to significantly reduced subjective fear levels after a context change compared to a control condition, resulted in a partial eta squared of 0.15, indicative of a large effect (Cohen, 1988). Conservatively assuming a medium-to-large effect size ($f^2 = 0.25$) and power = 0.80, a power analysis conducted with G*Power

indicated that a sample size of 34 would be sufficient to detect a significant effect. A minimum sample size of 40 was planned for in order to increase power to detect a smaller effect and investigate potential moderators, and data collection was continued until no longer feasible. A post-hoc sensitivity analysis indicated that with the current sample size, controlling for an additional covariate (STAI-S), the study had power = .80 to detect a medium effect size of $f^2 = 0.18$.

Results

Baseline Characteristics and Overall Response to Exposure Training

Demographics across condition can be seen in Table 1, with baseline clinical characteristics seen in Table 2. No baseline differences were found for any demographic or clinical variables.

With regard to effects of exposure training, means and standard errors of BAT Fear across time-points and condition can be seen in Figure 3. A 2 x 2 mixed-effects ANOVA showed a main effect of time-point on BAT Fear during Visit 1, $F(1,43) = 598.78$, $p < .001$, $\eta_p^2 = .93$, such that fear at BAT 1B ($M = 8.18$, SE = 1.78) was significantly reduced compared to BAT 1A ($M = 73.59$, $SE = 2.18$), with no significant effect of condition, $F(1,43) = 2.94$, $p = 0.10$, $\eta_p^2 = .06$, or time by condition interaction, $F(1,43) = 0.35$, $p = 0.85$, $\eta_p^2 = .00$. Similarly, there was a significant main effect of time-point on heart rate, $F(1,41) = 55.23$, $p < .001$, $\eta_p^2 = .57$, showing a decrease from BAT 1A ($M = 77.01$, $SE = 1.36$) to BAT 1B ($M = 68.80$, $SE = 1.29$), but no significant effect of condition, $F(1,41) = 1.17$, $p = .29$, $\eta_p^2 = .02$, or time by condition interaction, $F(1,41) = 1.52$, $p = .22$, $\eta_p^2 = .04$. For behavioral avoidance, all participants remained in the closet

for the full two minutes at BAT 1B, in contrast to BAT 1A in which eight SE participants (35%) and three EMR participants (14%) exited early (not significantly different, $\chi^2 = 2.72$, $p = 0.10$). There was a significant main effect of time-point on BAT duration, $F(1,43) = 8.72$, $p = .005$, $\eta_p^2 = .17$, but again no effect of condition, $F(1,43) = 0.21$, $p = .89$, $\eta_p^2 = .00$, or time by condition interaction, $F(1,43) = 0.21$, $p = .89$, $\eta_p^2 = .00$. In sum, exposure training led to significant and large improvements in subjective fear, heart rate and behavioral avoidance, with no differences in response to exposure across conditions.

At Visit 2, CLQ scores ($M = 95.18$, $SE = 5.60$) from prior to randomization showed a similarly large and significant reduction compared to scores pre-exposure training from Visit 1 ($M = 120.33$, $SE = 5.23$; $F[1,43] = 23.06$, $p < .001$, $\eta_p^2 = .35$). No main effect of condition, $F(1,43) = 0.02$, $p = .89$, $\eta_p^2 = .00$, or time by condition interaction, $F(1,43) = 0.93$, $p = .34$, $\eta_p^2 = .02$, was found. However, there was a significant difference in state on the STAI-S at the beginning of Visit 2, $t(43) = -2.11$, $p = .04$, $d = 0.63$, indicating that at the beginning of Visit 2 (prior to all other Visit 2 procedures other than baseline heart rate measurement), EMR participants ($M = 42.58$, $SE = 2.75$) endorsed greater levels of state anxiety than SE participants ($M = 34.93$, $SE = 2.36$). Accordingly, STAI-S was controlled for in subsequent analyses examining the effect of condition. There was no significant difference in baseline heart rate at visit 2, $t(41) = 1.82$, $p = .55$, $d = 0.05$.

Return of Fear. To examine the extent to which the change in context from BAT 1 to BAT 2 led to a return of fear across conditions, one-way ANOVAs were conducted on fear ratings and heart rate across all three BATs. Results showed significant

differences across time-points in fear, $F(1.54, 67.78) = 140.69$, $p = <.001$, $\eta_p^2 = .76$, and heart rate $F(1.51, 66.20) = 27.68$, $p = <.001$, $\eta_p^2 = .40$. Paired-samples t-tests indicated fear rating at BAT 2 ($M = 44.04$, $SE = 4.29$) was significantly greater than at BAT 1B, $t(44) = 8.35$, $p < .001$, $d = 1.25$, and significantly lesser than at BAT 1A, $t(44) = 8.35$, $p < .001$, $d = 0.98$. Similarly, heart rate at BAT 2 ($M = 72.21$, $SE = 1.27$) was significantly greater than BAT 1B ($M = 68.80$, $SE = 0.92$; $t(42) = 2.21$, $p = .03$, $d = 0.34$), and significantly lower than BAT 1A ($M = 77.01$, $SE = 0.97$; $t(42) = 3.96$, $p < .001$, $d = 0.61$).

Primary Aim: Effects of Treatment Condition on Fear Outcomes at BAT 2

Results of the full regression models predicting fear rating and heart rate can be seen in Table 4. Controlling for BAT 1B Fear and STAI-S, the effect of treatment condition (EMR vs. SE) on Fear at BAT 2 was not significant, B = -9.79, $SE = 8.41$, $p = .25$, $sr^2 = .03$.

For heart rate data, after controlling for STAI-S and heart rate at BAT 1B, the effect of condition was significant, B = -6.73, $SE = 2.64$, $p = .01$, $sr^2 = .14$, indicating that EMR participants had a lower heart rate during BAT 2 relative to baseline than participants in SE. To ensure that such an effect was not confounded by the variable length of time participants spent in BAT 2, heart rate data during the first minute of BAT 2 was compared to the full duration of the BAT (among participants who stayed more than one minute, 95% of the sample), and a paired t-test showed no significant difference, $t(40) = -0.44$, $p = .66$, $d = .07$. Nonetheless, the effect of condition was also examined on heart rate during the first minute of BAT 2. Results again show a significant effect of condition, B = -5.35, $SE = 2.67$, $p = .04$, $sr^2 = .09$, with lower heart rate relative to

baseline in EMR vs. SE.[7]

Regarding behavioral avoidance, Figure 5 graphically depicts the portion of participants in EMR vs. SE groups exiting early across the 10 minutes of BAT 2, including when they exited. One participant asked to exit the scanner before entering entirely, so time was recorded as 0. When entered together in a Cox regression, exiting BAT 1A early was a significant predictor of exiting early during BAT 2, *Hazard Ratio (HR)* = 5.79, 95% CI [1.45, 37.10], $p = .02$, but treatment condition, $HR = 0.60$, 95% CI [0.12, 3.38], $p = .60$, and STAI-S, $HR = 1.05$, 95% CI [0.99, 1.12], $p = .13$) were not. Given that only seven of 45 participants (16%) exited the MRI scanner early ($n = 4$ in SE, $n = 3$ in EMR), results should be interpreted in the context of possible ceiling effects. Accordingly, BAT 2 duration was not used as a dependent variable in subsequent analyses.

