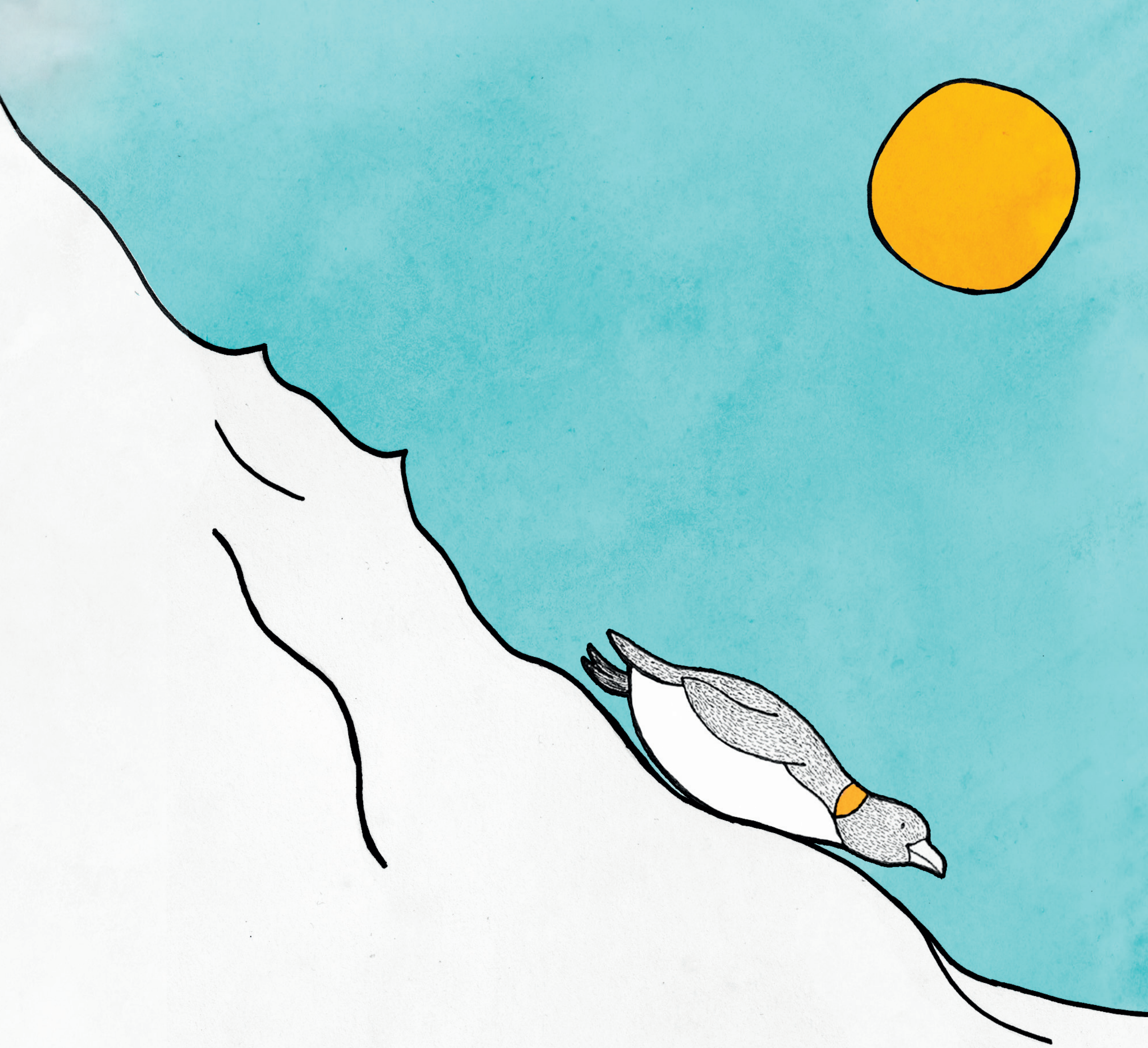

Creating Silver Linings

Modifying negative mental imagery in anxiety

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Creating Silver Linings

Modifying negative mental imagery in anxiety

Het Verlichten van de Storm

Negatieve mentale beelden veranderen bij angst

(met een samenvatting in het Nederlands)

Proefschrift

ter verkrijging van de graad van doctor aan de Universiteit Utrecht op gezag van de rector magnificus, prof. dr. H.R.B.M. Kummeling, ingevolge het besluit van het college voor promoties in het openbaar te verdedigen op vrijdag 1 oktober 2021 des middags te 2.15 uur

door

Elze Landkroon

geboren op 14 december 1991 te Haarlem

Promotor: Prof. dr. I. M. Engelhard

Copromotoren: Dr. E. Salemink

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in limine temporum stans Ianus tempus praeteritum et tempus futurum simul spectat

Standing in the doorway of time, Janus simultaneously gazes upon times past and times still to come

(Based on Koller, 1976)

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Chapter 1

General introduction

Most people experience fear throughout their life. For instance, when starting a new job, during financial troubles, or when suffering from severe health issues. From an evolutionary perspective, fear is an adaptive emotion that helps to predict and avoid potential future threats (Bateson et al., 2011; Miloyan et al., 2016). However, some people perceive potential threats too quickly, which can be very debilitating. Anxiety-related disorders are characterized by a persistent and excessive fear that is out of proportion to the actual threat (American Psychiatric Association, 2013). Individuals with anxiety-related disorders typically avoid feared stimuli and situations or endure them with great distress. The anxiety causes impairment in social, occupational, or other important areas of functioning. Different types of anxiety-related disorders are defined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), such as social anxiety disorder, panic disorder, agoraphobia, generalized anxiety disorder, specific phobia, posttraumatic stress disorder (PTSD), and obsessive-compulsive disorder (American Psychiatric Association, 2013).

Many individuals suffer from anxiety-related disorders. Overall, the life-time prevalence of anxiety-related disorders is high (16.6-33.7%; Kessler et al., 2005, 2012; Somers et al., 2006), with a current estimated global prevalence of 7.3% (Baxter et al., 2013). It is the most prevalent category of mental illnesses (Kessler et al., 2005). Anxiety-related disorders often develop early in life (Kessler et al., 2005), have a chronic course (Klein Hofmeijer-Sevink et al., 2012), are associated with comorbid disorders (Kessler et al., 2005), and worsen physical complaints (Engelhard et al., 2009). In addition, anxiety-related disorders compromise quality of life and psychosocial functioning (Mendlowicz & Stein, 2000). Mental and substance use disorders were the leading cause of non-fatal burden of disease in 2010 (Whiteford et al., 2013). Specifically, anxiety-related disorders accounted for 3.5% of the overall burden of disease and injury due to disability (Baxter et al., 2014). Anxiety-related disorders not only place a great burden on individuals suffering from them but also on society as a whole. Anxiety-related disorders are costly for society at large, similar to physical diseases (Smit et al., 2006). It has even been suggested that investing in scaling-up treatment for anxiety-related disorders would result in a higher return in terms of costs (Chisholm et al., 2016; Layard & Clark, 2015). Collectively, these findings clearly highlight the necessity for effective treatments for anxiety-related disorders to relieve the significant burden that these disorders place on individuals and society.

Contemporary learning theory

Case example

George is suffering from a social anxiety disorder. He fears social situations in which he is exposed to possible scrutiny by others. He especially fears social gatherings, such as parties. He worries that others will see his anxiety as he often turns red and sweats in social situations. He even fears that others will start laughing at him, not like him, or ignore him. As a result, George avoids social gatherings, which leads to feelings of loneliness.

When George was younger, a teacher in elementary school asked him to read a paragraph out loud. He felt that everybody was looking at him and he got a bit nervous. He mumbled and misread a sentence. All kids laughed at him, and he turned bright red. Even though he does not frequently think back to this experience, he often imagines himself bright red and looking embarrassed, especially in social situations. He worries that this will happen in novel social situations and that others will negatively evaluate him.

Contemporary learning theory provides insight into the etiology and maintenance of anxiety-related disorders (Davey, 1997; Vervliet et al., 2013). Fear conditioning is a valuable model for anxiety and relapse (e.g., Mineka & Zinbarg, 2006; Vervliet et al., 2013). According to contemporary learning theory, anxiety can develop when originally neutral situations (e.g., social situation, such as reading out loud in class; conditioned stimulus [CS]) become associated with aversive outcomes (e.g., social rejection; unconditioned stimulus [US]). The association between the CS and US can also develop without a direct conditioning experience. For example, the association can originate after receiving information about the association between the CS and the US or after vicarious learning (Davey, 1997). After learning a CS-US association, confrontation with a CS activates this association, which triggers the mental representation of the US. The elicited fear response (conditioned response [CR]) is mediated by the mental representation of the US (see Figure 1). Thus, the intensity of the CR is influenced by two factors: the strength of the CS-US association (i.e., outcome expectancy) and the mental representation of the US (i.e., US evaluation).

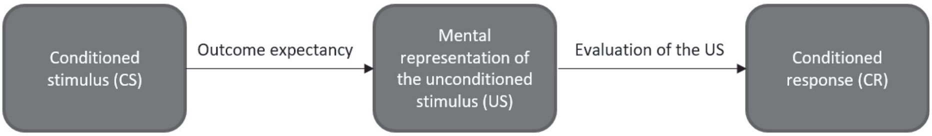

Figure 1. Representation of contemporary learning theory based on Davey (1997).

Consequently, any factor that changes the strength of the CS-US association or the mental representation of the US influences the intensity of the CR. Several factors can affect the strength of the CS-US association, such as the contingency between the CS and US (Davey, 1997). The case example of George presents one situation during which he was laughed at in elementary school. If he experienced more social situations in which he felt rejected, it could strengthen the CS-US association and increase the negative outcome expectancy in new social situations. Likewise, multiple factors can influence the mental representation of the US and its evaluation, such as cognitive rehearsal. For George, cognitive rehearsal of the kids laughing at him in elementary school (i.e., US) can further inflate the aversive evaluation of the US and thereby increase the intensity of the CR. These examples show how CR intensity can increase. However, when the strength of the CS-US association decreases or when the mental representation of the US is evaluated as less aversive, this would result in reduced CR intensity (Davey, 1997). The following section discusses the treatment of choice for anxiety-related disorders and how this is informed by learning theory.

Cognitive behavioral therapy

The recommended, evidence-based, psychological treatment for anxiety-related disorders is cognitive behavioral therapy (CBT; e.g., Bandelow et al., 2017; Katzman et al., 2014; National Institute for Health and Clinical Excellence, 2011). CBT aims to modify cognitive biases and reduce avoidance behavior and excessive anxiety. It includes a broad range of interventions, such as cognitive interventions and, crucially, exposure (Deacon & Abramowitz, 2004; Huppert et al., 2019). Exposure involves repeated confrontation with feared stimuli and situations either in real life (i.e., in vivo exposure), in imagination (i.e., imaginal exposure), via bodily sensations (i.e., interoceptive exposure), or in virtual reality.

The prevailing model for exposure therapy is inhibitory learning theory and heavily relies on learning theory. According to inhibitory learning theory, the presumed working mechanism of exposure therapy is disconfirmation of outcome expectancy and learning of new inhibitory associations (Craske et al., 2014). That is, the goal of exposure therapy is that patients learn what actually happens when confronting feared situations as opposed to what they fear will happen. As hypothesized by inhibitory learning theory, new inhibitory associations between the CS (e.g., social situation, such as reading aloud in class) and the new outcome (e.g., no rejection) are formed during exposure therapy, also called extinction learning. However, such new associations presumably co-exist next to the original threat association (e.g., social situation leads to rejection; Bouton, 2002; Vervliet et al., 2013). When confronted with a CS (e.g., new social situation), both associations compete for retrieval. The theory proposes that after successful exposure therapy, the new association is more easily retrieved and inhibits the original threat association.

CBT is an effective treatment to reduce anxiety (Hofmann et al., 2012). When CBT for anxiety-related disorders was compared to control conditions (e.g., care-as-usual), CBT was more effective directly after treatment (Cuijpers et al., 2016) and up to one year after treatment completion (Tolin, 2010; van Dis et al., 2020). Yet, there is room for improvement. First, a substantial minority of individuals with anxiety-related disorders drop out before (11-20%) and during (19.6-24%) treatment (Bentley et al., 2021; Carpenter et al., 2018; Fernandez et al., 2015). Although patients may drop out for practical reasons (e.g., difficulty planning a session) or because their symptoms improved, other reasons for drop-out include low motivation for treatment or poor readiness for change (Bentley et al., 2021; Taylor et al., 2012), or patients find it too difficult to confront themselves to feared situations (Benbow & Anderson, 2019). Second, for a large proportion of individuals with anxiety-related disorders who complete therapy, symptoms do not (fully) remit (Taylor et al., 2012). Treatment response (i.e., symptom reduction during treatment) and remission (i.e., end-state functioning below a certain threshold) for CBT in anxiety-related disorders are approximately 50% post-treatment and 55% at follow-up (Loerinc et al., 2015; Springer et al., 2018). Finally, a significant proportion of anxiety patients who initially clinically improve during treatment, experience a relapse of symptoms later on (Vervliet et al., 2013). According to inhibitory learning theory, fear can return when the original threat association is retrieved instead of the new inhibitory association. This can occur for instance after a time lapse (i.e., spontaneous recovery) or when an individual is exposed to a different context than during exposure (i.e., renewal; Bouton, 2002). A cohort study demonstrated that many individuals who showed a remitted anxiety-related disorder experienced a recurring anxiety-related or depressive disorder within four years (Scholten et al., 2016). Namely, 23.8% showed a recurrence of the same disorder, while 54.8% showed a recurrence of another anxiety-related or mood disorder. Recent meta-analyses demonstrated relapse rates between 0-14% after CBT in anxiety-related disorders (Levy et al., 2021; van Dis et al., 2020). However, only a limited number of randomized controlled trials investigated long-term efficacy, indicating that more research into relapse rates is necessary. Even though CBT is the most effective psychological treatment for anxiety-related disorders, the abovementioned limitations stress the need to optimize treatment.

Optimizing treatment for anxiety-related disorders

At least two approaches exist to enhance treatment for anxiety-related disorders. The first approach is to optimize exposure therapy itself. For instance, one approach based on inhibitory learning theory is to maximize the mismatch between what a patient expects during exposure and what actually happens to optimize the opportunity for learning (Craske, 2015). Yet, enhancing exposure therapy itself has several drawbacks. First, whether increasing a mismatch optimizes exposure therapy awaits empirical testing, although there is evidence contradicting this hypothesis (Scheveneels et al., 2021). Second, the original threat association can still become activated after treatment and result in relapse (Bouton, 2002). Finally, a meta-analysis demonstrated that anxiety patients show enhanced fear responding towards a CS that was no longer paired with a US during a fear conditioning procedure compared to healthy controls (Duits et al., 2015). This suggests that anxiety patients have impaired extinction learning, which could indicate that they also have learning difficulties during exposure therapy.

A novel possibility to enhance treatment for anxiety-related disorders is to focus on the second component that influences fear according to contemporary learning theory, namely the mental representation of the US. Fear conditioning studies showed that increasing and decreasing US threat intensity increased and decreased conditioned fear, respectively (Hosoba et al., 2001). Similarly, habituation to the actual US decreased the perceived intensity of threat and reduced fear renewal (Haesen & Vervliet, 2015; Leer et al., 2018). Although this provides evidence that the representation of the US influences CR, actual confrontation with the US is often undesirable in clinical practice. Instead, it can be more fruitful for a clinical application to modify the mental representation of the US. Exposure therapy does not target this mental representation, while this seems important in anxiety-related disorders (see Mertens, Krypotos, et al., 2020). For instance, previous fear conditioning research demonstrated that mental imagery of an aversive US can install conditioned fear (Mueller et al., 2019) and avoidance behavior (Krypotos et al., 2020). This shows that not only actual exposure to a US leads to fear, but also negative mental imagery of an aversive US. Modifying negative mental imagery could change the mental representation of the US and result in a more positive evaluation of the US, which would then lead to reduced CR.

Thus, modifying negative mental imagery may be a promising avenue to reduce anxiety and optimize current exposure-based treatments.

Mental imagery in anxiety-related disorders

Mental imagery refers to experiencing sensory information without direct stimulation from an external stimulus (Pearson et al., 2015). Although mental imagery can refer to all sensory modalities, most research focuses on visual mental imagery. Visual mental imagery and visual perception show neural overlap (Ganis et al., 2004; Pearson et al., 2015), and visual mental imagery has also been coined 'seeing with the mind's eye' (Kosslyn et al., 2001).

Negative mental imagery is a transdiagnostic process in anxiety-related disorders (Brewin et al., 2010; Holmes & Mathews, 2010). The content of the negative mental imagery is generally consistent with the specific diagnostic category. For instance, in social anxiety disorder, patients frequently report distorted mental representations of themselves appearing anxious (Dobinson et al., 2020; Hackmann et al., 1998, 2000). In specific phobias, individuals report images of dangerous spiders (Pratt et al., 2004) or snakes (Hunt et al., 2006). Individuals suffering from PTSD report flashbacks of the traumatic event, such as screaming victims of a crash (Engelhard et al., 2002).

This negative mental imagery can be triggered automatically and experienced as intrusive and distressing (Berntsen & Jacobsen, 2008; Hackmann & Holmes, 2004). Individuals with social anxiety tend to retrieve relatively more negative images and memories than low socially anxious individuals (Krans et al., 2014; Moscovitch et al., 2011). Moreover, individuals with social anxiety disorder also appraised memories of adverse experiences as more distressing and intrusive than a comparison group of healthy individuals (Moscovitch et al., 2018). Negative mental imagery involves meaningful elements of related aversive memories (Hackmann & Holmes, 2004; Holmes & Mathews, 2010). For instance, many individuals with a social anxiety disorder reported an aversive memory related to the current negative self-imagery (Dobinson et al., 2020; Hackmann et al., 2000). There was overlap in both perceptual properties and meaning between the memories and the related imagery. It has been proposed that because this negative mental imagery is often related to autobiographical memories, the constructed image can similarly reinstate the same emotions as during the original experience (Holmes & Mathews, 2010).

Even though negative mental imagery is often related to aversive memories, it typically represents anticipated future threats in anxiety-related disorders (Engelhard et al., 2010, 2012; Morina et al., 2011). Mental imagery of future events is altered in psychopathology (Brunette & Schacter, 2021). That is, individuals suffering from anxiety-related disorders imagine more vivid negative future scenarios associated with higher distress and higher plausibility than healthy individuals (Morina et al., 2011; Wu et al., 2015). Likewise, they report reduced vividness for positive future events and plausibility for these events compared to healthy individuals (Morina et al., 2011). Individuals with health anxiety and obsessive-compulsive disorder also reported stronger reactions to autobiographical memories and imagined future events, such as higher negative valence and emotional intensity, than healthy individuals (Gehrt et al., 2020). Collectively, mental imagery is more negative in anxious individuals than in healthy individuals.

People use mental imagery to recall earlier experiences and recombine these to form representations of novel situations that may occur in their personal future (Schacter & Addis, 2007). Processing of information via mental imagery has a stronger impact on the subjective emotional experience than verbal processing of the same information (Holmes & Mathews, 2005; for a review see Ji et al., 2016). Mental imagery allows individuals to anticipate future events and motivates behavior to achieve long-term personal goals, which is typically adaptive (Barsics et al., 2016; Bulley et al., 2017; Miloyan & Suddendorf, 2015; Schacter et al., 2017). Crucially, this also implicates that overly negative mental imagery can be maladaptive. It has been hypothesized that negative mental imagery plays a role in the development and maintenance of anxiety-related disorders (Hackmann & Holmes, 2004), such as in cognitive models of social anxiety disorder (Clark & Wells, 1995) and PTSD (Ehlers & Clark, 2000). For instance, previous research demonstrated that when socially anxious individuals held a negative self-image in mind that was related to a previous social situation in which they experienced anxiety, compared to a neutral self-image, it increased anxiety and negative thoughts (Hirsch et al., 2003, 2004; Makkar & Grisham, 2011; Stopa & Jenkins, 2007; Vassilopoulos, 2005; for a review see Ng et al., 2014). Even in individuals without social anxiety, holding a negative self-image in mind increased anxiety relative to a neutral and positive self-image (Hirsch et al., 2006). These negative self-images are activated and elicit anxiety when socially anxious individuals anticipate or confront anxiety-provoking situations (Hirsch & Holmes, 2007). Negative mental imagery is further reinforced by the experienced physiological symptoms during the anxiety-provoking situation, such as sweating. Patients make inferences about their performance based on this mental imagery and act upon this, for instance, by focusing their attention inwards and using safety behaviors (Hirsch et al., 2004; Hirsch & Holmes, 2007; Makkar & Grisham, 2011). This prevents individuals from noticing potentially positive outcomes and further reinforces anxiety. Negative self-imagery also results in worse performance during a new social interaction (Hirsch et al., 2003, 2004; Stopa & Jenkins, 2007; Vassilopoulos, 2005) and can therefore even result in more aversive outcomes. Taken together, negative mental imagery increases anxiety, negative thoughts, and avoidance behavior.

Although the idea was already recognized in Aaron Beck's cognitive therapy, recently, it has been suggested that more focus on mental imagery during CBT is necessary to optimize treatment (e.g., Arntz, 2019; Blackwell, 2021; Hirsch & Holmes, 2007; Ji et al., 2016; Saulsman et al., 2019). Mental imagery-based interventions can modify negative mental imagery of aversive memories that fuel anticipated future threats. Alternatively, mental imagery-based interventions can aim to change mental imagery of potential future threats directly. Modifying negative mental imagery has great potential to enhance treatment for two reasons. First, modifying negative mental imagery can have a cascading effect on reducing anxiety and avoidance behavior, and it can even increase willingness and engagement with feared situations during exposure therapy and potentially reduce drop-out rates. Second, it can possibly also reduce relapse after initially successful exposure therapy because when the original threat association is retrieved after exposure therapy (i.e., CS will lead to US), the fear response (i.e., CR) can remain low if the mental representation of the US is not overly negative.

Taken together, modifying negative mental imagery can potentially improve two of the current difficulties in treating anxiety-related disorders, namely substantial drop-out rates before and during therapy and relapse after treatment. This dissertation aims to investigate whether modifying negative mental imagery can resolve these difficulties. In the remainder of this introduction, two interventions to modify negative mental imagery are discussed.

Modifying negative mental imagery

Three main evidence-based psychological interventions exist that aim to modify negative mental imagery in anxiety-related disorders, namely imaginal exposure (Foa, 2011), eye movement desensitization and reprocessing (EMDR; Shapiro, 2017), and imagery rescripting (Arntz et al., 2007). Imaginal exposure has been primarily studied in PTSD, while recently, EMDR and imagery rescripting have been studied in a range of anxiety-related disorders. The current dissertation builds on those recent insights and focuses on EMDR and imagery rescripting.

Eye movement desensitization and reprocessing

A core element of EMDR is making eye movements while simultaneously retrieving an aversive memory (de Jongh & ten Broeke, 2020; Shapiro, 2017). That is, patients typically relive an aversive memory while following the therapist's finger moving from side to side with their eyes. Although initially EMDR was received with great skepticism in the scientific community (see Engelhard, 2012), meta-analyses demonstrated that EMDR is effective to treat PTSD (Bisson et al., 2007; Cusack et al., 2016), and it is now recognized as an evidence-based and first-choice treatment for PTSD in several guidelines, along with trauma-focused CBT (e.g., National Institute for Health and Clinical Excellence, 2011). A recent meta-analysis showed that EMDR may also be effective in other anxiety-related disorders, although research on this topic is still scarce (Cuijpers et al., 2020). EMDR has been extensively studied using a laboratory model of the eye movement component (Engelhard et al., 2019). Therefore, only the eye movement component of EMDR will be discussed in this dissertation.

Previous laboratory research demonstrated that making eye movements during memory retrieval of emotional autobiographical memories (i.e., dual-task intervention) reduces the emotionality and vividness of aversive memories and anticipated future threat images, compared to mere recall of the memory (e.g., Engelhard et al., 2010; Gunter & Bodner, 2008; Kemps & Tiggemann, 2007; van den Hout et al., 2001; for meta-analyses see Houben et al., 2020; Mertens, Lund, et al., 2020). Different theories for the working mechanism of EMDR have been suggested (Andrade et al., 1997; Gunter & Bodner, 2008; van den Hout & Engelhard, 2012), but working memory theory received most support (Andrade et al., 1997; Maxfield et al., 2008; van den Hout & Engelhard, 2012; see also Engelhard et al., 2019). Working memory theory relies on the limited capacity of working memory (Baddeley, 2012). Both memory retrieval and making eye movements compete for the limited resources of working memory. As a result, the emotionality and vividness of the memory are reduced, which is typically interpreted as devaluation of the mental representation of the memory (Andrade et al., 1997; van den Hout & Engelhard, 2012).

The next critical question is whether devaluation of the mental representation of the memory (i.e., US) with a dual-task intervention would decrease fear (i.e., CR). For this purpose, previous research used fear conditioning paradigms to test whether the intervention reduced fear (CR) and return of fear after extinction learning. The dual-task intervention indeed led to a devalued US memory, while the recall only condition (i.e., without making eye movements) did not (Leer, Engelhard, Altink, et al., 2013). Importantly, it also reduced CR compared to the recall only condition (Leer, Engelhard, Altink, et al., 2013). A similar study showed that a dual-task intervention reduced fear renewal compared to a filler task and mere recall of US memory (Leer, Engelhard, Dibbets, et al., 2013). However, the US memory was equally devalued in all groups, making it difficult to interpret these findings. These previous studies used a disgusting film clip or an aversive picture as US. Yet, aversive pictures do not model the complexity of real-life experiences (Scheveneels et al., 2016). A more recent study overcame this limitation by using a fear-relevant film clip as aversive stimulus (Dibbets et al., 2018). The study showed no difference in the mental representation of the US between groups that received a dual-task intervention or extinction. These studies show preliminary evidence that a dual-task intervention may reduce the return of fear, although the findings are mixed.

Imagery rescripting

Imagery rescripting is another mental imagery-based intervention. This experiential technique aims to modulate aversive mental imagery by changing its meaning (Arntz, 2012). Imagery rescripting typically consists of three phases (Arntz & Weertman, 1999; Smucker et al., 1995; Wild & Clark, 2011). In the first phase, patients are instructed to imagine an aversive memory or image as vividly as possible, in the here and now, but from the original perspective as their younger self. In the second phase, patients are instructed to intervene in the situation as their current adult self. They can change the imagery into a more positive scenario. Also, they can ask for help from other persons (e.g., police). In the third phase, participants are again instructed to imagine the aversive memory as their younger self but are now instructed to also imagine the interventions from their adult self in the previous phase and make more changes if they desire.

Imagery rescripting is effective in a range of anxiety-related disorders, such as PTSD (Arntz et al., 2007; Grunert et al., 2007; Langkaas et al., 2017; Raabe et al., 2015), specific phobia (Hunt & Fenton, 2007), social anxiety disorder (Frets et al., 2014; Nilsson et al., 2019; Norton & Abbott, 2016; Reimer & Moscovitch, 2015; Romano et al., 2020; Wild et al., 2007, 2008), and obsessive-compulsive disorder (Maloney et al., 2019; Veale et al., 2015). Two reviews (Arntz, 2012; Strachan et al., 2020) and a meta-analysis (Morina et al., 2017) showed that imagery rescripting is an effective transdiagnostic treatment to update negative memories or images and associated distress. In addition, imagery rescripting seems less distressing for therapists (Arntz et al., 2007) and less unpleasant for patients (Kunze et al., 2017) than exposure therapy for PTSD. Because some anxiety patients are unwilling or unable to confront feared situations during exposure therapy because they find it too aversive (Benbow & Anderson, 2019; Taylor et al., 2012), imagery rescripting seems a fruitful approach to enhance exposure willingness and potentially reduce drop-out rates in other anxiety-related disorders as well.

Aims and outline of this dissertation

This dissertation aimed to investigate whether mental imagery-based interventions can enhance exposure for anxiety. This dissertation comprises six research chapters (Chapters 2-7) divided into two different parts. Part I (Chapters 2-4) examines whether a dual-task intervention attenuates return of fear after extinction learning. Part II (Chapters 5-7) focuses on whether imagery rescripting of memories and anticipated future threats enhances exposure willingness.

To examine whether mental imagery-based interventions can reduce return of fear after extinction learning, fear conditioning paradigms are used in the first part of this dissertation. Previous research often used simple stimuli as US that typically only involved one modality (e.g., aversive picture or an electrical shock), which does not model the complexity of real-life events. Therefore, a novel two-day fear conditioning paradigm, including a renewal phase, is developed using a more complex fear-relevant aversive audiovisual stimulus in **Chapter 2**. This new paradigm is used to investigate whether a prolonged dual-task intervention modifies the mental representation of the US, and more importantly, reduces renewal of fear over time (**Chapter 3**). A similar procedure using different stimuli is used to examine whether a prolonged dual-task intervention reduces return of fear and intrusive memories over time (**Chapter 4**).

To investigate whether mental imagery-based interventions can enhance exposure willingness, individuals with pre-existing anxiety symptoms are examined in the second part of this dissertation. Modifying the mental representation of aversive memories hold the potential of increasing willingness to engage in feared situations because earlier experiences influence how people anticipate novel situations. In **Chapter 5**, it is investigated whether imagery rescripting of an aversive memory changes mental imagery of a feared future social situation in individuals with social anxiety. Modifying future-oriented mental imagery is another approach to increase the willingness to engage in feared situations during treatment because mental imagery of future situations can motivate behavior. In **Chapter 6**, a standardized future-oriented positive mental imagery exercise is examined in individuals with public speaking anxiety to reduce anxiety before and during exposure and increase exposure willingness. In **Chapter 7**, imagery rescripting focused on a feared future social situation is examined in healthy individuals with some degree of social anxiety to prepare them to actually engage in the feared situation.

Finally, in **Chapter 8**, the main findings of the studies are summarized and discussed.

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Part I

Modifying negative mental imagery to reduce return of fear

Chapter 2

Renewal of conditioned fear responses using a film clip as the aversive unconditioned stimulus

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Abstract

Background and objectives. Pavlovian fear conditioning paradigms are valuable to investigate fear learning and the return of extinguished fear in the lab. However, their validity is limited, because the aversive stimuli (e.g., electric shocks) typically lack the modalities and complexity of real-world aversive experiences. To overcome this limitation, we examined fear acquisition, extinction and contextual renewal using an audiovisual unconditioned stimulus (US).
Methods. On Day 1, 50 healthy participants completed an acquisition phase in a specific context (i.e., desk or bookcase, 'context A'). Pictures of colored lamps served as conditioned stimuli and an aversive film clip was used as US. On Day 2, extinction took place in the same context ('context A') or in a different context ('context B'). Afterwards, renewal was tested in the acquisition context (AAA vs. ABA design).
Results. As hypothesized, fear acquisition and extinction, as measured by US expectancy ratings, fear potentiated startle (FPS), and skin conductance responses (SCRs), were successful. Most importantly, conditioned responding was renewed on all measures in the ABA condition, but not in the AAA condition. Differential renewal (i.e., larger renewal for CS+ than for CS-) was only observed for US expectancy ratings.
Limitations. The return of conditioned responses was non-differential for FPS and SCR.
Conclusions. The current set-up enables investigation of fear renewal using an audiovisual US. Future studies can utilize this paradigm to investigate interventions that aim to reduce fear renewal by modifying the US memory, such as eye movement desensitization and reprocessing and imagery rescripting.

Introduction

Pavlovian fear conditioning paradigms are valuable to investigate fear learning and extinction in the lab (Vervliet, Craske, et al., 2013). In these paradigms, an initially neutral stimulus (conditioned stimulus; CS) is repeatedly paired with an aversive stimulus (unconditioned stimulus; US). This usually results in conditioned fear reactions to the CS (conditioned responses; CRs). Then, during extinction training, the CS is repeatedly presented without the US, which usually results in a reduction of fear responding to the CS. Studies examining these two phenomena have provided important insights into the etiology and treatment of anxiety disorders (e.g., Vervliet, Craske, et al., 2013).

Contemporary conditioning models argue that extinction learning results in the formation of a new, inhibitory association (CS-no US; Bouton, 2002). Hence, the original CS-US association remains intact, but is suppressed by the inhibitory CS-no US association. However, this latter association is vulnerable to context changes, and under certain circumstances the original threat association (CS-US) can become dominant again. For instance, a context change after extinction can facilitate the retrieval of the CS-US memory, and as a result, fear can return ('renewal'). In clinical practice, a switch from a therapy context to a non-therapy context could result in relapse of an extinguished fear response. Therefore, fear renewal poses a major limitation to current exposure-based treatments (Bouton, 2002; Vervliet, Craske, et al., 2013).

An alternative approach to reduce fear may be to modify the fear memory (e.g., Elsey et al., 2018). There is increased recognition that anxiety patients' feared catastrophes (illness, attack, humiliation, death) often take the form of vivid mental images, not just verbal thoughts (Hackmann & Holmes, 2004; Holmes & Mathews, 2010). These are typically visual but may also occur in other sensory modalities (auditory, tactile; e.g., Ehlers et al., 2002; Engelhard et al., 2002, 2010). The ability to imagine and reflect on experiences can not only evoke fear, but also opens up the opportunity for new ways of changing threat memories in humans. Imagery modification techniques are used in the treatment of posttraumatic stress disorder to target traumatic memories (e.g., Engelhard et al., 2019; Morina et al., 2017), and they hold great promise for the treatment of other anxiety disorders. However, most conditioning experiments use electrical stimulation or white noise as US, even though these stimuli do not model the complexity and visual nature of fear memories outside the lab (Beckers et al., 2013; Scheveneels et al., 2016). Therefore, using more complex multimodal stimuli as US would improve the ecological validity of conditioning models and provide a paradigm to test whether psychological interventions that directly target emotional memory features, such as eye movement desensitization and reprocessing (EMDR; Engelhard et al., 2019) and imagery rescripting (Morina et al., 2017), can be used to attenuate renewal of fear.

Recently, several fear conditioning studies used an aversive film clip as US (e.g., Dibbets et al., 2018; Kunze et al., 2015; Leer, Engelhard, Altink, et al., 2013; Wegerer et al., 2013). These studies indicated that using such a stimulus can result in strong conditioned fear responses and these responses typically diminish after an extinction procedure. They also showed that unexpected presentation of the US after extinction results in fear reinstatement, indicating that this paradigm is suitable for examining the return of fear through this procedure (Dibbets et al., 2018; Kunze et al., 2015). However, they did not examine the return of extinguished fear after a change in external context ('context renewal'), even though this can be an important source for relapse (e.g., after a switch from the therapy to non-therapy context; Bouton, 2002; Vervliet, Craske, et al., 2013). The aim of the current study was to examine whether the context renewal effect occurs when the US is an aversive film clip. We adjusted an existing fear conditioning paradigm that is known to elicit renewal (Milad et al., 2005) by using an aversive film clip (Dibbets et al., 2018) instead of electrical shock as US. Participants underwent a two-day fear conditioning paradigm with acquisition on Day 1 (context A) and extinction on Day 2 (context A or B), followed by a test phase in the acquisition context. Based on previous results, we hypothesized that fear would be conditioned on Day 1 and would be extinguished on Day 2. Most importantly, we hypothesized that a switch in context after extinction would result in return of the conditioned fear response.

Method

Pre-registration

The design, procedure, hypotheses, data analyses, and sample size were pre-registered on the Open Science Framework prior to the data collection (https://osf.io/pzu7s/).

Participants

Fifty-one individuals participated in the study. One participant was excluded from the data analysis, because she fell asleep during the second session (condition AAA), resulting in a final sample of 50 participants (34 females, 16 males), with a mean age of 21.60 years (*SD* = 2.13 years). The sample consisted of 45 undergraduate students, 3 graduate students, and 2 non-students. Exclusion criteria were self-reported poor eyesight, color blindness, hearing difficulties, the use of medication that influenced attention and concentration, (a history of) mental problems, pregnancy and serious medical conditions (e.g., heart problems). Initially, 67 individuals were interested in participating in this study, but 16 individuals could not participate on the basis of these exclusion criteria. Thus, 51 participants started the study. Participants received course credit or a small financial compensation. All participants gave written informed consent. The Ethics Committee of the Faculty of Social Sciences of Utrecht University (FETC16-054) approved this study.

Stimuli

Contextual stimuli were two pictures that each showed a specific room with a desk or a bookcase (see Milad et al., 2005). In each of these contexts, the same lamp was present. CSs were colors (blue and yellow) of the lit lamp. Context and CS types were counterbalanced across participants. The US was a film clip (6 s) of a woman who carries a pan of boiling water in a kitchen, slips, and falls, while spilling the water on her face (see Dibbets et al., 2018). At the end of the film clip, the woman has visible burns on her face and screams loudly (volume peak: 95 dB; https://www.youtube.com/watch?v=tN2gpRcFKAQ). The clip was an ad from the workplace health and safety marketing campaign from Ontario's workers' compensation board. Earlier research showed that participants do not habituate to this US, but sensitize over trials (Dibbets et al., 2018).

Questionnaires

The State-Trait Anxiety Inventory (STAI-DY; Spielberger et al., 1983) was used to assess state (STAI-S) and trait anxiety (STAI-T). It was included to examine whether anxiety levels were similar between conditions, because anxiety levels may influence fear learning (e.g., Duits et al., 2015; Lommen et al., 2010; Lonsdorf & Merz, 2017; but see, e.g., Torrents-Rodas et al., 2013).

Outcome measures

US expectancy

Participants rated US expectancy during each CS presentation (within 7 s after CS onset) on a visual analogue scale (VAS) at the bottom of the computer screen ('Do you expect the aversive film clip to follow?') ranging from -5 (= *definitely not*) to 5 (= *definitely*), with 0 (= *uncertain*) as midpoint.

Fear potentiated startle (FPS)

Psychophysiological responses were measured with the BioSemi ActiveTwo system, recorded with the software program Actiview, and analyzed with BrainVision Analyzer. FPS was measured with electromyography (EMG) of the left orbicularis oculi muscle with two 4 mm Ag/AgCl electrodes. One electrode was positioned approximately 1 cm below the pupil and the other electrode was positioned 1 cm below the lateral canthus. Two ground electrodes were attached on the forehead. Startle probes (50 ms; 105 dB) were administered through Sennheiser HD201 headphones. According to published guidelines, the data were filtered (28-500 Hz), rectified, and filtered again (14 Hz) for smoothing (Blumenthal et al., 2005). The peak amplitude was determined in 20–150 ms following probe onset and was baseline corrected (i.e., peak amplitude minus the mean amplitude between 30 ms before to 20 ms after probe onset).

Skin conductance response (SCR)

Two 5 mm Ag/AgCl electrodes were attached to the proximal part of the palm of the left hand. Electrodes were attached approximately 1.5 cm apart. According to published guidelines, data were filtered (lowpass filter: 10 Hz; notch filter: 50 Hz; Boucsein et al., 2012). Entire interval responses were calculated by subtracting the mean baseline (2 s before CS onset) from the highest amplitude in 1-7 s after CS onset (Pineles et al., 2009).

Procedure

The acquisition and extinction phases were on two separate days to ensure consolidation of acquisition memory into long-term memory (McGaugh, 2000; Nader, 2003). The extinction phase was immediately followed by the test phase (see Figure 1). Both testing sessions took approximately 45 minutes.

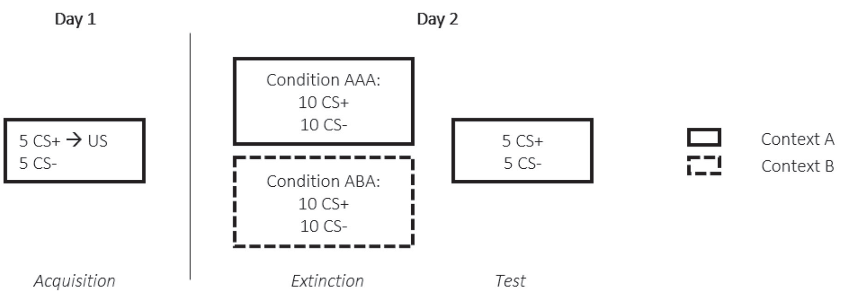

Figure 1. Overview of the experiment. The acquisition phase (Day 1) and test phase (Day 2) took place in context A. The extinction phase (Day 2) was in context A (n = 25) or B (n = 25).

Acquisition phase – Day 1

After participants gave written informed consent, they completed the STAI and screening questionnaire to ensure they had not used drugs or alcohol prior to the session. Next, electrodes were attached, and headphones were put on. Participants then read instructions on the computer screen. First, they were informed that the woman in the film clip was a sous-chef in a restaurant who would get promoted next year and would get married the following weekend. This information was provided to create context for the US (following Dibbets et al., 2018). Then, participants viewed a 10-s version of the aversive film clip (95 dB). Next, they were instructed about the CS-US contingency (following Milad et al., 2005). Ten habituation probes were used to stabilize startle reactivity. Then the acquisition phase followed, in which participants were presented each of the two CSs five times in a random order, but with no more than two consecutive presentations of the same CS. In each trial in the acquisition phase, the context picture (desk or bookcase) was presented for 14 s. Six seconds after context onset, the CS (i.e., lamp light on) was presented for 8 s within the context (as in Milad et al., 2005). Seven seconds after CS onset, the startle probe was presented. The US was presented at CS+ offset (100% reinforcement rate). Intertrial interval (ITI) was 10, 12, or 14 s and consisted of a black screen. In half of the trials, a probe was presented during the ITI and ITI duration was doubled (20, 24, or 28 s).

Extinction and test phases – Day 2

Participants entered the lab 24 h after the first testing day. Again, electrodes were attached. Participants were instructed to think back to what they had learned on the previous day (following Milad et al., 2005). Then, they received 10 habituation startle probes, followed by the extinction phase that consisted of 10 presentations of each CS in the acquisition context (condition AAA) or a new context (condition ABA). The test phase followed, in which each CS was presented five times in the acquisition context. The first CS presentation in the extinction and test phases was counterbalanced. In each phase, CS presentation was again semi-random, and timing of the trials was identical to that of Day 1. Finally, electrodes were removed, and participants indicated how aversive they found the film clip on a VAS ranging from 0 (= *not at all*) to 100 (= *definitely*).

Data analyses

Data preparation

The SCR data was range corrected to reduce individual variation and transformed with a log-transformation to reduce the skewedness of the distribution (Boucsein et al., 2012). A minimal response value of 0.02 μS was applied.[1] The FPS data was t-transformed to reduce individual variation (Blumenthal et al., 2005). For one participant, FPS data was missing on both days due to technical difficulties (ABA condition), and for one participant physiological data was missing on Day 2 (ABA condition). The available data of these two participants are included in the data analyses. The alpha level was .05 for all analyses. Cohen's *d* was used as measure of effect size for *t*-tests. When the assumption of sphericity was violated, degrees of freedom were corrected with Greenhouse-Geisser ($\varepsilon < .75$) or Huyn-Feldt ($\varepsilon > .75$).

Randomization check

STAI-S, STAI-T, and US aversiveness were compared to check for group differences on these measures using independent-samples *t*-tests.

Acquisition and extinction phase

The acquisition and extinction phases were analyzed with a 2 (Stimulus: CS+ vs. CS-) x 5 or 10 (Trial) repeated measures ANOVA on all outcome measures. The factor Condition (AAA vs. ABA) was added to investigate differences between conditions.

Renewal

Renewal was tested with a 2 (Stimulus; CS+ vs. CS-) x 2 (Trial; last extinction trial vs. first test trial) x 2 (Condition; AAA vs. ABA) interaction (Vervliet, Baeyens, et al., 2013). Separate analyses followed significant interactions.

Results

There were no differences between the conditions in STAI-S, STAI-T, and rated aversiveness of the film clip (see Table 1).

1 We explored if the quality improved by excluding participants who had an excessive number of zero and missing responses in their psychophysiological data (e.g., Sehlmeyer et al., 2009). Eight participants had to be excluded when participants with excessive zero and missing responses (more than 80% of the trials) on SCR were removed (*n* = 3 in ABA group, *n* = 5 in AAA group). The main effect of CS during the acquisition phase showed a trend ($p = .06$, $\eta_p^2 = .09$) and the three-way interaction between stimulus x trial x condition was significant ($p = .02$, $\eta_p^2 = .07$). These differences in results are probably due to a decrease in power. All other results on SCR in extinction and renewal remained the same. Therefore, we decided to report the analyses on the full sample.

Table 1. Means (*SD*) of state anxiety (STAI-S), trait anxiety (STAI-T), and US aversiveness for AAA (n = 25) and ABA (n = 25) conditions.

	AAA	ABA	*t(48)*	*p*	*d*
STAI-S	34.04 (6.56)	33.28 (4.21)	0.49	.63	0.14
STAI-T	34.88 (7.10)	37.32 (9.37)	1.04	.31	0.29
US aversiveness	68.44 (18.93)	68.84 (22.90)	0.07	.95	0.02

US expectancy ratings

Acquisition

On Day 1, acquisition of US expectancy was evidenced by a significant increase in differential responding between CS+ and CS- over the 5 acquisition trials, $F(2.30, 112.47) = 80.31$, $p < .01$, $\eta_p^2 = .62$ (stimulus x trial; see Figure 2). The conditions did not differ in acquisition of US expectancy, $F(2.29, 109.85) = 0.45$, $p = .67$, $\eta_p^2 = .01$ (stimulus x trial x condition). All participants were aware of the contingencies at the end of the acquisition phase (US expectancy difference CS+ vs. CS- ≥ 6.90).

2

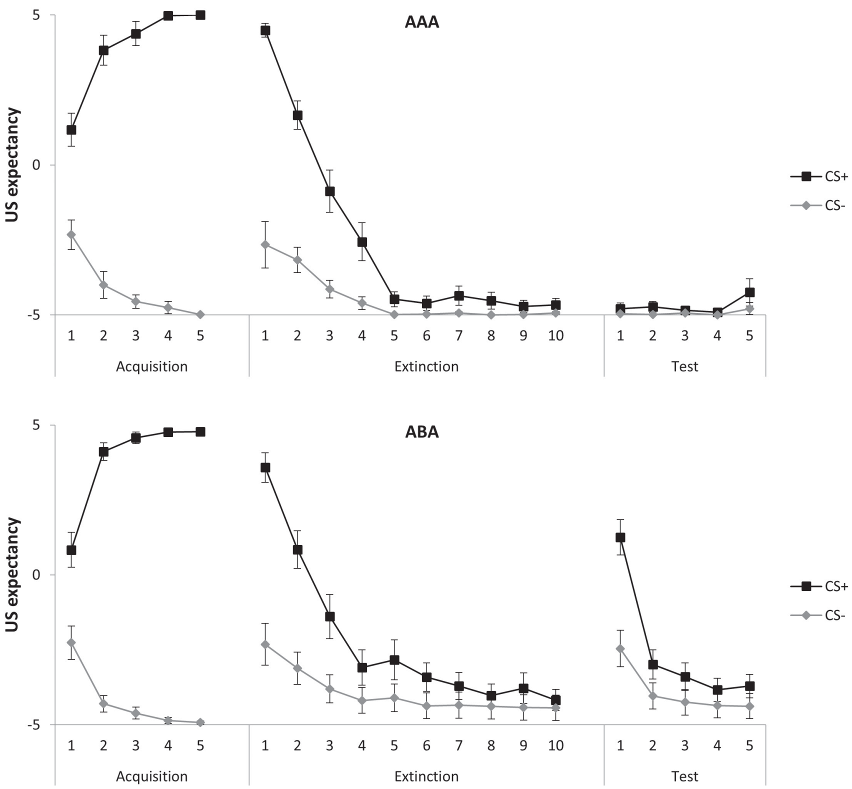

Figure 2. US expectancy on acquisition, extinction, and test phase of the experiment in the AAA (n = 25) and ABA (n = 25) conditions. Error bars represent standard error of the mean (SEM).

Extinction

Extinction of US expectancy ratings was demonstrated by a decrease in differential US expectancy ratings (CS+ vs. CS-) over the course of extinction trials, $F(3.35, 163.97) = 39.40$, $p < .01$, $\eta_p^2 = .45$ (stimulus x trial). At the first extinction trial, ratings for the CS+ were higher than for the CS-, $t(49) = 9.55$, $p < .01$, $d = 1.35$, while the scores did not differ at the last extinction trial, $t(49) = 0.90$, $p = .37$, $d = 0.13$. There was no difference in extinction learning between the conditions, $F(3.35, 160.73) = 1.14$, $p = .34$, $\eta_p^2 = .02$ (stimulus x trial x condition).

Renewal

There was a difference between the conditions in US expectancy ratings (CS+ vs. CS-) from the last trial of extinction to the first test trial, $F(1, 48) = 15.87$, $p < .01$, $\eta_p^2 = .25$ (stimulus x trial x condition). In line with our expectations, differential US expectancy increased for the ABA condition from the last trial of extinction to the first test trial, $F(1, 24) = 15.97$, $p < .01$, $\eta_p^2 = .40$ (stimulus x trial). In contrast, renewal was not observed in condition AAA, $F(1, 24) = 0.20$, $p = .66$, $\eta_p^2 = .01$ (stimulus x trial). In the ABA group, there was no difference between CS+ and CS- ratings at the end of extinction, $t(24) = 0.48$, $p = .64$, $d = 0.10$, while ratings were higher for the CS+ than CS- at the first test trial, $t(24) = 3.70$, $p < .01$, $d = 0.74$. In the AAA group, CS+ and CS- ratings did not differ at the end of extinction, $t(24) = 1.12$, $p = .28$, $d = 0.16$, or the first test trial, $t(24) = 0.89$, $p = .39$, $d = 0.18$. In summary, these results indicate a greater return of US expectancy for the threatening stimulus (CS+) compared to the control stimulus (CS-) in the ABA condition, but not in the AAA condition.

Fear potentiated startle

Acquisition[2,3]

There was no differential increase over the 5 acquisition trials, $F(8, 384) = 0.71$, $p = .69$, $\eta_p^2 = .01$ (stimulus x trial), but we did observe a main effect of stimulus, $F(2, 96) = 31.85$, $p < .01$, $\eta_p^2 = .40$ (see Figure 3). The mean score for CS+ ($M = 53.18$, $SD = 5.31$) was higher than the mean CS- score ($M = 49.63$, $SD = 4.74$), $t(48) = 4.19$, $p < .01$, $d = 0.60$, and the mean ITI score ($M = 46.94$, $SD = 3.18$), $t(48) = 7.37$, $p < .01$, $d = 1.05$. The mean CS- score was higher than the mean ITI score, $t(48) = 4.20$, $p < .01$, $d = 0.60$. A significant main effect of CS indicates successful acquisition (i.e., larger startle responses for CS+ than CS-). The conditions did not differ in acquisition of startle responses, $F(8, 376) = 1.76$, $p = .08$, $\eta_p^2 = .04$ (stimulus x trial x condition) and $F(2, 94) = 0.24$, $p = .79$, $\eta_p^2 = .01$ (stimulus x condition).

Extinction

2

The interaction between stimulus and trial was not significant, $F(11.71, 550.23) = 1.38$, $p = .18$, $\eta_p^2 = .03$. Startle responses decreased over time, $F(5.72, 269.02) = 28.29$, $p < .01$, $\eta_p^2 = .38$ (main effect trial). There was also a main effect of stimulus, $F(2, 94) = 16.99$, $p < .01$, $\eta_p^2 = .27$. The mean score for the CS+ ($M = 49.25$, $SD = 2.68$) was higher than the CS- mean score ($M = 48.17$, $SD = 3.36$), $t(48) = 2.28$, $p = .03$, $d = 0.33$, and both the mean CS+ score and the mean CS- score were higher than the mean ITI score ($M = 46.55$, $SD = 2.32$), $t(48) = 5.14$, $p < .01$, $d = 0.73$ and $t(48) = 2.73$, $p < .01$, $d = 0.39$ respectively. Conditions did not differ in extinction, $F(11.51, 529.43) = 0.97$, $p = .48$, $\eta_p^2 = .02$ (stimulus x trial x condition) and $F(2, 92) = 0.02$, $p = .98$, $\eta_p^2 = .00$ (stimulus x condition).

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2 We have visually inspected all FPS data. When we classified responses that showed artefacts as missing (3.7 % of all values) and classified non-responses as zero (5.1% of all values), the graphs and data analyses did not differ from the analyses on the full sample. We also used an alternative approach to classify non-responses as smaller than twice the baseline amplitude (11% of all values). With this approach, the graphs and data analyses again did not differ from the analyses on the full sample. However, because missing data are problematic for ANOVAs (i.e., due to listwise exclusion), we decided to report the data analyses on the full dataset (these alternative analyses and graphs are included in the supplemental materials).

3 We have also analyzed the data separately for individuals that displayed differential acquisition on the psychophysiology measures (higher CS+ responding than CS- responding on the last acquisition trial). The graphs and data analyses remained mostly the same to the analyses on the full sample (these additional analyses and graphs on both FPS and SCR are included in the supplemental materials).

Renewal

There was no evidence for a specific renewal effect, $F(1.82, 83.91) = 0.75$, $p = .46$, $\eta_p^2 = .02$ (stimulus x trial x condition), but the conditions differed in responding over trials, $F(1, 46) = 12.23$, $p < .01$, $\eta_p^2 = .21$ (trial x condition). Analyses for each condition separately showed a non-differential renewal effect. That is, in the ABA condition, there was a return of startle responding from the last extinction trial to the first test trial, $F(1, 22) = 16.59$, $p < .01$, $\eta_p^2 = .43$ (main effect trial). In contrast, the AAA condition showed no return of startle responding, $F(1, 24) = 0.00$, $p = .96$, $\eta_p^2 = .00$ (main effect trial). This implies that the return of non-differential startle responses in the ABA condition was due to the context switch and not to the passage of time.

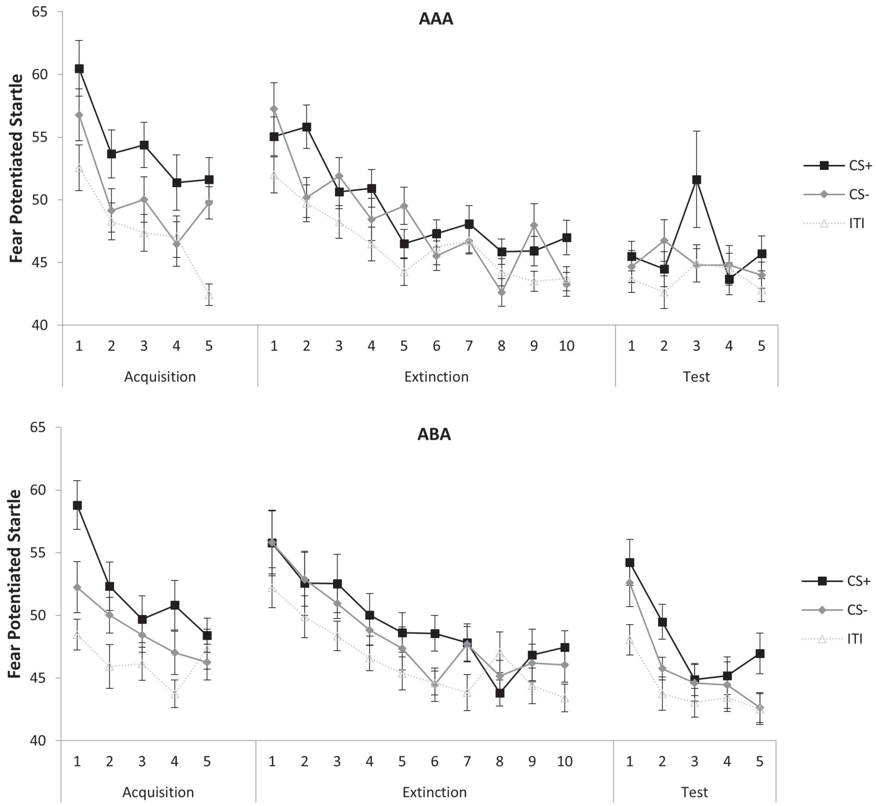

Figure 3. Fear potentiated startle response on acquisition, extinction, and test phase of the experiment in AAA (n = 25) and ABA (n = 24) conditions. Error bars represent SEM.

Skin conductance response

Acquisition

There was no differential increase over the 5 trials of acquisition, *F*(4, 196) = 0.21, *p* = .93, η_p^2 = .00 (stimulus x trial), but there was overall higher responding to the CS+ compared to the CS-, *F*(1, 49) = 7.34, *p* < .01, η_p^2 = .13 (main effect stimulus; see Figure 4). This indicates successful acquisition. This was similar across conditions, *F*(4, 192) = 2.23, *p* = .07, η_p^2 = .04 (stimulus x trial x condition) and *F*(1, 48) = 0.00, *p* = .97, η_p^2 = .00 (stimulus x condition).

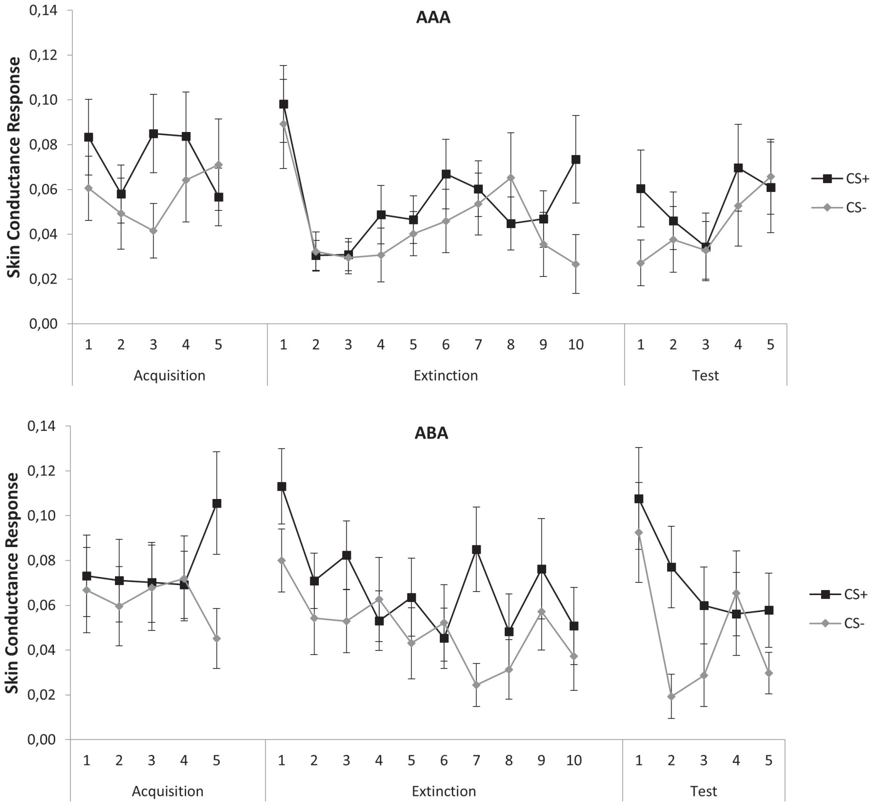

Figure 4. Skin conductance response (SCR) on acquisition, extinction, and test phase during CS presentation in AAA (*n* = 25) and ABA (*n* = 25) conditions. Error bars represent SEM.

Extinction

Similar to results for FPS, the interaction between stimulus and trial was not significant, *F*(6.63, 318.13) = 0.71, *p* = .65, η_p^2 = .02. SCRs to both the CS+ and CS- decreased over time, *F*(8.01, 384.62) = 4.18, *p* < .01, η_p^2 = .08 (main effect trial), but SCR was overall higher for the CS+ than CS-, *F*(1, 48) = 9.00, *p* < .01, η_p^2 = .16 (main effect stimulus). The conditions did not differ in extinction, $F(6.61, 310.82) = 1.29$, $p = .26$, $\eta_p^2 = .03$ (stimulus x trial x condition) and $F(1, 47) = 0.91$, $p = .35$, $\eta_p^2 = .02$ (stimulus x condition).

Renewal

There was no overall renewal effect, $F(1, 47) = 0.13$, $p = .72$, $\eta_p^2 = .00$ (stimulus x trial x condition), but conditions differed in responding over trials (last trial of extinction to first test trial), $F(1, 47) = 8.41$, $p < .01$, $\eta_p^2 = .15$ (trial x condition). Analyses for each condition separately showed a renewal effect. In the ABA condition, there was a return of SCR from the last extinction trial to the first test trial, $F(1, 23) = 8.34$, $p < .01$, $\eta_p^2 = .27$ (main effect trial). In contrast, in the AAA condition, there was no return of SCR, $F(1, 24) = 0.41$, $p = .53$, $\eta_p^2 = .02$ (main effect trial). Therefore, the context switch resulted in a non-differential return of SCR in the ABA condition only. However, in the AAA condition there was overall higher responding to the CS+ than to the CS- in SCR, $F(1, 24) = 8.13$, $p < .01$, $\eta_p^2 = .25$ (main effect stimulus), suggesting that SCR to the CS+ was not entirely extinguished.

Discussion

Taken together, our study demonstrates that conditioned acquisition, extinction, and, crucially, renewal of conditioned responses can be achieved using an audiovisual US (i.e., aversive film clip). The main finding was that in the ABA condition, a return to the original acquisition context after extinction resulted in a return of conditioned responses, whereas in the AAA condition (in which there was no context switch after extinction) conditioned responses remained low. Higher conditioned responses in the ABA condition were evidenced by increased US expectancy ratings, FPS, and SCR, thereby confirming our hypothesis with different response systems. However, the crucial test for renewal should consider the interaction between condition, time, and stimulus type (Vervliet, Baeyens, et al., 2013). In the current study, only an increase in differential responding for the US expectancy ratings was identified, while for FPS and SCR the increase in the ABA condition was non-differential. This demonstrates that conditioned responses for both threat and safety stimuli were increased in the ABA condition. Therefore, the return of conditioned responses was not only due to the CS+, but also due to general context effects that elevated fear in general (Vervliet, Baeyens, et al., 2013).

Findings for acquisition and extinction of conditioned responses are consistent with previous studies demonstrating that audiovisual stimuli can be used as US in conditioning paradigms (Dibbets et al., 2018; Kunze et al., 2015; Leer, Engelhard, Altink, et al., 2013;

Wegerer et al., 2013), and extends earlier studies by showing that it can be used to study the context renewal effect. Using an audiovisual US instead of electrical stimulation can improve the external validity of conditioning models (Scheveneels et al., 2016).

The fact that we were able to observe renewal of conditioned responses with our paradigm opens up an important area of investigation. As mentioned previously, an important challenge for exposure and other therapies is to counter relapse after successful therapy. This may require a change of patients' aversive (and appetitive) memories (e.g., Elsey et al., 2018). Such memories can represent vivid mental images of past or future threat events (e.g., see Engelhard et al., 2010; Hackmann & Holmes, 2004; Holmes & Mathews, 2010). Our renewal paradigm can be utilized to investigate whether mental imagery-based interventions that weaken such memories, such as EMDR therapy (e.g., Engelhard et al., 2019) and imagery rescripting (Morina et al., 2017), can counter renewal of conditioned responses.

Several limitations of our study should be acknowledged. First, acquisition was not as clearly visible for the psychophysiological measures as it was for US expectancy. Acquisition on SCR and FPS was only evidenced by a main effect of stimulus type instead of an interaction between time and stimulus. Several explanations can account for this difference. First, this observation could be explained by the fact that participants were instructed beforehand that only one CS would be followed by a US (e.g., Dawson & Biferno, 1973; Mertens et al., 2016). After the first trial of acquisition, differential responding to stimulus type was immediately present, which could account for the absence of an interaction effect. Indeed, this pattern during acquisition has been found in previous studies with comparable instructions (e.g., Leer, Engelhard, Dibbets, et al., 2013; Wegerer et al., 2013). Another possibility is that not all outcome variables measure the same construct. For instance, it is suggested that SCR and FPS measure arousal and fear respectively (e.g., Boucsein et al., 2012; Kindt & Soeter, 2013), while US expectancy measures contingency awareness (Soeter & Kindt, 2010). However, other researchers have argued that these different measures form an integrated response (Fanselow & Pennington, 2018). This is further evidenced by the substantial correlations between the outcome measures (Dawson & Furedy, 1976; Mertens et al., 2018; Sjouwerman et al., 2017). The absence of strong acquisition for the psychophysiological measures may reflect the lower reliability of these measures (Ney et al., 2018), rather than them reflecting different constructs (for a similar argument in the context of different memory systems see Shanks & Berry, 2012). Another interpretation for the absence of clear differential conditioning on the psychophysiological measures is that an audiovisual US may not be robust to induce differential conditioning on these measures. One study demonstrated that not all USs are equally effective to induce differential fear learning. Startle responses to a conditioning task with a shock were larger than to a scream (Glenn et al., 2012). However, other studies suggest that an unpleasant sound was equally effective to an aversive shock to produce differential fear conditioning (Neumann & Waters, 2006) or even more effective (Sperl et al., 2016). The possibility exists that our audiovisual US was not as effective as an aversive shock. A direct comparison between the USs is warranted to draw further conclusions on this matter.

A second limitation of the study is that the return of conditioned responses on SCR and FPS was non-differential (i.e., evident for both the threat and safety stimuli). It seems that for the ABA condition, both the CS and contextual cues became associated with the US. It is possible that participants in this condition interpreted contextual cues as a CS, because the context was not presented during ITIs (see Milad et al., 2005). Therefore, return to the original context might have increased arousal in general (see increases in ITI startle responses in Figure 3). We suggest that future studies replace the black screen during the ITI with the context picture. Nonetheless, previous research has demonstrated that non-differential return of conditioned responses is not uncommon, even in procedures not involving a context switch (i.e., reinstatement; Haaker et al., 2014). Furthermore, in our study, the return of conditioned responses was differential on US expectancy, which is a valid measure for understanding fear (Boddez et al., 2013). Finally, many participants were non-responders on SCR. When they were excluded from the analyses, the acquisition on SCR showed only a trend towards higher CS+ responding than CS-, which might be due to reduced statistical power. Also, without non-responders the two conditions differed in acquisition on SCR, indicating that acquisition on SCR was suboptimal. Even though acquisition differed between conditions when participants with an excessive number of non-responses were excluded, the results on extinction and renewal remained the same. This indicates that a context switch following extinction did renew conditioned responses on SCR.

In conclusion, this study demonstrates return of fear after conditioning with an aversive film clip. Building on earlier work by Milad et al. (2005) and Dibbets et al. (2018), we validated a conditioning paradigm with an audiovisual US to study renewal of conditioned responding. A return of conditioned responses was demonstrated upon a context switch after the extinction phase on both subjective and physiological measures. Future studies may use this paradigm to investigate whether interventions that aim to modify vivid emotional memories can be used to attenuate fear renewal.

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Supplemental materials

Screening non-responses in fear potentiated startle (FPS)

Many different approaches exist to screen non-responses in FPS data, such as visual inspection or using a minimum response criterion. In the manuscript, we presented the data on the full sample, because missing data are problematic for ANOVAs (i.e., due to list-wise exclusion of entries with missing data). Moreover, identifying non-responses can be subjective and therefore in our pre-registration we gave preference to automated data extraction. However, below we present test statistics and graphs for FPS using visual inspection and using a minimum response criterion to give more insight into the data. The different approaches result in similar outcomes as analyses on the full sample.

Identifying artefacts and non-responses with visual inspection

We have visually inspected all data points on FPS and removed responses that had artefacts (e.g., spontaneous blinks) during baseline (i.e., missing values; 3.7% of all data). In addition, we have set all responses that did not reflect a startle response to zero (5.1% of all values). After removing artefacts and screening for non-responses, the graph and the results of the data analyses remain highly comparable to the results presented in the manuscript on the full sample (see Table S1 and Figure S1).

Table S1. Test statistics for fear potentiated startle (FPS) after identifying artefacts and non-responses with visual inspection.

		df	*F*	*p*	η_p^2
Acquisition	**Stimulus**	**2, 50**	**24.33**	**< .01**	**.49**
	Trial	**4, 100**	**10.57**	**< .01**	**.30**
	Stimulus x Trial	8, 200	0.53	.83	.02
	Stimulus x Trial x Condition	8, 192	0.85	.56	.03
Extinction	**Stimulus**	**2, 50**	**13.55**	**< .01**	**.35**
	Trial	**5.34, 133.47**	**19.92**	**< .01**	**.44**
	Stimulus x Trial	8.66, 216.52	1.21	.29	.05
	Stimulus x Trial x Condition	8.52, 204.50	0.76	.65	.03
Renewal	**Trial x Condition**	**1, 37**	**7.10**	**.01**	**.16**
	Stimulus x Trial x Condition	2, 74	0.95	.39	.03
	ABA: Trial	**1, 19**	**11.35**	**< .01**	**.37**
	AAA: Trial	1, 18	0.69	.42	.04

2

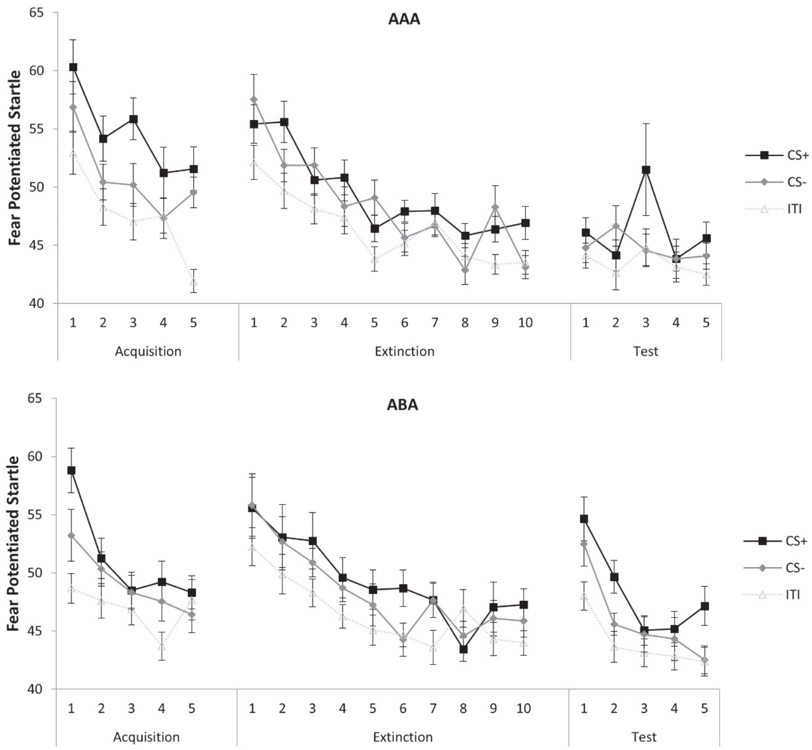

Figure S1. Fear potentiated startle (FPS) on acquisition, extinction, and test phase during CS presentation in AAA (*n* = 25) and ABA (*n* = 24) conditions after visual inspection (classifying missing data and non-responses). Error bars represent standard error of the mean (SEM).

Identifying non-responses with minimum response criterion

We have also classified the non-responses using a minimum response criterion. Non-responses were identified when data responses in the response window were smaller than twice the peak during baseline. After setting the non-responses to zero (11% of all values), the graph and the results of the data analyses remain the same to the results presented in the manuscript on the full sample (see Table S2 and Figure S2).

Table S2. Test statistics for fear potentiated startle (FPS) after identifying non-responses based on minimum response criterion.

		df	*F*	*p*	η_p^2
Acquisition	**Stimulus**	**2, 96**	**30.59**	**< .01**	**.39**
	Trial	**3.40, 163.32**	**16.41**	**< .01**	**.26**
	Stimulus x Trial	8, 384	0.75	.65	.02
	Stimulus x Trial x Condition	7.49, 351.91	1.67	.11	.03
Extinction	**Stimulus**	**2, 94**	**14.25**	**< .01**	**.23**
	Trial	**5.39, 253.22**	**22.32**	**< .01**	**.32**
	Stimulus x Trial	11.11, 522.32	1.27	.24	.03
	Stimulus x Trial x Condition	10.90, 501.25	0.98	.46	.02
Renewal	**Trial x Condition**	**1, 46**	**14.17**	**< .01**	**.24**
	Stimulus x Trial x Condition	2, 92	0.40	.67	.01
	ABA: Trial	**1, 22**	**16.12**	**< .01**	**.42**
	AAA: Trial	1, 24	0.33	.57	.01

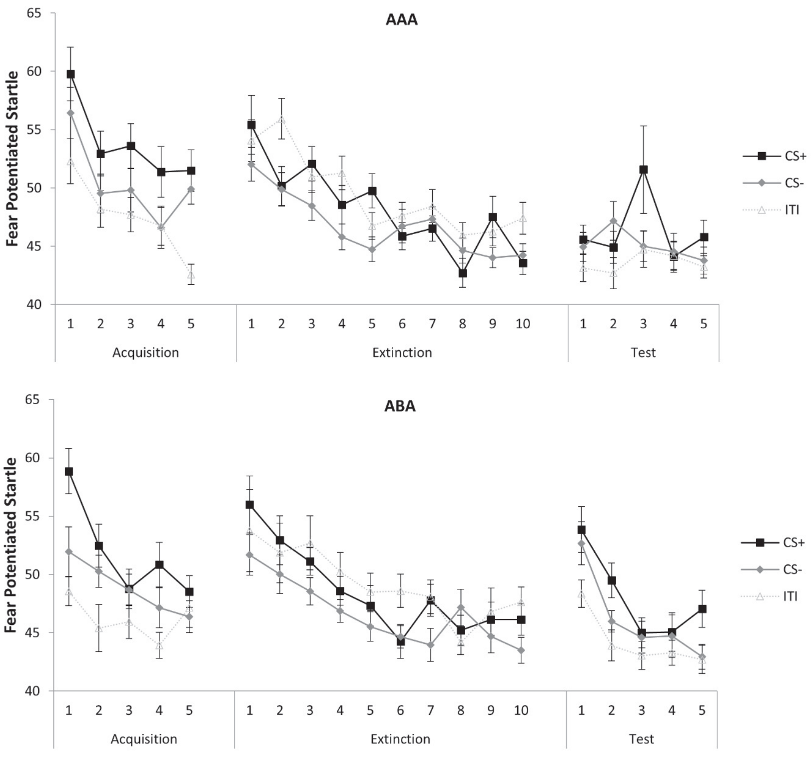

Figure S2. Fear potentiated startle (FPS) response on acquisition, extinction, and test phase of the experiment in AAA (n = 25) and ABA (n = 24) conditions after identifying non-responses based on a minimum response criterion. Error bars represent SEM.

Differential acquisition on psychophysiological measures

In the manuscript, we presented the results on the full dataset. However, not all participants demonstrated clear differential acquisition on the psychophysiological measures (higher CS+ responding than CS- responding on the last trial of acquisition). Here, we present the test statistics and graphs when selecting participants who demonstrated differential acquisition on the last acquisition trial on the psychophysiological measures to give more insight in the potency of the current paradigm to elicit conditioned responses.

Fear potentiated startle (FPS)

When we removed the participants who did not show differential learning on the last trial of acquisition on FPS, the results on FPS (n = 33) remained the same as the results on the full sample presented in the manuscript (see Table S3 and Figure S3). The only difference compared to the full sample is that now the Stimulus x Trial interaction on acquisition became significant. This makes sense, considering that only individuals who displayed differential learning were now included.

Table S3. Test statistics for fear potentiated startle (FPS) for participants displaying differential acquisition on last acquisition trial.

		df	*F*	*p*	η_p^2
Acquisition	**Stimulus**	**2, 64**	**35.76**	**< .01**	**.53**
	Trial	**4, 128**	**11.24**	**< .01**	**.26**
	Stimulus x Trial	**8, 256**	**2.75**	**.01**	**.08**
	Stimulus x Trial x Condition	8, 248	1.73	.09	.05
Extinction	**Stimulus**	**2, 64**	**10.45**	**< .01**	**.25**
	Trial	**5.69, 181.92**	**17.53**	**< .01**	**.35**
	Stimulus x Trial	10.35, 331.02	1.41	.17	.04
	Stimulus x Trial x Condition	10.02, 310.62	0.88	.56	.03
Renewal	**Trial x Condition**	**1, 31**	**7.87**	**<.01**	**.20**
	Stimulus x Trial x Condition	2, 62	0.21	.81	.01
	ABA: Trial	**1, 16**	**8.12**	**.01**	**.34**
	AAA: Trial	1, 15	0.45	.51	.03

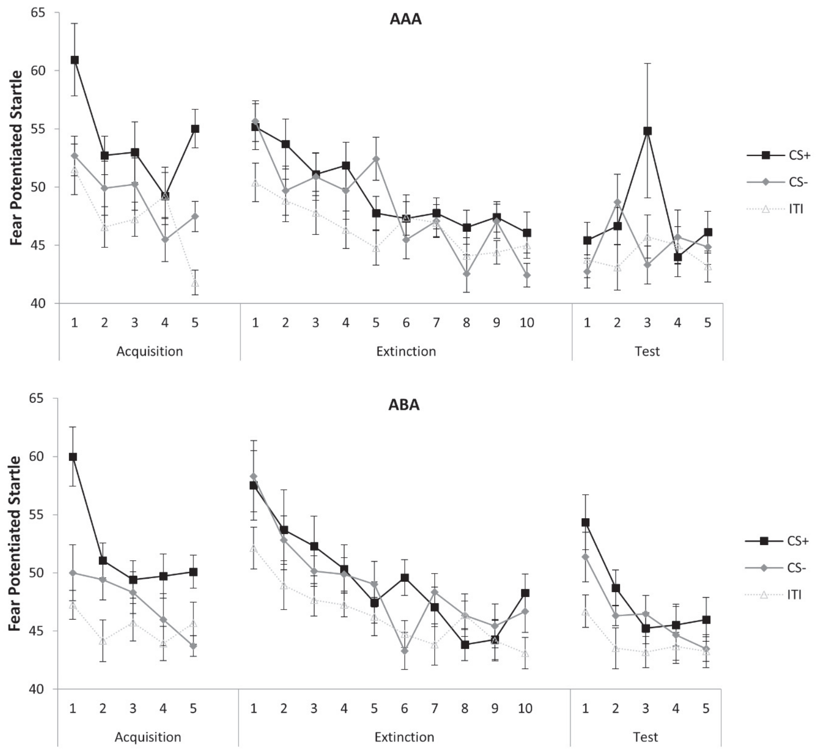

Figure S3. Fear potentiated startle (FPS) on acquisition, extinction, and test phase during CS presentation in AAA (*n* = 16) and ABA (*n* = 17) conditions for individuals who showed differential fear acquisition on last FPS trial in acquisition. Error bars represent SEM.

Skin conductance response (SCR)

When we removed the participants who did not show differential learning on the last trial of acquisition on SCR, the results remained mostly the same (*n* = 23; see Table S4 and Figure S4). One difference compared to the full sample is that now the Stimulus x Trial interaction on acquisition became significant. Again, this makes sense, considering that only individuals who displayed differential learning were now included. Another difference compared to the full sample is that now the non-differential renewal effect did not reach significance in the ABA group, but the effect size remained large. The considerable reduction of the sample size can explain the lack of statistical significance.

Table S4. Test statistics for skin conductance response (SCR) for participants displaying differential acquisition on last acquisition trial.

		df	*F*	*p*	η_p^2
Acquisition	**Stimulus**	**1, 22**	**10.49**	**< .01**	**.32**
	Trial	4, 88	1.40	.24	.06
	Stimulus x Trial	**4, 88**	**4.21**	**< .01**	**.16**
	Stimulus x Trial x Condition	4, 84	1.34	.26	.06
Extinction	Stimulus	1, 21	3.03	.10	.13
	Trial	**5.54, 116.26**	**2.00**	**.04**	**.09**
	Stimulus x Trial	5.22, 109.67	1.31	.26	.06
	Stimulus x Trial x Condition	9, 180	1.18	.31	.06
Renewal	**Trial x Condition**	**1, 20**	**4.36**	**.05**	**.18**
	Stimulus x Trial x Condition	1, 20	0.81	.38	.04
	ABA: Trial	1, 9	2.14	.18	.19
	AAA: Trial	1, 11	2.24	.16	.17

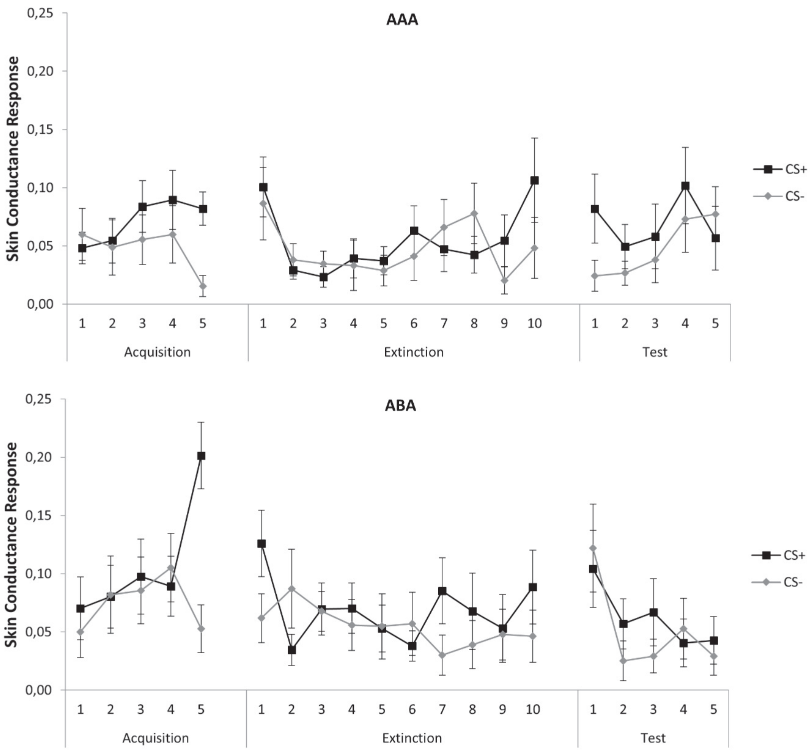

Figure S4. Skin conductance response (SCR) on acquisition, extinction, and test phase during CS presentation in AAA (*n* = 12) and ABA (*n* = 11) conditions for individuals who showed differential fear acquisition on last SCR trial in acquisition. Error bars represent SEM.