Exposure Thinking Manipulation Check. When asked after BAT 2, all but 3 participants endorsed thinking about the prior exposure training while in the mock MRI scanner. EMR participants' ratings of how much they thought about the prior exposure training while in the scanner ($M = 63.73$, $SD = 27.17$) were not significantly different from SE participants ($M = 50.91$, $SD = 30.52$; $t(43) = 1.49$, $p = .15$, $d = 0.44$), though means were in the expected direction. When comparing the portion of participants from each group who described thinking about what they learned from exposure training or

[7] Following recommendations by Sterne et al., (2009), a sensitivity analysis was conducted examining only participants with complete data and compared to the analysis using multiple imputation. The significant effect of condition remained, and effect sizes were slightly larger when examining heart rate during the full duration of BAT 2, B = -8.89, $SE = 3.30$, $p = .01$, $sr^2 = .20$, and the first minute only, B = -7.42, $SE = 3.53$, $p = .04$, $sr^2 = .14$.

used the memory to help them feel less anxious (i.e. safety retrieval), the difference approached significance, (EMR = 81%; SE = 56%; $\chi^2 = 3.02$, $p = 0.08$). After controlling for BAT 1B outcomes and STAI-S, safety retrieval did not significantly predict BAT 2 fear, B = -9.04, *SE* = 9.66, $p = .36$, $sr^2 = .02$, or heart rate, B = -1.38, *SE* = 2.99, $p = .65$, $sr^2 = .01$, nor did it its interaction with treatment condition, (fear: B = 13.74, *SE* = 21.66, $p = .53$, $sr^2 = .01$; heart rate: B = 5.49, *SE* = 5.72, $p = .34$, $sr^2 = .02$).

When asked at the conclusion of Visit 2 whether they thought revisiting the memory of prior training was helpful, 14 of 18 (78%) EMR participants (4 missing responses) responded affirmatively, with 2 participants being unsure and 2 participants saying it was not. A partial point bi-serial correlation with BAT 2 fear outcomes, controlling for outcomes at BAT 1B, showed responding yes was associated with lower fear ratings ($r = -.43$, $p = .07$) and heart rate ($r = -.54$, $p = .04$).

Effects of Treatment Condition on Secondary Outcomes

Visit 2. There was no significant effect of condition on pre-BAT 2 outcome expectancies (i.e. CLEQ scores), B = -3.06, *SE* = 5.79, $p = .60$, $sr^2 = .01$, or expected fear, B = -8.84, *SE* = 7.21, $p = .23$, $sr^2 = .04$, controlling for each variable at BAT 1B as well as STAI-S at the beginning of Visit 2. Accordingly, planned analyses of claustrophobic expectancies as a mediator of the effect of EMR vs. SE were not conducted. There was also no significant difference between conditions on MRI-related variables at the end of Visit 2, including outcome expectancies (i.e. CLEQ-MRI score), B = -2.00, *SE* = 5.92, $p = .74$, $sr^2 = .003$, expected fear, B = 5.21, *SE* = 8.23, $p = .53$, $sr^2 = .01$, or likelihood of getting a medically indicated MRI scan, B = 7.37, *SE* = 5.07, $p = .15$,

sr^2 = .05, controlling for baseline ratings, or in the case of the CLEQ-MRI, controlling for BAT 1B CLEQ scores.

Follow-up. Effects at follow-up mirrored those at Visit 2. Controlling for CLQ scores at Visit 2 (pre-randomization), there was no significant effect of treatment condition on CLQ at one-month follow-up, B = -11.71, *SE* = 9.25, *p* = .21, η_p^2 = .04. Similarly, there was no significant effect of condition on MRI fear, B = -2.20, *SE* = 9.25, *p* = .81, η_p^2 = .001, MRI likelihood, B = 8.75, *SE* = 5.63, *p* = .13, η_p^2 = .05, or CLEQ-MRI, B = -3.86, *SE* = 6.05, *p* = .53, η_p^2 = .01, controlling for baseline ratings, or for CLEQ-MRI controlling for BAT1B CLEQ.

Table 5 shows means of the CLQ and MRI-related variables across study time-points, along with the results of one-way ANOVAs examining differences in each variable across time when collapsing across condition. Significant decreases in CLQ scores, MRI fear, and MRI outcome expectancies were seen between all time-points, as were significant increases in likelihood of getting an MRI (all *p*s < .001).

Expectancy Violations

Expectancy violation variables were grouped according to time-point (initial exposure vs. mean across all six exposures), and then each type of expectancy violation (threat expectancy, coping self-efficacy, fear tolerance, and fear level) as measured by both surprise ratings and likelihood-occurrence discrepancy was entered in a stepwise regression model predicting BAT 2 fear and heart rate reactivity, controlling for condition and the relevant outcome at BAT 1B.

Prediction of BAT 2 Fear. When examining initial exposure predictors of fear at BAT 2, surprise ratings regarding coping self-efficacy, B = -0.33, *SE* = 0.14, *p* = .02, sr^2 = .10, and discrepancy between expected vs. actual fear levels, B = 0.45, *SE* = 0.21, *p* = .04, sr^2 = .10, emerged as significant, though effects were in opposite directions. Whereas greater coping self-efficacy surprise predicted lower fear, expecting greater fear than actually occurred (i.e over-predicting fear) during the first exposure was associated with higher fear ratings at BAT 2. Of note, likelihood-occurrence discrepancy for coping self-efficacy approached significance, B = -0.38, *SE* = 0.20, *p* = .06, sr^2 = .09, with its effect in same direction as coping self-efficacy surprise (i.e., greater expectancy violation predicting reduced fear). Expectancy violations related to threat expectancies and fear tolerance from the initial exposure were not significant predictors of BAT 2 fear, regardless of whether they were measured by surprise ratings or likelihood-occurrence discrepancies (all *p*s > .22). When examining expectancy violation variables averaged across all exposure trials, no individual predictor showed significant effects on BAT 2 fear (all *p*s > .11).