Chapter 3

Devaluation of threat memory using a dual-task intervention does not reduce context renewal of fear

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Abstract

Many patients who benefit from exposure-based therapy for anxiety disorders fail to maintain their gains. Learned fear may return when they encounter phobic stimuli in a different context than the one in which extinction occurred. In the current pre-registered experiment, we tested whether threat memory devaluation reduces context renewal of fear. A dual-task intervention was used to devalue threat memory. During this intervention, individuals recall the threat memory while simultaneously performing a demanding secondary task (e.g., making eye movements). On Day 1, participants (*N* = 75) underwent fear acquisition with an aversive film clip in context A. On Day 2, 25 participants were assigned to each group, namely a dual-task group, or one of two control groups: recall only task (without the dual-task) or no intervention. Afterwards, all participants underwent extinction training in context B and were then exposed to context A again in a test phase. The dual-task intervention effectively degraded threat memory compared to no intervention, but the recall only intervention was also partly effective. However, all three groups showed comparable fear renewal on subjective and physiological measures. This indicates that threat memory devaluation was not effective to prevent context renewal.

Introduction

Cognitive behavioral therapy (CBT) is the treatment of choice for anxiety disorders (National Institute for Health and Clinical Excellence, 2011). However, many patients who benefit from it fail to maintain their gains (e.g., McNally, 2007). Fear conditioning theory is useful to explain the extinction and return of fear (e.g., Mineka & Zinbarg, 2006; Vervliet, Craske, et al., 2013). After repeated exposure to feared stimuli without the occurrence of the expected threat, fear is typically extinghuised. According to the inhibitory learning model, extinction training involves learning of new safety associations that inhibit threat associations. However, this inhibition is fragile: under certain conditions, such as a passage of time ('spontaneous recovery') or a change in context ('renewal'), extinguished fear may return (Bouton, 2002; Craske, 2015; Craske et al., 2014). A context change indicates a different context than the one in which fear was extinguished (e.g., non-therapy setting vs. therapy setting).

A potential approach to diminish learned fear more permanently is by devaluing the threat memory itself. That is, learned fear results not only from threat expectancy (which is targeted by exposure in vivo), but also from the intensity of the threat memory ("threat intensity"; Davey, 1997; Vervliet, Craske, et al., 2013). Threat intensity may relate to idiosyncratic memories of past events and to imagined future threat events (e.g., Engelhard et al., 2010; Holmes & Mathews, 2010). A stimulus that signals a high expectancy of intense threat will elicit strong fear; a low expectancy and/or weak threat will elicit less fear (Vervliet, Craske, et al., 2013). An important implication of the memory devaluation approach is that even after a context switch, when threat expectancy may be high again, fear responses can remain low when threat intensity is devalued. Laboratory studies have indeed shown that an increase or a decrease of threat intensity can increase or decrease conditioned fear, respectively (Hosoba et al., 2001). Likewise, habituation decreases the perceived intensity of threat and reduces context renewal of conditioned fear (Haesen & Vervliet, 2015; Leer et al., 2018).

In these studies, the *actual* threat stimulus was used during the devaluation procedure. Regarding potential therapeutic applications, it is more fruitful to manipulate the *mental representation* of threat. Mental images and memories of threat can occur in any sensory modality but are typically visual (e.g., Ehlers et al., 2002; Engelhard et al., 2002, 2010). Imagery-based treatments to modulate them are imaginal exposure, imagery rescripting, and eye movement desensitization and reprocessing (EMDR), which are effective treatments for trauma-related disorders (Arntz, 2012; Bisson et al., 2007; Powers et al., 2010).

Several studies have examined whether these methods devalue threat memories in the laboratory and can be used to reduce the return of fear. Specifically, imagery rescripting aims to alter a threat memory through imagination of a more neutral or positive ending and targets reappraisal (Morina et al., 2017). Research has indicated that adding imagery rescripting to extinction training, compared to extinction training alone, attenuates renewal of threat expectancy (Dibbets et al., 2012). Likewise, EMDR may deflate threat memory by recalling the threat memory while performing a demanding dual-task (e.g., making bilateral eye movements) simultaneously (Engelhard et al., 2019). Several fear conditioning studies found that this dual-task approach decreases conditioned fear responses. First, a dual-task intervention, compared to merely recalling the memory (which serves to control for the imaginal exposure component; Powers et al., 2010), reduced conditioned subjective fear but not psychophysiological responses (Leer, Engelhard, Altink, et al., 2013). Second, a dual-task intervention reduced renewal of threat expectancy, compared to a filler task (no intervention) or mere recall of threat memory, but there was no evidence for threat devaluation (Leer, Engelhard, Dibbets, et al., 2013). Finally, dual-tasking or imagery rescripting interventions did not devalue threat memory and did not reduce threat expectancy, compared to extinction training (Dibbets et al., 2018).

In summary, laboratory studies have examined whether mental imagery-based procedures focusing on threat devaluation reduce fear, but the evidence is mixed, and it is unclear whether these interventions can prevent the return of fear. The current study examined whether a dual-task intervention before extinction training reduces fear renewal. This study differs from the above-mentioned experiments in several ways. First, they used a disgusting film clip (Leer, Engelhard, Altink, et al., 2013) or aversive picture (Leer, Engelhard, Dibbets, et al., 2013) as threatening stimulus. Aversive pictures do not entail the complexity of real-world experiences (Scheveneels et al., 2016). Therefore, the current study used a fear-relevant audiovisual aversive stimulus showing a traumatic scene (see Dibbets et al., 2018; Landkroon et al., 2019). Second, previous studies presented acquisition and intervention phases on the same day, so the intervention may have interfered with the consolidation process instead of with the threat memory (McGaugh, 2000). To prevent this possibility, we used a two-day paradigm and presented the acquisition and intervention phases on separate days. Third, previous research used a visual filler task as 'no intervention' control group, which also reduced intensity of threat memory (Leer, Engelhard, Dibbets, et al., 2013). A filler task might work as dual-task, which is why the current study used a 'no task' control group instead. Finally, in earlier studies, the threat devaluation intervention followed the extinction phase. However, in clinical practice, drop-out in CBT is a major problem (Fernandez et al., 2015). Devaluing threat memory before exposure might increase the willingness of patients to start exposure therapy. Therefore, in the current study, the intervention preceded the extinction phase.

A two-day fear conditioning paradigm (Landkroon et al., 2019) was used in which context was manipulated to elicit fear renewal. On Day 1, fear acquisition took place in context A. On Day 2, participants were randomly allocated to one of three groups (dual-task, recall only task, or no task), before extinction took place in context B. Afterwards, renewal was tested in context A. We hypothesized that the dual-task and recall only task groups, relative to the 'no task' group, would show reduced unpleasantness and vividness of threat memory and that the dual-task group would show stronger reductions than the recall only group. Moreover, we hypothesized that the dual-task and recall only task groups, relative to the 'no task' group, would show reduced fear on the first extinction trial and after a context switch on conditioned responses. Research has shown that prolonged recall of an aversive memory can lead to a reduction of vividness and emotionality in the lab (van Veen et al., 2020), which is consistent with the efficacy of imaginal exposure treatment for posttraumatic stress disorder (Powers et al., 2010). Therefore, we also considered the possibility of reduced fear on the first extinction trial and reduced renewal in the recall only group.

Method

Pre-registration

The hypotheses, sample size, methods, and data-analysis steps of this study were pre-registered on the Open Science Framework prior to finishing data collection (https://osf.io/aCS-k/).

Participants

We recruited 84 participants at the campus of Utrecht University. Exclusion criteria were: self-reported (past or current) mental health problems or a serious medical condition, color blindness, hearing/eye sight difficulties, pregnancy, and medication that influences attention, memory, and concentration. Nine participants were excluded prior to data analyses for the following reasons. One was excluded due to equipment failure. Two were excluded, because they showed no differential learning on threat expectancy (i.e., higher unconditioned stimulus [US] expectancy ratings for conditioned stimulus [CS]+ than CS- at the end of the acquisition phase; see our pre-registration). Four participants quit the experiment on Day 1 because they found the US too aversive. Two participants did not complete the second day of testing, because they found the US too aversive or felt ill. The final sample consisted of 75 participants (17 male/58 female; M_{age} = 20.96, SD_{age} = 2.53). Sixty-nine were students (60 undergraduate, 9 graduate). Participation was compensated with course credit or money. All participants gave written informed consent. The Ethics Committee of the Faculty of Social Sciences of Utrecht University approved this study (FETC16-054).

Stimuli

A validated paradigm to induce renewal with an audiovisual US was used (Landkroon et al., 2019), which was based on work by Milad et al. (2005) and Dibbets et al. (2018). Pictures of two different rooms were used as context, in which the same lamp was present. CSs were light colors of the lamp (blue and yellow). The US was an aversive film clip (6 s), that depicts a woman falling down in a kitchen, spilling boiling water on her face, and screaming (volume peak: 95 dB). At the end of the clip, a close-up of her burned face is shown. This clip was used in a promotional ad from the health and safety marketing campaign from Ontario's workers' compensation board and did not contain real-life footage. Previous research demonstrated that participants do not habituate to this US (Dibbets et al., 2018). The experiment was programmed in E-Prime 2.0 (Psychology Software Tools).

Questionnaires

State and trait anxiety were assessed with the State-Trait Anxiety Inventory (STAI-DY; (Spielberger et al., 1983) to test whether state and trait levels of anxiety did not differ between groups before the experiment, because these variables are associated with fear learning (e.g., Duits et al., 2015; Lonsdorf & Merz, 2017; but see Engelhard et al., 2009; Torrents-Rodas et al., 2013).

Outcome measures

US memory ratings

Two questions measured unpleasantness ('How unpleasant is the image you recalled?') and vividness ('How vivid is the image you recalled?') of US memory on a visual analogue scale (VAS) ranging from 0 (= *not at all unpleasant/vivid*) to 100 (= *very unpleasant/vivid*; Leer, Engelhard, Altink, et al., 2013).

Conditioned responses

Subjective measures. Participants rated US expectancy during each CS presentation on a VAS presented at the bottom of the computer screen (‘Do you expect the aversive film clip to follow?’) ranging from -5 (= *definitely not*), 0 (= *uncertain*) to 5 (= *definitely*). Before each phase of the experiment and after every three trials, fear, valence, and arousal in response to the CSs were measured with pen-and-paper. Fear was measured on a 9-point scale (‘How fearful do you feel when you see this picture?’) ranging from 1 (= *not at all*) to 9 (= *very much*). Valence and arousal were measured with Self-Assessment Manikins (SAM; Bradley & Lang, 1994), ranging from 1 (= *negative/no activation*) to 9 (= *positive/a lot of activation*). For the ratings, CSs were presented in a fixed order (first yellow, then blue).

Psychophysiological measures. A BioSemi ActiveTwo system was used to register electromyography (EMG) and skin conductance responses (SCR). Two reference electrodes were positioned on the forehead (approximately 1 cm below the hairline). To measure fear potentiated startle (FPS), two 4 mm Ag/AgCl electrodes filled with electrolyte conductive gel (Signa) were attached to the left orbicularis oculi muscle (approximately 1 cm below the pupil and 1 cm below the lateral canthus). SCR was measured with two 5 mm Ag/AgCl electrodes filled with electrolyte conductive gel (Signa), which were attached to the proximal part of the palm of the left hand. Recording and analyses of FPS and SCR was similar to previous work (Landkroon et al., 2019) and according to guidelines (Blumenthal et al., 2005; Boucsein et al., 2012; Pineles et al., 2009).

Procedure

Day 1

Electrodes for psychophysiological measures were attached and headphones were placed. Then, participants completed the STAI-S and STAI-T on the computer, and they received information about the woman in the aversive film clip. They read that the woman was a sous-chef in a restaurant who would get promoted next year and get married the following weekend (see Dibbets et al., 2018; Landkroon et al., 2019). Participants then viewed a 10-s version of the aversive film clip. Afterwards, they received instructions about the contingencies between the CSs and US (Landkroon et al., 2019; Milad et al., 2005). Participants were instructed that a lamp would be presented on screen that could turn either blue or yellow when it was lit, and that one of these colors would be followed by the aversive film clip. The other color would never be followed by the film clip on either day. They were instructed to learn to predict when the aversive film clip would be shown. They practiced rating the US expectancy scale and rated scales measuring fear, valence, and arousal to the CSs. Before the acquisition phase, they heard 10 habituation startle probes, which were presented to stabilize startle reactivity (Blumenthal et al., 2005).

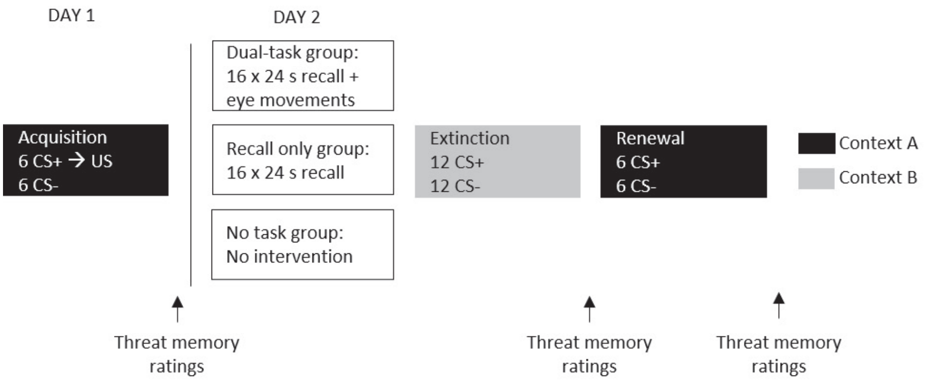

Figure 1. Acquisition and renewal phases were presented in context A. The extinction phase was presented in context B. During the dual-task and recall only interventions, the background color of the screen was black. After three trials, CSs were rated (fear, valence, and arousal).

Acquisition phase. The acquisition phase consisted of two blocks. Per block, participants were exposed to each CS three times in a random order, with no more than two consecutive repetitions. Context A (i.e., picture of desk or bookcase) was presented throughout the acquisition phase (see Figure 1). Context presentation and CS type were counterbalanced across participants. After 6 s, the CS was presented for 8 s (desk or bookcase with lit lamp). Within 7 s after CS onset, participants could rate their US expectancy. Then the startle probe was administered through headphones (50 ms; 104 dB). At CS+ offset, the US was presented, followed by the intertrial interval (ITI), while at CS- offset the ITI started immediately. The ITI was 10, 12, or 14 s and consisted of the context picture. In half of the trials, a startle probe was presented at the end of the ITI and then the ITI duration was doubled, which increased total ITI duration to 20, 24, or 28 s, respectively. After the acquisition phase, participants were asked to select the most aversive image of their memory of the film clip and to recall this image and focus on it for 10 s. Afterwards, they rated the unpleasantness and vividness of the US memory.

Day 2

Intervention phase. Twenty-four hours later, participants were seated in the same laboratory. The 'no task' control group started with the extinction phase. The other two groups were asked to retrieve the most aversive image from their US memory and then rated its unpleasantness and vividness. Then, the intervention started. Participants in the dual-task and recall only groups were instructed to recall the image and keep it in mind for 24 s. Only the dual-task group made simultaneous eye movements by visually tracking a dot on the computer screen moving from left to right and back (1.2 Hz, see van Veen et al., 2015), without moving their head. After 24 s, there was a 10-s break. There were 4 trials per block, and 4 blocks. After each block, participants were asked to recall the image again and to rate its unpleasantness and vividness. Total duration of each intervention was about 10 min (including the 10-s breaks).

Extinction phase. Electrodes were then attached and participants were instructed to remember what they had learned on the previous day (see Milad et al., 2005). They rated fear, valence, and arousal to the CSs and heard 10 startle probes. The extinction phase existed of four blocks and the US was never presented. The first CS presentation was counterbalanced across participants. The extinction phase was presented in a different context (B) than the acquisition phase. Timing and CS measures (fear, valence, arousal) were similar to Day 1. At the end of the extinction phase, all three groups were asked to recall the aversive image and rate its unpleasantness and vividness.

Renewal phase. The context then switched to the original acquisition context A. The renewal phase consisted of two blocks, again without US presentation. Timing, CS measures, and the US memory ratings were identical to previous phases. The presentation of the first CS was counterbalanced across participants.

Reinstatement phase. Within context A, the sound of the original US was presented three times in a row. Next, one block of CSs was presented. Timing, CS measures, and US memory ratings were identical to previous phases. The CS+ was shown first. This reinstatement procedure was included for exploratory purposes only and results are not presented here.

End of experiment. Participants in the dual-task group were asked whether they were able to track the dot with their eyes on a VAS (0 = *not at all*, 100 = *absolutely*). Additionally, participants in both the dual-task and recall only groups were asked whether they could adhere to the instructions to vividly recall the US memory (0 = *not at all vivid*, 100 = *extremely vivid*). All participants were asked to which degree they thought their memory of the film clip had changed (0 = *not at all*, 100 = *extremely*). Finally, electrodes were removed, and participants were debriefed and reimbursed.

Data analyses

Data preparation

Startle responses were scored by subtracting the average activity during the baseline period (30 ms before to 20 ms after startle probe onset) from the peak amplitude in the 20-150 ms interval after probe onset. Individual variation of startle responses was reduced with a t-transformation (Blumenthal et al., 2005). SCR were scored by subtracting the average of the baseline period (2 s before CS onset) from the maximal amplitude during the 1-7 s interval after CS onset (Pineles et al., 2009). Similar to the study by Landkroon et al. (2019), individual variation in SCR was reduced by a range correction and then normalized with a log-transformation (Boucsein et al., 2012). A minimal response value of 0.02 μS was applied (Cacioppo et al., 2007). When the assumption of sphericity was violated, degrees of freedom were corrected with Greenhouse-Geisser ($\varepsilon < .75$) or Huyn-Feldt ($\varepsilon > .75$).

Randomization check

We tested whether groups differed on state anxiety (STAI-S), trait anxiety (STAI-T), and US memory ratings after the acquisition phase, using one-way ANOVAs. We also explored whether the dual-task and recall only groups differed in retrieving the US memory vividly during the intervention, and whether the three groups differed in whether they thought their US memory had changed, using one-way ANOVAs.

Unpleasantness and vividness of US memory

First, we tested whether the dual-task group showed larger reductions in unpleasantness and vividness of threat memory than the recall only group during the intervention, with two repeated measures ANOVAs. Then, we tested whether the dual-task group had lower unpleasantness and vividness ratings of threat memory than the other two groups after the extinction and renewal phases, using 2 (Time: pre vs. post) x 3 (Group: dual-task, recall only, no task) repeated measures ANOVAs.

Acquisition and extinction phase

To examine whether differential acquisition and extinction took place, we analyzed acquisition and extinction phases with separate 2 (Stimulus: CS+ vs. CS-) x 6 or 12 (Trial) repeated measures ANOVAs (with Group as between-subjects factor) on US expectancy, FPS, SCR, and subjective fear, valence, and arousal to the CSs. Also, to assess whether the dual-task group showed reduced conditioned fear on the first trial of extinction, compared to the recall only and no task groups, we performed a 2 (Stimulus: CS+ vs. CS-) x 2 (Trial: last acquisition vs. first extinction trial) x 3 (Group: dual-task, recall only, no task) repeated measures ANOVA.

Renewal

To examine whether the dual-task group showed less renewal of conditioned fear, compared to the other two groups, we conducted a 2 (Stimulus: CS+ vs. CS-) x 2 (Trial: last extinction trial vs. first renewal trial) x 3 (Group: dual-task, recall only, no task) repeated measures ANOVA (following Vervliet, Baeyens, et al., 2013).

Results

There were no group differences in gender distribution, $\chi^2(2) = 1.07$, $p = .59$, and in age, state, trait anxiety, whether participants thought their US memory had changed during the experiment, *F*s < 1 (see Table 1). At the end of the experiment, the recall only group indicated that they retrieved the US memory more vividly during the intervention than the dual-task group, $t(48) = 2.63$, $p = .01$, $d_s = 0.74$.

Table 1. Distribution of gender (male/female frequency), means (SD) of age, state anxiety (STAI-S), trait anxiety (STAI-T), adherence to instructions during intervention phase (i.e., making eye movements and vividly recalling the US), and whether participants thought their US memory changed for the three groups (*n* = 25 per group).

	Dual-task	Recall only	No task
Gender	4/21	6/19	7/18
Age	20.56 (2.24)	21.08 (3.17)	21.24 (2.11)
STAI-S	34.00 (8.34)	33.60 (8.77)	35.28 (8.07)
STAI-T	35.32 (8.81)	36.52 (7.41)	37.32 (7.20)
Eye movements	74.40 (19.55)	-	-
Recall US	59.44 (20.26)	73.20 (16.63)	-
Memory changed	45.96 (22.08)	41.64 (26.97)	37.12 (20.61)

US memory unpleasantness and vividness

Post-acquisition and intervention

Directly after the acquisition phase, there were no significant differences between the three groups in ratings of US unpleasantness, $F(2, 72) = 1.11$, $p = .36$, and vividness, $F(2, 72) = 0.79$, $p = .46$ (see Figures 2 and 3). Both intervention groups showed reduced unpleasantness during the intervention phase, $F(2.07, 99.30) = 13.35$, $p < .01$, $\eta_p^2 = .22$, which did not significantly differ between groups, $F(2.07, 99.30) = 2.23$, $p = .11$, $\eta_p^2 = .04$ (trial x group). Likewise, both groups showed reduced vividness during the intervention phase, *F*(1.84, 88.28) = 5.46, $p < .01$, $\eta_p^2 = .10$, which did not significantly differ between groups, *F*(1.84, 88.28) = 0.54, $p = .57$, $\eta_p^2 = .01$ (trial x group).

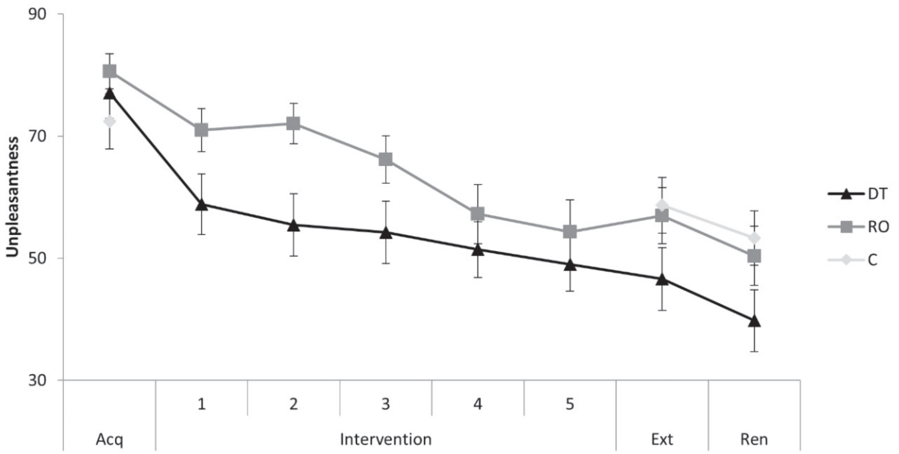

Figure 2. Unpleasantness of the threat memory after acquisition (Acq), during the intervention, after extinction (Ext), and after renewal (Ren) in the dual-task (DT), the recall only (RO), and the no task control (C) groups. Error bars represent standard error of the mean (SEM).

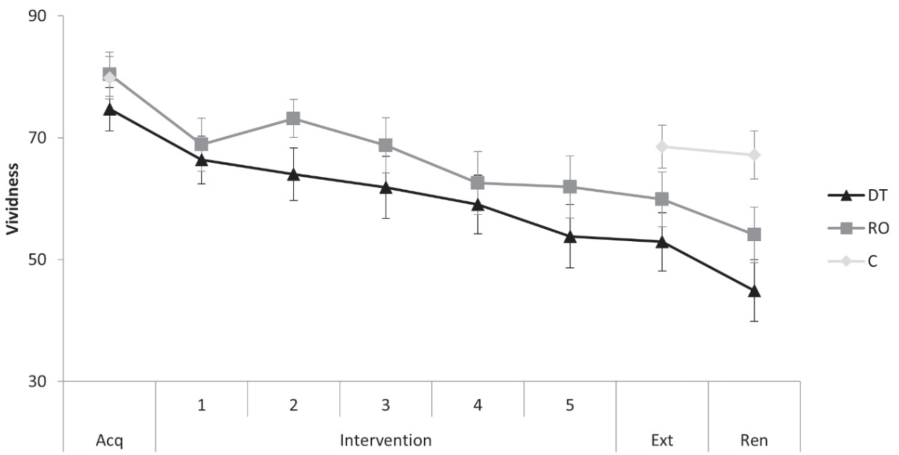

Figure 3. Vividness of the threat memory after acquisition (Acq), during the intervention, after extinction (Ext), and after renewal (Ren) in the dual-task (DT), recall only (RO), and no task control (C) groups. Error bars represent SEM.

Post-extinction and post-renewal

Unpleasantness decreased from after the acquisition phase to after the extinction phase, *F*(1, 72) = 67.12, $p < .01$, $\eta_p^2 = .48$, and this differed between groups, *F*(2, 72) = 3.12,

p = .05, η_p^2 = .08. All three groups showed a reduction (dual-task: t(24) = 6.17, p < .01, d_z = 1.23, recall only, t(24) = 5.76, p < .01, d_z = 1.15, no task: t(24) = 2.62, p = .02, d_z = 0.52). Furthermore, independent samples t-tests showed that as predicted, unpleasantness decreased more in the dual-task group than in the no task group, t(48) = 2.33, p = .02, d_s = 0.66. From directly after acquisition to after renewal, unpleasantness also decreased, F(1, 72) = 94.07, p < .01, η_p^2 = .57, and this decrease differed again between groups, F(2, 72) = 3.19, p = .047, η_p^2 = .08. All three groups showed again a reduction (dual-task: t(24) = 7.63, p < .01, d_z = 1.53, recall only: t(24) = 6.16, p < .01, d_z = 1.23, no task: t(24) = 3.38, p < .01, d_z = 0.68), and again as predicted, compared to the no task group, the decrease in unpleasantness was larger for the dual-task group, t(48) = 2.45, p = .02, d_s = 0.69.

Vividness decreased from after acquisition to after extinction in all groups, F(1, 72) = 56.81, p < .01, η_p^2 = .44, but contrary to our predictions, this did not differ between the three groups, F(2, 72) = 1.93, p = .15, η_p^2 = .05. From after the acquisition phase to after the renewal phase, vividness also decreased, F(1, 72) = 74.98, p < .01, η_p^2 = .51, and this decrease did differ between groups, F(2, 72) = 3.88, p = .03, η_p^2 = .10. All three groups showed a reduction (dual-task: t(24) = 5.45, p < .01, d_z = 1.09, recall only: t(24) = 6.24, p < .01, d_z = 1.25, no task: t(24) = 3.23, p < .01, d_z = 0.65). As predicted, compared to the no task group, the decrease in vividness was larger for the dual-task group, t(48) = 2.54, p = .01, d_s = 0.72, and the recall only group, t(48) = 2.37, p = .02, d_s = 0.67. However, the dual-task and recall only groups did not differ in reduction of vividness, t(48) = 0.50, p = .62, d_s = 0.14.

Subjective measures

US expectancy

Acquisition and extinction. Differential responding on US expectancy increased between the CS+ and CS- over the 6 trials of acquisition, F(2.66, 170.44) = 241.00, p < .01, η_p^2 = .79 (stimulus x trial), for all three groups, F(5.29, 163.96) = 0.66, p = .67, η_p^2 = .02 (stimulus x trial x group; see Figure 4). During the extinction phase, differential responding reduced, F(3.36, 198.45) = 55.69, p < .01, η_p^2 = .49 (stimulus x trial), for all groups, F(6.72, 191.56) = 1.39, p = .21, η_p^2 = .05 (stimulus x trial x group). The change from the last acquisition trial to the first extinction trial also did not differ between the three groups, F(2, 69) = 1.79, p = .18, η_p^2 = .05 (stimulus x trial x group). This suggests that the dual-task and recall only interventions had no effect on US expectancy directly after the intervention.

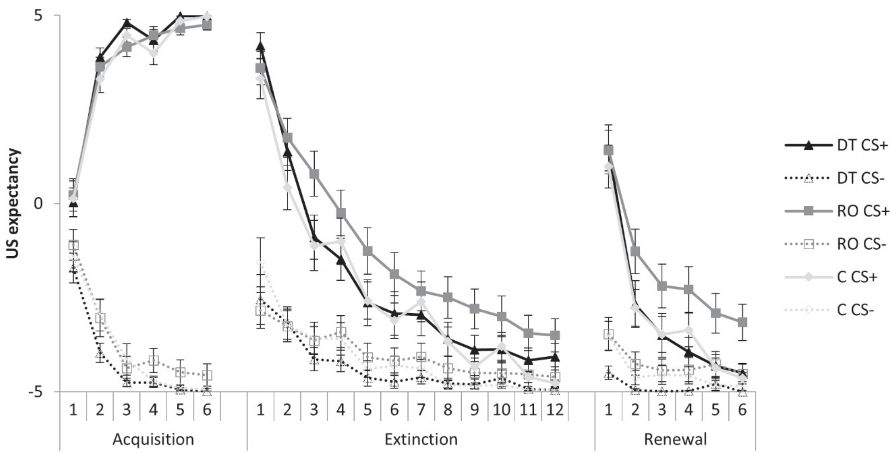

Figure 4. US expectancy during acquisition, extinction, and renewal in the dual-task (DT), recall only (RO), and no task control (C) groups. Error bars represent SEM.[1]

Renewal. There was differential renewal in all groups, with a larger increase to CS+ than to CS-, $F(1, 70) = 130.48$, $p < .01$, $\eta_p^2 = .65$ (stimulus x trial). We did not observe differences in renewal between the groups, $F(2, 70) = 1.06$, $p = .35$, $\eta_p^2 = .03$ (stimulus x trial x group). Thus, a context switch increased differential US expectancy similarly in all three groups. US expectancy re-extinguished as evidenced by reduced differential conditioning in all groups, $F(2.62, 172.96) = 60.12$, $p < .01$, $\eta_p^2 = .48$ (stimulus x trial).

CS ratings

The results of fear, valence, and arousal to the CSs resemble the results of US expectancy. For parsimony, the data and the test statistics of the CS ratings are not described here but are provided in the supplemental materials.

1 When participants did not use a mouse click to give their US expectancy, we classified these values as missing (51 MVs; 1.26%). In the analyses, missing cases were deleted listwise. We also conducted the analyses without excluding these data points, which yields identical significance and direction of the results reported here.

Psychophysiological measures

Fear potentiated startle

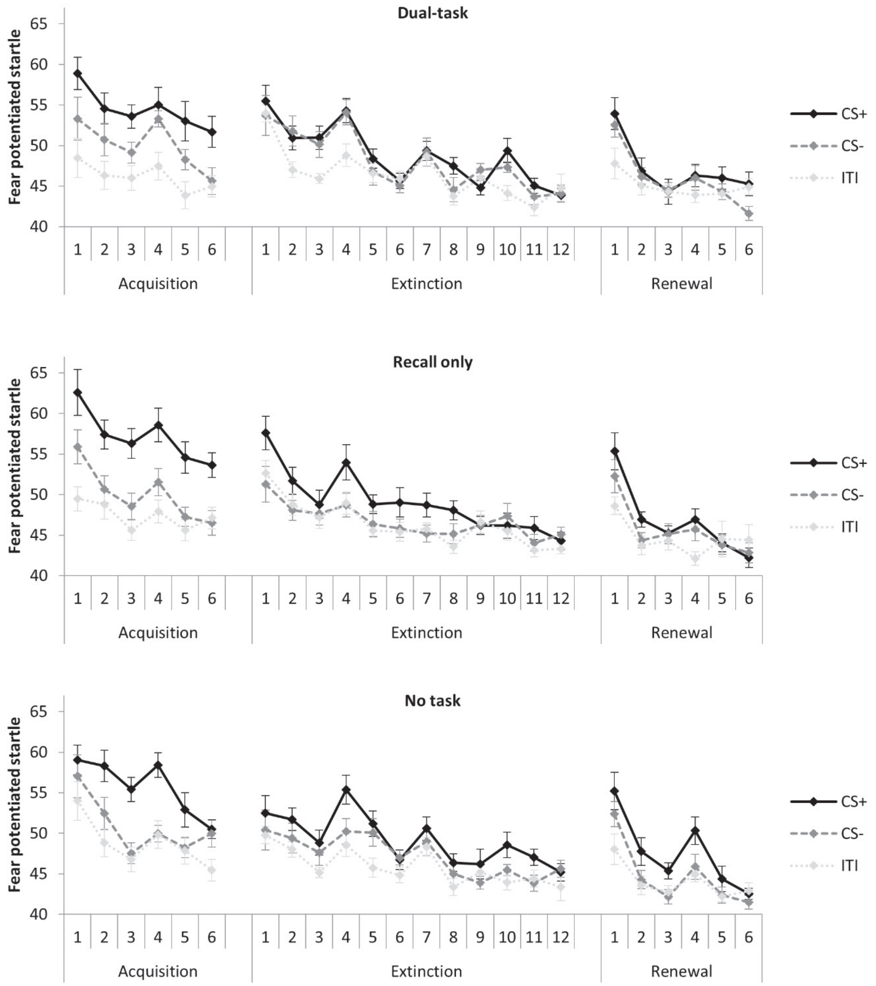

Figure 5. Fear potentiated startle response during acquisition, extinction, and renewal in the dual-task, recall only, and no task control groups. Error bars represent SEM.

Acquisition and extinction. Acquisition was evidenced by a main effect of stimulus, $F(2, 148) = 94.65$, $p < .01$, $\eta_p^2 = .56$, but not by a differential increase over time, $F(9.26, 685.22) = 0.72$, $p = .69$, $\eta_p^2 = .01$ (stimulus x trial; see Figure 5). The mean startle response amplitude for CS+ ($M = 55.79$, $SD = 5.36$) was higher than for CS- ($M = 50.32$, $SD = 4.11$), $t(74) = 9.88$, $p < .01$, $d_z = 1.14$, and ITI ($M = 47.46$, $SD = 4.62$), $t(74) = 12.49$, $p < .01$, $d_z = 1.44$.

The mean startle response amplitude was also higher for CS- than for ITI, $t(74) = 4.61$, $p < .01$, $d_z = 0.53$. This indicates successful acquisition (i.e., larger startle responses for CS+ than CS-). There were no group differences, $F(19.23, 692.30) = 0.90$, $p = .59$, $\eta_p^2 = .02$ (stimulus x trial x group) and $F(4, 144) = 1.46$, $p = .22$, $\eta_p^2 = .04$ (stimulus x group). During the extinction phase, FPS diminished to all CSs, $F(7.62, 563.61) = 34.46$, $p < .01$, $\eta_p^2 = .32$ (main effect trial), but did not extinguish differentially, $F(15.26, 1128.94) = 1.50$, $p = .10$, $\eta_p^2 = .02$ (stimulus x trial). A main effect of stimulus indicated that differential responding existed on FPS, $F(2, 148) = 26.97$, $p < .01$, $\eta_p^2 = .27$. The mean startle response amplitude for CS+ ($M = 49.03$, $SD = 2.74$) was higher than for CS- ($M = 47.38$, $SD = 2.56$), $t(74) = 4.22$, $p < .01$, $d_z = 0.49$, and for ITI ($M = 46.25$, $SD = 2.32$), $t(74) = 7.27$, $p < .01$, $d_z = 0.84$. The mean startle response amplitude was also higher for CS- than for ITI, $t(74) = 3.07$, $p < .01$, $d_z = 0.35$. Groups did not differ in extinction, $F(30.29, 1090.60) = 0.75$, $p = .83$, $\eta_p^2 = .02$ (stimulus x trial x group) and $F(4, 144) = 1.09$, $p = .37$, $\eta_p^2 = .03$ (stimulus x group), or the transition from acquisition to extinction phase, $F(4, 144) = 0.55$, $p = .70$, $\eta_p^2 = .02$ (stimulus x trial x group). This suggests that the dual-task and recall only interventions had no effect on FPS directly after the intervention.

Renewal. There was evidence for a non-differential renewal effect, $F(1, 72) = 114.66$, $p < .01$, $\eta_p^2 = .61$ (main effect trial), which did not differ between the three groups, $F(4, 144) = 0.27$, $p = .90$, $\eta_p^2 = .01$ (stimulus x trial x group). FPS re-extinguished, as evidenced by reduced responding in all groups, $F(4.84, 348.49) = 53.55$, $p < .01$, $\eta_p^2 = .43$ (main effect trial).

Skin conductance response

Acquisition and extinction. Acquisition on SCR was evidenced by a significant increase in differential responding between the CS+ and CS-, $F(4.80, 355.07) = 4.84$, $p < .01$, $\eta_p^2 = .06$ (stimulus x trial; see Figure 6), and did not differ between groups, $F(10, 360) = 1.47$, $p = .15$, $\eta_p^2 = .04$ (stimulus x trial x group). During the extinction phase, SCR diminished to both CSs, $F(9.95, 736.17) = 8.32$, $p < .01$, $\eta_p^2 = .10$ (main effect trial), but did not extinguish differentially, $F(10.02, 741.45) = 1.25$, $p = .26$, $\eta_p^2 = .02$ (stimulus x trial). SCR was overall higher for the CS+ ($M = 0.054$, $SD = 0.04$) than for the CS- ($M = 0.047$, $SD = 0.03$), $F(1, 74) = 4.92$, $p = .03$, $\eta_p^2 = .06$ (main effect stimulus). There was no difference in extinction between the groups, $F(20.76, 747.23) = 1.00$, $p = .46$, $\eta_p^2 = .03$ (stimulus x trial x group) or the transition from acquisition to extinction phases, $F(2, 72) = 0.86$, $p = .43$, $\eta_p^2 = .02$ (stimulus x trial x group). This suggests that the dual-task and recall only interventions had no immediate effect on SCR.

Renewal. There was evidence for a differential renewal effect on SCR: the increase to CS+ was larger than to CS-, $F(1, 72) = 4.41$, $p = .04$, $\eta_p^2 = .06$ (stimulus x trial), but this did not differ between the three groups, $F(2, 72) = 0.10$, $p = .91$, $\eta_p^2 = .00$ (stimulus x trial x group).

SCR re-extinguished in all groups, $F(5, 360) = 2.96$, $p = .01$, $\eta_p^2 = .04$ (main effect trial), with a stronger decrease for CS+ than CS-, $F(4.96, 356.96) = 2.30$, $p = .045$, $\eta_p^2 = .03$ (stimulus x trial). This differential decrease was due to differential renewal and thus CS- responding remained low in the test phase.

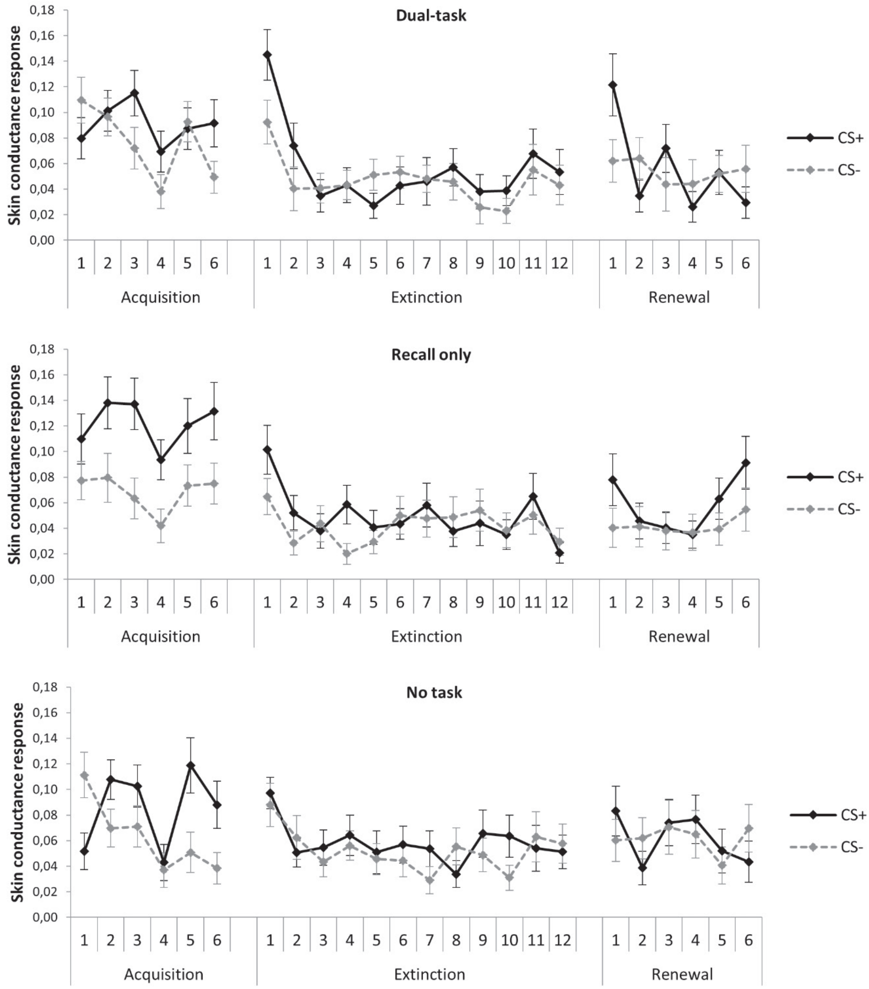

Figure 6. Skin conductance response (SCR) during acquisition, extinction, and renewal in the dual-task, recall only, and no task control groups. Error bars represent SEM.