Prediction of BAT 2 Heart Rate. When examining heart rate at BAT 2, the only initial exposure predictor that emerged as significant in the stepwise regression was fear level expectancy violations, with greater over-predictions of fear associated with greater BAT 2 heart rate, B = -0.38, *SE* = 0.20, *p* = .06, sr^2 = .09 (all other *p*s > .15). No expectancy violation measure averaged across all exposures significantly predicted BAT 2 heart rate (all *p*s > .11).

Prediction of Claustrophobia Symptoms. Based on results from the stepwise approach, a separate regression model was then tested that included just the significant predictors from the previous analyses, coping self-efficacy surprise and fear level expectancy violation during the initial exposure, and examined effects on CLQ scores at Visit 2 and follow-up, controlling for Visit 1 CLQ scores and treatment condition. No significant effects were seen for CLQ at Visit 2 (coping self-efficacy: B = -0.23, *SE* = 0.16, $p = .17$, $sr^2 = .05$; fear level: B = 0.34, *SE* = 0.17, $p = .22$, $sr^2 = .03$), but coping self-efficacy surprise significantly predicted CLQ scores at follow-up, B = -0.38, *SE* = 0.20, $p = .06$, $sr^2 = .09$, with greater surprise about coping self-efficacy during the initial exposure being associated with reduced claustrophobia symptoms on the CLQ. For initial exposure fear level expectancy violations, there was a trend for greater over-predictions of fear to be associated with higher CLQ scores, but it did not reach significance, B = .56, *SE* = 0.32, $p = .09$, $sr^2 = .10$.

Discussion

This study sought to examine whether mentally reinstating the memory of previous exposure training for claustrophobia would enhance the generalization of gains from exposure to a new context, specifically a mock MRI scanner. Results showed that exposure training successfully lead to reductions in fear ratings, heart rate and avoidance during a behavioral approach test (BAT) in the exposure training context. One week later, a partial return of fear of fear effect was seen for subjective fear and heart rate reactivity in the mock MRI, enabling this study to meaningfully investigate the effect of EMR on generalization of gains following exposure training. Results of the primary analyses

showed that compared to SE, EMR led to significantly reduced heart rate reactivity during BAT 2, reflective of a medium-sized effect ($sr^2 = .14$). The impact of EMR vs. SE on subjective fear was in the expected direction (i.e., reduced fear in EMR compared to SE), but the effect was small ($sr^2 = .03$) and not significant. Furthermore, no significant differences were seen between conditions on negative outcome expectancies, self-reported claustrophobia symptoms at one-month follow-up, or behavioral avoidance in the mock MRI, though there appeared to be a ceiling effect for avoidance since few participants exited the mock MRI in either condition.

The absence of effect on subjective fear ratings is in contrast to the findings of Mystkowski and colleagues (2006), who found mental reinstatement to lead to decreased subjective fear during a BAT with spider phobics, but consistent with findings of Elsesser et al. (2013) in dental phobia and Laborda et al. (2016) in social phobia. A notable difference between the study by Mystkowski et al. (2006) and the present research, beyond the type of phobia treated, is that generalization was examined with the same exposure stimulus (a spider) across distinct contexts, whereas in the current study the context and stimulus differed, potentially leading to more difficulty generalizing.

With regard to heart rate outcomes, this is the first study to show effects of mental reinstatement on heart rate reactivity during exposure following a context change, though it should be noted that only one (Elsesser et al., 2013) of the three prior mental reinstatement studies examined effects on heart rate. That effects were specific to heart rate is somewhat surprising given that the "enhanced" aspects of the procedure were in large part designed to target top-down reasoning processes about the relevance of prior

learning to a new feared situation, and therefore might be more likely to impact subjective fear ratings and threat expectancies. In particular it was hypothesized that the advantage of EMR over the control condition would be mediated by superior impacts on negative outcome expectancies, but no difference in expectancies was found across conditions. Nonetheless, despite equivalent subjective ratings of fear and outcome expectancies, the EMR intervention led to decreased physiological reactivity compared to SE when entering a novel feared situation in the mock MRI scanner, with heart rate levels essentially equivalent to post-exposure training in a familiar claustrophobic context.

The discordance between subjective and physiological outcomes in this study is noteworthy in that it highlights the distinct response systems of fear originally delineated by Lang (1968). De-synchrony between these response systems has been shown to be greatest under conditions of less severe emotional arousal (Calvo & Miguel-Tobal, 1998; Hodgson & Rachman, 1974), which appears to have been reflected in this study in the relatively moderate levels of fear experienced on average during BAT 2. Although researchers are frequently drawn to prioritize physiological outcomes as more objective indicators of emotional states directly linked to underlying brain circuitry (e.g., Perusini & Fanselow, 2015), others have argued that the subjective, conscious report of fear reflects a valid and reliable measurement that is particularly important since subjective distress tends to be what drives people to seek treatment (LeDoux, 2014; LeDoux and Hofmann, 2018). In this account, physiological responses reflect defensive survival circuits that can contribute to the conscious experience of fear, but do not determine it. Thus in this study, the EMR intervention appeared to have an effect on reducing a

measure of autonomic arousal (heart rate) reflective of underlying defensive circuitry (Friedman, 2007), However, this reduced autonomic arousal did not appear to impact the conscious experience fear enough to lead to a concordant reduction in subjective fear ratings.

A number of possible explanations exist for the non-significant findings of EMR on self-reported variables. For one, results of the manipulation check applied after BAT 2 showed that a sizable portion (56%) of the participants in the SE condition reported thinking about their prior exposure training during BAT 2 *and* specifically described thinking about what they learned or used the memory to help them feel less afraid. There was a trend toward more MRE participants (81%) revisiting their exposure training in this way, but such a pattern suggests that not everyone in the MRE condition explicitly recalled the more helpful aspects of their prior exposure training while going in the mock MRI canner, and that numerous participants revisited their exposure training without going through those procedures. It should be noted that there were substantial limitations to this manipulation check given that it was done retrospectively, ratings did now a significant relationship with fear during BAT 2, and there may have been a social desirability bias impacting participants from both conditions. Furthermore, MRE procedures still could have had an effect without leading to explicit memory retrieval (e.g. see Shin & Newman, 2018). Nonetheless, such a pattern reflects the likelihood that prior learning was likely fairly salient for all participants in the study. Although BAT 2 occurred one week after initial training and occurred in a location, the novelty of coming in for a research study visit on claustrophobia could made reinstatement of prior safety

memories easily occur, as could have the SE procedure in which participants recalled a neutral memory from around the same time as the first study visit.

Also potentially contributing to the high salience of prior learning for all participants, and consequently to the limited impact of EMR, is the creation of the audio-recording after exposure training, in which participants reviewed what happened during the exposure training and what they learned about their fear. Expression of fear and safety memories are influenced by consolidation processes as well as retrieval (Quirk & Mueller, 2011), and the elaborated review of exposure training may have functioned as a strong extinction memory consolidation intervention, reducing possible effects of a later retrieval-based manipulation. In fact, Raeder and colleagues (2019) showed that reactivating the memory of exposure training and evaluating one's success in facing feared scenarios immediately after a single session of exposure training for height phobia led to reduced recovery of fear and increased self-efficacy during BATs done two to three days later and at one-month follow-up. After using a similar intervention for all participants in the present study, a sizeable return of fear effect (large effect size, d = 1.25) was still present, suggesting there was still substantial room for improvement from the EMR intervention. However, the median peak fear level across conditions was 40 out of 100, meaning that many participants did not experience substantial fear levels after a change in context. Moderator analyses did not show the effect of treatment condition to be significantly impacted by claustrophobia severity or state anxiety prior to the manipulation, which might be expected if ceiling effects were present, though such tests were limited by the small sample size.

Expectancy Violations

By tracking feared expectations and outcomes at each trial of exposure training, this study enabled the investigation of a number of different types of expectancy violations as a predictor of outcomes. Results showed that expectancy violations pertaining to coping self-efficacy and expected fear levels during participant's initial exposure were significantly related to self-reported fear outcomes, though in opposite directions. Specifically, greater surprise about coping self-efficacy outcomes (i.e. surprise about coping better than expected) predicted lower fear ratings at BAT 2, as well as self-reported claustrophobia symptoms at one-month follow-up. There was also some indication that likelihood-outcome discrepancies related to coping-self efficacy fears predicted fear and heart rate reactivity during BAT 2, though this result was not consistent across analytic approaches. The finding that learning related to coping self-efficacy, i.e. the ability to actively manage fearful thoughts, feelings and behaviors, was associated with outcomes is consistent with previous literature showing improvements in coping self-efficacy to mediate subsequent symptom reduction during exposure therapy (Fentz et al., 2013; Gallagher et al., 2014). Furthermore, experimentally manipulating self-efficacy prior to an extinction learning task has been shown to lead to reduced physiological responding and negative evaluations of a conditioned stimulus (Zlomuzica, Preusser, Schneider, & Margraf, 2015). The present study extends these findings by showing that a strong expectation of poor coping self-efficacy, followed by the realization that one can effectively cope, is predictive of reduced fear in a new feared context.

With regard to fear level expectancy violations, discrepancy between expected and actual fear (i.e. expected minus actual fear levels, or over-prediction of fear) at the initial exposure was significantly positively associated with greater fear ratings and heart rate reactivity during BAT 2. There were also positive associations between over-prediction of fear across all exposures and fear outcomes at BAT 2, though this result was not consistent across analytic approaches. Although realizing that fear was consistently lower than expected should theoretically help facilitate therapeutic learning (Craske, Vervliet, & Hermans, 2018), it is important to note that in the present study attention was not explicitly drawn to expected vs. actual fear discrepancies like it was for specific feared outcomes, as surprise about fear levels was not rated. Over-prediction of fear may have instead reflected or an inability to update expectations about fear levels based on actual experience suggestive of a more rigid cognitive style. The direction of this effect is also consistent with the findings of Kircanski & Peris (2015), who found that over-predictions of fear early in exposure treatment predicted worse mid-treatment outcome. A study by Guzick et al. (2018), on the other hand, found that greater variability in expected vs. actual fear over the full course of treatment, which meant a higher proportion of over-predictions, was associated with improved outcome. Of note, expectancy violations in the current study were based on a massed set of identical exposures, in contrast to a full course of treatment with varying types of exposures in the above-mentioned studies. It may be that over-predictions of fear are related to outcome when a limited number of exposure situations have been encountered, but as more situations are approached this situation changes.

This is the first study to show that expectancy violations about specific feared outcomes (rather than expected fear levels) is predictive of subsequent fear levels. However it should be noted that conclusions about the belief domains used in this study (coping self-efficacy, fear tolerance, and threat expectancies) should be considered very much tentative. The categories of beliefs used in the CLEQ, which were subsequently used to distinguish expectancy violation beliefs, were based on items selected from prior measures as well as distinctions between theorized mechanisms of exposure. Although internal consistency within belief domains was strong, sample size limitations prevented full psychometric analysis. Given that expectancy violations related to different types of beliefs can have divergent effects on future outcomes, better delineating the types of beliefs related to exposure outcomes is an important direction for future research.

Limitations

Results of this study should be considered within the context of a number of limitations. For one, administration of BATs was not blinded, making it impossible to rule out that knowledge of experimental condition subtly impacted experimenter behavior. Although a standardized script was followed for each BAT, having a separate experimenter conduct outcome assessment served as a stronger control. Relatedly, although SE procedures were designed to mimic EMR procedures in terms of memory reinstatement, it was not designed to be an equally plausible alternative in terms of helping reduce fear outcomes, so participant expectancy effects may have played a role in EMR.

Regarding the EMR intervention itself, another limitation is that because it

included multiple ingredients (i.e. recall of exposure memory, listening to audio recording, and identifying relevance of exposure memory), it is difficult to know whether certain elements may have been driving or impeding effects. Multiple components were used in order to maximize likelihood of improving outcomes given that exposure is already a fairly robust intervention, but it is also possible that certain elements of the procedure ended up increasing fear levels, particularly for certain participants like those who emphasized fear reduction in their exposure recordings. Unlike previous research examining mental reinstatement, however, we assessed and analyzed a number of different components of the memory recall procedures, enabling more specific understanding of the factors potentially influencing mental reinstatement.