Discussion

In the current study, we examined whether a dual-task intervention, compared to two control conditions (recall only and no intervention), would reduce the intensity of threat memory and attenuate return of fear. The main findings can be summarized as follows. First, in all three groups, the unpleasantness and vividness of the threat memory decreased during and after the intervention. As predicted, relative to no intervention, the dual-task intervention resulted in a larger decrease in unpleasantness and vividness and the recall only intervention resulted only in a larger decrease in vividness. However, the two intervention groups did not differ in the reduction of unpleasantness and vividness of threat memory during and after the intervention. Second, the three groups did not differ on any of the outcome measures at the first extinction trial, which indicates that the dual-task intervention had no effect on fear responses directly after the intervention. Finally, the three groups demonstrated no difference in renewal on all outcome measures, suggesting that the dual-task intervention did not counter fear renewal.

Both interventions, compared to no intervention, resulted in threat devaluation in terms of memory vividness but only the dual-task intervention reduced memory unpleasantness more than the no task group. In line with our hypothesis, this suggests that the dual-task intervention was more effective than the recall only intervention. Partial effects of the recall only condition may be explained by intervention duration. Earlier studies that demonstrated a superior effect of a dual-task intervention, compared to a recall only intervention, on threat devaluation typically used a short intervention (4 or 6 blocks of 24 s; e.g., Engelhard et al., 2010; Gunter & Bodner, 2008; Leer, Engelhard, Altink, et al., 2013; van den Hout et al., 2001). Habituation after such brief exposure may not be expected (see Engelhard et al., 2010). The current study used 16 blocks of 24 s, and recent evidence suggests that when the intervention length of dual-task and recall only interventions is increased to this duration, both interventions affect unpleasantness and vividness of aversive memory (van Veen et al., 2020).

Even though threat memory was devalued, we found no immediate effect on conditioned responses or on fear renewal. Two experiments have found that a dual-task intervention reduces conditioned fear (Leer, Engelhard, Altink, et al., 2013) or fear renewal (Leer, Engelhard, Dibbets, et al., 2013), but they used a one-day paradigm. In the current study, the intervention took place one day after acquisition. Although we used a distressing audiovisual clip to increase the aversiveness and complexity of the US, the unpleasantness of the associated threat memory was already reduced in all three conditions one day later. Therefore, there was less room for the intervention to further devalue threat memory. Moreover, in the current study, the intervention was given before (instead of after; Leer, Engelhard, Dibbets, et al., 2013) the extinction phase. The extinction phase may have overwritten the effects of the dual-task intervention, which may explain why we did not find group differences on renewal. However, this cannot account for a lack of group differences on the first extinction trial directly after the intervention.

A different interpretation for the finding that the dual-task group showed threat devaluation but not reduced fear renewal is that the intervention effects are context-dependent (during the intervention, a black screen was shown; during the renewal phase, the bookcase or desk were shown). However, this is an unlikely explanation, because studies have shown that the effects of threat memory deflation generalize over contexts (Leer & Engelhard, 2015), and effects of the dual-task intervention persist after a background switch (Leer, Engelhard, Dibbets, et al., 2013) and over time (Gunter & Bodner, 2008; Leer et al., 2014). A more likely explanation is that the intervention was not strong enough to reduce learned fear. Unpleasantness and vividness of threat memory were still high at the end of the intervention (mean score > 45 on a 0-100 scale), indicating that the memory was still relatively aversive. This is in line with previous work on aversive autobiographical memories, where vividness and emotionality ratings remained similarly high after the intervention (e.g., Mertens et al., 2019; van Schie et al., 2016). How could the intervention be optimized? One way is to further increase taxation of the dual-task (e.g., by using complex counting rather than making eye movements; van den Hout et al., 2010). Alternatively, in the EMDR protocol, patients are allowed to associate based on the first aversive threat memory and thus deviate from the original image (de Jongh & ten Broeke, 2012), while in the current study only one image was devalued. Also, the intervention could improve when other aspects of the EMDR protocol, rather than merely the dual-tasking component, are used, such as formulating negative cognitions and focusing on improving the validity of positive cognitions (Shapiro, 2017). Moreover, pharmacological interventions (e.g., Kindt et al., 2009) or other mental imagery-based interventions like imagery rescripting might be more powerful, although a first comparison showed no difference between imagery rescripting and a dual-task procedure on the aversiveness of threat memory and on conditioned responses (Dibbets et al., 2018). Future research may elucidate whether a stronger intervention to devalue threat memory reduces fear renewal. It also seems important to examine whether EMDR or other interventions aimed at devaluing threat memory before exposure therapy for anxiety disorders may facilitate exposure, because a substantial number of patients do not start or drop-out during exposure therapy (Fernandez et al., 2015).

There are several limitations of this study. First, we tested individuals that reported no (history of) psychological problems. It is unclear whether the findings generalize to individuals who suffer from psychological difficulties. In future research, a threat devaluation procedure should be tested in a subclinical sample. Second, as mentioned, the emotional intensity of the threat memory did not decrease to (nearly) 0, thus the intervention may not have been strong enough to result in effects on learned fear. Despite these limitations, several strengths should be noted. First, this study was pre-registered (Asendorpf et al., 2013). Second, a two-day fear conditioning paradigm was used with an audiovisual US to ensure that the intervention intervened with a consolidated, ecologically valid threat memory. Third, the study was well-controlled, using active and passive groups to control for time, general intervention effect, and mere recall of the threat memory. Finally, subjective and physiological outcome measures were collected, which showed the same patterns and enhances confidence in our conclusions.

To summarize, using a two-day paradigm, this study examined whether threat memory devaluation prevents renewal of conditioned fear. Even though threat memory devaluation took place, it did not attenuate the return of fear. Future studies may use a more potent dual-task intervention, use a different intervention (such as imagery rescripting), focus on employing a more realistic threat memory, and examine a subclinical sample. Given the pressing problem of return of fear in clinical practice, there is a need for more research about ways to enhance treatment effects.

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Supplemental materials

Fear

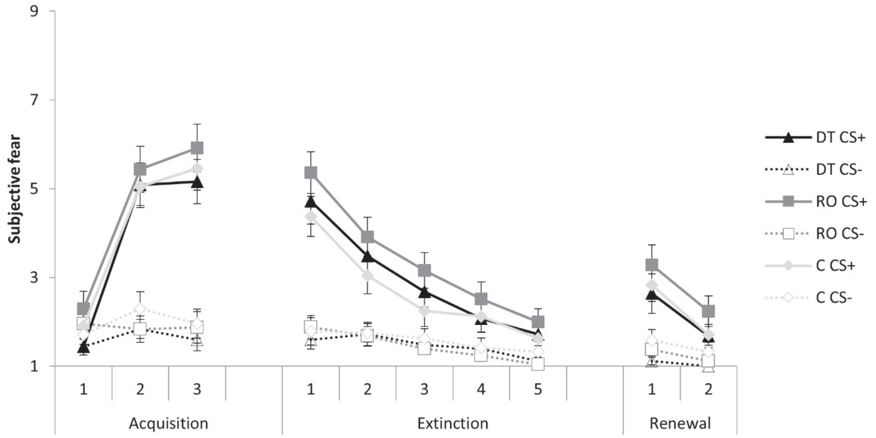

Figure S1. Subjective fear during acquisition, extinction, and renewal in the dual-task (DT), recall only (RO), and no task control (C) groups. Error bars represent standard error of the mean (SEM).

Acquisition and extinction

Over the 6 trials of acquisition, there was a significant increase in differential responding on subjective fear between the CS+ and CS-, $F(2, 144) = 89.85$, $p < .01$, $\eta_p^2 = .56$ (stimulus x trial; see Figure S1), which did not differ between groups, $F(4, 140) = 0.50$, $p = .74$, $\eta_p^2 = .01$ (stimulus x trial x group). There was a reduction in differential fear responding during the extinction phase, $F(2.28, 169.01) = 58.60$, $p < .01$, $\eta_p^2 = .44$ (stimulus x trial), which also did not differ between groups, $F(4.51, 162.30) = 0.38$, $p = .84$, $\eta_p^2 = .01$ (stimulus x trial x group). Groups did not differ in the change from the last acquisition trial to the first extinction trial, $F(2, 71) = 0.32$, $p = .73$, $\eta_p^2 = .01$ (stimulus x trial x group), which suggests that the dual-task and recall only interventions had no immediate effect on subjective fear.

Renewal

There was differential renewal on subjective fear, with a larger increase to CS+ than to CS-, $F(1, 71) = 29.80$, $p < .01$, $\eta_p^2 = .30$ (stimulus x trial), which did not differ between the groups, $F(2, 71) = 0.05$, $p = .95$, $\eta_p^2 = .00$ (stimulus x trial x group). Subjective fear re-extinguished as evidenced by reduced differential conditioning in all groups, $F(1, 71) = 24.24$, $p < .01$, $\eta_p^2 = .26$ (stimulus x trial).

Valence

All scores were reversed, so that a higher score reflects a more negative valence.

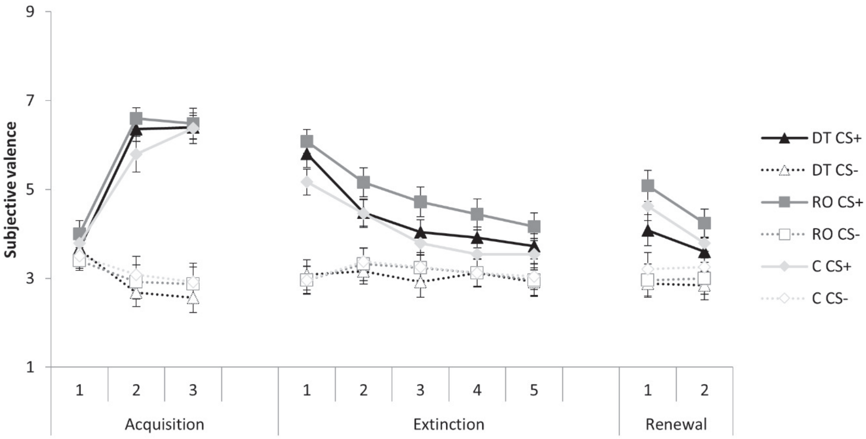

Figure S2. Subjective valence during acquisition, extinction, and renewal in the dual-task (DT), recall only (RO), and no task control (C) groups. Error bars represent SEM.

Acquisition and extinction

Over the 6 trials of acquisition, there was a significant increase in differential responding on valence between the CS+ and CS-, $F(1.83, 131.89) = 72.28$, $p < .01$, $\eta_p^2 = .50$ (stimulus x trial; see Figure S2), which did not differ between groups, $F(3.77, 131.94) = 0.64$, $p = .62$, $\eta_p^2 = .02$ (stimulus x trial x group). There was a reduction in differential responding on valence during the extinction phase, $F(2.03, 149.95) = 31.02$, $p < .01$, $\eta_p^2 = .30$ (stimulus x trial), which also did not differ between groups, $F(4.04, 145.38) = 0.09$, $p = .99$, $\eta_p^2 = .00$ (stimulus x trial x group). Groups did not differ in the change from the last acquisition trial to the first extinction trial, $F(2, 71) = 1.02$, $p = .37$, $\eta_p^2 = .03$ (stimulus x trial x group), which suggests that the dual-task and recall only interventions had no immediate effect on subjective valence.

Renewal

There was differential renewal on valence, with a larger increase to CS+ than to CS-, $F(1, 71) = 20.77$, $p < .01$, $\eta_p^2 = .23$ (stimulus x trial), which did not differ between the groups, $F(2, 71) = 0.96$, $p = .39$, $\eta_p^2 = .03$ (stimulus x trial x group). Valence re-extinguished as evidenced by reduced differential conditioning in all groups, $F(1, 71) = 27.97$, $p < .01$, $\eta_p^2 = .28$ (stimulus x trial).

Arousal

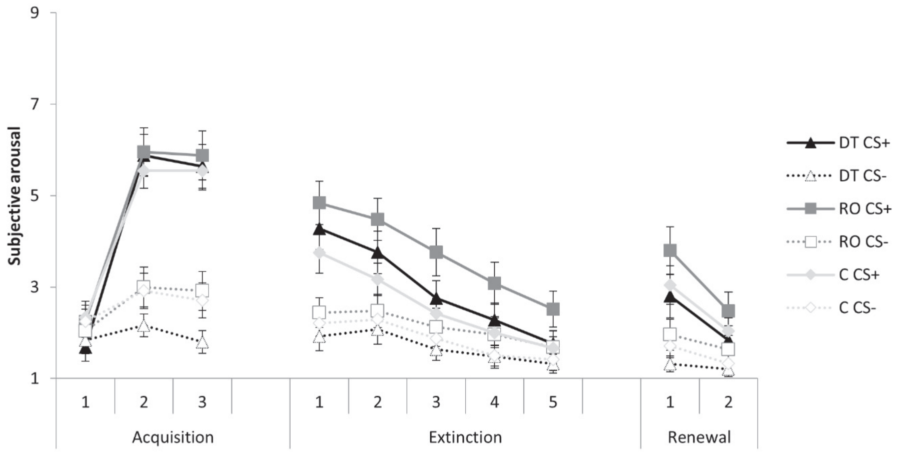

Figure S3. Subjective arousal during acquisition, extinction, and renewal in the dual-task (DT), recall only (RO), and no task control (C) groups. Error bars represent SEM.

Acquisition and extinction

Over the 6 trials of acquisition, there was a significant increase in differential responding on arousal between the CS+ and CS-, $F(2, 144) = 90.74$, $p < .01$, $\eta_p^2 = .56$ (stimulus x trial; see Figure S3), which did not differ between groups, $F(4, 140) = 1.16$, $p = .33$, $\eta_p^2 = .03$ (stimulus x trial x group). There was a reduction in differential responding during the extinction phase, $F(2.80, 206.97) = 29.24$, $p < .01$, $\eta_p^2 = .28$ (stimulus x trial), which also did not differ between groups, $F(5.59, 201.15) = 0.66$, $p = .67$, $\eta_p^2 = .02$ (stimulus x trial x group). Groups did not differ in the change from the last acquisition trial to the first extinction trial, $F(2, 71) = 0.94$, $p = .40$, $\eta_p^2 = .03$ (stimulus x trial x group), which suggests that the dual-task and recall only interventions had no immediate effect on arousal.

Renewal

There was differential renewal of arousal, with a larger increase to CS+ than to CS-, $F(1, 71) = 27.10$, $p < .01$, $\eta_p^2 = .28$ (stimulus x trial), which did not differ between the groups, $F(2, 71) = 0.20$, $p = .82$, $\eta_p^2 = .00$ (stimulus x trial x group). Arousal re-extinguished as evidenced by reduced differential conditioning in all groups, $F(1, 71) = 19.53$, $p < .01$, $\eta_p^2 = .22$ (stimulus x trial).

Chapter 4

Threat memory devaluation by a dual-task intervention: Testing return of fear and intrusive memory over 48 hours

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Author contributions: EL and IE developed the study concept and designed the study. EL was responsible for data collection and performed the data analyses. All authors were involved in the interpretation of the data. EL drafted the paper and ES and IE provided critical revisions. All authors approved the final version of the manuscript.

4

Abstract

Background and objectives. In dual-tasking, individuals recall a threat-related memory while performing a demanding dual-task. This is a fruitful approach to reduce the unpleasantness and vividness of aversive memories and to reduce conditioned fear responses. Crucially, it remains unclear whether dual-tasking can also reduce conditioned fear responses and intrusive memories over time. In this pre-registered two-day fear conditioning paradigm, we examined whether a dual-task intervention reduces return of fear and the frequency of intrusive memories of an aversive film over time.

Methods. On Day 1, 76 healthy participants underwent fear acquisition with aversive film clips. They were then randomly allocated to one of three conditions: dual-tasking, memory recall without a dual-task ('recall only'), or no task. Afterwards, they underwent an extinction phase and were asked to record intrusive film memories over 48 h. On Day 3, return of fear was assessed.

Results. On Day 1, fear acquisition and extinction were successful. On Day 3, spontaneous recovery and renewal were evident, but, overall, participants reported few intrusions. The dual-task and recall only groups reported reduced unpleasantness of threat memory compared to the no task group, but they did not show reduced (return of) fear responses or fewer intrusions.

Limitations. Intrusion frequency was low in all three groups, which limits the detection of intervention effects.

Conclusions. Even though dual-tasking and recall only devalued threat memory temporarily compared to no task, these interventions did not reduce (return of) fear responses and intrusions. Future studies could focus on improving the potency of imagery-based interventions.

Introduction

Cognitive behavioral therapy is a recommended treatment for anxiety disorders (National Institute for Health and Clinical Excellence, 2011), in which patients are systematically confronted with fear-provoking stimuli and situations to disconfirm their threat expectancies during exposure. For many patients, fear reduces during treatment, but for a significant minority improvements are not retained after treatment (relapse rates: 0-14%; van Dis et al., 2020). Its presumed working mechanism is the learning of safety associations that inhibit threat associations (Bouton, 2002; Craske et al., 2014). However, threat associations can be expressed again, for instance, after a time lapse ('spontaneous recovery') or exposure to a new context ('renewal'; Bouton, 2002). Thus, there is a need to improve treatment for anxiety disorders.

According to contemporary learning theories, fear is determined by the strength of the threat association (i.e., threat expectancy), and by the intensity of the mental representation of threat (i.e., threat intensity; Davey, 1997; Vervliet, Craske, et al., 2013). Therefore, another potential approach to reduce fear, besides disconfirming threat expectancy, is by devaluing the intensity of this mental threat representation. Theoretically, this latter approach could reduce the return of fear because it may not rely on inhibitory learning: when the threat association is reactivated after treatment (e.g., due to a time lapse or a context switch), but the mental representation of threat is less threatening, fear responses can remain low.

Several psychological interventions for posttraumatic stress disorder (PTSD) aim at devaluing the mental representation of threat, such as eye movement desensitization and reprocessing (EMDR) therapy. EMDR uses a dual-task approach, in which patients recall a traumatic memory while performing a demanding task (e.g., making bilateral eye movements; Shapiro, 2017). Experimental laboratory research has shown that dual-tasks reduce self-reported unpleasantness and vividness of emotional memories and of images of feared future events, which is typically interpreted as devaluation of the mental threat representation (Engelhard et al., 2019). This technique offers great therapeutic potential, because many patients with anxiety disorders suffer from future-oriented threat images ("flashforwards"), rather than memories of threatening events ("flashbacks"; Brewin et al., 2010; Engelhard, van den Hout, et al., 2010; Holmes & Mathews, 2010). Therefore, dual-tasks seem promising as intervention for anxiety disorders to modulate anxiety-relevant memories.

Earlier fear conditioning research has indeed provided evidence that dual-tasks, compared to mere recall of aversive memories, reduce conditioned fear responses (Leer, Engelhard, Altink, et al., 2013; Leer, Engelhard, Dibbets, et al., 2013). These studies used aversive visual stimuli to retrieve a visual threat memory during the intervention. Using aversive pictures, Leer, Engelhard, Dibbets, et al. (2013) found that dual-tasking reduced renewal of threat expectancy compared to a control condition in which participants completed a filler task, but not compared to a control condition in which participants merely imagined the memory ('recall only'). Three other studies using film clips as aversive stimuli found that dual-tasking reduced self-reported threat expectancy and fear more than 'recall only' did (Leer, Engelhard, Altink, et al., 2013), but did not attenuate renewal (Landkroon et al., 2020) or reinstatement one day later (Dibbets et al., 2018) on both subjective and psychophysiological measures. Thus, fear conditioning research has demonstrated the potential of dual-tasks to attenuate (return of) conditioned fear on the same day, but findings are not as promising in studies with multiple sessions.

These earlier studies investigated whether devaluation of threat memory reduces conditioned responses. However, patients often suffer from intrusive threat-related imagery (Hackmann & Holmes, 2004). These can be recollected without a retrieval attempt and are experienced as distressing and as if the event is currently happening (Berntsen, 2010). Such intrusive memories may prevent natural memory decay, resulting in enhanced memory for these aversive events (Herz et al., 2020), and may be involved in installment and preservation of learned fear and avoidance (Mertens, Krypotos, et al., 2020). Hence, interventions that modulate intrusive memories may also enhance treatment of anxiety disorders.

The trauma film paradigm can be used as a laboratory analog for investigating the development and treatment of intrusive memory (James et al., 2016). Studies showed that after viewing a traumatic film, reactivation of the aversive film memory before playing the computer game Tetris reduced the intrusion frequency in the subsequent week compared to no task (Badawi et al., 2020; Holmes et al., 2009, 2010; James et al., 2015). The procedure in these trauma film studies differs from dual-task interventions, because participants were not instructed to actively retrieve the trauma memory *while* playing Tetris (i.e., no dual-task). One study that used dual-tasks within the trauma film paradigm, demonstrated that a dual-task intervention reduced intrusive memories compared to no task, but only when the intervention length was relatively long (16 x 24 s; exp 2; van Schie et al., 2019), and not with a shorter intervention (6 x 24 s; exp 1; van Schie et al., 2019), although these results were not replicated (exp 3; van Schie et al., 2019). As such, increasing the intervention length of the dual-task intervention seems necessary to improve intervention effects. Taken together, trauma film paradigm studies have demonstrated that secondary tasks after or during memory retrieval reduce intrusion frequency.

Previously, research demonstrated that fear conditioning with 30-s film clips successfully induces intrusive memories (Wegerer et al., 2013). Combining fear conditioning and a trauma film paradigm allows us to investigate dual-task interventions that target intrusive memory. The important next step is to examine whether dual-tasking can prevent return of fear and intrusive memory over time.

The current study investigates whether dual-tasking with an increased intervention length before extinction training reduces conditioned responding directly after the intervention, and most importantly, return of fear and intrusive memories of aversive film clips two days later. We hypothesized that both dual-task and recall only interventions, compared to no task, attenuate conditioned responses directly after the intervention, spontaneous recovery, renewal, and intrusive memories. We hypothesized that recall only is also effective, because previous research demonstrated that when mere recall of aversive memories is prolonged (as in imaginal exposure; Powers et al., 2010), intensity of aversive memories is reduced (van Veen et al., 2020). Based on earlier research (e.g., Leer, Engelhard, Altink, et al., 2013), we hypothesized that the effects of dual-tasking are stronger than of recall only.

Method

Participants

Ninety participants were recruited. Exclusion criteria (self-report) were: serious medical conditions; medication use that influences attention, memory or concentration; (a history of) psychological problems; poor sight/color blindness; hearing difficulties; proneness to fainting; pregnancy; and suicidal ideation (score 2 or 3 on item 9) on the Beck Depression Inventory (BDI-II; Beck et al., 1996). These are common exclusion criteria in fear conditioning/trauma film studies given the aversive stimuli (e.g., Landkroon et al., 2020; Siegesleitner et al., 2019). Fourteen participants were excluded for the following reasons: BDI-II item (1), quit Day 1 (2; ill [1], US too aversive [1]), nonattendance Day 3 (5), and unaware of US expectancy contingencies (6; see 2.6.1 Data exclusion). The final sample consisted of 76 participants (mostly students; n = 73). The sample size was powered to investigate the primary hypotheses (see pre-registration on Open Science Framework: https://osf.io/

g2q8t/). We expected a medium effect size (η_p^2 = .08) for conditioned fear immediately after the intervention (CS fear: η_p^2 = .14; US expectancy: η_p^2 = .08 in Leer, Engelhard, Altink, et al., 2013), a small to medium effect size (η_p^2 = .04) for return of fear (US expectancy: η_p^2 = .08 in Leer, Engelhard, Dibbets, et al., 2013), and a medium to large effect size (*f* = .37) for intrusion frequency (Cohen's *d* = 0.62-0.79 in Holmes et al., 2009, 2010). For conditioned fear and return of fear, a power analysis with G-Power for repeated measures (RM) ANOVAs with 3 groups and 2 measurements (*f* = .29 or .20, α = .05, power = .80) yielded a total sample size of 33 and 63, respectively. For intrusion frequency, a power analysis for a one-way ANOVA (*f* = .37, α = .05, power = .80) yielded a sample size of 75. The Ethics Committee of the Social Sciences Faculty of Utrecht University approved this study (FETC15-104).

Stimuli

Conditioned stimuli (CSs) were three pictures of men's faces (Langner et al., 2010). Context pictures were a yellow (context A) and a cyan (context B) background. CSs and context colors were counterbalanced across participants. The unconditioned stimulus (US) was a violent scene from the movie Irréversible (Noé, 2002), in which a man is killed with a fire extinguisher. This film clip has been used successfully to induce intrusive memories (Arnaudova & Hagenaars, 2017). The film clip was split into six fragments of 30 s each and presented in sequential order to reduce potential habituation effects (e.g., Leer, Engelhard, Altink, et al., 2013; Rattel et al., 2019).

Questionnaire

The State-Trait Anxiety Inventory (STAI-DY; Spielberger et al., 1983) was used to measure whether state and trait anxiety differed between groups, because they may influence fear learning (Lonsdorf & Merz, 2017; but see Torrents-Rodas et al., 2013). Higher scores reflect higher levels of anxiety (range: 20-80).

Outcome measures

US memory ratings

Participants were asked to select the most aversive mental image of the US, keep it in mind for 10 s, and then rate its unpleasantness and vividness on two visual analog scales (VASs; 0 = *not at all unpleasant/vivid*; 100 = *very unpleasant/vivid*; Leer, Engelhard, Altink, et al., 2013).

Conditioned responses

US expectancy. US expectancy was rated online during each CS presentation on a VAS (-5 = *definitely not followed by aversive film clip*; 0 = *uncertain*; 5 = *definitely followed by aversive film clip*; Landkroon et al., 2019).

CS measures. Fear to each CS was measured on a 9-point scale, from '*not at all*' to '*very much*' (Landkroon et al., 2020). Valence and arousal were rated with Self-Assessment Manikins (SAM; Bradley & Lang, 1994) on 9-point scales from '*negative*'/'*no activation*' to '*positive*'/'*a lot of activation*' respectively. Valence was reverse-scored: higher scores reflect a more negative evaluation.

Intrusive memory

Participants were instructed that intrusive memories of the film clip could pop into their mind unexpectedly and that these intrusions could be experienced as mental images (e.g., visual, auditory), verbal thoughts or a combination (see Holmes et al., 2010). Participants were asked to keep a diary for 48 h and to list each occurrence of an intrusion immediately. They were asked to describe its content and form (image/thought/combination), and rate its unpleasantness and vividness (1 = *not at all unpleasant*/*vivid*; 10 = *very unpleasant*/*vivid*). Mental image-based intrusions (image and combination) were added as a total score (Holmes et al., 2009, 2010).

Procedure

Day 1

Participants gave informed consent and completed the BDI-II, STAI-S, and STAI-T. They were told that two faces would be followed by aversive film clips and a third face would never be followed by aversive film clips on either day, and that it was their task to predict when an aversive film clip would be shown. Then they practiced rating US expectancy, read instructions about the CS measures, and rated the CSs with pen-and-paper.

Acquisition. Six trials for each CS type were presented in context A (see Figure 1). Two CSs but not the CS- were followed by a US. The CSs were presented for 8 s and participants could rate US expectancy within 7 s. Intertrial intervals were 2, 3 or 4 s. After every three trials, CSs were rated. Lastly, participants were asked to select and rate the most aversive mental image from the film clips (Landkroon et al., 2020).

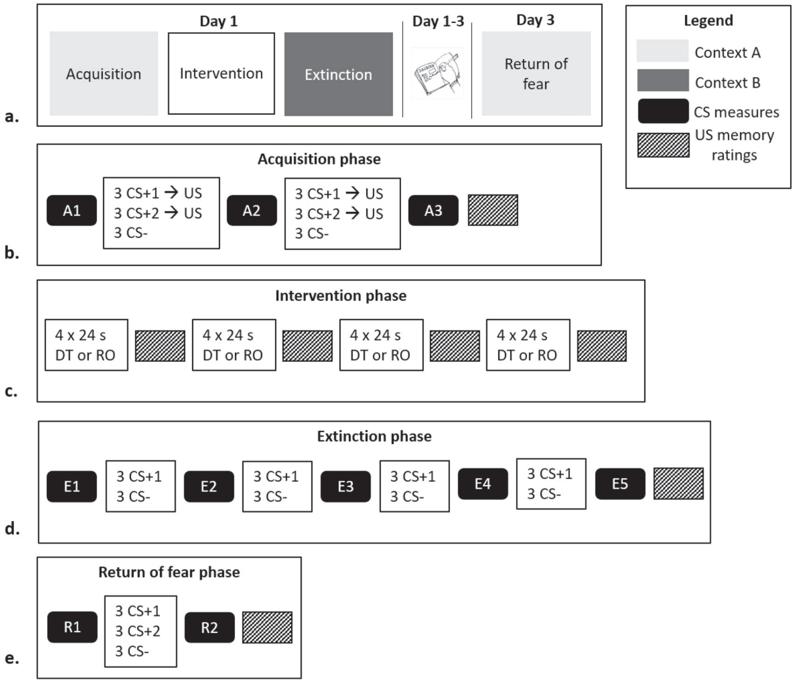

Figure 1. Overview study design. Panel a) Overview of the experimental phases of the experiment. Intrusions are measured with a diary between Day 1 and 3. Panel b) Trials and measurements in the acquisition phase. Conditioned responses are measured by unconditioned stimulus (US) expectancy during every conditioned stimulus (CS) presentation, and by CS measures (fear, valence, and arousal; A1-A3). Panel c) Trials and measurements in the intervention phase for the dual-task (DT) and recall only (RO) groups. Threat memory devaluation is measured by US memory ratings (unpleasantness and vividness). Panel d) Trials and measurements in the extinction phase. Conditioned responses are measured by US expectancy during every CS presentation, and by CS measures (E1-E5). Panel e) Trials and measurements in the return of fear phase. Spontaneous recovery is measured with the first CS measures (R1). Renewal is measured with US expectancy on the first CS presentation.

Intervention. Participants were randomly assigned to conditions. During dual-tasking, participants were asked to recall the most aversive image for 24 s while visually tracking a dot on a computer screen that moved at 1.2 Hz (van Veen et al., 2015) without moving their head. Then, participants were instructed to stop retrieving the image for 10 s. There were 16 trials in total, and after every 4 trials, participants rated their memory (see Landkroon et al., 2020; van Veen et al., 2020). Participants in the recall only group followed the same procedure without making eye movements. In the no task group, participants continued immediately with the next phase. This group was not matched in duration to the intervention groups, because sitting in silence potentially results in recall or rumination of threat memory (Mertens, Krypotos, et al., 2020) and a filler task can serve as a dual-task intervention (Tadmor et al., 2016).

Extinction. Twelve trials for CS+1 and CS- were presented in context B, without the US. Timing and ratings were the same as in the acquisition phase. Afterwards, participants were asked to rate their threat memory and received diary instructions.

Days 1 - 3

Participants were instructed to record intrusions.

Day 3

Participants returned to the lab after 48 h, because trauma film paradigm studies have shown that most intrusions occur within the first 48 h (e.g., James et al., 2015). First, participants rated CSs (spontaneous recovery) and were presented with context A (renewal). Each CS was presented three times. The first trial was counterbalanced. Timing and ratings were the same as in previous phases. Participants rated US memory again. Then, the experimenter ensured whether all diary entries concerned the film clips (Holmes et al., 2010). Participants rated diary compliance on a VAS (0 = *not at all complied*; 100 = *complied perfectly*). Participants in the intervention groups were asked to rate whether they followed instructions during the intervention phase to vividly recall the US (both intervention groups) and to track the dot (dual-task group only), on VASs (0 = *not at all* (*vivid*); 100 = *extremely vivid/ absolutely*; Landkroon et al., 2020). Finally, participants were debriefed (van Schie et al., 2019).

Data analyses

Violations of the sphericity assumption were corrected with Greenhouse-Geisser ($\varepsilon <$ .75) or Huyn-Feldt ($\varepsilon >$ .75). Deviations from normality (Kolmogorov-Smirnov tests) were further examined using bootstrap confidence intervals, and as these barely deviated from the standard confidence intervals, the influence of normality deviations was considered negligible. Moreover, ANOVAs are robust to deviations from normality (Schmider et al., 2010). We calculated 90% confidence intervals (CI) for effect sizes (Lakens, 2013) using the MBESS package in R (Kelley, 2017).

We conducted our analyses within a Null-Hypothesis Significance Testing and a Bayesian framework (Krypotos et al., 2020). Within the Bayesian framework, Bayes factors were calculated that quantify the amount of evidence that the data shows for the alternative hypothesis compared to the null hypothesis in JASP (default settings; JASP Team, 2020). For instance, $BF_{10} = 3$ indicates that the data are three times more likely under the alternative hypothesis than the null hypothesis (vice versa for $BF_{10} = 0.33$).

Data exclusion

Participants were excluded from analyses if they were unaware of contingencies (see pre-registration: higher US expectancy on the last acquisition trial for CSs+ than for CS-; Dibbets et al., 2018).

Randomization and manipulation checks

First, to ensure successful randomization, chi-square test or one-way ANOVAs were performed on sex distribution, age, state, trait anxiety, and diary and intervention compliance. Second, to check successful fear acquisition, we used 3 (Stimulus: CS1+ vs. CS2+ vs. CS-) x 6 (or 3) (Time) x 3 (Group) RM ANOVAs for US expectancy and CS ratings. Third, to test the expected group differences in unpleasantness and vividness of threat memory separate 5 (Time: post-acquisition, 4 intervention trials) x 2 (Group: dual-task vs. recall only) RM ANOVAs were conducted. Finally, to test whether memory ratings remained low after the extinction and return of fear phases in both intervention groups, compared to no task group, 3 (Group: dual-task vs. recall only vs. no task) x 2 (Time: post-acquisition vs. post-extinction or post-renewal) RM ANOVAs were conducted.

Main analyses

To test whether conditioned responding was reduced directly after the intervention and two days later in the intervention groups, compared to the no task group, 3 (Group: dual-task vs. recall only vs. no task) x 2 (Stimulus: CS1+ vs. CS-) x 2 (Time: immediate effect: last acquisition trial vs. first extinction trial; spontaneous recovery: last CS measures Day 1 vs. first CS measures Day 3; renewal: last extinction trial vs. first renewal trial) RM ANOVAs for US expectancy and CS measures were performed (following Vervliet, Baeyens, et al., 2013). Moreover, we aimed to test whether the predicted intervention effects generalized to conditioned responding to a CS that was not extinguished by conducting separate 2 (Stimulus: CS+1 vs. CS+2) x 3 (Group: dual-task vs. recall only vs. no task) RM ANOVAs on the first trial of spontaneous recovery and renewal. To investigate whether intrusion frequency, unpleasantness and vividness were reduced after the interventions, compared to no task, separate one-way ANOVAs were used. Exploratory analyses on correlations between threat devaluation and outcome measures were included in supplemental materials.

Results

Randomization and manipulation checks

Randomization checks

Groups did not significantly differ in age, state, and trait anxiety, but did in sex distribution[1] (see Table 1). Diary compliance differed between groups. Compliance was lower in the dual-task group than in the recall only group, $p < .01$ (Bonferroni corrected), $BF_{10,\,U} = 8.95$. We deem this group difference not important, because intrusion frequency was not affected by diary compliance as a covariate and even in the dual-task group diary compliance was high. The dual-task and recall only groups indicated that they adhered equally to intervention instructions.

Table 1. Distribution of sex (male/female frequency), means (standard deviation) of age, state anxiety (STAI-S), trait anxiety (STAI-T), adherence to instructions during intervention phase (i.e., making eye movements and vividly recalling the US), and diary compliance.

	Dual-task (n = 25)	Recall only (n = 25)	No task (n = 26)	Test statistics
Sex	9/15*	13/12	5/21	$\chi^2(2) = 5.98$, $p = .05$, Cramer's $V = .28$, CI [.00, .45], $BF_{10} = 1.78$
Age (years)	21.54* (1.69)	21.88 (2.22)	21.73 (2.01)	$F(2, 72) = 0.18$, $p = .84$, $\eta_p^2 = .01$, CI [.00, .03], $BF_{10} = 0.13$
STAI-S	34.44 (9.44)	31.04 (8.29)	32.38 (8.55)	$F(2, 73) = 0.95$, $p = .39$, $\eta_p^2 = .03$, CI [.00, .09], $BF_{10} = 0.24$
STAI-T	34.16 (9.12)	30.44 (7.22)	31.58 (6.40)	$F(2, 73) = 1.55$, $p = .22$, $\eta_p^2 = .04$, CI [.00, .12], $BF_{10} = 0.37$
Eye movements	70.76 (17.28)	-	-	
Recall US	69.88 (22.66)	74.20 (25.24)	-	$F(1, 48) = 0.41$, $p = .53$, $\eta_p^2 = .01$, CI [.00, .09], $BF_{10} = 0.33$
Diary compliance	81.00 (15.80)	92.52 (11.21)	86.54 (12.34)	$F(2, 73) = 4.73$, $p = .01$, $\eta_p^2 = .12$, CI [.02, .22], $BF_{10} = 4.04$

* For one participant sex and age was missing

1 Because Cramer's *V* was medium to large, we investigated whether sex influenced the results. When sex was entered as a covariate in the main analyses, the results remained the same, indicating that the sex distribution did not affect the main outcomes. We report the analyses without sex as a covariate.

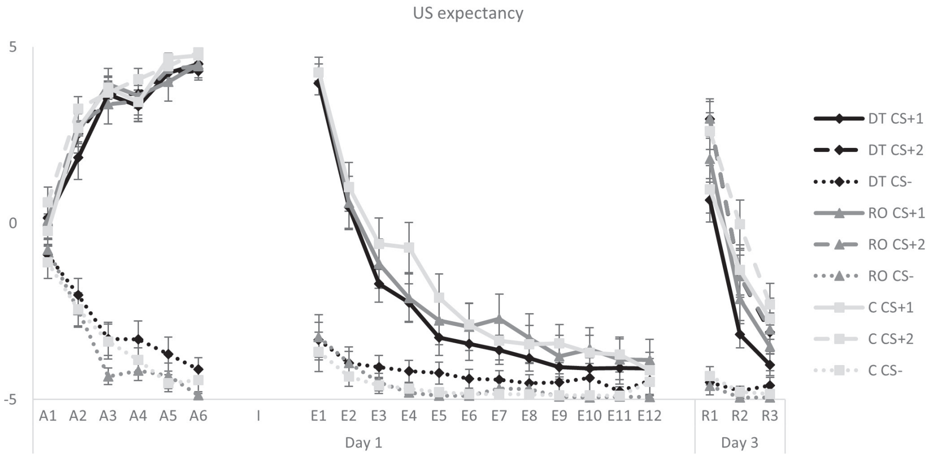

Figure 2. US expectancy during the acquisition (A1-A6), extinction (E1-E12), and return of fear phases (renewal; R1-R3) in the dual-task (DT), recall only (RO), and no task control (C) groups. I = intervention phase. Error bars represent standard error of the mean (SEM).

Acquisition phase

As predicted, there was a significant interaction between CS type and time on US expectancy and CS fear, valence, and arousal, *F*s > 33.81, *ps* < .01, η_p^2s > .31, CI range [.24, .57][2], *BF*s$_{10}$ > 1.71 x 10^{13} (see Figures 2 and 3). CSs+ responding increased on all outcome measures over time, *F*s > 37.12, *p*s < .01, η_p^2s > .33, CI range [.23, .60], *BF*s$_{10}$ > 7.60 x 10^{10}. CS- responding decreased over time, *F*s > 4.14, *p*s < .03, η_p^2s > .05, CI range [.00, .47], *BF*s$_{10}$ > 1.72, except on CS arousal, *F*(1.85, 138.63) = 0.55, *p* = .56, η_p^2 = .01, CI [.00, .04], BF_{10} = 0.07. Fear acquisition measured with US expectancy, CS valence and arousal did not differ between groups, *F*s < 1.07, *p*s > .38, η_p^2s < .03, CI range [.00, .05], *BF*s$_{10}$ < 0.03 (stimulus x time x group). For CS fear, acquisition differed between groups when all timepoints were analyzed, *F*(7.85, 282.46) = 2.54, *p* = .01, η_p^2 = .07, CI [.01, .09], BF_{10} = 0.20 (stimulus x time x group), but not when acquisition was analyzed pre-post, *F*(3.72, 133.92) = 1.47, *p* = .22, η_p^2 = .04, CI [.00, .08], BF_{10} = 0.11 (stimulus x time x group). In sum, differential acquisition was successful on all outcome measures.