It should also be noted that even though the study was adequately powered to detect a medium-sized effect for the main outcomes, sample size is still a limitation, particularly for secondary analyses involving moderation. Even for main outcomes, non-significant effects were consistently in the direction of superior outcomes for EMR, but may have been too small to detect in the present study. This may be especially true given the modest return of fear seen for a large portion of the sample, and particularly for behavioral avoidance as an outcome, which showed a clear ceiling effect. Relatedly, the control procedures in the SE condition may have inadvertently elicited reinstatement of the exposure memory in a way that reduced differences seen between conditions. Specifically, vividly imagining a neutral memory that occurred close in proximity to the initial study visit as well as listening to an audio-recording made during that visit may have prompted SE participants to implicitly or explicitly recall the memory of exposure

training more than they otherwise would have. Although the elaborated procedures of the EMR condition would still be expected to lead to a stronger reinstatement of prior learning, overlap between conditions could have reduced the magnitude of effects to a level not detectable given the present sample size. This idea is also supported by the results of the manipulation check mentioned previously, in which the difference in proportion of EMR vs SE participants who explicitly revisited the memory of exposure training prior to or during BAT 2 compared only approached significance.

Implications and Future Directions

Within this study and across other investigations of mental reinstatement techniques (Elsesser et al., 2013; Laborda et al., 2016; Mystkowski et al., 2006), effects of revisiting a prior exposure memory in order to enhance generalization appear to be limited, and it is difficult to make definitive conclusions about the clinical utility of such an exposure augmentation strategy as it has been applied to date. Nonetheless, the presence of significant effects on psychophysiological reactivity, possible moderators (e.g. post-reinstatement positive affect) and limitations of this study related to sample size suggests that further investigation of mental reinstatement and related techniques could be beneficial.

In order to better understand the processes in play in extant findings on mental reinstatement, one future direction would be to experimentally manipulate the manner in which the memory is recalled, as well as the formation of the memory itself. For instance, Raeder and colleagues (2019) found that immediately after exposure treatment, having participants reactivate the memory of the exposure experience and connect it to other

mastery experiences led to improved fear outcomes compared to reactivating the memory and comparing it to other stressful experiences. An extension of this research would be to examine whether mental reinstatement of exposure after such a self-mastery reactivation exercise could amplify its effects, and potentially extend benefits to a novel situation, which Raeder et al. (2019) did not test.

Regarding expectancy violations, findings from this study are certainly in need of replication given the exploratory nature of the analyses and small sample size. However, they suggest that the experience of coping more effectively than one expected during an exposure helps to facilitate durable reductions in fear. Such a finding offers important evidence in a clinical context for a central tenet of inhibitory learning theory, which is that therapeutic learning is facilitated through maximizing of expectancy violations (Craske et al., 2008; Rescorla-Wagner, 1972). This is particularly notable given a number of recent studies that failed to find evidence in support of expected associations between expectancy violations and outcomes (de Kleine et al., 2017; Scheveneels, Boddez, Van Daele, & Hermans, 2019; Scheveneels, Boddez, Vervliet, & Hermans, 2019). This study also demonstrated the value of investigating the different types of expectancies that may be violated during exposure, as previous research has largely focused on a single indicator of expectancies, most frequently expected fear levels. The types of beliefs that drive fear can vary widely both across and within different types of anxiety presentations, and the present results show that examining expectancy violations with greater specificity in regards to belief domains may help to clarify inconsistent findings. Further research investigating the types of expectancy violations that are most predictive of outcomes,

both within and across individuals, will be important to continue refine inhibitory learning theory and elucidate the cognitive mechanisms driving change during exposure. In addition, in order to demonstrate that expectancy violations function as mechanism of change, future research will need to manipulate treatment in such a way that facilitates greater expectancy-outcome mismatches (e.g. Deacon et al., 2013), and demonstrate that this in turn leads to improved outcomes.

Lastly, although the current study was not specifically designed as an intervention for treatment of MRI-related claustrophobia, it illustrates the utility of exposure therapy for decreasing MRI-related fear when access to a real scanner is limited. Specifically, MRI-related fear and expected likelihood of getting a medically-indicated MRI substantially improved as a result of two visits involving exposure to feared spaces. Given the major public health implications of MRI avoidance due to claustrophobia (Munn et al., 2015), this study could serve as the basis for future research investigating an efficient exposure-based intervention for fear of MRI scans.

Conclusion

Results of the present study showed that an intervention involving mental reinstatement of prior exposure training for claustrophobia led to reduced heart rate reactivity when entering a new feared situation, but effects on subjective fear rating or feared outcome expectancies were not significant. In addition, no impact of intervention was seen on self-reported claustrophobia symptoms or MRI fear-related variables at one-month follow-up. Compared to results of prior studies examining a similar manipulation, the elements added to the procedure, including listening to an audio-recording of what

participants learned from prior exposure training, did not appear to meaningfully improve outcomes. Analysis of exposure training processes showed that expectancy violations related to coping self-efficacy, particularly during participants' first exposure, led to less fear in a novel exposure situation one week later, as well as less self-reported claustrophobia symptoms at one-month follow-up. Under-predictions of fear levels, however, were associated with greater fear levels in the novel feared situation. More research is needed to understand how to most effectively facilitate the formation and retrieval of safety memories in order to enhance generalization of learning from exposure.

Table 1

Baseline Clinical Characteristics

	EMR (n = 22) *M (SD) or n (%)*	SE (n = 23) *M (SD) or n (%)*	p value for T, χ^2 or Fisher's Exact Test
Specific Phobia Diagnosis (Claustrophobia)			0.15
Currently meets	19 (86%)	19 (82%)	
Past only	2 (9%)	0 (0%)	
Does not meet	1 (5%)	4 (17%)	
Psychiatric medication	2 (9%)	4 (17%)	0.67
MRI Variables			
Prior MRI Experience	13 (59%)	12 (52%)	0.64
MRI Fear (0-100)	75.4 (19.1)	71.5 (18.9)	0.49
MRI Likelihood (0-100)	56.5 (27.4)	67.0 (34.7)	0.27
Questionnaire Scores			
CLQ-fear	58.6 (17.4)	59.4 (17.7)	0.87
CLQ-avoidance	59.6 (19.2)	62.8 (16.8)	0.59
STAI-T	44.0 (11.7)	42.6 (11.4)	0.68
STAI-S	43.8 (10.7)	40.9 (11.3)	0.38
BAT 1A Variables			
Peak Fear (0-100)	76.3 (14.0)	70.9 (15.1)	0.22
End Fear (0-100)	63.4 (22.6)	59.1 (22.9)	0.54
Exited early	8 (36%)	3 (14%)	0.10
CLEQ	48.6 (16.1)	51.9 (20.6)	0.56

Note: EMR = Enhanced Mental Reinstatement; SE = Standard Exposure; CLQ = Claustrophobia Questionnaire; STAI-T = State-Trait Anxiety Inventory – trait; STAI-S = State-Trait Anxiety Inventory – state; CLEQ = Claustrophobia Expectancies Questionnaires.