2 When test statistics are summarized, the CI range shows the lowest and highest bound of all summarized effect sizes.

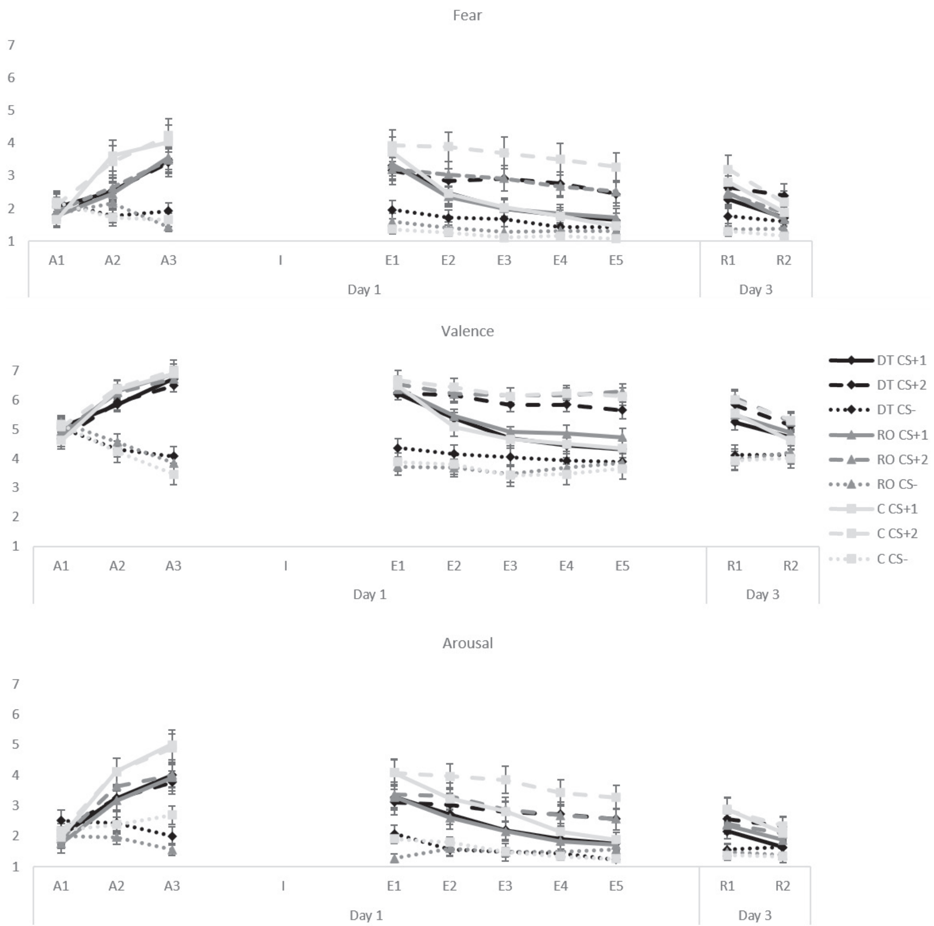

Figure 3. CS fear, CS valence, and CS arousal during the acquisition (A1-A3), extinction (E1-E5), and return of fear (ROF; ROF1-ROF2) phases in the dual-task (DT), recall only (RO), and no task control (C) groups. I = intervention phase. Error bars represent SEM.

Post-acquisition memory ratings

As intended, unpleasantness and vividness did not significantly differ between groups after acquisition, Fs < 3.12, ps ≥ .05, η_p^2s < .08, CI range [.00, .17], BFs$_{10}$ < 1.22 (see Figure 4).[3]

US memory ratings

Intervention phase

Memory unpleasantness and vividness decreased during the intervention phase, Fs > 27.61, ps < .01, η_p^2s > .36, CI range [.23, .56], BFs$_{10}$ > 2.24 x 10^{15} (main effect of time), but

3 See supplemental materials A for a specification of the selected aversive images.

contrary to the hypothesis, this decrease did not differ between the intervention groups, *F*s < 0.38, *p*s > .69, η_p^2s < .01, CI range [.00, .04], *BF*s$_{10}$ < 0.05 (time x group).

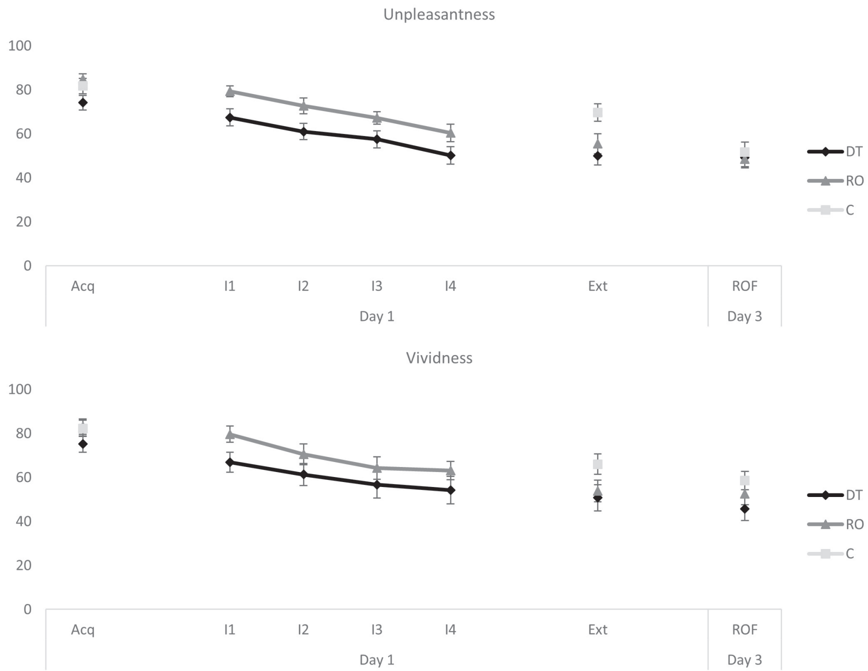

Figure 4. Unpleasantness and vividness of threat memory after the acquisition phase (Acq), during the intervention phase (I1-I4), and after the extinction (Ext) and return of fear (ROF) phases in the dual-task (DT), recall only (RO), and no task control (C) groups. Error bars represent SEM.

Post-extinction

Memory unpleasantness decreased for all groups from after acquisition to after extinction, $F(1, 73) = 74.68$, $p < .01$, $\eta_p^2 = .51$, CI [.37, .60], $BF_{10} = 2.19 \times 10^{10}$ (main effect time), which differed between groups, $F(2, 73) = 4.18$, $p = .02$, $\eta_p^2 = .10$, CI [.01, .21], $BF_{10} = 2.91$ (time x group). Compared to the no task group, unpleasantness decreased more in the intervention groups, *F*s > 4.45, *p*s < .05, η_p^2s > .08, CI range [.00, .26], *BF*s$_{10}$ > 1.65. However, there was no difference between the two intervention groups, $F(1, 48) = 0.79$, $p = .38$, $\eta_p^2 = .02$, CI [.00, .11], $BF_{10} = 0.39$. Memory vividness decreased from after acquisition to after extinction, $F(1, 73) = 98.82$, $p < .01$, $\eta_p^2 = .58$, CI [.45, .66], $BF_{10} = 9.17 \times 10^{11}$ (main effect time), which unexpectedly did not differ between groups, $F(2, 73) = 2.62$, $p = .08$, $\eta_p^2 = .07$, CI [.00, .16], $BF_{10} = 0.82$ (time x group).

Post-renewal

From after acquisition to after return of fear, unpleasantness and vividness decreased, *F*s > 109.02, *p*s < .01, η_p^2s > .60, CI range [.48, .74], *BF*s$_{10}$ > 1.78 x 10^{14}, but this did not differ between groups, *F*s < 1.69, *p*s > .19, η_p^2s < .05, CI range [.00, .13], *BF*s$_{10}$ < 0.42 (time x group). This suggests that the interventions were not successful in reducing unpleasantness and vividness of threat memory over time, compared to no task.

Main analyses

Extinction phase

Unexpectedly, there was no group difference from the last acquisition trial to the first extinction trial on all outcome measures, *F*s < 1.43, *p*s > .23, η_p^2s < .04, CI range [.00, .08], *BF*s$_{10}$ < 0.13 (stimulus x time x group), suggesting that both interventions had no immediate effect on US expectancy and CS measures. Differential extinction for CS type was found on all outcome measures, *F*s > 12.84, *p*s < .01, η_p^2s > .15, CI range [.09, .54], *BF*s$_{10}$ > 4714.75 (stimulus x time), and this did not differ between groups, *F*s < 1.29, *p*s > .23, η_p^2s < .04, CI range [.00, .04], *BF*s$_{10}$ < 0.01 (stimulus x time x group).

4

Return of fear

Spontaneous recovery. CS fear, valence, and arousal increased more for the CS+1 than CS- from the last extinction trial to the first test trial 48 hours later, *F*s > 11.54, *p*s < .01, η_p^2s > .13, CI range [.04, .34], *BF*s$_{10}$ > 6.60 (stimulus x time), but unexpectedly, this did not differ between groups, *F*s < 2.21, *p*s > .11, η_p^2s < .06, CI range [.00, .14], *BF*s$_{10}$ < 0.38 (stimulus x time x group; see Figure 3). Thus, the interventions did not reduce spontaneous recovery compared to no task.

Renewal phase. US expectancy increased more for the CS+1 than CS- from the last extinction trial to the first test trial, $F(1, 72) = 118.15$, $p < .01$, $\eta_p^2 = .62$, CI [.50, .70], $BF_{10} = 5.85 \times 10^{18}$ (stimulus x time), but this did not differ between groups, $F(2, 72) = 0.20$, $p = .82$, $\eta_p^2 = .01$, CI [.00, .04], $BF_{10} = 0.13$ (stimulus x time x group; see Figure 2). The interventions did not reduce fear renewal compared to no task.

Given the lack of expected group differences on spontaneous recovery and renewal, detailed results on generalization of the interventions to the non-extinguished CS+2 are not reported.[4]

4 Exploratory analyses revealed a similar pattern on conditioned responses to the CS+2 on the first trial of the spontaneous recovery and renewal phases, namely no differences between groups.

Intrusions

Intrusion frequency was low in all groups, suggesting that the paradigm was limited in inducing sufficient intrusions to test the hypotheses (see Figure 5). Intrusion frequency did not differ between groups, $F(2, 72) = 1.07$, $p = .35$, $\eta_p^2 = .03$, CI [.00, .10], $BF_{10} = 0.26$, nor did intrusion unpleasantness and vividness ratings, Fs < 1.34, ps > .27, η_p^2s < .07, CI range [.00, .17], $BF\text{s}_{10} < 0.42$ (see Table 2).

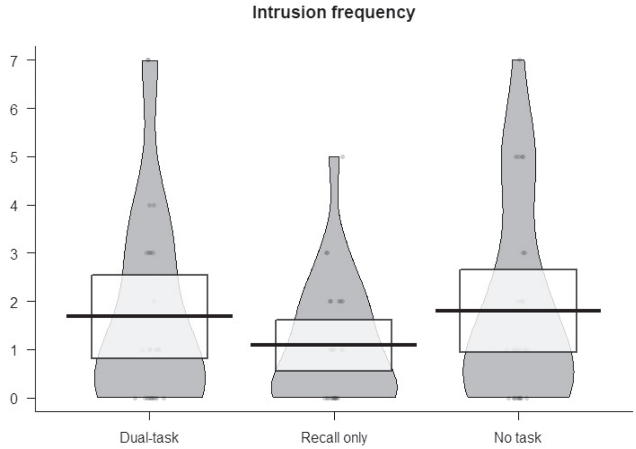

Figure 5. Intrusion frequency over 48 h in between testing sessions. Means (lines), 95% confidence intervals (boxes), individual data points (dots), and the density of data distribution (beans).

Table 2. Means and standard deviations of unpleasantness and vividness of intrusive memories.

	Dual-task (*n* = 15)	Recall only (*n* = 14)	No task (*n* = 16)
Intrusion unpleasantness	4.53 (1.51)	4.08 (1.08)	5.17 (2.54)
Intrusion vividness	5.23 (1.32)	5.61 (0.87)	5.44 (1.92)

Discussion

This study aimed to investigate whether a dual-task intervention, and to a lesser extent a recall only intervention, reduces conditioned responses directly after the intervention, and return of fear and intrusive memories two days later. The main findings can be summarized as follows. First, the dual-task and recall only interventions decreased unpleasantness and vividness of threat memory similarly during the intervention phase, indicating threat devaluation. Second, inconsistent with the hypotheses, the dual-task and recall only groups did not differ from the no intervention group in conditioned responses immediately after the intervention, spontaneous recovery, renewal or intrusion frequency.

During the intervention phase, memory unpleasantness and vividness decreased similarly in both intervention groups, which contrasts studies with a short intervention duration that consistently found beneficial effects of a dual-task intervention compared to recall only (Lee & Cuijpers, 2013; Mertens, Lund, et al., 2020). However, our findings corroborate with research that also used an increased intervention duration (Landkroon et al., 2020; van Schie et al., 2019; van Veen et al., 2020). Moreover, a meta-analysis demonstrated that EMDR with or without eye movements might equally reduce clinical symptoms (Cuijpers et al., 2020). Thus, prolonged recall only may serve as imaginal exposure, and adding a dual-task may not further reduce intensity of threat memory.

Contrary to the prediction, compared to the no intervention group, both intervention groups did not show reduced conditioned fear responses directly after the intervention or two days later. Moreover, threat memory devaluation was inconsistently related to these outcome measures and Bayesian analyses provided support for the null hypothesis. Potentially, threat devaluation does not reduce conditioned responses. While earlier one-day studies demonstrated that a dual-task intervention reduced conditioned responses directly after the intervention, compared to recall only (Leer, Engelhard, Altink, et al., 2013) and compared to no task (Leer, Engelhard, Dibbets, et al., 2013), the latter study found no group differences in threat devaluation. This suggests that the observed differences in conditioned responses did not result from threat devaluation. In multiple-day studies, a dual-task intervention did not reduce conditioned responses compared to a control task, when tested one day after the intervention (Dibbets et al., 2018) or when the intervention was 24 h after fear acquisition (Landkroon et al., 2020). Collectively, this suggests that threat devaluation may not reduce conditioned responses, in contrast to contemporary learning theory (Davey, 1997).

An alternative interpretation of why the interventions did not reduce conditioned responses compared to no intervention, is that the interventions were not potent enough to devalue threat memory adequately and as a result, conditioned responses would not be attenuated. Indeed, threat memory was still rated as relatively unpleasant in both intervention groups after the intervention (>50 on 0-100 scale; see e.g., Dibbets et al., 2018; Landkroon et al., 2020; Leer, Engelhard, Altink, et al., 2013). Reducing the unpleasantness even further during such a brief intervention in the lab may not be feasible. Moreover, the interventions reduced unpleasantness of threat memory compared to no intervention after the extinction phase, but not after two days. Newly acquired footage as threat memory is perhaps more susceptible to decay over time than autobiographical memories (McGaugh, 2000), and consequently, unpleasantness also decreased in the no intervention group after two days.

There are several possibilities to increase the potency of interventions. First, the potency of a dual-task intervention may be enhanced by including other elements of the EMDR protocol, such as increasing the validity of positive cognitions (de Jongh & ten Broeke, 2012; Shapiro, 2017). This may be difficult in fear conditioning and trauma film paradigms, because these paradigms do not use idiosyncratic memories. Instead, aversive autobiographical memories might be more appropriate to investigate cognitive interventions. Behavioral avoidance tasks can then be used to measure conditioned responses (Beckers et al., 2013). Second, future studies can select other imagery-based interventions that may sort larger effects, such as imagery rescripting (Morina et al., 2017), in which a threat memory is imagined and changed into a more positive scenario. Future research using a more potent intervention and using mediation analyses could disentangle whether threat devaluation reduces conditioned responses or whether these are ultimately not related.

Another issue that warrants discussion is the low intrusion frequency. This resulted in minimal room for the interventions to reduce this frequency even further. Previous studies using the same trauma film reported between 2.5 and 5.5 intrusions (Streb et al., 2016; van Schie et al., 2019; Verwoerd et al., 2008). Those studies used a longer film clip (10 min vs. our 6 clips of 30 s), a longer diary period (4-7 days vs. our 2 days), and did not use a fear conditioning paradigm with intervening materials between 'acquisition' and 'diary'. However, previous studies with similar designs as our study (30-s film clips, 2-day diary, and intervening tasks after the film) reported four to eight intrusions (Rattel et al., 2019; Wegerer et al., 2013). The latter studies differed from our study in two ways that may influence intrusion frequency. First, the earlier studies used different film scenes, although all scenes showed severe violence. Second, in previous research participants registered intrusions with the Intrusive Memory Questionnaire each evening retrospectively, while here participants were instructed to register intrusions immediately. Future research may investigate these potential explanations for differences in intrusion frequency and then investigate interventions to reduce intrusion frequency and conditioned responses with an improved paradigm. Alternatively, future studies may test interventions in individuals who already experience intrusive imagery (Homer & Deeprose, 2017).

Several limitations of the experimental paradigm should be noted. First, as abovementioned, the potency of the interventions may be insufficient and intrusion frequency was overall low. Second, the acquisition and intervention phases took place on the same day. Future multiple-day studies could ensure that the interventions interfere with *consolidated* threat memories (McGaugh, 2000). Third, no psychophysiological measures of associative or evaluative fear learning were taken. It remains unclear whether a dual-task intervention affects psychophysiological measures (Landkroon et al., 2020; but see Engelhard, van Uijen, et al., 2010), so it is recommended that future studies also use these outcome measures to assess all components of learned fear (Constantinou et al., 2020). Finally, expected effect sizes based on previous research can be inflated (Brysbaert, 2019), resulting in underpowered studies. Yet, this seems an unlikely explanation for our null findings, because the Bayes factors provide evidence for the null hypotheses. Strengths of this study include using both active and passive control groups, having multiple self-report outcome measures showing similar results (see Constantinou et al., 2020; Wegerer et al., 2013), and the study's pre-registration (Krypotos et al., 2019).

In conclusion, both dual-task and recall only interventions reduced aversiveness of threat memory compared to no task, but the interventions did not reduce conditioned fear responding, return of fear or intrusions. Future studies may improve interventions and focus on intrusive autobiographical memories. Considering the major impact of fear relapse and intrusive memories, further research on improving mental imagery-based interventions is warranted.

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Supplemental materials

A. Selection of aversive images from the film clips

In Table S1, we present the images that participants chose as the most aversive image from the film clips. Most individuals selected the smashed face as the most aversive image, followed by an image involving hitting with the fire extinguisher, and arm breaking. Some participants further specified these images.

Table S1. Selected aversive image of the film clip (frequency and percentage).

Image	Frequency (%)
Smashed face	48 (63.16%)
Jaw still moving	4 (5.26%)
Jaw breaking	3 (3.95%)
Fire extinguisher	23 (30.26%)
First hit	5 (6.58%)
Last hit	5 (6.58%)
Right before first hit	1 (1.32%)
Right before last hit	1 (1.32%)
Arm breaking	5 (6.58%)

B. Correlations between threat memory devaluation and the outcome measures

To investigate whether threat memory devaluation is linked to the outcome measures, we have conducted exploratory correlations (see Table S2). First, threat memory devaluation was calculated for threat memory unpleasantness [baseline unpleasantness – intervention Trial 4 unpleasantness]. Second, we calculated conditioned responding immediately after the intervention for the CS+1 on US expectancy, CS fear, valence and arousal and corrected the scores with the last acquisition trial [CS+1 first extinction trial – CS+1 last acquisition trial]. For the CS measures (fear, valence, and arousal), one composite score was formed (average), because they measure one construct (Cronbach's α = .75). Third, we calculated renewal for the CS+1 on US expectancy corrected for the last extinction trial [CS+1 renewal Trial 1 – CS+1 extinction Trial 12]. Fourth, we calculated return of fear for CS fear, valence and arousal in the same manner [CS+1 return of fear Trial 1 – CS+1 extinction Trial 5] and averaged these scores again (Cronbach's α = .72). Finally, we correlated threat memory devaluation with measures of conditioned responding directly after the interventions, return of fear, and intrusion frequency.

The results show that a larger decrease in memory unpleasantness (i.e., more threat memory devaluation) was correlated with a smaller decrease in US expectancy immediately after the intervention, while this effect dissipated over time (i.e., on Day 3). Moreover, as expected, a larger decrease in memory unpleasantness was correlated with a larger decrease in CS aversiveness directly after the intervention, while over time this association was reversed (i.e., on Day 3). No significant correlation was found between memory unpleasantness and intrusion frequency.

Table S2. Correlations between threat memory devaluation and CS+1 responses immediately after the interventions, return of fear, and intrusions.

		Devaluation unpleasantness	*n*
Immediately after the interventions			
	US expectancy	$r = .32, p = .026, BF_{10} = 1.96$	50
	CS measures	$r = -.39, p = .006, BF_{10} = 7.28$	50
Return of fear			
	US expectancy	$r = .16, p = .262, BF_{10} = 0.33$	49
	CS measures	$r = .28, p = .046, BF_{10} = 1.22$	50
Intrusions			
	Frequency	$r = -.01, p = .964, BF_{10} = 0.18$	50

Part II

Modifying negative mental imagery to enhance exposure willingness

Chapter 5

The effect of imagery rescripting on prospective mental imagery of a feared social situation

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Under review.

Author contributions: EL, ES, SB, EK, JH, and IE developed the study concept and all authors contributed to the study design. EL was responsible for data collection and performed the data analyses. EL and KM gave clinical supervision. All authors were involved in the interpretation of the data. EL drafted the paper and ES, KM, SB, EK, JH, and IE provided critical revisions. All authors approved the final version of the manuscript.

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Abstract

Negative mental imagery appears to play a role in anxiety disorders, and can involve aversive memories or anticipated future threats. Modulating aversive memories through imagery rescripting generally reduces negative memory appraisals and anxiety. This pre-registered two-day study investigated whether it also reduces negative imagery of future threats. On Day 1, socially anxious individuals (*N* = 52) were randomly assigned to imagery rescripting or progressive relaxation (control condition). Before each intervention, they were asked to imagine a feared social situation that may happen in their future and evaluate this situation. They assessed the aversive memory before and after the intervention. The future feared situation was again evaluated at follow-up on Day 2. Results showed reduced negative memory appraisals after both interventions. Likewise, in both groups, negative details decreased and positive details increased in prospective mental imagery, and anxiety and avoidance towards the imagined event decreased. The imagery rescripting group showed increased positive appraisals of memory and future threat, and decreased negative future-threat appraisals, compared to the progressive relaxation group. The findings suggest that effects of imagery rescripting extend to mental imagery of future threat, but replication with a passive control condition is needed.

Introduction

Negative mental imagery is common in anxious and depressed individuals (Brewin et al., 2010; Holmes & Mathews, 2010). In social anxiety disorder, negative self-images are usually distorted mental representations of how an individual is perceived by others (Hackmann et al., 1998). This negative imagery often corresponds with aversive autobiographical memories (Dobinson et al., 2020; Hackmann et al., 2000). Indeed, socially anxious individuals retrieve relatively more negative images and memories (Krans et al., 2014; Moscovitch et al., 2011), and appraise these negative memories as more distressing and intrusive than healthy individuals (Moscovitch et al., 2018). In addition, negative mental imagery can represent anticipated future threats (Brewin et al., 2010; Engelhard et al., 2010; Holmes & Mathews, 2010). Individuals with anxiety disorders typically imagine negative future scenarios more vividly, with greater distress and higher perceived likelihood, compared to individuals without anxiety disorders (Morina et al., 2011). Taken together, socially anxious individuals tend to experience negative mental imagery about social situations.

Generally, mental imagery is useful to anticipate potential outcomes of future situations and adjust behavior (Schacter et al., 2017). To form representations of novel situations, people recombine elements of earlier experiences (Schacter & Addis, 2007). Episodic *threat* memories of earlier experiences are crucial for survival because they enable us to learn and adapt future behavior (e.g., Bulley et al., 2017). However, when anticipated threats are exaggerated or unrealistic, mental imagery can become maladaptive and presumably play a role in maintaining anxiety and avoidance behavior (Clark & Wells, 1995; Hofmann, 2007; Miloyan et al., 2016; Miloyan & Suddendorf, 2015; Rapee & Heimberg, 1997). Previous research in socially anxious individuals showed that holding a negative self-image in mind (compared to a neutral self-image), increases anxiety, negative thoughts, self-focused attention, and safety behaviors, and reduces performance in social interactions (e.g., Hirsch et al., 2003, 2004; Makkar & Grisham, 2011; Stopa & Jenkins, 2007; Vassilopoulos, 2005; for a review see Ng et al., 2014). These increases in anxiety, safety behaviors, and self-focused attention may prevent individuals from judging their performance on the basis of objective evidence, and instead base their judgments on their negative self-images (Hirsch & Holmes, 2007). Similarly, imagining positive outcomes of feared future situations can reduce the perceived plausibility of negative outcomes and anxiety, and increase willingness to engage in feared situations (e.g., Landkroon, Meyerbröker, et al., submitted; Landkroon, van Dis, et al., submitted). Thus, mental imagery can guide both approach and avoidance behavior.

An effective clinical intervention for modulating aversive threat memories is imagery rescripting. Imagery rescripting is an experiential technique in which the patient imagines changes to the sequence of events in a threat memory to update its meaning (Arntz, 2012; Wild & Clark, 2011). Patients are encouraged to change the imagined scenario in any way to make it more positive. Imagery rescripting can reduce symptomatology in a range of anxiety disorders, including social anxiety disorder (Morina et al., 2017). There is evidence that imagery rescripting helps anxious individuals to reappraise encapsulated beliefs (Reimer & Moscovitch, 2015; Romano, Moscovitch, et al., 2020; Wild et al., 2007, 2008) and regain a sense of mastery (Kunze et al., 2019). Interestingly, research has also demonstrated that imagery rescripting affects memory by showing that when participants describe their memory again after treatment, they use more positive and neutral elements compared to participants who received supportive counseling but not to those who received imaginal exposure (Romano, Moscovitch, et al., 2020). Yet, it remains unknown whether imagery rescripting of negative memories also affects the way anxious individuals imagine *future* fear-related events. Indeed, it is possible that impacting future imagined events is one of the essential mechanisms of imagery rescripting.

Given that negative threat memories should impact the mental representation of anticipated future threats (e.g., Schacter & Addis, 2007), the aim of this analog study was to investigate whether one-session imagery rescripting of a negative threat memory changes how high socially anxious individuals imagine the future threat event one day later. In line with earlier research, we hypothesized that imagery rescripting would reduce negative memory appraisals compared to progressive relaxation as a control intervention. Importantly, we hypothesized that imagery rescripting of a negative threat memory would reduce negative prospective mental imagery of threat compared to progressive relaxation. That is, we expected that imagery rescripting would reduce the number of negative details and increase the number of positive details when participants imagine a feared social event, and it would also reduce anticipatory anxiety and avoidance for this event. Finally, we explored whether imagery rescripting, compared to progressive relaxation, changes positive memory appraisals, emotional appraisals of the future imagined situation, avoidance towards a novel social situation, and whether changes in memory reappraisal were related to changes in reappraisal of the imagined future situation.

Methods

Participants

Native Dutch-speaking individuals between 18 and 30 years old were included if they scored ≥30 on the Social Phobia Inventory (SPIN) via an online screening. Participants were excluded if they endorsed self-reported severe medical issues (e.g., heart problems, respiratory difficulties, neurological symptoms) and severe self-reported psychiatric complaints (i.e., suicidal ideation, psychotic symptoms, mania, or substance dependence; see Romano, Moscovitch, et al., 2020) during the online screening. In line with the a priori power analysis, the final sample consisted of 52 participants (see Figure 1). G*Power yielded a sample size of 52 participants for an expected small to medium effect (f = .20, α = .05 and power = .80) using a mixed ANOVA. This study was approved by the Ethics Committee of the Faculty of Social Sciences of Utrecht University (FETC20-154). All participants provided written informed consent, and they participated individually. This study was pre-registered on the Open Science Framework (https://osf.io/7yk8j/).

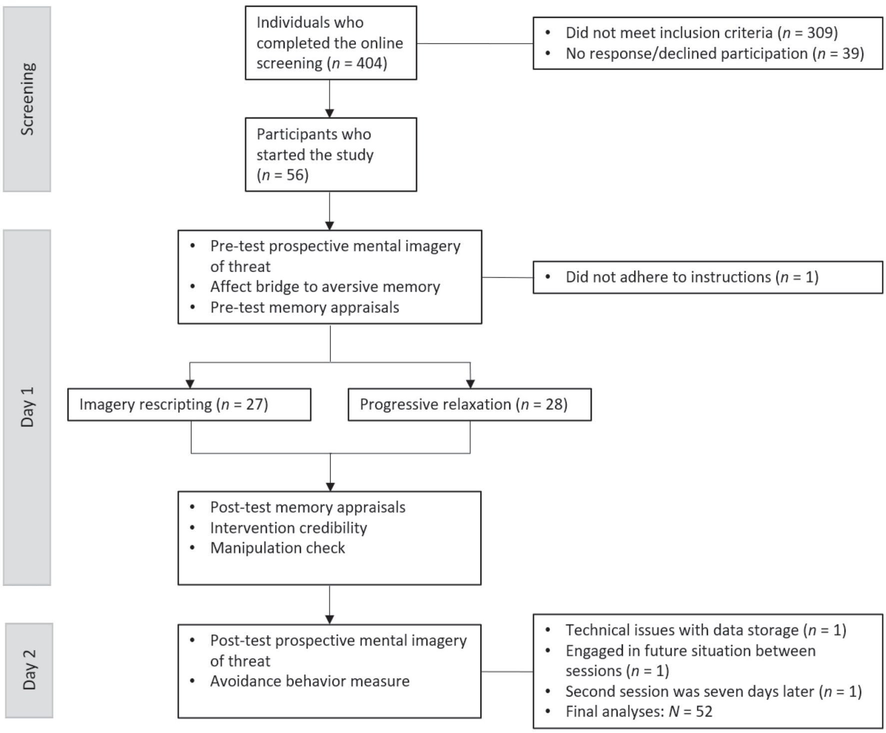

Figure 1. Flow of participants and procedure.

Interventions

The interventions lasted approximately 15 minutes. A treatment rationale was provided for each intervention and both treatments were presented as treatment for social anxiety. In both intervention groups, participants were encouraged to close their eyes during the intervention.

Imagery rescripting

The imagery rescripting protocol consisted of three phases, based on previous research (Arntz & Weertman, 1999; Frets et al., 2014; Romano, Moscovitch, et al., 2020; Wild & Clark, 2011). In phase one, participants were instructed to relive an aversive event as their younger self. They were encouraged to describe the sequence of events as detailed as possible, also including their own thoughts and feelings. In phase two, participants were asked to imagine the event again but now from an observer perspective and see the events unfold as their current self. Participants were instructed to intervene in the situation in imagination in any way they wanted to make the scene more positive or satisfying. In phase three, they were asked to relive the memory again from the younger self perspective, including the new information from phase two. They were able to make more changes if they desired.

Progressive relaxation

In the progressive relaxation group, participants were instructed to practice tensing and relaxing their muscles (Hazlett-Stevens, 2008). The experimenter first demonstrated tensing the muscle groups and participants were encouraged to try tensing these muscles as well. They could ask questions if anything was unclear. After the demonstration, the experimenter guided them throughout the intervention phase. Participants were instructed to tense and relax each muscle group one by one. They were asked to tense a muscle group for 5 to 7 s and then to relax for 45 to 60 s. In total, they practiced with eight muscle groups. Afterwards, they were asked whether they felt any tension in their body. In case participants still felt tension, the muscle group in which they felt this was again tensed and relaxed, until they felt no more tension in their body. Participants in this condition were instructed to focus on the exercise and they were not asked to think back to the memory while performing the relaxation exercises to prevent memory exposure.

Materials

Credibility ratings of the interventions

Three items measured whether participants thought the intervention was credible on a 9-point scale (1 = *not at all useful*; 9 = *very useful*; Devilly & Borkovec, 2000; Romano, Moscovitch, et al., 2020). Internal consistency was good in this study (α = .80).

Manipulation check

Participants were asked to indicate whether they were able to follow the instructions during the intervention phase on a visual analog scale (VAS). That is, they were asked whether they could imagine a positive ending to their memory or were able to tense and relax their muscles in the imagery rescripting group and progressive relaxation group respectively (0 = *not at all*; 100 = *extremely well*). In addition, participants were asked whether they experienced the intervention as pleasant (0 = *not at all*; 100 = *extremely*) and whether they thought of the future situation (0 = *not at all*; 100 = *all the time*). The progressive relaxation group was asked whether they thought of the memory during the intervention (0 = *not at all*; 100 = *all the time*).

Screening questionnaire

The Social Phobia Inventory (SPIN) is a 17-item self-report questionnaire that assesses fear, avoidance, and physiological symptoms that are characteristic for social anxiety (0 = *not at all;* 4 = *extremely*; Boelen & Reijntjes, 2009; Connor et al., 2000). The score ranges from 0 to 68, with higher scores reflecting higher levels of social anxiety. Internal consistency was acceptable in this study (α = .77).

Main outcomes measures

Memory appraisals.

Encapsulated beliefs. After selecting an aversive social memory, participants were asked about their encapsulated belief in this memory with the downward arrow technique. They were asked to formulate an encapsulated belief and rate its credibility on a VAS (0 = *not at all credible*; 100 = *extremely credible*; Wild et al., 2007, 2008).

Emotional appraisals. Participants were instructed to retrieve their aversive memory and rate how they felt while thinking about the memory with the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988). The PANAS consists of 10 items concerning positive affect and 10 items concerning negative affect. The items are scored on a 5-point scale (1 = *very slightly or not at all*; 5 = *extremely*). Two sum scores were formed separately for positive and negative affect. Internal consistencies were acceptable to good in the current study (α = .77-.90).

Mastery. Three VASs measured how helpless participants felt when they thought about the aversive memory, the degree of control they experienced over the content of their memory, and their tolerability of emotions elicited by the memory (0 = *not at all*; 100 = *extremely*; see Kunze et al., 2019; Landkroon, Meyerbröker, et al., submitted). The scores on these items were summed. Internal consistency was acceptable (α = .69-.71).

Prospective mental imagery of threat.

Narratives imagined future situation. Participants were asked to identify a social situation they feared that may happen in their personal future. They were not allowed to select a feared situation that could happen between testing sessions. They were instructed to imagine the situation from their own perspective by focusing on sensory details and bodily sensations. They were asked to describe the situation in several phases (see also Romano, Moscovitch, et al., 2020). First, in the free recall phase, they were asked to describe the event as detailed as possible, including their thoughts and feelings. Second, three general questions were asked to probe the participant to elicit more information. Finally, participants were asked specific questions to elicit a more detailed narrative. The specific probes included questions about the facial expressions of others, experienced emotions, bodily sensations, thoughts, the worst part of the situation and the meaning for their self-image. This phase was included so participants were able to recall a related aversive memory with a similar meaning later on.

The narratives were audiotaped and transcribed. The free recall and general probe phase were coded following the standardized coding of the Autobiographical Interview (Levine et al., 2002; see also Moscovitch et al., 2018; Romano, Moscovitch, et al., 2020). After selecting the main event in the narrative, the text was segmented into separate details that contain one piece of information. Each segment was classified as an internal or external detail. Internal details are episodic details related to the main event at a specific time and place, while external details are episodic details unrelated to the main event or semantic details. In addition, for each segment the valence was coded as positive, negative or neutral (Moscovitch et al., 2018; Romano, Moscovitch, et al., 2020). Two separate sum scores were formed for negative and positive internal details, because internal details reflect episodic richness. The ratio between [negative internal details / total internal details] was calculated to control for the total number of internal details, and the same was done for positive details [positive internal details / total internal details].

A research assistant was trained by one of the authors (EL) to code the narratives. After the training phase, the research assistant and EL scored 11 practice narratives. After removing the narrative with the poorest reliability (see Romano, Moscovitch, et al., 2020), ICCs (absolute agreement; two-way mixed model) were .883, .925, and .902 on internal details, negative internal details, and positive internal details, indicating high reliability and successful training. The research assistant scored all narratives (*n* = 104) and a random subset was scored by author EL (15%; *n* = 16). ICCs were .997, .997, and .919 for total internal details, negative internal details, and positive internal details respectively.

Anticipatory anxiety and avoidance of the imagined future situation. Anxiety and avoidance towards the imagined future event was measured with the Fear Questionnaire (FQ; Marks & Mathews, 1979) using a 9-point scale (0 = *not fearful/would not avoid*; 8 = *extreme panic/would definitely avoid*). Although the correlations between items were low (*r* = -.01 at t1; *r* = .34 at t2), the sum score was used because together these items reflect the severity of distress towards the event.

Exploratory measures

Emotional appraisals of the imagined future situation. Emotional appraisals of the imagined feared future event were measured with the PANAS. Participants were instructed to fill in the questionnaire about how they felt when imagining the feared future event. Two sum scores were formed for the positive and negative items separately. Internal consistencies were low to good in the current study (α = .57-.90).

Avoidance behavior. At the end of the experiment, participants were asked whether they wanted to participate in another study during which they had to give a presentation. They were asked to rate their willingness to participate on a VAS as a measure of performance related avoidance behavior (0 = *not at all;* 100 = *extremely*). If they did not want to participate, they were asked why.

Procedure

Participants were recruited via social media, student associations, and Sona Systems. Interested students were screened online on the inclusion and exclusion criteria. If they scored within the range of interest, they were invited for the study. Due to the COVID-19 pandemic, the entire study took place via videocalls from participants' and experimenters' homes using the program StarLeaf.

Day 1

Participants were asked to describe a narrative of an upcoming social situation they feared (see Figure 1). Afterwards, they provided a working title consisting of a few words, and rated the FQ and emotional appraisals concerning this event. All participants were asked to focus on the feelings, thoughts, and emotions that were associated with the feared situation. They were then asked to let go of the future situation and recall a memory during which they had experienced similar feelings (affect bridge). Then, participants were asked to relive the memory for 1 min and to focus on their feelings, bodily sensations, and thoughts. Participants rated the credibility of their encapsulated belief, emotional memory appraisals, and mastery. After random group assignment to imagery rescripting or progressive relaxation using a randomizer tool (randomizer.org, stratified for gender), participants received their assigned intervention. After the intervention, participants were asked to relive the memory again for 1 min as they now experienced it, and rated the credibility of the encapsulated belief, emotional memory appraisals, and mastery again. Also, participants rated the intervention credibility and manipulation check.

Day 2

Participants were presented with the working title of the upcoming social situation they feared and were asked to imagine and formulate the narrative of the social situation again. Importantly, participants were instructed that it was not required they gave the same description as the previous day, but that they could describe the situation however they imagined it now. Participants rated the FQ and emotional appraisals regarding the future event again. Participants were then told that the study was over and were asked about their willingness to participate in another study. Finally, participants were debriefed and reimbursed (money or course credit). Participants in the control condition were offered a session of imagery rescripting.

Data analyses

All analyses were conducted within a Null-Hypothesis Significance Testing and a Bayesian framework (Krypotos et al., 2020). Within the Null-Hypothesis Significance Testing framework, confidence intervals (CI) for effect sizes were reported using the MBESS package in R (Kelley, 2017). For partial eta-squared, 90% confidence intervals were reported and 95% CIs for Cohen's *d* (Lakens, 2013). Within the Bayesian framework, Bayes factors were computed that quantify the evidence that the data provides for the alternative hypothesis relative to the null hypothesis in JASP using the default settings (JASP Team, 2020). For example, $BF_{10} = 3$ demonstrates that these data are three times more likely under the alternative hypothesis than the null hypothesis, while $BF_{10} = 0.33$ indicates that the data are three times more likely under the null hypothesis than the alternative hypothesis.

To check whether randomization was successful, independent *t*-tests were conducted on age and SPIN scores, and chi-square tests on gender distribution, employment status, and highest education level. To assess whether the manipulation was executed well, independent *t*-tests were conducted on intervention credibility, intervention duration, whether participants were able to follow the instructions during the intervention phase, intervention pleasantness, and whether they thought of the future situation during the intervention.

To test whether the credibility of the encapsulated belief and negative emotional appraisals decreased, and mastery increased in the imagery rescripting group compared to the control group, separate 2 (time: pre vs. post intervention) x 2 (condition: imagery rescripting vs. control) mixed ANOVAs were conducted. With respect to the imagined future situation, we analyzed whether in the imagery rescripting group, compared to the control group, the number of negative internal details decreased, the number of positive internal details increased, and FQ scores decreased, using 2 (time: pre vs. post intervention) x 2 (condition: imagery rescripting vs. control) mixed ANOVAs.