Table 2

Results from regression models examining effect of condition on primary outcomes during BAT 2

Outcome	**Step**	**Predictor**	**ΔR^2**	**B**	***SE* B**	***β***	***sr*²**
Fear Rating	1.	BAT 1B Fear	.19*	0.42	0.35	.17	.04
		STAI-S		0.87	0.32	.38**	.15
	2.	Condition	.03	-9.79	8.41	-.17	.03
Heart Rate	1.	BAT 1B HR	.01	0.03	0.22	0.03	.00
		STAI-S		-0.02	0.11	-0.04	.00
	2.	Condition	.14*	-6.73	2.64	-0.33*	.14
Outcome	**Step**	**Predictor**	**$\Delta\chi^2$**	**Hazard Ratio**	**95% CI for Hazard Ratio**		***p***
Avoidance (Time to exit)	1.	STAI-S	6.62*	1.04	0.98 to 1.10		.15
		BAT 1A Exited		7.55*	1.52 to 37.44		.01
	2.	Condition	0.28	0.64	0.12 to 3.38		.60

Note: * = $p < .05$; ** = $p < .01$; BAT = Behavioral Approach Test; STAI-S = State Trait Anxiety inventory – State, measured at the beginning of Visit 2; HR = Heart rate.

Table 3

Claustrophobia symptom scores and MRI fear variables across study time-points.

	Condition	Visit 1: Baseline *M (SD)*	Visit 2: Post-Treatment[a] *M (SD)*	One-mo. follow-up *M (SD)*	Effect of Time (*F*-test)[b]	η_p^2
CLQ	EMR	118.4 (36.1)	98.4 (38.1)	72.0 (34.0)	31.70**	0.42
	SE	122.2 (34.1)	92.0 (37.0)	79.2 (46.3)		
MRI Fear	EMR	75.5 (19.1)	52.7 (24.1)	39.6 (31.0)	36.46**	0.46
	SE	71.5 (18.9)	46.3 (30.8)	39.4 (34.4)		
MRI Likelihood	EMR	56.6 (27.4)	74.1 (25.3)	84.4 (17.6)	21.57**	0.33
	SE	67.0 (34.7)	74.3 (30.6)	80.7 (28.4)		
CLEQ-MRI concern	EMR	-	24.5 (19.6)	15.7 (17.6)	9.91*	0.19
	SE	-	23.9 (22.1)	18.1 (22.5)		
CLEQ-MRI likelihood	EMR	-	40.7 (25.5)	26.4 (28.2)	18.92**	0.31
	SE	-	36.1 (29.8)	24.3 (21.0)		

Note: *$p < .01$; **$p < .001$; [a]CLQ administered pre-BAT 2 at Visit 2, whereas other variables captures after BAT 2. [b]Follow-up paired samples t-tests (collapsed across condition) indicated significant differences between all Visit 1 and Visit 2 variables, and between Visit 2 and follow-up (all p's < .001); EMR = Enhanced Mental Reinstatement; SE = Standard Exposure; CLQ = Claustrophobia Questionnaire; CLEQ-MRI – Claustrophobic Expectancies Questionnaire for an MRI scan.

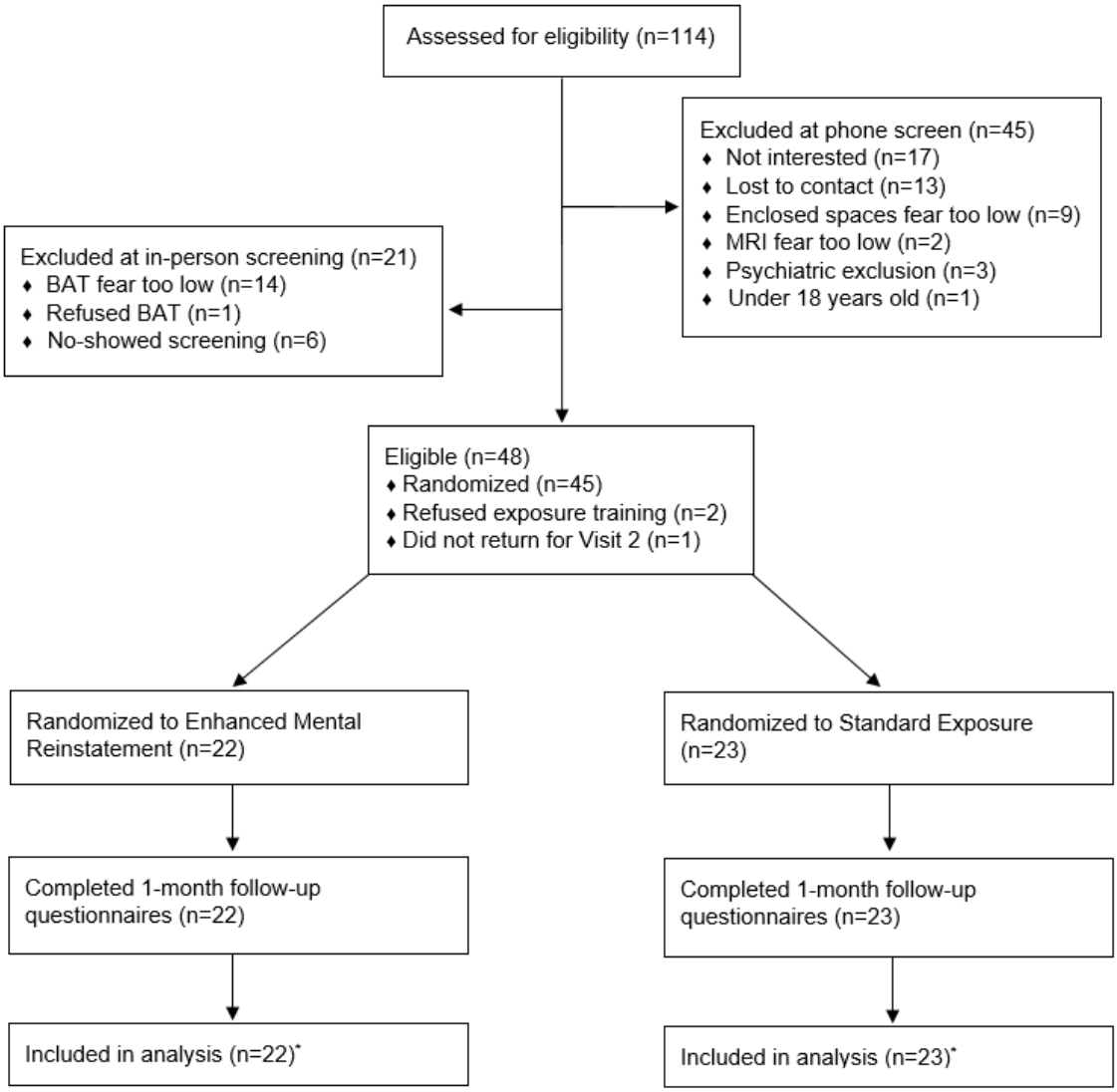

Figure 1. CONSORT diagram of participant screening, randomization, and study completion. Randomization occurred at Visit 2, following completion of exposure training at Visit 1. *For heart rate analysis, $n = 21$ for enhanced mental reinstatement and $n = 22$ for standard exposure due to equipment failure.