The following exploratory analyses were conducted. First, to explore potential group differences over time in positive emotional appraisals towards the memory, a 2 (time: pre vs. post intervention) x 2 (condition: imagery rescripting vs. control) mixed ANOVA was done. Second, to explore potential group differences over time in the emotional appraisals of the feared future event, 2 (time: pre vs. post intervention) x 2 (condition: imagery rescripting vs. control) mixed ANOVAs were conducted on positive and negative appraisals separately. Third, to investigate potential group differences in whether participants would avoid a situation in which they would have to give a presentation, an independent *t*-test was done. Finally, in addition to our pre-registered exploratory analyses, we also explored whether changes in memory appraisals were related to changes in prospective mental imagery of threat by reporting correlations between these difference scores.

Results

Randomization check

There were no group differences in age, SPIN score, gender distribution, employment status, or highest education level (*p*s > .05; *d*s < 0.48; Cramer's *V*s < .23; BFs_{10} < 0.94; see Table 1).

Table 1. Means (standard deviations) of demographics and randomization variables.

	Progressive relaxation (n = 26)	Imagery rescripting (n = 26)
Age	22.81 (2.87)	22.58 (2.75)
SPIN	39.15 (6.42)	43.00 (9.42)
Men / women / other	3 / 23 / 0	4 / 21 / 1
Student / employed / looking for work	21 /4 / 1	24 / 2 / 0
Highest education level		
Secondary / intermediate vocational education	12	15
(Applied) university bachelor	10	10
University master	3	1
Other	1	0

Note. SPIN = Social Phobia Inventory.

Credibility of the interventions and manipulation check

There were no group differences in intervention credibility, intervention duration, whether participants followed the instructions during the intervention phase, intervention's pleasantness, or whether they thought about the feared future event during the intervention (ps > .05; ds < 0.50; BFs_{10} < 1.02; see Table 2). Additionally, participants in the progressive relaxation condition generally indicated that they barely thought about the memory during the intervention phase. Collectively, this indicates that the interventions were comparable in terms of credibility and duration, and that the manipulation was successful in both groups.

Table 2. Means (standard deviations) of intervention characteristics.

	Progressive relaxation (n = 26)	Imagery rescripting (n = 26)
Credibility	18.62 (4.17)	19.96 (3.89)
Duration (min)	15.44 (0.99)	14.64 (5.20)
Followed instructions	79.23 (11.24)	72.04 (17.26)
Pleasantness	77.38 (17.22)	78.12 (16.55)
Thought of future event	12.12 (17.84)	17.85 (17.69)
Thought of memory	13.73 (16.28)	-

Main outcomes

Memory appraisals

Encapsulated beliefs. From before to after the intervention phase, there was a strong decrease in the credibility of the encapsulated belief, $F(1, 50) = 126.88$, $p < .001$, $\eta_p^2 = .72$, 90% [.60, .78], $BF_{10} = 2.63 \times 10^{12}$ (see Table 3). Crucially, the Condition x Time interaction was not significant, $F(1, 50) = 3.03$, $p = .088$, $\eta_p^2 = .06$, 90% [.00, .18], $BF_{10} = 0.93$, nor was the main effect of condition, $F(1, 50) = 2.76$, $p = .103$, $\eta_p^2 = .05$, 90% [.00, .17], $BF_{10} = 0.99$.

Table 3. Means (standard deviations) for the outcome measures.

	Progressive relaxation (*n* = 26)		Imagery rescripting (*n* = 26)	
	t1	t2	t1	t2
Memory appraisal				
Encapsulated belief	80.31 (15.23)	56.85 (20.98)	76.04 (20.50)	44.00 (24.54)
Negative emotional appraisal	36.54 (6.66)	26.00 (7.41)	37.12 (7.58)	23.19 (8.13)
Positive emotional appraisal	20.31 (6.20)	20.69 (6.48)	21.23 (5.26)	27.58 (6.89)
Mastery	146.69 (63.58)	197.38 (53.34)	147.46 (59.38)	216.65 (42.00)
Prospective mental imagery				
Fear Questionnaire	8.81 (2.79)	7.85 (3.32)	8.27 (2.66)	6.00 (2.59)
Negative emotional appraisal	34.31 (4.86)	29.69 (6.37)	36.81 (6.71)	27.23 (9.04)
Positive emotional appraisal	23.88 (4.94)	21.54 (6.41)	23.12 (3.40)	26.12 (6.70)

Emotional appraisals. From before to after the intervention phase, negative emotional appraisals of the memory decreased, $F(1, 50) = 132.37$, $p < .001$, $\eta_p^2 = .73$, 90% [.61, .79], $BF_{10} = 1.04 \times 10^{14}$ (see Table 3). Yet, the Condition x Time interaction was not significant, $F(1, 50) = 2.53$, $p = .118$, $\eta_p^2 = .05$, 90% CI [.00, .17], $BF_{10} = 0.77$, nor was there a main effect of condition, $F(1, 50) = 0.39$, $p = .533$, $\eta_p^2 = .01$, 90% CI [.00, .09], $BF_{10} = 0.36$.

Mastery. From before to after the intervention, mastery increased, $F(1, 50) = 83.19$, $p < .001$, $\eta_p^2 = .63$, 90% CI [.48, .71], $BF_{10} = 2.06 \times 10^9$ (see Table 3). However, the Condition x Time interaction was not significant, $F(1, 50) = 1.98$, $p = .165$, $\eta_p^2 = .04$, 90% CI [.00, .15], $BF_{10} = 0.60$, nor was the main effect of condition, $F(1, 50) = 0.53$, $p = .472$, $\eta_p^2 = .01$, 90% CI [.00, .10], $BF_{10} = 0.44$.

Taken together, both interventions reduced negative memory appraisals, but unexpectedly, there were no differences between the interventions.

Prospective mental imagery of threat

Narratives future imagined situation. From Day 1 to Day 2, there was a decrease in the ratio of negative internal details, $F(1, 50) = 7.80$, $p = .007$, $\eta_p^2 = .14$, 90% CI [.02, .28], $BF_{10} = 6.25$ (see Figure 2). Unexpectedly, the Condition x Time interaction was not significant, $F(1, 50) = 0.22$, $p = .638$, $\eta_p^2 = .00$, 90% CI [.00, .08], $BF_{10} = 0.30$, nor was the main effect of condition, $F(1, 50) = 0.11$, $p = .747$, $\eta_p^2 = .00$, 90% CI [.00, .06], $BF_{10} = 0.30$. Likewise, there was an increase in the ratio of positive internal details from Day 1 to Day 2, $F(1, 50) = 11.66$, $p = .001$, $\eta_p^2 = .19$, 90% CI [.05, .34], $BF_{10} = 29.38$. Again, the Condition x Time interaction was not significant, $F(1, 50) = 0.06$, $p = .802$, $\eta_p^2 = .00$, 90% CI [.00, .05], $BF_{10} = 0.28$, nor was the main effect of condition, $F(1, 50) = 0.02$, $p = .883$, $\eta_p^2 = .00$, 90% CI [.00, .03], $BF_{10} = 0.30$.

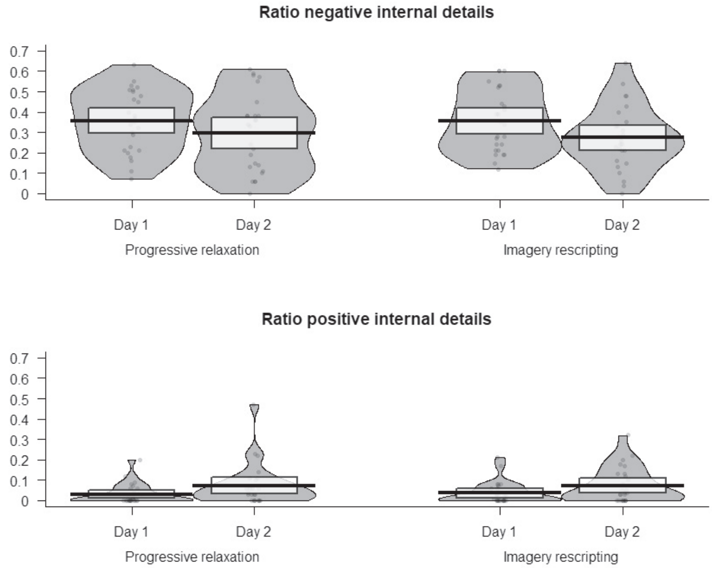

Figure 2. Ratio of negative internal details (negative internal details / total internal details) and positive internal details (positive internal details / total internal details) in the narratives of the future imagined situation before (Day 1) and after (Day 2) the interventions. Means (lines), 95% confidence intervals (boxes), individual data points (dots), and the density of the data distribution (beans).

Anticipatory anxiety and avoidance of the imagined future situation. Anxiety and avoidance for the future event decreased from Day 1 to Day 2, $F(1, 50) = 21.07$, $p < .001$, $\eta_p^2 = .30$, 90% CI [.13, .44], $BF_{10} = 453.74$ (see Table 3). Yet, the Condition x Time interaction was not significant, $F(1, 50) = 3.45$, $p = .069$, $\eta_p^2 = .07$, 90% CI [.00, .19], $BF_{10} = 1.11$, nor was the main effect of condition, $F(1, 50) = 2.83$, $p = .099$, $\eta_p^2 = .05$, 90% CI [.00, .18], $BF_{10} = 1.01$.[1]

Taken together, both interventions reduced negative prospective mental imagery of threat and they even made it more positive. Contrary to the hypothesis, there were no differences between interventions.

Exploratory analyses

Positive emotional appraisals of the memory. Positive emotional appraisals of the memory increased over time, $F(1, 50) = 22.51$, $p < .001$, $\eta_p^2 = .31$, 90% CI [.14, .45], $BF_{10} = 154.57$, and differed between groups, $F(1, 50) = 6.12$, $p = .017$, $\eta_p^2 = .11$, 90% CI [.01, .25], $BF_{10} = 3.45$ (see Table 3). Crucially, there was a significant Condition x Time interaction on positive emotional appraisals of the memory, $F(1, 50) = 17.66$, $p < .001$, $\eta_p^2 = .26$, 90% CI [.10, .41], $BF_{10} = 174.86$. Follow-up analyses demonstrated that positive emotional appraisals of the memory increased in the imagery rescripting group, $t(25) = 5.40$, $p < .001$, $d = 1.06$, 95% CI [0.57, 1.53], $BF_{10} = 1658.93$, but not in the progressive relaxation group, $t(25) = 0.48$, $p = .632$, $d = 0.09$, 95% CI [-0.29, 0.48], $BF_{10} = 0.23$.

Emotional appraisals of the imagined future event. From Day 1 to Day 2, negative emotional appraisals of the future event decreased, $F(1, 50) = 47.19$, $p < .001$, $\eta_p^2 = .49$, 90% CI [.31, .60], $BF_{10} = 1.04 \times 10^{14}$, with no main effect of condition, $F(1, 50) = 0.00$, $p = .991$, $\eta_p^2 = .00$, 90% CI [.00, .00], $BF_{10} = 0.36$ (see Table 3). The effect was further evidenced by a significant Condition x Time interaction, $F(1, 50) = 5.78$, $p = .020$, $\eta_p^2 = .10$, 90% CI [.01, .24], $BF_{10} = 0.77$. Follow-up paired *t*-test demonstrated that in both the progressive relaxation group, $t(25) = 3.45$, $p = .002$, $d = 0.68$, 95% CI [0.24, 1.10], $BF_{10} = 18.58$, and the imagery rescripting group, $t(25) = 6.09$, $p < .001$, $d = 1.19$, 95% CI [0.68, 1.69], $BF_{10} = 8241.43$, negative emotional appraisals decreased, with a stronger decrease in the imagery rescripting group. There were no main effects of time, $F(1, 50) = 0.17$, $p = .684$, $\eta_p^2 = .00$, 90% CI [.00, .07], $BF_{10} = 0.22$, or condition, $F(1, 50) = 2.12$, $p = .151$, $\eta_p^2 = .04$, 90% CI [.00, .16], $BF_{10} = 0.68$, on positive emotional appraisals of the future event from Day 1 to Day 2. Importantly, there was a significant Condition x Time interaction, $F(1, 50) = 11.18$, $p = .002$, $\eta_p^2 = .18$, 90% CI [.05, .33], $BF_{10} = 24.01$. While the positive appraisals of the future event decreased in the progressive relaxation group, $t(25) = 2.57$, $p = .017$, $d = 0.50$, 95% CI [0.09, 0.91], $BF_{10} = 3.07$,

1 When anxiety and avoidance were analyzed separately given the low correlation between items at t1, the results remained the same as when the sum score was used.

they increased in the imagery rescripting group, $t(50) = 2.29$, $p = .031$, $d = 0.45$, 95% CI [0.04, 0.85], $BF_{10} = 1.86$.

Avoidance behavior. Groups did not differ significantly in willingness to participate in another experiment in which participants would be required to give a presentation, $t(50) = 1.98$, $p = .053$, $d = 0.55$, 95% CI [-0.01, 1.10], $BF_{10} = 1.37$, although the effect was in the expected direction (progressive relaxation: $M = 39.85$, $SD = 32.50$; imagery rescripting: $M = 57.96$, $SD = 33.33$).

Correlations. The correlations between difference scores on memory appraisals[2] [Time 2 – Time 1] and difference scores on the prospective mental imagery of threat[3] [Time 2 – Time 1] are reported in Table 4. Changes in memory appraisals were unrelated to changes in the narratives of the prospective mental imagery of threat. Interestingly, reduced credibility of the encapsulated belief, negative emotional memory appraisals, increased positive memory appraisals and mastery were related to reduced anxiety and avoidance towards the feared event (FQ). Likewise, memory reappraisal, except for mastery, was also related to reduced negative emotional appraisals of the future event. Increased positive emotional appraisals of the memory were related to increased positive emotional appraisals of the feared event. Finally, changes in memory appraisals were not related to avoidance to participate in another study. Overall, these findings suggest that memory reappraisal is related to how individuals appraise feared future situations.

2 Changes within memory appraisals were significantly correlated with each other in the expected direction (*r*s > |.38| - |.64|), except for the correlation between changes in mastery and positive emotional memory appraisals.

3 Changes within prospective mental imagery of threat were significantly correlated with each other in the expected direction (*r*s > |.30| - |.67|), except for correlations with avoidance behavior towards a novel social situation.

Table 4. Correlation matrix between difference scores on memory appraisals and difference scores on the prospective mental imagery of threat for the entire sample (N = 52).

	Ratio negative internal details	Ratio positive internal details	Fear Questionnaire	Negative future emotional appraisals	Positive future emotional appraisals	Avoidance behavior
Encapsulated belief	r = .15, p = .276, BF_{10} = 0.31	r = -.06, p = .701, BF_{10} = 0.19	r = .42, p = .002, BF_{10} = 19.24	r = .28, p = .047, BF_{10} = 1.18	r = -.24, p = .081, BF_{10} = 0.76	r = -.12, p = .397, BF_{10} = 0.25
Negative emotional memory appraisals	r = .10, p = .463, BF_{10} = 0.23	r = -.11, p = .447, BF_{10} = 0.23	r = .40, p = .003, BF_{10} = 11.07	r = .39, p = .004, BF_{10} = 10.05	r = -.26, p = .063, BF_{10} = 0.93	r = -.01, p = .944, BF_{10} = 0.17
Positive emotional memory appraisals	r = -.27, p = .054, BF_{10} = 1.05	r = .17, p = .220, BF_{10} = 0.36	r = -.33, p = .017, BF_{10} = 2.76	r = -.30, p = .030, BF_{10} = 1.70	r = .54, p < .001, BF_{10} = 599.67	r = .11, p = .458, BF_{10} = 0.23
Mastery	r = .10, p = .493, BF_{10} = 0.22	r = -.06, p = .675, BF_{10} = 0.19	r = -.35, p = .010, BF_{10} = 4.18	r = -.09, p = .549, BF_{10} = 0.21	r = .07, p = .603, BF_{10} = 0.20	r = -.01, p = .974, BF_{10} = 0.17

Discussion

This study aimed to investigate whether one-session imagery rescripting of a negative threat memory changes how individuals with social anxiety imagine the future one day later. Consistent with our hypotheses, the credibility of the encapsulated belief of the aversive autobiographical memory and negative emotional appraisals reduced, and mastery increased, indicating memory reappraisal. In contrast with our hypotheses, this effect was similar in both groups. Similarly, as expected, negative internal details reduced and positive internal details increased in the prospective mental imagery of threat and anxiety and avoidance towards this imagined event decreased. Unexpectedly, both interventions showed similar effects. The exploratory findings showed that only after imagery rescripting, positive emotional appraisals regarding the memory and the future threat increased, and that negative emotional future-threat appraisals decreased most after imagery rescripting. Finally, memory reappraisal was related to changes in prospective mental imagery of threat. Taken together, both intervention groups showed reappraisal of the aversive memory, which was indirectly related to changes in prospective mental imagery of threat via reappraisals of the future event.

One striking finding is that reappraisal of an aversive memory was related to positive changes in how an individual imagines a future feared situation one day later (see Schacter et al., 2017; Schacter & Addis, 2007). Memory reappraisal was not related to changes in the content of the narratives of prospective mental imagery per se but was related to *reappraisal* of the imagined event. Furthermore, positive reappraisal of the imagined event was associated with a more positive narrative of the prospective mental imagery. This finding extends previous research demonstrating that imagery rescripting facilitates increases in positive/neutral memory details during later recall (Romano, Moscovitch, et al., 2020) by showing that it can also affect reappraisal of prospective mental imagery of threat one day later and that such reappraisal is associated with more positive narratives of future events. Such a more optimistic outlook of future situations is critical because this can reduce anxiety and increase approach behavior (Miloyan & Suddendorf, 2015; Schacter et al., 2017), though we did not find a correlation between more positive narratives and decreased avoidance towards a novel situation. Our findings are also in line with previous research demonstrating that imagery rescripting of an aversive memory reduces fear and avoidance towards social situations in the subsequent week measured retrospectively with a questionnaire (Reimer & Moscovitch, 2015). An important future direction is to investigate whether changes in prospective mental imagery are retained over time, given that anxious individuals have difficulties recalling memory for positive prospective mental imagery over time which may reduce effective goal-directed behavior (Montijn et al., 2021; Romano, Tran, et al., 2020). Additionally, a crucial future endeavor is whether individuals engage more in the actual future situation after receiving an intervention to modify aversive memories.

Both interventions led to changes in reappraisal of the aversive memory and prospective mental imagery of threat quite similarly such that reactions to them were more positive and less negative. The efficacy of imagery rescripting is in line with previous research. It has been suggested that imagery rescripting changes the meaning of the aversive memory (Arntz, 2012). Similar to previous research, imagery rescripting reduced the credibility of the encapsulated belief (Reimer & Moscovitch, 2015; Romano, Moscovitch, et al., 2020; Wild et al., 2007, 2008), negative emotional memory appraisals (Romano, Moscovitch, et al., 2020), and increased positive emotional memory appraisals (Reimer & Moscovitch, 2015) and mastery (Kunze et al., 2019). Our study extends previous work by showing that imagery rescripting also changes *future-threat* appraisals, suggesting that imagery rescripting of an aversive memory also influenced reappraisal of a related imagined future event. Another interpretation of the changes in reappraisal of future events in the imagery rescripting group is that participants applied the skills from imagery rescripting directly to the prospective mental imagery of threat during follow-up. However, we deem this interpretation unlikely because prospective mental imagery of threat was also more positive in the progressive relaxation condition.

The efficacy of progressive relaxation contrasts earlier findings that suggested that adding imagery rescripting to cognitive behavioral therapy is more effective to reduce test anxiety than adding progressive relaxation (Reiss et al., 2017). Yet, a recent study also found unexpectedly that biweekly sessions of progressive relaxation for eight weeks were effective to reduce social anxiety and related difficulties up to three months (Cougle et al., 2020). Participants in the current study generally indicated that they did not think back to the aversive memory during the intervention but feelings of relaxation may have become associated with the aversive memory. Participants were asked to relive the aversive memory for 1 min after the progressive relaxation and before rating the outcome measures. Anxiety patients often use their emotional response to infer threat (Arntz et al., 1995; Miloyan & Suddendorf, 2015). It seems plausible that they also use positive emotions to infer the absence of threat (e.g., 'If I feel relaxed, it must be safe'). Although the effect of progressive relaxation on emotions may be short-lived, it may have led to cognitive reappraisal of the aversive memory because participants noticed they could cope with the aversive memory and were not overwhelmed by negative emotions but felt relaxed instead. This may have enhanced feelings of self-efficacy in implementing cognitive reappraisal, which seems an important mediator in cognitive behavioral therapy to reduce social anxiety (Goldin et al., 2012; Kivity et al., 2021).

Two other explanations can elucidate why both interventions were overall similarly effective. First, participants in both groups recalled the aversive memory during the pre- and post-test. Even in the progressive relaxation group, participants were exposed to their aversive memory and it has been suggested that imaginal exposure could be an effective intervention to reduce social anxiety (Huppert et al., 2003). Yet, this explanation seems unlikely given that the imaginal exposure period was very short, and memory appraisal effects are not strong then (van Veen et al., 2020). Second, placebo effects and demand characteristics could have played a role in the current study. However, there were group differences in positive memory appraisals and in future-threat appraisals, which suggests that the interventions had some differential effects and were not entirely due to placebo effects. Additionally, previous work has suggested that both interventions can be effective in reducing social anxiety (Cougle et al., 2020; Morina et al., 2017). To rule out exposure, placebo effects, or demand characteristics, future studies should replicate these findings using different control groups, such as a more passive control groups and an imaginal exposure alone group.

Several limitations should be noted. First, as mentioned above, no passive control group was used, rendering it impossible to rule out potential placebo effects. Second, the entire procedure took place via videocalls due to the COVID-19 outbreak. Although participants generally indicated that video calling did not interfere with the study, it may have influenced our findings. For instance, the webcam may have increased anxiety (e.g., through increased self-focused attention) or decreased it (e.g., through more safety cues at home). Third, reliability of several measures was limited. Future research should include better validated instruments. Finally, several interactions between time and condition resulted in Bayes factors around 1 (e.g., encapsulated beliefs, FQ, avoidance behavior), indicating that there was not enough evidence to favor either the null or alternative hypothesis. A replication study using a larger sample size is therefore warranted to investigate potential smaller effects between active interventions.

Taken together, the current study showed that changing an aversive memory also updates appraisals of prospective mental imagery of threat which are related to positive changes in the imagery content, regardless of how these changes in memory occur. Although emotional appraisals of both the aversive memory and the prospective mental imagery of threat were more positive after imagery rescripting than progressive relaxation, the current study found no further differences in the interventions' efficacy. To preclude placebo effects, more research to unravel the working mechanisms of the interventions is necessary using different control groups. In conclusion, this study underlines the impact of negative memories on feelings of the future and the potential benefit of modifying these aversive memories during treatment for social anxiety disorder.

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Chapter 6

Future-oriented positive mental imagery reduces anxiety for exposure to public speaking

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Abstract

Exposure therapy is the recommended treatment for anxiety disorders, but many anxious individuals are unwilling to expose themselves to feared situations. Episodic simulation of future situations contributes to adaptive emotion regulation and motivates behavior. This study investigated whether future-oriented positive mental imagery reduces anticipatory anxiety and distress during exposure, and increases exposure willingness and duration. Forty-three individuals with moderate public speaking anxiety were randomized to a standardized positive mental imagery exercise about future public speaking or no-task. All participants were then asked to present in a virtual reality environment. Anticipatory anxiety reduced in the positive mental imagery group, but not in the control group. Additionally, the positive mental imagery group reported lower distress during exposure than the control group, but groups did not differ in exposure willingness. Due to limited variance, effects on exposure duration could not be tested. Future-oriented positive mental imagery is promising to prepare individuals for exposure to previously avoided situations.

Introduction

Exposure-based therapy is the treatment of choice for anxiety disorders (National Institute for Health and Clinical Excellence, 2011), which involves exposure to feared situations and stimuli. Although exposure-based therapy for anxiety disorders is generally effective, its effectiveness is limited by attrition rates. That is, previous research showed drop-out rates before (11-20%) and during (19.6-24%) treatment for anxiety disorders (Bentley et al., 2021; Carpenter et al., 2018; Fernandez et al., 2015). One potential explanation for these attrition rates is that individuals may be too anxious or unwilling to confront feared situations (Benbow & Anderson, 2019), possibly due to negative expectations surrounding the event associated with negative mental imagery. It has been suggested that strategies focusing on enhancing motivation before treatment may reduce drop-out rates (Bentley et al., 2021).

Negative mental imagery about feared outcomes of future situations is common in individuals suffering from anxiety-related disorders (Brewin et al., 2010; Engelhard et al., 2010; Holmes & Mathews, 2010; Saulsman et al., 2019). For example, some people with social anxiety may imagine that others think they are stupid and see themselves looking nervous, anxious, and embarrassed (Hackmann et al., 1998). These negative mental images are often linked to earlier aversive memories (Hackmann & Holmes, 2004). Negative mental imagery has a stronger impact on emotions than verbal processing of the same information (Holmes & Mathews, 2005), and it may maintain fear and avoidance behavior (e.g., Holmes & Mathews, 2010; Krypotos et al., 2020; Mertens et al., 2020). For instance, when socially anxious individuals held a negative self-image in mind that was related to a previous social situation in which they felt anxious, they reported more anxiety, safety behaviors, and negative thoughts during a new social situation than when they held a neutral self-image in mind (e.g., Hirsch et al., 2003, 2004; Makkar & Grisham, 2011). It has been suggested that engaging in positive mental imagery in anticipation of a feared event may counter automatic negative expectations and promote exposure willingness (Brunette & Schacter, 2021; Pictet, 2014; Saulsman et al., 2019).

Thus far, research on positive mental imagery interventions has mostly focused on memories of aversive events. For instance, during imagery rescripting, patients are asked to recall an aversive memory and imagine that the course of the event is changed into a more desired outcome (Arntz, 2012). This generally reduces anxiety symptomatology (Morina et al., 2017). In addition, previous research has shown that when socially anxious individuals hold a positive self-image in mind, they report lower anxiety, higher self-esteem, and enhanced performance during a social situation than when holding a negative self-image in mind (Stopa et al., 2012; Stopa & Jenkins, 2007; Vassilopoulos, 2005). Although these findings are promising, the differences between the positive and negative imagery groups may have been explained by increased fear in the negative imagery group instead of decreased fear in the positive imagery group. Indeed, a previous study in confident speakers has shown that differences between imagery type were mainly driven by the negative imagery (Hirsch et al., 2006). Therefore, to test whether positive imagery reduces fear-relevant responses and behavior, it is critical to compare a positive imagery group with a neutral or no-imagery control group. One study has compared negative, positive, and neutral self-imagery in individuals with social anxiety disorder and non-clinical participants, but unexpectedly found no differences between type of imagery (Ng & Abbott, 2016). The positive self-image was based on a previous social experience during which participants felt confident, assured, or at ease. However, socially anxious individuals can have difficulties retrieving detailed imagery of positive experiences (Moscovitch et al., 2011), so it may be more useful to generate positive mental imagery of future feared events to increase engagement in feared situations (see Pictet, 2014).

Using positive mental imagery of future events fits nicely with insights from cognitive science that suggest that positive episodic future thinking may be effective to prepare for exposure. Episodic future thinking refers to the ability to imagine events that may occur in someone's personal future (Schacter et al., 2017). People imagine emotional future-oriented events frequently (Barsics et al., 2016), which serves several adaptive functions (Bulley et al., 2017; Miloyan & Suddendorf, 2015). First, imagining emotional future-oriented events influences anticipatory emotions of these events (Barsics et al., 2016). Imagining more specific episodic details during future-oriented positive mental imagery of constructive behaviors can decrease anxiety towards feared events (Jing et al., 2016). In addition, future-oriented positive mental imagery can enhance positive affect (Schubert et al., 2020), and it can decrease later automatic responses to a stressful situation (Hagenaars et al., 2015). This suggests that future-oriented positive mental imagery may reduce anxiety before and during feared situations. Second, future-oriented mental imagery allows an individual to anticipate the likelihood of different outcomes, which motivates goal-directed approach and avoidance behavior (Bulley et al., 2017; Miloyan & Suddendorf, 2015). For example, imagining constructive behaviors with more specific episodic details improves problem solving, and is related to higher perceived plausibility of a positive outcome and decreased perceived difficulty to cope with a bad outcome (Jing et al., 2016). Also, in healthy participants and individuals with major depressive disorder, future-oriented positive mental imagery increased motivation and real-life engagement in these imagined activities (e.g., Libby et al., 2007; Renner et al., 2017, 2019). Likewise, imagining desired outcomes of future events can increase decision-making that contributes to achieving those outcomes (e.g., reduced caloric intake in overweight women wanting to improve eating habits; O'Neill et al., 2016).

Previous studies in anxiety indeed suggest that future-oriented positive mental imagery may reduce anxiety and increase exposure willingness (Hunt & Fenton, 2007; McEvoy et al., 2015), but they combined future-oriented positive mental imagery with other cognitive strategies, making it difficult to determine the specific effects of mental imagery. The current study investigates whether future-oriented positive mental imagery alone reduces anticipatory anxiety and increases willingness to engage in exposure in virtual reality (VR). VR-exposure for public speaking anxiety allows for standardization of the audience (Parsons, 2015; van Dis et al., 2021). In addition, VR-exposure generated comparable effects as exposure in vivo for various anxiety disorders (Carl et al., 2019; Emmelkamp & Meyerbröker, 2021), including social anxiety disorder (Emmelkamp et al., 2020) and public speaking anxiety (Reeves et al., 2021). Furthermore, the effects of VR-exposure generalize to real life in clinical samples (Morina et al., 2015).

More specifically, this study aimed to investigate whether a standardized future-oriented positive mental imagery exercise of a public speaking scenario would reduce public speaking anxiety before and during VR-exposure in individuals with moderate public speaking anxiety. First, we hypothesized that positive mental imagery, compared to no-task, would reduce anticipatory anxiety and increase exposure willingness. Second, we expected that it would decrease distress during exposure in VR and increase exposure duration. Finally, we examined changes in mood to explore whether mood may explain potential group differences, and we explored whether positive mental imagery would improve participants' perception of their performance during exposure and reduce safety behavior, compared to no-task.

Methods

Participants

Native Dutch-speaking individuals were recruited via Utrecht University, Facebook, and an International Science ("InScience") Film Festival in Nijmegen, the Netherlands. They were asked to rate two items measuring anxiety and avoidance regarding giving a public presentation (0 = *none/never*; 8 = *extremely/always;* Culver et al., 2011). If they scored ≥ 5 on both items, they were screened on the exclusion criteria: self-reported medical complaints (e.g., heart, respiratory, or neurological difficulties), eyesight difficulty without glasses, nausea during 3D movies, and hearing difficulties. Previous research used ≥ 6 and ≥ 5 as cut-off score for anxiety and avoidance respectively (e.g., Niles et al., 2015), but the cut-off score for both items was set at ≥ 5 in the current study to increase feasibility in a naturalistic setting. Fifty-nine individuals completed the informed consent procedure and then the questionnaires. They were excluded from further participation (n = 5) if they had elevated scores on the Beck Depression Inventory (BDI-II; ≥ 18 and/or > 1 on suicidal ideation; Beck et al., 1996) to prevent potential worsening of depressive symptoms (following van Dis et al., 2021). In addition, participants were excluded from data analyses (n = 11) if they had relatively low anticipatory anxiety at t1 (≤ 40, see main outcome measures; Engelhard et al., 2011). The final sample consisted of 43 participants, in line with the a priori power analysis indicating that at least 40 participants were needed to detect a medium effect size using mixed ANOVA with two measurements and two groups (f = .23; power = .80; α = .05). The Faculty of Social Sciences of Utrecht University gave ethical approval for this study (FETC19-121). This study is pre-registered on the Open Science Framework (https://osf.io/kap2w/).

Measures

Questionnaires

Personal Report of Confidence as a Speaker (PRCS). The PRCS is a 12-item self-report questionnaire that assesses public speaking anxiety (Hook et al., 2008). The 12-item version of the PRCS has good reliability, and convergent and divergent validity (Hook et al., 2008). An example item is “I am terrified at the thought of speaking before a group of people”. The items were translated from English to Dutch and back-translated by independent researchers. Each statement is rated as true or false. All items endorsed as true are sum-scored. Higher scores reflect higher public speaking anxiety. Internal consistency was sufficient in this study (α = .66).

VR experience scale. The VR experience scale measures physiological complaints (nausea, headache, and dizziness), realness, immersion, and presence during the VR-presentation, and whether presenting in VR was as challenging as in real life, rated on a 5-point Likert scale (1 = *barely*; 5 = *very much*; van Dis et al., 2021). An example item is “The virtual reality environment looked real”. Scores on physiological complaints were averaged.

Main outcome measures

Before VR-exposure. Anticipatory anxiety ("How anxious would you be if you had to give a presentation in VR now?") and willingness ("How willing are you to give a presentation in VR now?") to present in front of a VR-audience were measured on two visual analog scales (VASs; 0 = *not at all*; 100 = *extremely*).

During VR-exposure. At the start of the VR-exposure and at 1-minute intervals, participants rated distress on a 100-point Subjective Units of Distress scale (SUDS; 0 = *no distress*; 25 = *mild distress*; 50 = *moderate distress*; 75 = *severe distress*; 100 = *very severe distress;* Wolpe, 1990). Total VR-exposure duration was also measured.

Exploratory outcome measures

Mood. Mood was measured on a VAS (0 = *unpleasant*; 100 = *pleasant*).

Behaviors Checklist (BCL). The BCL is a self-report questionnaire with 18 items rated on a 9-point Likert scale assessing the quality of participants' behavior during their presentation (0 = *not at all*; 8 = *extremely*; Mansell & Clark, 1999; Stopa & Clark, 1993). We used a Dutch version that was translated and used in previous research (van Dis et al., 2021). Participants were asked to rate whether they displayed certain characteristics during VR-exposure. Example items are "confidence" and "quivering voice". Positive items were reverse-scored and a sum score was calculated. Higher scores reflect a more negative evaluation of participants' performance. Previous research demonstrated high internal consistency (van Dis et al., 2021; Vasey et al., 2012). Internal consistency was good in this study (α = .87).

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Safety behavior. Participants rated whether they faced the audience during the presentation on a VAS (0 = *not at all*; 100 = *always*). A higher score reflects lower use of safety behaviors.

Intervention characteristics

To check whether the positive mental imagery exercise was successful, participants rated whether the public speaking scenario was easy to imagine, was credible, had a positive ending, and changed appraisal regarding public speaking on VASs (0 = *not at all*; 100 = *very easy to imagine/credible/positive*). For changed appraisal, an extra anchor was used (0 = *negative change*; 50 = *no change*; 100 = *positive change*).

Intervention phase

Positive mental imagery exercise

The future-oriented positive mental imagery exercise was based on an imagery rescripting procedure (Frets et al., 2014), but was adapted to a future scenario. Participants were asked to close their eyes and listen to a 4-min standardized audio script describing a public speaking scenario. They were instructed to imagine the scenario as detailed as possible from a first-person perspective, as if they were the person giving the presentation. The scenario started with negative thoughts and feelings of anticipatory anxiety (activation phase; e.g., “others will think I am stupid”, feeling anxious, racing heart). This activation phase lasted approximately 1.5 min. After the activation phase, anxiety dissipated, and the scenario ended positively (mastery phase; e.g., “I think I can do this”, heart rate slows, the audience is enthusiastic). The mastery phase lasted approximately 2.5 min.

No-task control

Participants in the no-task control condition immediately rated the main outcome measures again.

Procedure

Participants were tested at InScience Festival 2019 (n = 23) and Utrecht University (n = 36; personal protective equipment was used [e.g., face mask] while testing 18 participants during the COVID-19 outbreak). Participants were told that the study was about presenting in virtual reality to minimize expectations for the positive mental imagery exercise and reduce potential placebo effects. Participants gave informed consent, completed BDI-II and PRCS, and provided demographic information (age, sex, educational level, occupation). After receiving instructions about the VR set-up and SUDS ratings, they practiced with SUDS ratings in a neutral VR environment. Then, participants rated their mood, willingness, and anticipatory anxiety (t1). Next, participants closed their eyes and were instructed to listen to an audio script with a neutral mental imagery exercise (i.e., grabbing a drink from the fridge) to practice mental imagery from a first-person perspective while trying to imagine as many details as possible. After random group assignment (stratified for age, sex, and employment status), they were asked to listen to the positive mental imagery exercise or continue with the measurements (i.e., no-task group). Then, all participants were asked to rate their mood, willingness, and anticipatory anxiety again (t2) and to undergo VR-exposure. They were instructed to present as long as possible or until they would be instructed to stop presenting (Culver et al., 2011). The maximum duration of the presentation was 5 min. They were also instructed that they could repeat themselves during the presentation. They chose a topic (climate change, smoking in public, or organ donation), rated its difficulty on a VAS (0 = *very easy*; 10 = *very difficult*), and prepared the presentation for 1 min. Afterward, they completed the BCL and rated mood, willingness, anxiety, safety behavior, and VR experience (t3). Participants in the positive mental imagery condition rated how they experienced the exercise. Finally, all participants were debriefed and reimbursed.

Virtual reality environments

The neutral environment displayed a 360-degree picture of a living room. The speech environment depicted a 360-degree video of an audience in a meeting room with neutral to positive facial expressions (van Dis et al., 2021). Both environments were presented with an Oculus Rift headset.

Data analyses

Confidence intervals (CI) were calculated for effect sizes using the MBESS package in R (Kelley, 2017). That is, 95% CI for Cohen's *d* and 90% CI for partial eta squared are reported (Lakens, 2013).

To test whether randomization was successful, independent samples *t*-tests were conducted for public speaking anxiety, age, VR experience, and speech topic difficulty. Similarly, potential group differences in sex, employment status, and educational level were assessed by chi-square tests. To determine how participants perceived the positive mental imagery exercise, descriptive statistics of the intervention characteristics are reported.

To determine whether the positive mental imagery group, relative to the no-task group, reported decreased anticipatory anxiety and increased exposure willingness, two separate 2 (time: pre-intervention vs. post-intervention) x 2 (condition: positive mental imagery vs. control) mixed ANOVAs were executed. Nearly all participants (91%) presented the maximum duration and completed all SUDS ratings (two drop-outs in both groups). Therefore, to test whether the positive mental imagery group, relative to the control group, reported lower distress (SUDS) during VR-exposure, a 6 (time: SUDS) x 2 (condition: positive mental imagery vs. control) mixed ANOVA was conducted instead of analyzing the pre-registered max and mean SUDS scores. Paired or independent samples *t*-tests followed up significant ANOVAs. In addition, group differences in VR-exposure duration were not analyzed due to limited variance.

To explore whether anxiety and willingness to present differed between groups after the VR-exposure, two separate 2 (time: pre-VR-exposure vs. post-VR-exposure) x 2 (condition: positive mental imagery vs. control) mixed ANOVAs were conducted. To explore whether mood differences over time might explain intervention effects, mood ratings were examined with mixed ANOVAs. Potential group differences in BCL scores and safety behavior were explored with independent samples *t*-tests.

Results

Randomization and intervention characteristics

There were no significant group differences in baseline characteristics, VR experience, and speech topic difficulty, indicating successful randomization (see Table 1).

Participants in the positive mental imagery condition generally indicated they could vividly imagine the positive mental imagery scenario (M = 73.27, SD = 19.41), found it credible (M = 71.09, SD = 23.05), and thought the ending was positive (M = 82.23, SD = 17.27). Moreover, they generally indicated that they experienced a positive change regarding their view of giving a presentation after the positive mental imagery exercise (M = 62.50, SD = 14.37). Collectively, this suggests that the positive mental imagery intervention was successful.

Table 1. Test statistics for group comparisons of randomization variables: Means (standard deviations) for age, PRCS, VR experience, and speech topic difficulty, and frequencies for sex, employment status, and education level.

	Positive mental imagery (n = 22)	Control (n = 21)	Test statistics
Age	32.40 (10.86)	30.53 (9.86)	$t(37) = 0.56$, $p = .577$, $d_s = 0.18$, 95% CI [-0.45, 0.80]
PRCS†	8.00 (2.62)	8.71 (1.90)	$t(41) = 1.02$, $p = .314$, $d_s = 0.31$, 95% CI [-0.29, 0.91]
Male/female	5/17	5/16	$\chi^2(1) = .01$, $p = .933$, Cramer's $V = .01$, 95% CI [.00, .23]
Student/employed	10/12	12/9	$\chi^2(1) = .59$, $p = .443$, Cramer's $V = .12$, 95% CI [.00, .42]
Education level			$\chi^2(4) = 3.26$, $p = .515$, Cramer's $V = .28$, 95% CI [.00, .48]
Secondary education	4	6	
Intermediate vocational education	4	2	
Applied university bachelor	7	4	
University bachelor	2	5	
University master	5	4	
VR experience			
Physical complaints	1.17 (0.30)	1.22 (0.46)	$t(41) = 0.47$, $p = .643$, $d_s = 0.14$, 95% CI [-0.46, 0.74]
Realness	3.50 (1.26)	3.24 (1.14)	$t(41) = 0.71$, $p = .479$, $d_s = 0.22$, 95% CI [-0.38, 0.82]
Immersion	3.55 (1.18)	3.48 (1.33)	$t(41) = 0.18$, $p = .857$, $d_s = 0.06$, 95% CI [-0.54, 0.65]
Presence	3.68 (1.17)	3.43 (1.29)	$t(41) = 0.68$, $p = .503$, $d_s = 0.21$, 95% CI [-0.39, 0.80]
VR as challenging as real life	2.95 (0.95)	3.38 (1.20)	$t(41) = 1.29$, $p = .203$, $d_s = 0.39$, 95% CI [-0.21, 1.00]
Speech topic difficulty	59.18 (14.80)	61.95 (20.01)	$t(41) = 0.52$, $p = .607$, $d_s = 0.16$, 95% CI [-0.44, 0.76]

Note. Age was missing for three participants (positive mental imagery, n = 2; control, n = 1).
PRCS = Personal Report of Confidence as a Speaker, VR = virtual reality.
† There were no differences in PRCS scores between the testing sites.

Before VR-exposure

Anticipatory anxiety

From before to after the intervention phase, anticipatory anxiety to give a presentation decreased (main effect time), *F*(1, 41) = 4.14, *p* = .048, η_p^2 = .09, 90% CI [.00, .24] (see Figure 1). Crucially, the Condition x Time interaction effect on anticipatory anxiety was not statistically significant, but there was a medium effect size, *F*(1, 41) = 4.02, *p* = .051, η_p^2 = .09, 90% CI [.00, .24]. Therefore, we further examined this interaction. Post-hoc analyses showed that anxiety decreased over time in the positive mental imagery group, *t*(21) = 2.51, *p* = .020, d_z = 0.53, 95% CI [0.08, 1.00], but not in the control group, *t*(20) = 0.02, *p* = .981, d_z = 0.01, 95% CI [-0.43, 0.44].

Willingness

From before to after the intervention phase, there were no significant main or Condition x Time interaction effects on willingness to give a presentation, *F*s < 2.60, *p*s > .114, η_p^2s < .07, 90% CI range [.00, .20] (see Figure 1).

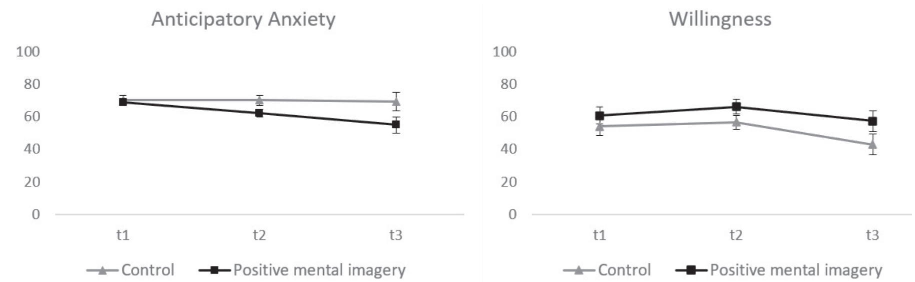

Figure 1. Anticipatory anxiety and willingness to give a presentation in virtual reality (VR) before the intervention phase (t1), after the intervention phase/before the VR-exposure (t2), and after the VR-exposure (t3) in the positive mental imagery and control groups. Error bars represent standard error of the mean.

During VR-exposure

There was a significant Condition x Time interaction effect on distress during VR-exposure, *F*(2.45, 90.70) = 3.79, *p* = .019, η_p^2 = .09, 90% CI [.01, .18] (see Figure 2). Post-hoc analyses demonstrated a linear decrease in SUDS during the VR-exposure in the positive mental imagery group, *F*(1, 19) = 5.51, *p* = .030, η_p^2 = .23, 90% CI [.01, .44], and an increase in the control group showing quadratic growth, *F*(1, 18) = 13.31, *p* = .002, η_p^2 = .43, 90% CI [.12, .60]. There were no main effects on SUDS, *F*s < 2.50, *p*s > .075, η_p^2s < .07, 90% CI range [.00, .13].

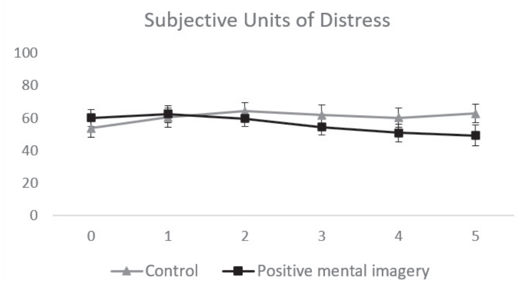

Figure 2. Subjective units of distress ratings during the VR-exposure at the start of the presentation and 1-min intervals in the positive mental imagery and control groups. Error bars represent standard error of the mean.

Exploratory analyses

After VR-exposure

From before to after the VR-exposure, anxiety did not change in either group (no main effect time nor interaction effect), *F*s < 1.36, *p*s > .250, η_p^2s < .04, 90% CI range [.00, .16] (see Figure 1). However, overall, the positive mental imagery group reported lower anxiety than the control group (main effect condition), *F*(1, 41) = 5.04, *p* = .030, η_p^2 = .11, 90% CI [.01, .26]. From before to after the VR-exposure, there was no group difference on willingness to present (no main effect condition nor interaction effect), *F*s < 3.00, *p*s > .090, η_p^2s < .07, 90% CI range [.00, .21], but willingness decreased in both groups (main effect time), *F*(1, 41) = 9.60, *p* = .004, η_p^2 = .19, 90% CI [.04, .35] (see Figure 1).

Mood

From before to after the intervention phase, there was no group difference on mood (no main effect condition nor interaction effect), *F*s < 0.34, *p*s > .567, η_p^2s < .01, 90% CI [.00, .10], but positive mood increased in both groups (main effect time), *F*(1, 41) = 8.52, *p* = .006, η_p^2 = .17, 90% CI [.03, .33] (see Table 2). From before to after the VR-exposure, mood became more negative in both groups (main effect time), *F*(1, 41) = 42.47, *p* < .001, η_p^2 = .51, 90% CI [.32, .63]. There was also a significant Condition x Time interaction effect on mood, *F*(1, 41) = 7.31, *p* = .010, η_p^2 = .15, 90% CI [.02, .31]. While there was no difference between groups in mood before the VR-exposure, *t*(41) = 0.01, *p* = .994, d_s = 0.00, 95% CI [-0.59, 0.60], mood was more negative in the control group than in the positive mental imagery group after the VR-exposure, *t*(41) = 2.91, *p* = .006, d_s = 0.89, 95% CI [0.25, 1.51]. This suggests that positive mental imagery reduced the increase in negative mood.

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Table 2. Means (standard deviations) of the exploratory variables mood, self-reported performance (BCL), and safety behavior.

	Positive mental imagery (*n* = 22)	Control (*n* = 21)
Mood		
t1	49.45 (20.42)	53.29 (24.51)
t2	60.95 (17.49)	61.00 (21.40)
t3	47.95 (20.00)	29.57 (21.49)
BCL	85.63 (19.36)	97.81 (17.93)
Safety behavior	74.45 (17.98)	77.38 (26.59)

Note. BCL = Behaviors Checklist, VR = virtual reality.

BCL

The positive mental imagery group rated their speech performance during VR-exposure more positively than the control group, $t(41) = 2.14$, $p = .039$, $d_s = 0.65$, 95% CI [0.03, 1.26] (see Table 2).

Safety behavior

Groups did not differ in self-reported avoidance of facing the audience, $t(41) = 0.43$, $p = .673$, $d_s = 0.14$, 95% CI [-0.47, 0.73] (see Table 2).

Discussion

This study investigated whether future-oriented positive mental imagery, compared to a no-task control condition, reduces anticipatory anxiety and increases exposure willingness in individuals with moderate public speaking anxiety. Positive mental imagery decreased anticipatory anxiety, as predicted, but did not increase willingness to give a presentation in VR. Moreover, positive mental imagery reduced distress during exposure, which increased in the control condition. Finally, we could not examine differences in exposure duration due to a lack of variation. In sum, the study demonstrated that future-oriented positive mental imagery can decrease anticipatory anxiety and distress during actual exposure to a feared situation.

Positive mental imagery may have attenuated the emotional evocative power of negative mental imagery, which could encourage reappraisal of the feared event (Engelhard et al., 2019). It may induce episodic specificity of imagining constructive behaviors, which reduces anxiety and the subjective plausibility of negative outcomes (Jing et al., 2016). That is, imagining corrective information such as positive self-representations can result in reappraisal of the maladaptive beliefs that drive the negative outcome expectancies of the feared event (Arntz, 2012; Strachan et al., 2020). Similarly, positive mental imagery of future events can enhance perceived control over the situation (Boland et al., 2018; Hallford et al., 2018) and reduce the perceived difficulty of coping with a bad outcome (Jing et al., 2016). Thus, potentially due to reappraisal of the feared event, anticipatory anxiety and distress during VR reduced in the current study. Because we did not control for episodic specificity of the intervention, the mode of processing (e.g., imagery vs. verbal), or its valence, the exact working mechanisms of the intervention remain unclear. Also, although participants were not instructed about the actual aim of the study, placebo effects or demand characteristics may potentially have influenced the results. Future studies should examine these potential working mechanisms.

Next to the influence on emotion regulation, positive mental imagery of future events also influences motivation and decision-making to achieve long-term personal goals (Bulley et al., 2017; Schacter et al., 2017). Unexpectedly, future-oriented positive mental imagery did not increase exposure willingness in the current study. This may result from using a standardized script rather than an idiosyncratic script that is more personally relevant (Kearns & Engelhard, 2015; Lehner & D'Argembeau, 2016). Future research could examine ways to improve the efficacy of the intervention, such as by using an idiosyncratic script, or by investigating a potential benefit of repeatedly simulating the positive event rather than just once (Szpunar & Schacter, 2014; but see Boland et al., 2018). Additionally, knowing that presenting was part of the experiment might have resulted in a biased sample of participants that were more willing to present. This explanation is supported by the relatively high exposure willingness at the start of the study that remained stable during the intervention phase. It may be fruitful to investigate whether positive mental imagery enhances exposure willingness in individuals who are more reluctant to start exposure therapy, as well as its long-term efficacy.

Exploratory analyses showed that positive mental imagery did not increase positive mood compared to the no-task control group directly after the exercise. This suggests that the positive mental imagery exercise did not merely work through positive mood induction, which was also found in earlier imagery rescripting research (Hagenaars et al., 2015; Hagenaars & Arntz, 2012), but that the content of the mental imagery was important (Schacter et al., 2017). Furthermore, positive mental imagery resulted in a less negative mood after the VR-exposure (see also Schubert et al., 2020) and a more positive perceived speech performance than no-task control. These results corroborate previous findings that future-oriented positive mental imagery results in positively biased memories (Devitt & Schacter, 2018) and that positive mental imagery boosts task performance (e.g., Hirsch et al., 2003; Vassilopoulos, 2005). Although negative self-imagery can increase safety behavior (Hirsch et al., 2004), we found no evidence that future-oriented positive mental imagery reduces safety behavior in this study.

Several limitations are noteworthy. First, although the sample size was in line with the a priori power analysis, the study was underpowered to detect small effects. To aid the interpretation of our findings, we reported effect sizes and their confidence intervals. While p-values indicate whether an effect may rely on chance, it has been suggested that indicators of effect strength are more important than p-values (Cumming et al., 2012; Sullivan & Feinn, 2012). The effect sizes support the interpretation that the positive mental imagery exercise reduced anticipatory anxiety and distress during VR-exposure. Nonetheless, these findings await further replication, preferably with larger samples. Second, it remains unclear whether the findings generalize to clinical samples. Additionally, we did not collect information about participants' ethnic or cultural identification and socioeconomic status, which makes it difficult to determine generalization of the findings. Third, no objective ratings of automatic fear processing, such as psychophysiological outcomes (e.g., heart rate; Kearns & Engelhard, 2015), or speech performance (e.g., observer ratings) were used. Finally, nearly all participants completed the VR-exposure, so we could not examine potential group differences in VR-duration. This finding suggests that public speaking anxiety was not severe in the current sample. Indeed, SUDS were lower in the current sample than in previous research using VR-exposure (van Dis et al., 2021), and PRCS scores were moderate (50^{th} percentile; Heeren et al., 2013). The finding may also suggest that VR-exposure is not as challenging as exposure in vivo, although attrition rates for these interventions are quite similar (Benbow & Anderson, 2019) and SUDS were still quite high. Future research may increase exposure duration to facilitate attrition, examine clinical samples, and investigate potential differences between exposure in VR and in vivo. This study's strengths include using a standardized future-oriented positive mental imagery exercise and a standardized exposure session that can be easily applied in (online) interventions.

To conclude, the current study demonstrated that positive mental imagery of a feared situation reduced anticipatory anxiety and distress during the feared situation. It did not increase willingness to engage in the feared situation. Future studies should investigate ways to enhance their efficacy, especially for willingness to engage in and anxiety for exposure-based treatment. For now, the results are promising for individuals who are anxious to engage in feared situations.

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6

Chapter 7

Future-oriented imagery rescripting facilitates conducting behavioral experiments in social anxiety

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Author contributions: All authors developed the study concept and contributed to the study design. EL was responsible for data collection and performed the data analyses. EL and KM gave clinical supervision. All authors were involved in the interpretation of the data. EL drafted the paper and KM, ES, and IE provided critical revisions. All authors approved the final version of the manuscript.

Abstract

Distressing mental images are common in anxiety disorders and can make it difficult for patients to confront feared situations, for example during cognitive behavioral therapy. This study investigated whether imagery rescripting focused on a feared social situation prepares participants to engage in the feared situation. Sixty healthy individuals were asked to formulate a behavioral experiment to test negative beliefs about a social situation they feared. They were either assigned to imagery rescripting focused on the feared outcome of the behavioral experiment or to a 'no intervention' control condition (i.e., break). All participants were then asked to conduct the behavioral experiment. Before the behavioral experiment, the imagery rescripting condition showed, compared to the control condition, reduced anticipated probability and severity of the feared outcome, lower anxiety and helplessness levels, and increased willingness to conduct the behavioral experiment. Imagery-based interventions focused on feared outcomes seem promising to prepare anxious individuals to engage in treatment.

Introduction

The efficacy of cognitive behavioral therapy (CBT) for social anxiety disorder is well established (National Institute for Health and Clinical Excellence, 2011), and a core technique is exposure to feared situations. Setting up exposure with a behavioral experiment format can promote inhibitory learning (Craske et al., 2014). In behavioral experiments, patients test the validity of their negative beliefs in real-life situations (Bennett-Levy et al., 2004). However, attrition rates in CBT are high; up to 11% of patients drop out before CBT starts, and another 20% drop out during treatment (Davidson et al., 2004; Fernandez et al., 2015).

One potential explanation for these high attrition rates is that patients may be unwilling or unable to confront their fears during CBT (Benbow & Anderson, 2019). This may result from mental imagery about feared outcomes. Distressing mental images are common in anxiety disorders, including social anxiety disorder (Clark & Wells, 1995; Rapee & Heimberg, 1997; for a review, see Ng, Abbott, & Hunt, 2014), in which it is commonly related to social memories (Hackmann et al., 2000) and represents feared outcomes (e.g., 'looking foolish'; Hackmann, Surawy, & Clark, 1998). Such negative self-imagery appears to play a role in the maintenance of social anxiety disorder. Previous research has demonstrated that it increases anxiety, negative thoughts, and use of safety behaviors and decreases performance quality in social situations (Hirsch et al., 2003, 2004, 2006; Stopa & Jenkins, 2007; Vassilopoulos, 2005). Moreover, negative mental imagery may serve to maintain anxiety and avoidance behavior (Krypotos et al., 2020) and impede extinction learning (Mertens et al., 2020). Thus, updating such images may be a promising approach to increase willingness to engage in behavioral experiments and perhaps also reduce attrition rates.

One method to update negative or distressing memories is imagery rescripting. This intervention typically consists of three phases (Arntz & Weertman, 1999; Wild & Clark, 2011). In the first phase, patients are asked to relive a negative memory as their younger self. In the second phase, they are instructed to relive the memory again, but now as their adult self. They are instructed to imagine aiding the younger self in the memory and attending to their unmet needs. In the third phase, they are asked to relive the memory once again as their younger self, but now they also imagine previous phase's modifications. They can make more changes if they desire. Imagery rescripting is a promising treatment for social anxiety disorder (e.g., Frets et al., 2014; Nilsson et al., 2012; Norton & Abbott, 2016; Romano et al., 2020; Wild et al., 2007, 2008), and other anxiety-related disorders (for a meta-analysis see Morina et al., 2017).

Imagery rescripting typically focuses on distressing memories of past events, but negative imagery in social anxiety disorder can also represent anticipated future threats. Such vivid and unpleasant "flashforwards" are a transdiagnostic process in anxiety disorders (see Brewin et al., 2010; Engelhard et al., 2010, 2011; Holmes & Mathews, 2010). Individuals with anxiety disorders imagine more vivid negative future scenarios associated with higher distress and perceived likelihood than healthy participants (Morina et al., 2011). In addition, compared to non-anxious persons, they report less vivid positive future events and find it less plausible that these events will occur in their future than a healthy comparison group. Thus, individuals with anxiety disorders perceive the future more negatively.

The capacity to imagine events that may occur in an individual's personal future is called episodic future thinking, and it serves several adaptive functions (Bulley et al., 2017; Miloyan & Suddendorf, 2015; Schacter et al., 2017). It influences anticipatory emotions (Barsics et al., 2016) and enables individuals to estimate the probability of different outcomes and associated costs, motivating goal-directed behavior to achieve long-term personal goals (Bulley et al., 2017; Miloyan & Suddendorf, 2015). Imagining positive future events increases motivation and actual undertaking of the imagined activities (Libby et al., 2007; Renner et al., 2017, 2019).

Applying imagery rescripting to future-related negative mental imagery may be a fruitful approach to reduce avoidance of feared social situations. Previous research in social anxiety disorder found reduced attrition rates when standard CBT was combined with imagery enhancements, such as imagery rescripting and positive imagery of new core beliefs, compared to standard CBT (McEvoy et al., 2015). However, the results are limited by a lack of randomization to treatment, and it remains unclear whether specifically future-oriented positive imagery contributed to reduced attrition rates. Another study in individuals with fear of public speaking showed that a future-oriented positive mental imagery exercise reduced anticipatory anxiety and distress during virtual reality exposure compared to no intervention but did not enhance exposure willingness (Landkroon et al., submitted). Potentially, exposure willingness did not increase because this study used a standardized future-oriented positive mental imagery exercise, while episodic future thinking has a more substantial impact when personal relevant goals are imagined (Lehner & D'Argembeau, 2016). To conclude, these studies highlight the potential of adding future-oriented imagery rescripting to a CBT intervention to reduce anxiety and attrition rates.

This study aimed to investigate in healthy participants whether compared to a no intervention control condition, personalized imagery rescripting focused on a feared social behavioral experiment reduces their fear of the behavioral experiment and increases their willingness to carry it out. More specifically, we hypothesized that future-oriented imagery rescripting, compared to no intervention, would (1) decrease the anticipated probability and severity of the negative outcome of the experiment, (2) reduce anxiety and helplessness related to the experiment and (3) increase participants' willingness to conduct it. We explored whether imagery rescripting increased the behavioral experiment's efficacy itself by further reducing the probability and severity of the negative expected outcome, anxiety and helplessness levels, and increasing participants' willingness to conduct a similar behavioral experiment.

Methods

Participants

Recruitment took place at Utrecht University and via social media. Individuals were included if they scored within the normal range on the Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1998). Based on previous research, we set the cut-offs at ≥ 10 and ≤ 30 (Carleton et al., 2007; Voncken & Dijk, 2013). A priori exclusion criteria were: self-reported serious medical condition (e.g., heart problems, respiratory difficulties or neurological symptoms), current psychological difficulties, and/or treatment by a psychiatrist or psychologist. Seventy-two participants enrolled in the study. During the study, 10 of them were excluded because they could not formulate a behavioral experiment or because they rated their negative outcome probability and/or severity lower than 40% (these criteria were set beforehand). Two participants quit because they were too upset during the experiment. The final sample consisted of 60 participants. Participants were compensated with course credit or money (€2 per 15 minutes). All of them gave written informed consent. The Ethics Committee of the Faculty of Social Sciences from Utrecht University gave ethical approval (FETC15-080). The study was pre-registered on the Open Science Framework (https://osf.io/b745c/).

Measures

Main outcome measures

Anticipated negative outcome probability and severity of the behavioral experiment were measured with visual analog scales (VASs; 0 = *not at all likely/not at all*; 100 = *very likely/horrible*; see Craske, 2015). Three VASs were added to measure current anxiety and helplessness while thinking of the behavioral experiment and willingness to conduct the behavioral experiment (0 = *none/not at all willing*; 100 = *extreme/extremely willing*).

Exploratory measures

First, we assessed how many participants actually completed the behavioral experiment in each group (*yes/no*). Second, the level of distress during the behavioral experiment was measured retrospectively on a VAS (0 = *none*; 100 = *extreme*; see Craske, 2015). Third, safety behavior was measured on two VASs to assess whether participants completed the behavioral experiment as planned and whether they used safety behavior (0 = *not at all*; 100 = *extremely well/a lot*). Finally, the experimenter guided participants to formulate a general conditional statement of what they were mostly worried about in social situations (e.g., "If I make a mistake, others will not like me"). The validity of this statement was measured on a VAS (0 = *not at all likely*; 100 = *extremely likely*) to examine whether imagery rescripting and the behavioral experiment influenced the validity of this general statement.

Manipulation check for imagery rescripting

To assess whether imagery rescripting was carried out well, participants were asked to rate on VASs whether their imagery script was easy to imagine, ended positively, and was credible (0 = *not at all easy to imagine/positive/credible*; 100 = *very easy to imagine/positive/credible*; Landkroon et al., submitted). Additionally, they were asked to rate whether imagery rescripting changed how they thought about conducting the behavioral experiment on a VAS (0 = *more negatively*; 50 = *no change*; 100 = *more positively*).

Questionnaires

Social Interaction Anxiety Scale (SIAS)

The SIAS consists of 20 items that assess social anxiety (Mattick & Clarke, 1998). All items were answered on a 5-point scale (0 = *not at all typical of me*; 4 = *very typical of me*). Three items were reverse-scored, and then all items were summed (range 0-80). A higher score reflects a higher level of social anxiety. Item 14 was changed from "I have difficulty talking to attractive people from the opposite sex" to "I have difficulty talking to people whom I feel attracted to". Internal consistency was poor in this study (α = .56).

Brief Fear of Negative Evaluation Scale (BFNE)

The BFNE consists of 12 items assessing whether someone fears negative evaluation from others (Leary, 1983). Items were scored on a 5-point Likert scale (1 = *not at all characteristic of me*; 5 = *extremely characteristic of me*). The BFNE was used to help individuals formulate their general conditional statement (see Behavioral experiment) and was not further analyzed.

Intervention phase

Imagery rescripting group

Participants were first asked to practice imagining a future neutral event as vividly as possible for 1 min (i.e., cutting a lemon), as if it was happening here and now. They were asked to close their eyes and focus on all sensory modalities and describe the situation. Then the imagery rescripting instructions followed. This procedure was based on the protocol of Frets et al. (2014), which was adapted to fit future scenarios by asking participants to imagine the whole scene as their current self and by omitting phase three (the compassionate phase). In phase one, participants were asked to imagine the feared outcome of their behavioral experiment again for about 1 min. In phase two (mastery), they were instructed to intervene when the worst outcome was about to happen by ending the imagery positively in any way they wanted. The second phase lasted approximately 5 min. If participants finished the rescripting quickly, they were asked to repeat the mastery phase but were allowed to make changes to the scenario if they desired.

No intervention control group

Another experimenter pretended to complete a chore in the lab and explained that participants had a break until the original experimenter returned. During this time, they were allowed to use their phones, read a magazine, or go to the bathroom.

Behavioral experiment

Designing behavioral experiment (Part A)

Participants filled in the BFNE about situations they are worried about. The experimenter then guided them to formulate a general conditional statement based on their answers on the BFNE. Based on this statement, they were asked to formulate a behavioral experiment that could immediately be conducted to test their general conditional statement (following Bennett-Levy et al., 2004; OxCADAT Resources, 2020). Behavioral experiments were individually tailored. Participants were asked to close their eyes and imagine their worst fear about what could happen during the behavioral experiment. Afterward, they were asked to describe the behavioral experiment on a record sheet (OxCADAT Resources, 2020) and rated their perceived probability and severity of the anticipated negative outcome.[1] If these ratings were not above 40%, then the behavioral experiment was adjusted (see for similar argument Engelhard et al., 2011). If the ratings were then still below 40%, the person was excluded from further participation.

Conducting behavioral experiment (Part B)

Participants were asked to conduct the behavioral experiment immediately on campus. The experimenter accompanied each participant to view whether they completed the behavioral experiment but kept some distance.

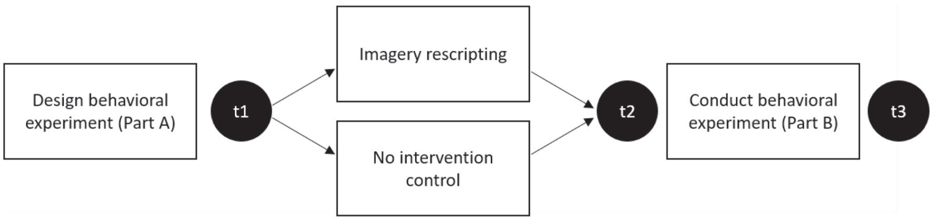

Figure 1. Overview of the experiment. The circles represent the main outcome measurements.

Procedure

After participants designed their behavioral experiment (Part A), they completed the main outcome measures on a computer and rated the validity of the general conditional statement (t1; see Figure 1). The experimenter then explained that she would consult a colleague to discuss the behavioral experiment and left the room.

Then, a second experimenter entered the lab to guide the intervention phase and ensure that the first experimenter guiding the behavioral experiment remained blind to condition. Participants were then randomly assigned to the imagery rescripting or no intervention control group (stratified for sex and SIAS score). The total duration of each intervention was approximately 11 min. After the intervention, participants were asked to complete the main outcome measures and rate the validity of their general conditional statement again (t2). Then, the second experimenter left the room.

The first experimenter re-entered the room and asked the participant to conduct their behavioral experiment (Part B). After conducting or refusing to complete the behavioral experiment, they were asked to imagine that they had to conduct the behavioral experiment

1 These measures highly correlated with the outcome measures assessed later on a computer. Moreover, the results of the analyses on the data of the behavioral experiment form were similar to the main outcome measures. Therefore, these data are not reported in the result section.

again. They were then requested to complete the main outcome measures (t3), rate the validity of the general conditional statement, experienced distress during the behavioral experiment, and use of safety behaviors (t3). In the imagery rescripting condition, participants also rated how they experienced imagery rescripting. Finally, all participants were debriefed and reimbursed.

Data analyses

The data were analyzed within a Null-Hypothesis Significance Testing and a Bayesian framework (Krypotos et al., 2020; Landkroon et al., 2021). Within the Null-Hypothesis Significance Testing framework, confidence intervals for effect sizes were calculated using the MBESS package in R (Kelley, 2017). Within the Bayesian framework, Bayes factors were calculated that measure the amount of evidence the data provides for the alternative hypothesis relative to the null hypothesis using the default settings in JASP (JASP Team, 2020). A $BF_{10} = 3$ indicates that the data are three times more likely under the alternative hypothesis than the null hypothesis, while the opposite is true for $BF_{10} = 0.33$.

Randomization and manipulation checks

To examine whether randomization was successful, independent samples *t*-tests on age and SIAS score and a chi-square test on sex distribution were used. Additionally, descriptive statistics were examined to ensure that imagery rescripting was carried out well.

Main analyses

To examine whether imagery rescripting, compared to no intervention, reduced the anticipated negative outcome probability and severity of the behavioral experiment, anxiety and helplessness levels, and increased willingness, separate 2 (time: pre vs. post intervention) x 2 (condition: imagery rescripting vs. control) repeated measures ANOVAs were done. Significant results were followed up by paired *t*-tests.

Exploratory analyses

First, we aimed to explore whether more participants in the imagery rescripting group conducted the behavioral experiment than in the control group. However, all participants completed the behavioral experiment, so this analysis could not be carried out. Second, to explore whether, relative to the control group, the imagery rescripting group reported lower distress and safety behaviors during the behavioral experiment, independent samples *t*-tests were used. Third, to explore whether the imagery rescripting group reported lower negative outcome probability and severity of the expected negative outcome of the behavioral experiment, anxiety, and helplessness, and more willingness to conduct a similar behavioral experiment, two 2 (time: pre vs. post behavioral experiment and pre intervention vs. post behavioral experiment) x 2 (condition: imagery rescripting vs. control) repeated measures ANOVA were done. The analysis from pre intervention to post behavioral experiment was not reported in the pre-registration. Significant results were followed up by paired *t*-tests. Finally, to explore whether the imagery rescripting group showed a decrease in the validity of the general conditional statement before and after the behavioral experiment compared to the control group, three 2 (time: pre vs. post intervention, pre vs. post behavioral experiment, and pre intervention vs. post behavioral experiment) x 2 (condition: imagery rescripting vs. control) repeated measures ANOVAs were conducted, and significant results were followed up by paired *t*-tests. The analysis from pre intervention to post behavioral experiment was not reported in the pre-registration.

Results

Randomization and manipulation checks

The imagery rescripting group was, on average, older than the control group (see Table 1)[2]. Groups did not differ in SIAS scores or sex distribution.

Manipulation check for imagery rescripting

The imagery rescripting group reported that they could vividly imagine the scenario (M = 77.13, SD = 19.51), and that they thought the scenario was credible (M = 65.37, SD = 21.37) and had a positive ending (M = 89.03, SD = 8.94). Participants in the imagery rescripting group indicated that they thought more positively about the behavioral experiment after the imagery rescripting (M = 73.20, SD = 17.79). Overall, this indicates that participants carried out imagery rescripting well.

2 When age was entered as a covariate in the main outcome analyses, the ANOVAs still demonstrated the crucial significant Time x Condition interactions. Therefore, we report results without age as covariate.

Table 1. Means (standard deviations) and test statistics [95% confidence interval] of age (years) and social anxiety level (SIAS), and sex (frequency) for the two conditions.

	Imagery rescripting (n = 30)	Control (n = 30)	Test statistics
Age	22.60 (2.84)	21.40 (1.50)	t(44.04) = 2.05, p = .046, d_s = 0.53 [0.01, 1.04], BF_{10} = 1.49
Male/female	6/24	7/23	χ^2(1) = .10, p = .754, Cramer's V = .04 [.00, 0.28], BF_{10} = 0.39
SIAS	19.80 (5.67)	19.57 (5.85)	t(58) = .16, p = .876, d_s = 0.00 [-0.50, 0.51] , BF_{10} = 0.27

Note. SIAS = Social Interaction Anxiety Scale.

Main outcome measures

The separate repeated measures ANOVAs on the main outcomes from before (t1) to after the intervention phase (t2) showed a significant main effect of Time, Fs > 6.56, ps < .014, η_p^2s > .10, 90% CI range[3] [.01, .48], BFs$_{10}$ > 2.51, but no main effect of Condition, Fs < 1.73, ps > .193, η_p^2s < .03, 90% CI range [.00, .13], BFs$_{10}$ < 0.62, except for the severity of the expected outcome, F(1, 58) = 17.27, p < .001, η_p^2 = .23, 90% CI [.09, .37], BF_{10} = 214.90 (see Figure 2). As predicted, all Time x Condition interactions were significant, Fs > 6.86, ps < .012, η_p^2s > .10, 90% CI range [.01, .52], BFs$_{10}$ > 4.21. Paired samples t-tests for the imagery rescripting group demonstrated decreases from t1 to t2 for the probability of the negative outcome, anxiety, and helplessness, and increases for willingness to do the experiment, ts > 2.87, ps < .008, d_zs > 0.52, 95% CI range [0.14, 1.81], BFs$_{10}$ > 5.78. These variables did not significantly change over time for the control group, ts < 1.36, ps > .185, d_zs < 0.25, 95% CI range [-0.35, 0.61], BFs$_{10}$ < 0.45. Both groups showed decreases in the anticipated severity of the negative outcome, but this decrease was larger in the imagery rescripting group, t(29) = 4.45, p < .001, d_z = 0.81, 95% CI [0.39, 1.22], BF_{10} = 227.23, than in the control group, t(29) = 2.99, p = .006, d_z = 0.55, 95% CI [0.16, 0.93], BF_{10} = 7.30. These findings indicate that compared to the no intervention control condition, imagery rescripting was successful in reducing the probability and severity of the expected negative outcome of the behavioral experiment as well as associated anxiety and helplessness, and in increasing willingness to engage in the behavioral experiment.

3 When test statistics are summarized, the CI range shows the lowest and highest bound of all summarized effect sizes.

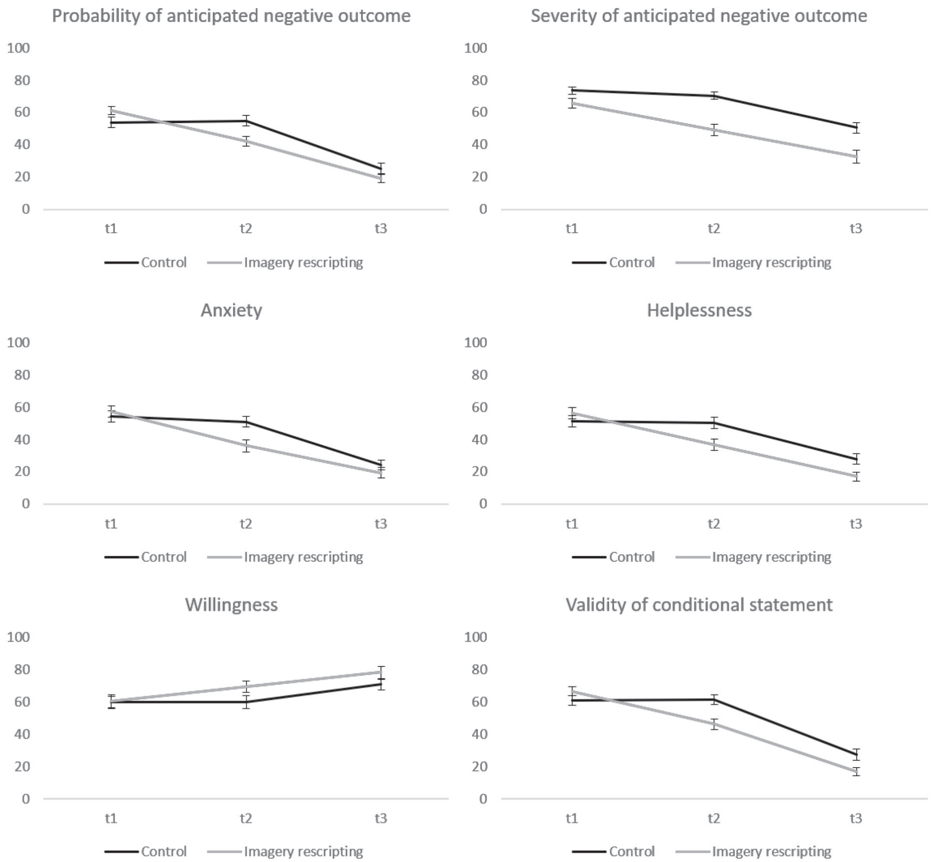

Figure 2. Means for the main outcome measures and validity of the conditional statement before the intervention (t1), after the intervention/before the behavioral experiment (t2), and after the behavioral experiment (t3) in the no intervention control and imagery rescripting groups. Error bars represent standard error of the mean.

Exploratory analyses

Conducting the behavioral experiment

There were no group differences in self-reported distress during the behavioral experiment, compliance with the experiment, or safety behavior use (see Table 2).

Table 2. Means (standard deviations) and test statistics [95% confidence interval] of distress during and compliance with the behavioral experiment, and use of safety behavior.

	Imagery rescripting (n = 30)	Control (n = 30)	Test statistics
Distress	48.80 (21.63)	50.53 (21.20)	$t(58) = .31$, $p = .755$, $d_s = 0.08$ [-0.43, 0.59], $BF_{10} = 0.27$
Compliance	85.10 (12.36)	83.30 (19.17)	$t(58) = .43$, $p = .667$, $d_s = 0.11$ [-0.40, 0.62], $BF_{10} = 0.28$
Safety behavior	37.63 (25.74)	34.07 (20.53)	$t(58) = .59$, $p = .555$, $d_s = 0.15$ [-0.36, 0.66], $BF_{10} = 0.30$

After the behavioral experiment

Separate repeated measures ANOVAs from before (t2) to after the behavioral experiment (t3) demonstrated strong reductions over time in the anticipated probability and severity of the negative outcome, anxiety, and helplessness, and an increase in willingness, Fs > 35.20, ps < .001, η_p^2s > .37, 90% CI [.21, .75], BFs$_{10}$ > 69273.51 (see Figure 2). This indicates that the behavioral experiment was successful in both groups. The Time x Condition interaction was only significant for anxiety, $F(1, 58) = 4.88$, $p = .031$, $\eta_p^2 = .08$, 90% CI [.00, .20], $BF_{10} = 1.88$. Anxiety decreased in both groups, but this decrease was larger in the no intervention control group, $t(29) = 7.74$, p < 001, $d_z = 1.41$, 95% CI [0.90, 1.92], $BF_{10} = 856559.28$, than in the imagery rescripting group, $t(29) = 5.49$, p < 001, $d_z = 1.00$, 95% CI [0.56, 1.44], $BF_{10} = 3111.87$.

In addition, from before the intervention phase (t1) to after the behavioral experiment (t3), there was a significant main effect for Time, Fs > 34.53, ps < .001, η_p^2s > .37, 90% CI range [.21, .83], BFs$_{10}$ > 48975.12 (see Figure 2). Interestingly, there was a significant Time x Condition interaction on the probability of the expected negative outcome and helplessness, Fs > 6.77, ps < .013, η_p^2s > .10, 90% CI range [.01, .28], BFs$_{10}$ > 4.35. Although in both groups the probability of the expected negative outcome and helplessness decreased, there was a larger reduction in the imagery rescripting group, ts > 10.92, ps < .001, d_zs > 1.99, 95% CI range [1.37, 2.89], BFs$_{10}$ > 1.04×10^9, than in the no intervention control group, ts > 5.90, ps < .001, d_zs > 1.07, 95% CI range [0.62, 2.22], BFs$_{10}$ > 8815.77. This reflects that imagery rescripting had an additional effect on reducing the probability of the expected negative outcome and helplessness levels, above and beyond the efficacy of the behavioral experiment.

General conditional statement

These data are in line with the results on the probability of the negative expected outcome and are reported in the supplemental materials.

Discussion

This study examined whether imagery rescripting focused on future negative mental imagery related to a behavioral experiment would reduce the fearful anticipation of the experiment. As hypothesized, imagery rescripting reduced the anticipated probability of the expected negative outcome of the behavioral experiment, anxiety, and helplessness, and it increased willingness to conduct the experiment, while no intervention did not. In addition, imagery rescripting resulted in a larger decrease in the severity of the expected negative outcome of the behavioral experiment compared to no intervention. In sum, imagery rescripting was successful in changing the fearful anticipation of a behavioral experiment.

Previous research demonstrated that imagery rescripting is useful to update distressing memories in social anxiety disorder (e.g., Wild et al., 2007, 2008) and anxiety-related disorders in general (Morina et al., 2017). Yet, negative mental imagery of future events, so-called flashforwards, are also common in anxiety disorders (Brewin et al., 2010; Engelhard et al., 2010; Holmes & Mathews, 2010) and may also maintain anxiety and reduce extinction learning (e.g., Krypotos et al., 2020; Mertens et al., 2020; Mueller et al., 2019). Few studies so far have examined how such images can be modulated, and have shown that EMDR has great potential (Engelhard et al., 2010). To our knowledge, no prior studies have yet investigated imagery rescripting focused on future-oriented negative mental imagery. The current findings extend previous research in two ways. First, imagery rescripting is not only effective to update distressing memories (Morina et al., 2017), but also to update future-oriented mental imagery and to prepare individuals to engage in feared situations. Second, imagery rescripting may also increase the efficacy of a behavioral experiment even further because it reduced the anticipated probability of the expected negative outcome, helplessness levels, and validity of the general conditional statement even further than the behavioral experiment only. Future studies should investigate whether these findings replicate and examine long-term efficacy because these exploratory findings contrast inhibitory learning theory that states that reducing the perceived probability of expected negative outcomes before a behavioral experiment reduces its efficacy (Craske et al., 2014). Taken together, the current study extends prior research on imagery rescripting of distressing memories (Arntz, 2012; Strachan et al., 2020) by showing that imagery rescripting focused on a feared future-related imagery also leads to positive reappraisal of that situation. This study and other experimental research (e.g., McGlade & Craske, 2021) suggest that mental imagery-based interventions are a promising tool to enhance exposure efficacy. An important next step would be to investigate in (sub)clinical samples whether such interventions enhances their willingness to expose themselves to fear-provoking situations in treatment.