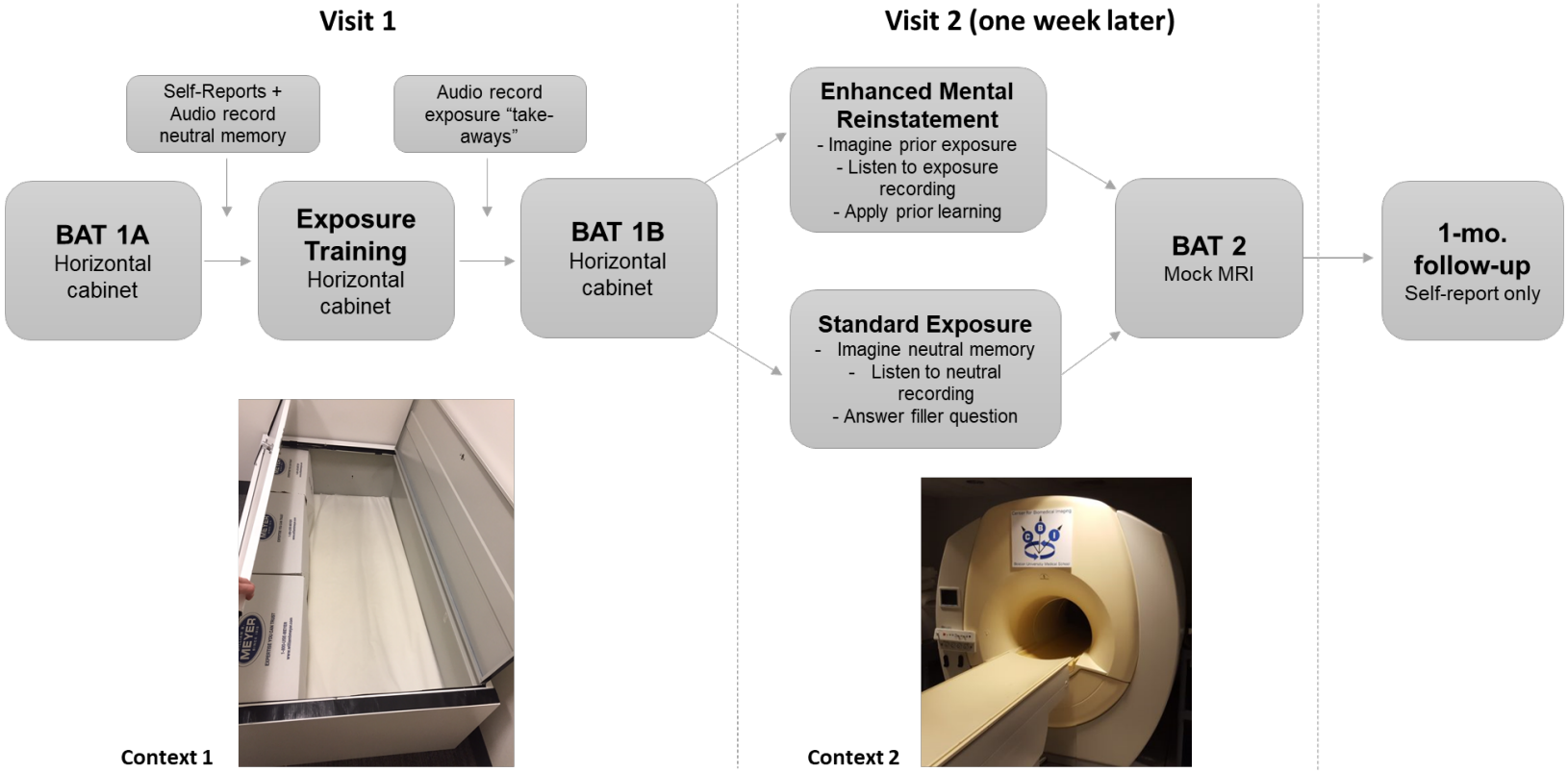

Figure 2. Schematic of study design and contexts for Behavioral Approach Tests (BAT). Open space in cabinet (Context 1) is 6' x 3' x 1.5', and doors were closed on top of participants. Diameter of tube in mock MRI scanner (Context 2) is 2'. Participants were slid in to tube headfirst until their entire upper body was enclosed, and then were moved an additional 6" back in the scanner at two-minute intervals. Back of the scanner was covered in opaque plastic to increase sense of enclosure.

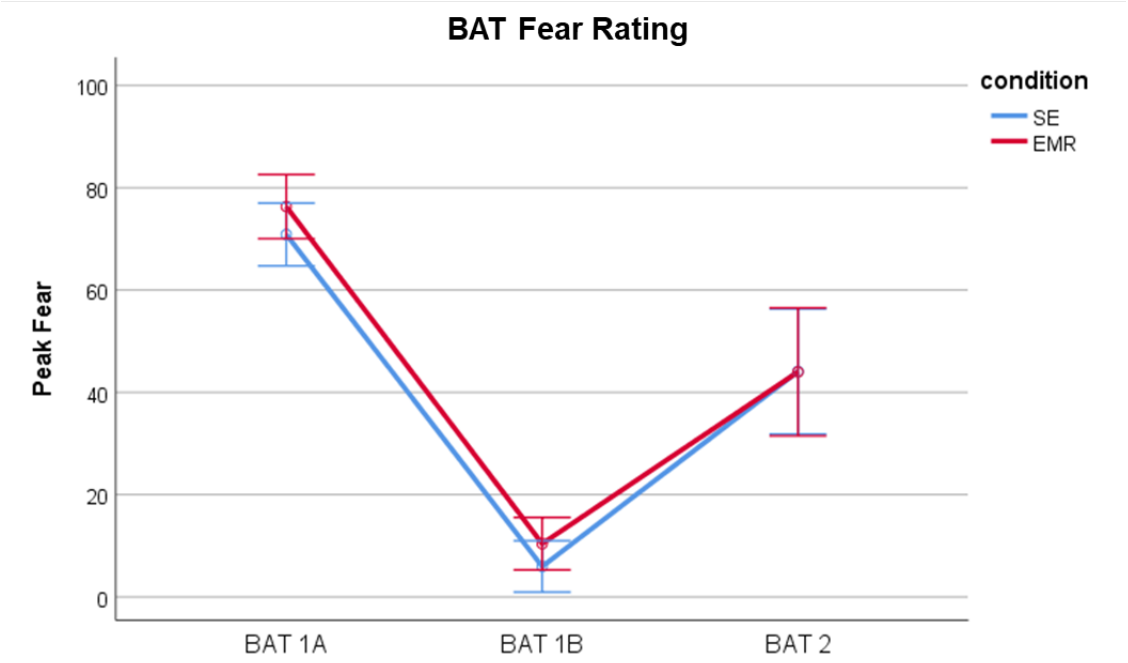

Figure 3. Peak fear rating during Behavioral Approach Tests (BAT) across conditions. Error bars reflect 95% confidence intervals. SE = Standard Exposure; EMR = Enhanced Mental Reinstatement.

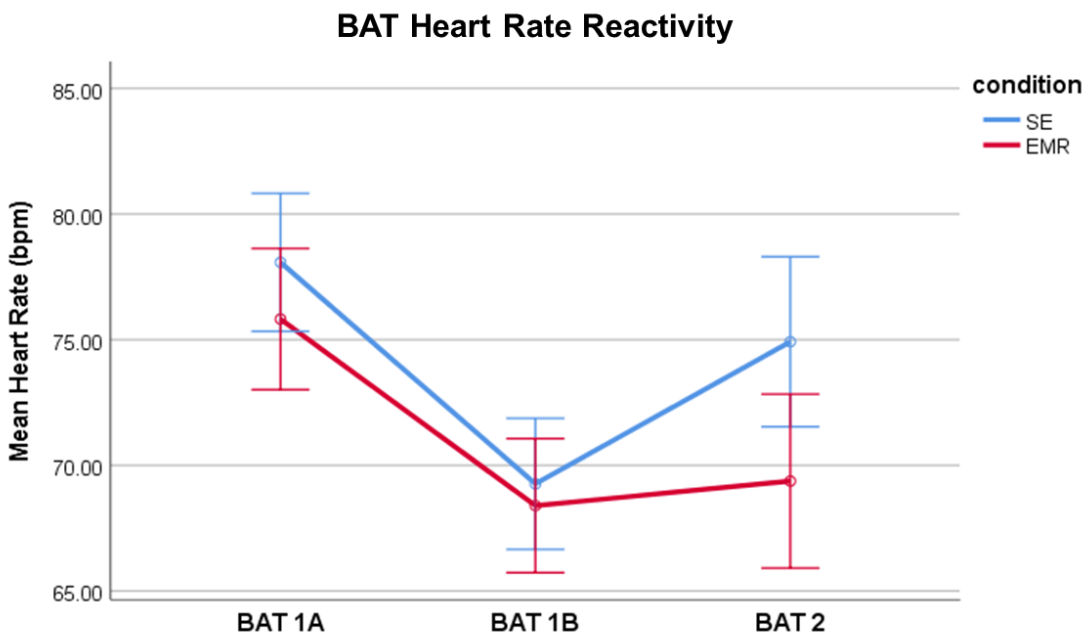

Figure 4. Heart rate during behavioral approach tests (BATs) across conditions. Error bars reflect 95% confidence intervals. Heart rate values are adjusted for baseline. SE = Standard Exposure; EMR = Enhanced Mental Reinstatement; bpm = beats per minute.

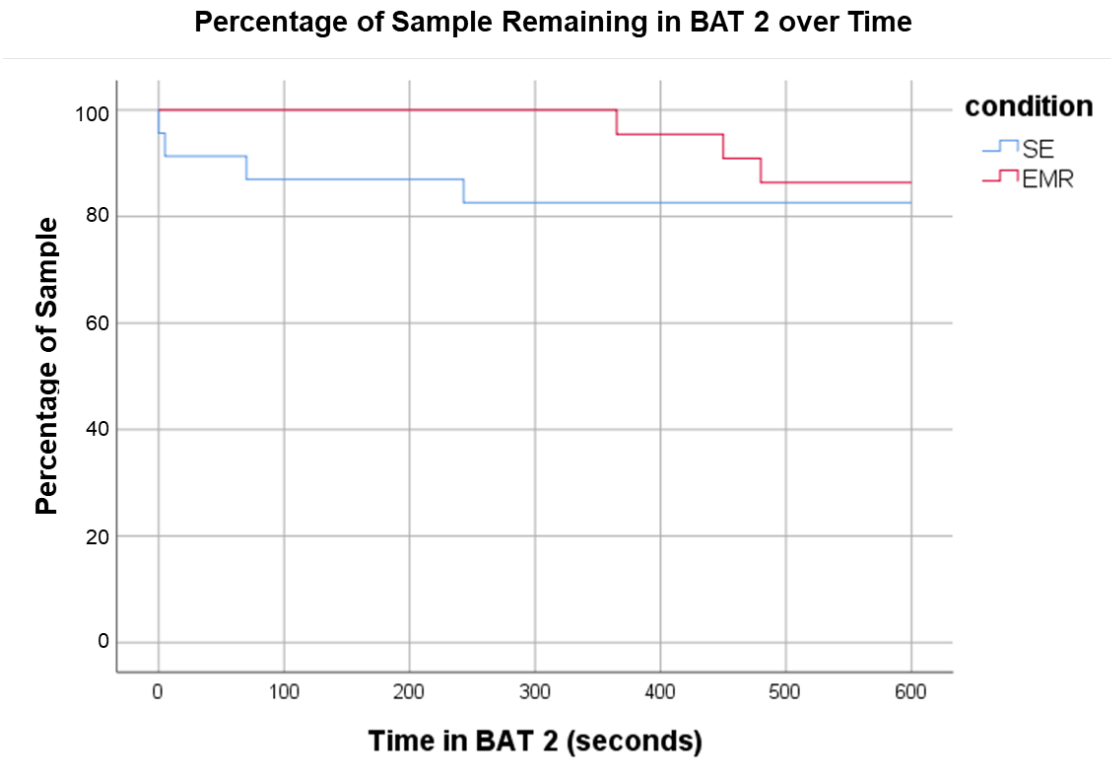

Figure 5. Percentage of Enhanced Mental Reinstatement (EMR) vs. Standard Exposure (SE) sample that exited BAT 2 across time

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