The working mechanisms of this future-oriented imagery rescripting intervention can be explained with insights on episodic future thinking (Schacter et al., 2017). Imagining future events that can occur in someone's personal future influences anticipatory emotions, the plausibility of outcomes of future events, and motivates behavior (Bulley et al., 2017; Miloyan & Suddendorf, 2015; Schacter et al., 2017). Similar to our findings, previous studies showed that imagining positive future events sorts positive effects. First, earlier research demonstrated that increasing specific details in positive episodic future thinking decreases anxiety and the plausibility of negative outcomes and increases the plausibility of positive outcomes (e.g., Boland et al., 2018; Hallford et al., 2020; Jing et al., 2016). Second, previous work also showed that detailed positive mental imagery of future events increases a sense of control over the future situation (Boland et al., 2018; Hallford et al., 2018) and higher perceived coping when a bad outcome would occur (Jing et al., 2016). Finally, previous research showed that positive mental imagery of future events could serve as a "motivational amplifier" and increase motivation to engage in activities (e.g., Holmes & Mathews, 2010; Renner et al., 2019). Future studies may use insights from cognitive science to optimize the intervention even further. For instance, imagining more specific details during imagery rescripting focused on future events (Jing et al., 2016) or repeating imagery rescripting may result in larger efficacy (Szpunar & Schacter, 2013; but see Boland et al., 2018).

Several limitations of this study should be noted. First, a non-clinical sample of college students was tested, limiting the generalizability of these findings to other populations or (sub)clinical samples. However, even non-clinical college students commonly experience social anxiety symptoms (Purdon et al., 2001), and both imagery rescripting and the behavioral experiment were individually tailored to target participants' fears. So, although approximately 14% of the participants could not formulate a behavioral experiment with strong negative anticipated outcomes, the included participants reported fear for the behavioral experiment. Second, outcome measures were subjective self-report measures, while observer ratings and physiological reactivity to mental imagery can provide valuable additional information (e.g., Kearns & Engelhard, 2015). Finally, we did not assess imagery ability, which can influence the intervention's efficacy (McEvoy et al., 2015). Future research should examine whether individual differences in imagery ability affect imagery rescripting's efficacy. Strengths of the study include the pre-registration, individual tailoring of both the imagery rescripting intervention and the behavioral experiment, and the use of two experimenters so that the one guiding the behavioral experiment could remain blind to condition.

To summarize, this study demonstrated that future-oriented imagery rescripting focused on updating feared mental images related to a social anxiety behavioral experiment was successful compared to no intervention in reducing threat beliefs, anxiety, and helplessness, and to increase willingness to conduct the experiment. Additionally, this study provided preliminary evidence that imagery rescripting may be beneficial to increase the behavioral experiment's efficacy. Future research should replicate these findings and test the efficacy of this intervention in (sub)clinical samples. The results fit with a growing literature suggesting that imagery-based interventions have great potential to enhance the effects of standard CBT.

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Supplemental materials

General conditional statement

From before (t1) to after the intervention (t2), there was a significant main effect of Time on the validity of the general conditional statement, $F(1, 58) = 25.44$, $p < .001$, $\eta_p^2 = .31$, 90% CI [.15, .44], $BF_{10} = 238.95$ (see Figure 2). Interestingly, there was a significant Time x Condition interaction, $F(1, 58) = 28.60$, $p < .001$, $\eta_p^2 = .33$, 90% CI [.17, .46], $BF_{10} = 8529.92$. While the validity did not change in the control group, $t(29) = 0.35$, $p = .730$, $d_z = 0.06$, 95% CI [-0.30, 0.42], $BF_{10} = 0.21$, it decreased in the imagery rescripting group, $t(29) = 5.78$, $p < .001$, $d_z = 1.05$, 95% CI [0.60, 1.50], $BF_{10} = 6489.61$. From before (t2) to after the behavioral experiment (t3), the validity of the general conditional statement decreased in both groups, $F(1, 58) = 196.23$, $p < .001$, $\eta_p^2 = .77$, 90% CI [.68, .82], $BF_{10} = 3.15 \times 10^{19}$, and was overall lower in the imagery rescripting group, $F(1, 58) = 11.79$, $p = .001$, $\eta_p^2 = .17$, 90% CI [.05, .31], $BF_{10} = 29.29$. From before the intervention phase (t1) to after the behavioral experiment (t3), there was a strong effect of time, $F(1, 58) = 356.34$, $p < .001$, $\eta_p^2 = .86$, 90% CI [.80, .89], $BF_{10} = 6.52 \times 10^{26}$. More importantly, there was a significant Time x Condition interaction on the validity of the general conditional statement, $F(1, 58) = 13.64$, $p < .001$, $\eta_p^2 = .19$, 90% CI [.06, .33], $BF_{10} = 54.48$. Although in both groups the validity of the general conditional statement decreased, there was a larger reduction in the imagery rescripting group, $t(29) = 15.73$, $p < .001$, $d_z = 2.87$, 95% CI [2.05, 3.69], $BF_{10} = 6.02 \times 10^{12}$, than in the no intervention control group, $t(29) = 10.90$, $p < .001$, $d_z = 1.99$, 95% CI [1.36, 2.61], $BF_{10} = 9.71 \times 10^8$. This suggests that imagery rescripting had an additional effect on reducing the validity of the general conditional statement, above and beyond the efficacy of the behavioral experiment.

Chapter 8

General discussion

Although cognitive behavioral therapy (CBT) is the most effective psychological treatment for anxiety-related disorders, its effectiveness is limited by a substantial minority that drop outs before and during treatment, or experiences relapse after initially successful treatment. This dissertation aimed to examine whether modulating negative mental imagery with mental imagery-based interventions could enhance exposure therapy (a central approach within CBT) for anxiety-related disorders. In part I, it was examined whether a dual-task intervention reduces return of fear after extinction training. In part II, it was investigated whether imagery rescripting of aversive memories and anticipated future threats enhances exposure willingness and actual engagement with feared situations. This final chapter will discuss the main findings, theoretical and clinical implications, and related future directions.

Modifying negative mental imagery to reduce return of fear

Previous research has contributed significantly to our understanding of anxiety-related disorders and their treatment. Although CBT is the recommended psychological treatment for anxiety-related disorders (e.g., National Institute for Health and Clinical Excellence, 2011) as outlined in the introduction, there is still room for improvement, such as reducing drop-out and relapse rates. Fear conditioning paradigms are useful to investigate fear learning, extinction, and return of fear (e.g., Mineka & Zinbarg, 2006; Vervliet et al., 2013), relevant processes for understanding exposure therapy. Recently, it has been put forward that fear conditioning research has a narrow focus on associative learning and does not consider the role of episodic memory (Dunsmoor & Kroes, 2019). In addition, previous fear conditioning paradigms often lack ecological validity as they typically use simple aversive stimuli (e.g., shocks or aversive pictures) that do not model the complexity of real-life events (Scheveneels et al., 2016). Developing a paradigm with a more complex fear-relevant multimodal stimulus as the unconditioned stimulus (US) opens up the possibility of investigating imagery modification techniques (e.g., dual-task interventions) targeting episodic memory to attenuate return of fear. Previous research showed that aversive fear-relevant film clips, an example of a more complex stimulus, can be used for fear learning (e.g., Dibbets et al., 2018; Kunze et al., 2015; Wegerer et al., 2013). After successful extinction learning, stressors such as contextual changes (e.g., physical, temporal, and internal contexts) can result in return of fear (Bouton, 2002; Vervliet et al., 2013). For instance, unexpected presentations of the US after extinction learning resulted in reinstatement of fear (Dibbets et al., 2018; Kunze et al., 2015), suggesting that such a procedure using more complex film clips is useful to investigate the return of fear. Presenting the same US as stressor to induce return of fear could influence the mental representation of the US and override potential intervention effects aimed at changing the mental representation of the US. A different procedure to induce return of fear involves an external context switch but it is unknown whether an external context switch after fear learning using complex film clips can elicit fear renewal.

A novel two-day fear conditioning paradigm was developed with a more complex fear-relevant audiovisual US and a renewal phase as presented in **Chapter 2**. Twenty-four hours after fear learning, participants underwent fear extinction (i.e., conditioned stimulus [CS] presentation without the US) in a different context. Afterward, half of the participants were again presented with the same context as during fear extinction, while the other half was exposed to the same context as during fear learning to test return of fear (i.e., renewal). Differential renewal was observed for subjective measures (i.e., US expectancy), while non-differential renewal was found for psychophysiological measures (i.e., fear potentiated startle and skin conductance response). This novel paradigm extends previous work in two ways. First, an existing fear conditioning paradigm known to elicit fear renewal (Milad et al., 2005) was adjusted using a fear-relevant film clip as US (Dibbets et al., 2018). Second, the intervention phase was one day after fear learning, ensuring that the intervention targeted a threat memory and did not interfere with consolidation (McGaugh, 2000). The results indicated that this novel paradigm is suitable for investigating mental imagery-based interventions to modify US memory and reduce fear renewal.

A critical next step in reducing return of fear was to use this paradigm to test a dual-task intervention aimed at modifying US memory and reducing fear renewal (**Chapter 3**). One day after fear acquisition, participants underwent a dual-task procedure, recall only or no intervention. In the dual-task condition, participants recalled the most aversive part of the film clip while making eye movements simultaneously as a dual-task (i.e., a procedure from eye movement desensitization and reprocessing [EMDR]). The recall only condition (i.e., recall without eye movements) controlled for the imaginal exposure component of the dual-task procedure because imaginal exposure is an effective treatment for posttraumatic stress disorder (PTSD; Powers et al., 2010). After the intervention phase, all participants received extinction training before exposure to the acquisition context (i.e., renewal phase). All groups showed US memory devaluation (i.e., reduced unpleasantness and vividness) during and after the intervention. Importantly, US memory devaluation was larger in the dual-task condition than in the no intervention group, while the recall only group only partly devalued US memory (i.e., reduced vividness) compared to the no intervention group. However, there were no group differences in conditioned responses immediately after the intervention phase (i.e., first extinction trial) or fear renewal. The study showed that the interventions did not counter fear renewal.

In **Chapter 4**, it was examined whether a dual-task intervention reduced the frequency of intrusive memories in daily life. Intrusive memories are images and thoughts that are recollected without a retrieval attempt as if the event is happening again and can be very distressing (e.g., flashback of an aversive event [US]; Berntsen, 2010). It has been suggested that such intrusive memories prevent natural memory decay (Herz et al., 2020) and that they are involved in the onset and maintenance of learned fear (Mertens et al., 2020). Previously, it has been argued that intrusive memories can be seen as conditioned responses to trauma cues (i.e., CS; Franke et al., 2021; Wegerer et al., 2013), suggesting that intrusive memories can be studied in fear conditioning paradigms. The trauma film paradigm is typically used to expose individuals to analog trauma by showing a longer aversive film clip (e.g., 20 minutes) to investigate intrusive memories (James et al., 2016), but it has been shown that combining fear conditioning with 30-s film clips could also induce intrusive memories over two consecutive days (Rattel et al., 2019; Wegerer et al., 2013).

Following previous research, the aversive stimuli (i.e., US) in **Chapter 4** were six consecutive film clips (i.e., 30 s each). After fear learning, participants again underwent a dual-task procedure, recall only or no intervention. All participants then underwent an extinction phase. For participants in the no intervention group, extinction training immediately followed fear learning. Participants recorded intrusive memories in a diary over 48 h between testing sessions. Afterward, participants returned to the laboratory to test the return of fear (i.e., spontaneous recovery and renewal). Although the dual-task intervention and recall only intervention devalued US memory compared to no intervention at the end of Day 1, there were no group differences in US memory devaluation on Day 3. Also, the groups did not differ in conditioned responses immediately after the intervention (i.e., the first trial of extinction), return of fear two days later, or intrusion frequency in between sessions. The intrusive memories were relatively low in all three groups, making it difficult for the interventions to reduce the frequency even further. Two potential explanations for the low frequency of intrusive memories are that all participants received extinction training before recording intrusions in a diary over 48 hours and that participants only recorded intrusive memories related to the aversive film clips (i.e., US memory) but not to the CS. That is, a recent study demonstrated that extinction training reduced the probability and severity of intrusive memories of both the CS and US over four days (Franke et al., 2021).

These findings fit with another recent study that demonstrated that poor extinction or generalization to a safety stimulus predicted intrusions one week later (Leen et al., 2021). Taken together, similar to Chapter 3, the interventions did not reduce the return of fear or the development of intrusive memories.

The results from Chapters 3 and 4 are in line with previous research that showed that a dual-task intervention can devalue US memory (Engelhard et al., 2019; van den Hout & Engelhard, 2012), but contrast earlier studies that found that a dual-task intervention was more effective compared to mere recall of the aversive memory (e.g., Engelhard et al., 2010; Gunter & Bodner, 2008; Leer, Engelhard, Altink, et al., 2013; van den Hout et al., 2001; for a review see Houben et al., 2020). Differences in intervention length may explain this discrepancy in findings. Previous studies that showed a beneficial effect of a dual-task intervention compared to recall only typically used a short intervention (4 or 6 times 24 s), while the current studies used a prolonged intervention (16 times 24 s). While habituation after brief exposure during recall only (i.e., 4 or 6 times 24 s) is unlikely and may even inflate US memories (e.g., Leer et al., 2014; van Veen et al., 2020), a prolonged recall only intervention may serve as imaginal exposure and thus differences between dual-tasking and recall only dissipate (van Veen et al., 2020). Moreover, a recent meta-analysis analyzed dismantling studies that compared the full EMDR protocol to the EMDR protocol without eye movements and demonstrated similar efficacy with or without eye movements (Cuijpers et al., 2020; but see Lee & Cuijpers, 2013). Thus, the efficacy of adding a dual-task during recall of aversive memories may be limited compared to recall alone.

Regardless of whether a dual-task intervention is more effective than mere recall of aversive memory, the studies reported in Chapters 3 and 4 showed evidence for US memory devaluation. However, the interventions did not reduce intrusions or conditioned responses directly after the intervention or during a return of fear phase; thus the observed US memory devaluation did not impact the subsequent fear responses. This contrasts earlier studies showing that the dual-task intervention reduced conditioned responses (Leer, Engelhard, Altink, et al., 2013), fear renewal (Leer, Engelhard, Dibbets, et al., 2013), and intrusive memories (van Schie et al., 2019; experiment 2). How can these different findings be reconciled? A likely explanation for these contrasting findings is that the studies differed in whether they used one-day or multiple-day paradigms. Earlier studies showing reduced conditioned responses and fear renewal after a dual-task intervention used one-day fear conditioning paradigms (Leer, Engelhard, Altink, et al., 2013; Leer, Engelhard, Dibbets, et al., 2013), while fear renewal was examined one day after fear learning in Chapter 3 and two days after the dual-task intervention in Chapter 4. Similarly, a dual-task intervention did not reduce conditioned responses compared to control interventions (i.e., imagery rescripting and extinction) when tested one day after the intervention (Dibbets et al., 2018). Potentially, these newly created, non-personal memories in the laboratory quickly fade over time. Participants who did not receive an additional intervention to devalue US memory also showed reduced unpleasantness and vividness of US memory after one or two days (Chapters 3 and 4). This indicates that memories of such novel stimuli are more susceptible to decay over time than older autobiographical memories (e.g., Schwabe et al., 2014; Wichert et al., 2011), making it difficult to examine intervention effects after a time lapse. Still, differences in number of days cannot explain why no group differences were found on the first trial of extinction in Chapter 4 (i.e., still on one day). Possibly, intervention effects may have been abolished because participants were presented with a new external context during the extinction phase. Thus, although previous studies have provided some evidence that a dual-task intervention can affect conditioned responses within the same day, this was not replicated in our research.

Fear conditioning paradigms have great value in studying fear learning, yet the novel paradigm still has several limitations to study whether a dual-task intervention can reduce conditioned fear responses. First, the unpleasantness and vividness ratings of the created threat memory quickly reduced even in participants who did not receive an additional intervention, leaving less room for the intervention to further devalue threat memory. Second, the dual-task intervention (a model for eye movements in EMDR) was potentially not potent enough to exert an influence on conditioned responses over time above natural decay, given that the threat memory was still relatively unpleasant after the intervention in Chapters 3 and 4. It has been argued that changing emotional and cognitive responses towards the aversive memory (i.e., reappraisal) may be necessary for a dual-task intervention to be effective (Gunter & Bodner, 2008). Because the aversive film clips lack personal relevance (e.g., Strohm et al., 2019) and do not affect the individual as real-life experiences would, the intervention may not have influenced emotional and cognitive responses towards the memory as strongly. Indeed, trauma film paradigm studies that may have a stronger emotional impact have shown that memory reactivation followed by a working memory taxation task (e.g., playing Tetris) reduced intrusive memories over time (Badawi et al., 2020; Holmes et al., 2009, 2010; James et al., 2015). Additionally, other components from EMDR may add to its efficacy, such as increasing the validity of positive cognitions (de Jongh & ten Broeke, 2020). Given that fear conditioning paradigms do not use idiosyncratic memories, it may be difficult to implement such other strategies within these paradigms. Finally, we only measured subjective experiences and physiological responses, but not behavioral avoidance (Beckers et al., 2013; Scheveneels et al., 2016). The procedure was a relative passive process in which the participants could not exert control. Deciding whether to avoid or approach feared situations may be a crucial determinant for fear relapse (Krypotos et al., 2018), thus the lack of a possibility to avoid situations limits the usability of fear renewal as a model for fear relapse (Scheveneels et al., 2016).

These methodological considerations challenge the usefulness of examining a dual-task intervention in such a fear conditioning paradigm. Recently, eye movements after memory reactivation were examined within a fear conditioning paradigm that used fear-relevant stimuli in anxious participants (Jellestad et al., 2021). However, the efficacy of the intervention on conditioned responses was not convincing. This alternative approach to examine individuals with pre-existing anxiety symptoms can also be used to investigate autobiographical memories instead of aiming to change such novel threat memories that are created in the laboratory. Besides, anxiety patients often imagine negative *future* events (i.e., episodic future thinking; e.g., Engelhard et al., 2010) and the subjective feeling of "pre-experiencing" future events depends on whether this event is personally relevant (e.g., Lehner & D'Argembeau, 2016). Therefore, the second part of this dissertation used a more clinical approach investigating participants with subclinical anxiety levels to test whether a different mental imagery-based intervention modified aversive memories and anticipated future threats and increased willingness to engage in exposure.

Modifying negative mental imagery to enhance exposure willingness

The second part of this dissertation investigated whether mental imagery-based interventions can increase willingness to engage in feared situations. Idiosyncratic fears were examined in individuals with subclinical anxiety levels to overcome the limitation of using non-idiosyncratic stimuli in fear conditioning paradigms. Imagery rescripting was used to modify negative mental imagery in the second part of this dissertation. Previous research showed that imagery rescripting is an effective experiential technique to modify aversive memories to update their meaning (Arntz, 2012; Morina et al., 2017). Modifying aversive memories is especially important because they underlie negative mental imagery in anxiety-related disorders (Holmes & Mathews, 2010). Also, individuals use previous experiences to construct mental imagery of potential future events (Schacter et al., 2017; Schacter & Addis, 2007). How individuals imagine situations in their personal future can influence their emotions, the subjective plausibility of certain events, and motivate goal-directed approach and avoidance behavior (Bulley et al., 2017; Holmes & Mathews, 2010; Miloyan & Suddendorf, 2015). When anticipated future threats are exaggerated or unrealistic, mental imagery can be maladaptive and maintain anxiety and avoidance behavior (e.g., Clark & Wells, 1995; Engelhard et al., 2010; Hofmann, 2007; Miloyan & Suddendorf, 2015; Rapee & Heimberg, 1997).

An essential question was whether modifying aversive memories also changes how individuals imagine anticipated future threats. In **Chapter 5**, we examined whether imagery rescripting of an aversive social memory reduces negative prospective mental imagery in individuals with social anxiety, compared to progressive relaxation as a control intervention. Participants imagined a feared social situation that may happen in their personal future. Then they received one of the interventions and imagined the feared future event again one day later. Both interventions strongly reduced negative memory appraisals. Similarly, both interventions reduced negative prospective mental imagery of future threat, and even made it more positive, and decreased anxiety and avoidance towards the imagined future event. Imagery rescripting was more effective than progressive relaxation in changing emotional appraisals of the memory and future threat, but the finding that both interventions were overall similarly effective was unexpected. A recent study also demonstrated that unexpectedly, progressive relaxation can reduce social anxiety (Cougle et al., 2020). Participants may have used emotional reasoning to infer an absence of threat from their relaxed state (Arntz et al., 1995; Engelhard & Arntz, 2005; Miloyan & Suddendorf, 2015), which may have led to increased self-efficacy. Future research is warranted to preclude potential placebo effects or imaginal exposure effects using different control conditions, such as a passive control or imaginal exposure. Nonetheless, these findings provide valuable insight into the efficacy of modifying aversive memories. They corroborate earlier findings suggesting that imagery rescripting leads to reappraisal of aversive memories (Arntz, 2012; Strachan et al., 2020) and extend these findings by showing that imagery rescripting can also update how individuals imagine a feared future event (see Schacter et al., 2017; Schacter & Addis, 2007). It remains unknown whether it would also increase actual engagement with the feared situation.

To investigate whether changing negative mental imagery increases engagement with a feared situation, a mental imagery-based intervention directly aimed at changing mental imagery of feared future events was examined. A standardized future-oriented positive mental imagery exercise was compared to no task in individuals with public speaking anxiety in **Chapter 6**. After the intervention phase, participants were asked to give a presentation in front of a virtual reality audience as exposure session. The results indicated that positive mental imagery reduced anticipatory anxiety and distress during actual engagement with the feared situation (i.e., exposure in virtual reality) compared to no task, but did not increase willingness to engage in virtual reality exposure. Nearly all participants completed the exposure session, potentially because of demand bias or because participants only had moderate levels of public speaking anxiety. Therefore, it was not possible to investigate drop-out during exposure. These findings show that the standardization of such a future-oriented positive mental imagery exercise has great potential for easy application in clinical practice and online interventions. However, a drawback of a standardized intervention in our study is that it may decrease the intervention's efficacy. One central tenet of episodic future thinking is that it includes situations that may happen in someone's personal future, motivating behavior to achieve long-term personal goals (Lehner & D'Argembeau, 2016; Schacter et al., 2017). The scenario in the standardized intervention may potentially not fit within the personal future for all participants, which could be one of the explanations why willingness to engage in exposure did not increase. Testing a more idiosyncratic intervention may be necessary to increase willingness to engage in feared situations.

The next step was to investigate a personalized future-oriented mental imagery intervention. In **Chapter 7**, personalized future-oriented imagery rescripting of anticipated future threats was compared to no intervention to investigate whether it could prepare individuals to engage in feared social situations. Healthy individuals were asked to formulate a behavioral experiment to test negative beliefs about a social situation they feared. Before conducting the behavioral experiment, participants received imagery rescripting or no intervention (i.e., a break). Imagery rescripting of the anticipated future event reduced the anticipated probability and severity of the feared outcome, lowered anxiety and helplessness levels, and increased willingness to conduct the behavioral experiment compared to no intervention. Additionally, imagery rescripting reduced the anticipated probability of the expected negative outcome, helplessness levels, and the validity of the general conditional statement (i.e., general statement about their fears in social situations) even further than the behavioral experiment alone, suggesting that imagery rescripting may enhance the efficacy of a behavioral experiment. Imagery rescripting of an anticipated feared social event seems a fruitful approach to enhance standard CBT.

The findings in Chapters 6 and 7 provide insight into the power of positive mental imagery of future events. Previous work in socially anxious individuals showed that negative self-imagery can increase anxiety (e.g., Hirsch et al., 2003, 2004; Makkar & Grisham, 2011; Stopa & Jenkins, 2007). Similarly, positive self-imagery can reduce anxiety, increase self-esteem, and enhance social performance compared to negative self-imagery in socially anxious individuals (e.g., Stopa et al., 2012; Stopa & Jenkins, 2007; Vassilopoulos, 2005). Although these findings were promising, group differences could have been driven by negative self-imagery. Moreover, self-imagery was based on earlier experiences and did not reflect imagery of the future per se. Positive interventions to improve mental health are booming (Quoidbach et al., 2015), and it has been shown that positive mental imagery of future events can increase happiness in healthy participants but it did not reduce anxiety levels in general (Quoidbach et al., 2009). The findings from Chapters 6 and 7 extend earlier work by showing that positive mental imagery of a feared *future* situation can decrease (anticipatory) anxiety compared to no intervention.

In line with previous research, Chapter 7 demonstrated that both the subjective plausibility and severity of the expected negative outcome reduced after modifying prospective mental imagery (e.g., Boland et al., 2018; Hallford et al., 2020; Jing et al., 2016). Previous work in healthy individuals and individuals with major depressive disorder showed that positive mental imagery of the future increased motivation and actual engagement in the imagined situation (Renner et al., 2017, 2019). These situations included enjoyable (e.g., taking a bath) and routine (e.g., sorting household paperwork) activities and such activities differ from feared situations in anxiety-related disorders. It has been suggested that positive imagery may increase approach behavior in anxiety (Pictet, 2014). Indeed, modifying future-oriented mental imagery affected emotions and the perceived plausibility of future outcomes in individuals with some degree of anxiety, and increased willingness to engage in the feared situation (Chapter 7). Additionally, the finding that a personalized intervention increased willingness to engage with a feared situation (Chapter 7), while a standardized intervention that potentially fits less within participants' personal future did not (Chapter 6), is in line with research that shows that personal relevance influences the feeling of "pre-experiencing" of the imagined event (Lehner & D'Argembeau, 2016). Despite increased willingness after imagery rescripting in Chapter 7, all participants engaged in the behavioral experiment in both groups. Whether imagery rescripting of anticipated future threats can increase engagement with feared situations awaits replication in clinical samples, who are more reluctant to conduct exposure.

Taken together, these findings show that imagery rescripting not only has the potential to update aversive memories (Morina et al., 2017) but also to update future-oriented mental imagery. This seems a fruitful approach to reduce anxiety, negative threat beliefs and increase willingness to engage in feared situations. In short, modifying mental imagery of feared events seems to prepare individuals to confront these feared situations.

Theoretical implications

The findings presented in this dissertation provide insights into contemporary learning theory. According to contemporary learning theory, two different factors contribute to fear responding, namely the CS-US association and the mental representation of the US (Davey, 1997). Contemporary learning theory places emphasis on fear learning through direct, vicarious, or verbal pathways (Davey, 1997; Mertens et al., 2018). Importantly, mental imagery of aversive situations also affects fear learning. For instance, mental rehearsal of a CS-US contingency, compared to rehearsal of a neutral US or no rehearsal, can install avoidance learning (Krypotos et al., 2020; experiment 1) and preserve conditioned fear over time (Joos et al., 2012). Also, mental imagery of an aversive situation that was not previously encountered (i.e., thumbtack in heel) can induce conditioned fear responding (Mueller et al., 2019). These findings imply that the mental representation of a US should be seen as a broad concept that can include aversive experiences and anticipated future threats. This fits with the findings presented in this dissertation showing that interventions aimed at modifying mental imagery of aversive memories and anticipated future threats can reduce (anticipatory) anxiety (Chapters 5-7). Although contemporary learning theory does not preclude the importance of anticipated threats (e.g., outcome expectancy) or mental imagery, a larger focus on mental imagery of (not previously encountered) anticipated threats seems essential for anxiety-related disorders and should guide future research to improve treatments for anxiety (see also Mertens et al., 2020).

The findings from Chapters 6 and 7 raise some questions about the role of expectancy violation during exposure therapy (for a critical discussion see Scheveneels et al., 2021). Inhibitory learning theory assumes that exposure learning relies on outcome expectancy violation (Craske et al., 2014). That is, a larger mismatch between what someone expects and what happens during exposure would increase learning (i.e., prediction error). According to this theory, interventions aimed at reducing the negative outcome expectancy before exposure learning would decrease its efficacy. Imagery rescripting of an anticipated future threat before a behavioral experiment led to greater reductions in the expected negative outcome, helplessness levels, and the validity of the general conditional statement after the behavioral experiment than a behavioral experiment alone, even though imagery rescripting already reduced the negative outcome expectancy before the behavioral experiment (Chapter 7). This finding seems to be inconsistent with the expectancy violation hypothesis, although we did not measure whether fear reduction persisted over time. Moreover, it is possible that imagery rescripting enhanced learning during the behavioral experiment. Previous research has shown that negative self-imagery can increase self-focused attention and safety behavior (Hirsch et al., 2004; Hirsch & Holmes, 2007; Makkar & Grisham, 2011). As such, positive mental imagery of anticipated future threats may have allowed participants to focus their attention outwards (Aue & Okon-Singer, 2015). Participants may have noticed more positive outcomes and interpreted these more positively (see Hirsch et al., 2006). Consequently, this could have led to the incorporation of new learning that disconfirmed negative outcome expectancies even further. To date, there is scant evidence that shows enhanced exposure effects when specifically targeting expectancy violation as proposed by inhibitory learning theory (Huppert et al., 2019; Scheveneels et al., 2021). Whether pre-exposure interventions such as imagery rescripting enhance or decrease exposure efficacy is an empirical question that should be examined in future studies.

The memory processes involved in mental imagery-based interventions remain unclear. One possibility is that the interventions result in new, more positive mental representations, while leaving the original mental representation of threat intact. This perspective is consistent with that of inhibitory learning (Craske et al., 2014), competition retrieval (Brewin, 2006), and updated emotional processing theory (Foa et al., 2006) that assume that new mental representations develop during treatment that conflict with the original mental representation of threat, and therefore inhibit or compete with the original mental representation during later retrieval. This perspective suggests that the original mental representation of threat can become activated over time and induce fear relapse. Alternatively, these mental imagery-based interventions change the mental representations of threat memories itself. When memories are reactivated, they can become labile again, and during this transient state, they are malleable and can be updated before reconsolidation (Schwabe et al., 2014). However, many inconsistent findings have been found in studies investigating reconsolidation in humans (e.g., Beckers & Kindt, 2017; Elsey et al., 2018). The current dissertation did not investigate the underlying memory processes. It should be noted that these different interpretations are not necessarily mutually exclusive and that disentangling these different working mechanisms is extremely challenging (see Huppert et al., 2019 for a review on how predictive coding models could integrate theories and further our understanding of this topic).

Clinical implications

Although replication in clinical samples is necessary, the findings in this dissertation can ultimately have implications for clinical practice. The studies presented in part II show that reappraisal of negative memories can change appraisal of mental imagery of feared future events. Similarly, changing mental imagery of anticipated future threats can reduce anticipatory anxiety and increase exposure willingness. These findings underline that mental imagery of both negative memories and anticipated future threats can influence emotions and behavior (see Schacter et al., 2017). Based on these findings, an implication for clinical practice is that CBT for anxiety-related disorders could potentially be enhanced when modifying mental imagery of aversive experiences and anticipated threats is included. This is in line with recent reviews that plea for a greater focus on mental imagery in research and clinical practice (e.g., Arntz, 2020; Blackwell, 2021; Hirsch & Holmes, 2007; Ji et al., 2016; Saulsman et al., 2019). Note that the EMDR protocol has recently also included flashforwards as a target for treatment (de Jongh & ten Broeke, 2020; Shapiro, 2017), based on basic findings from the laboratory (Engelhard et al., 2010).

The optimal timing of such imagery-based interventions depends on whether these interventions are effective with or without exposure. Chapter 7 suggests that imagery rescripting of anticipated future threats before exposure may increase its efficacy, potentially by enhancing the ability to learn during exposure. If these findings are replicated in clinical samples, this has two implications for clinical practice. First, mental imagery-based interventions can reduce anticipatory anxiety. Given the influence of emotions associated with mental imagery on behavior (e.g., Bulley et al., 2017; Miloyan & Suddendorf, 2015), this can have a cascading effect on behavior. That is, mental imagery-based interventions may pave the way for patients to engage in feared situations and potentially reduce treatment drop-out rates. Second, mental imagery-based interventions preceding exposure therapy could potentially result in faster symptom reduction, which is crucial to alleviate experienced distress.

Based on the studies presented in this dissertation, it remains unclear whether modulating negative mental imagery can reduce relapse rates. The findings presented in part I provide no evidence that mental imagery-based interventions can reduce return of fear after extinction training. However, methodological challenges may have obscured the interpretation of these findings. Therefore, these findings also do not necessarily preclude the possibility that modifying negative mental imagery can reduce relapse rates after exposure therapy, as has been argued previously (Arntz, 2020).

Future directions

The presented research in this dissertation provides future directions. To further optimize mental imagery-based interventions, future research should try to further elucidate how such interventions work, along the lines of the experimental work on EMDR (Engelhard et al., 2019). Studying mediators as mechanisms of change can help understand why interventions are effective (Kazdin, 2009). The paradigm used in the first part of this dissertation can be improved by using fear-relevant stimuli to investigate mental imagery-based interventions in anxious individuals (e.g., Jellestad et al., 2021). Alternatively, mechanisms of change can be investigated using idiosyncratic mental imagery similar to the studies in the second part of this dissertation. In the second part of this dissertation, interventions' efficacy has been attributed to cognitive reappraisal resulting from positive mental imagery but the presented work did not control for the valence of the intervention. Another plausible interpretation is that constructing a more detailed scenario of the future situation (i.e., increased episodic details) was responsible for the interventions' efficacy. Previous research has shown that Memory Specificity Training in individuals with depression (Raes et al., 2009) and Future Specificity Training in healthy individuals (Hallford et al., 2020) increased episodic specificity during memory recall and simulations of future situations, which was associated with improved problem solving skills. Similarly, increased episodic specificity of constructive behaviors has been shown to reduce anxiety and subjective plausibility of a negative outcome and increase perceived coping with a bad outcome (Jing et al., 2016). Since individuals with anxiety disorders may lack vivid imagery of positive past experiences (Moscovitch et al., 2011) and positive future events (Morina et al., 2011), this suggests that not only the positive valence but also the episodic specificity of mental imagery may be necessary. Future studies should aim to disentangle these potential explanations.

Our understanding of treatment outcome predictors in anxiety-related disorders is limited (Cuijpers et al., 2019), and future research could investigate potential mental imagery-related predictors. For example, modulating negative mental imagery may enhance treatment outcomes, although this may depend on mental imagery ability. Previous work has shown that greater mental imagery ability was associated with more significant symptom change during an imagery-enhanced CBT intervention for social anxiety disorder (McEvoy et al., 2015). Another future endeavor is to investigate whether mental imagery-based interventions enhance exposure willingness and increase actual engagement with feared situations in clinical samples. Previous work in social anxiety disorder demonstrated that adding several imagery interventions (e.g., imagery rescripting, video feedback, positive imagery of core beliefs) to CBT can increase its efficacy (Ahn & Kwon, 2018; McEvoy et al., 2015; Norton et al., 2021; but see McEvoy et al., 2020), but the specific effects of pre-exposure interventions on exposure efficacy remain unclear. Finally, whether return of fear reduces after adding such mental imagery-based interventions should be investigated using more ecologically valid methods than the used fear conditioning paradigms in this dissertation, such as by eliciting context renewal of fear in individuals with public speaking anxiety by changing the room (Culver et al., 2011) or virtual context (van Dis et al., 2021).

Conclusion

This dissertation aimed to further our understanding of interventions that modify negative mental imagery in anxiety-related disorders using insights from contemporary learning theory, clinical research, and cognitive science. The current findings suggest that CBT techniques may be augmented with mental imagery-based interventions. Future research should further unravel the working mechanisms of the presented interventions to optimize treatments. Additionally, replicating these findings and investigating long-term treatment outcomes (e.g., relapse) in clinical samples is necessary. In conclusion, mental imagery-based interventions show great potential to modify negative mental imagery and prepare individuals to engage in previously avoided situations.

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Dutch summary
Nederlandse samenvatting

De meeste mensen ervaren periodes van angst tijdens hun leven, bijvoorbeeld bij de start van een nieuwe baan of tijdens (ernstige) gezondheidsproblemen. Vanuit evolutionair oogpunt is angst een adaptieve emotie die ons helpt om te overleven. Sommige mensen zijn echter dusdanig angstig dat zij daar last van hebben. Angststoornissen worden gekenmerkt door een aanhoudende angst die buitensporig is voor de situatie. Mensen die lijden aan angststoornissen, vermijden beangstigende stimuli en situaties of doorstaan deze met veel angst. Bovendien zorgen angststoornissen voor een beperkt functioneren op het gebied van werk en relaties. Een aanzienlijk aantal mensen heeft last van een angststoornis: ongeveer één op de vijf mensen voldoet ergens in hun leven aan de criteria van een angststoornis. Goede behandelingen voor angststoornissen zijn essentieel om de lijdensdruk te verminderen.

Volgens de hedendaagse leertheorie kan angst ontstaan wanneer neutrale stimuli of situaties (bijvoorbeeld sociale situaties) geassocieerd worden met aversieve uitkomsten (bijvoorbeeld sociale afwijzing). Wanneer een dergelijke associatie is ontstaan, kan confrontatie met een beangstigende situatie leiden tot het ophalen van deze associatie. Vervolgens wordt ook een mentale representatie van de aversieve uitkomst opgeroepen die bijdraagt aan de angstreactie. Kortom, de angstreactie wordt beïnvloed door twee factoren: de sterkte van de associatie en de mentale representatie van een aversieve uitkomst. Deze theorie biedt aanknopingspunten voor behandelingen bij angststoornissen, namelijk door de associatie te verzwakken of door de mentale representatie minder onaangenaam te maken.

Cognitieve gedragstherapie (CGT) is de aanbevolen, *evidence-based* behandeling voor angststoornissen volgens klinische richtlijnen. Het doel van CGT is om negatieve gedachten, vermijdingsgedrag en buitensporige angst te verminderen. Een belangrijk onderdeel van CGT is exposure waarbij patiënten systematisch worden blootgesteld aan beangstigende stimuli en situaties. Het veronderstelde mechanisme van exposure therapie is dat patiënten leren dat de door hen gevreesde uitkomst niet plaatsvindt en daarmee hun negatieve verwachtingen ontkracht worden. Alhoewel CGT effectief is voor de behandeling van angststoornissen, zijn er ook beperkingen. Sommige mensen met een angststoornis stoppen met de behandeling, mogelijk omdat zij die te confronterend vinden. Een andere beperking van exposure therapie is dat verondersteld wordt dat een nieuwe associatie wordt gevormd (sociale situaties leiden niet tot afwijzing), maar dat de originele associatie ook blijft bestaan (sociale situaties leiden tot afwijzing). Wanneer deze oorspronkelijke associatie wordt opgehaald, bijvoorbeeld omdat mensen zich in een andere omgeving bevinden, kunnen zij een terugkeer van angstklachten ervaren na een initieel succesvolle behandeling.

Een manier om behandelingen voor angststoornissen te verbeteren is door niet alleen in te grijpen in de negatieve verwachting (de associatie) zoals exposure therapie doet, maar door ook de mentale representatie te veranderen die geactiveerd wordt bij blootstelling aan beangstigende situaties. Mensen met een angststoornis ervaren vaak levendige mentale beelden van negatieve herinneringen of beangstigende rampscenario's voor de toekomst. Wat mensen zich inbeelden, kan vervolgens emoties, verwachtingen en gedrag beïnvloeden. Ingrijpen in wat mensen met angststoornissen zich inbeelden, kan daarom de behandeling verbeteren. Ten eerste kan het terugkeer van angstklachten voorkomen doordat de mentale representaties zelf veranderd zijn. Ten tweede kan het makkelijker worden voor patiënten om zich bloot te stellen aan gevreesde situaties als zij minder last hebben van deze negatieve beelden. In dit proefschrift werd onderzocht of het veranderen van negatieve mentale beelden bij angst behandeling zou kunnen verbeteren. In het eerste deel van dit proefschrift werd gekeken of het veranderen van deze mentale representaties de terugkeer van angst kon verminderen. In het tweede deel van dit proefschrift werd onderzocht of het veranderen van mentale representaties het makkelijker kon maken om beangstigende situaties aan te gaan.

Het veranderen van negatieve mentale beelden om terugkeer van angst te verminderen

In **hoofdstuk 2** werd een angstconditioneringsparadigma ontwikkeld dat in vervolgonderzoek gebruikt kan worden om na te gaan of het minder onaangenaam maken van een herinnering aan gevaar de terugkeer van angst kan verminderen. Participanten leerden dat een plaatje van een gele lamp op een bureau gevolgd werd door een onprettig filmpje, terwijl het plaatje van een blauwe lamp op een bureau niet werd gevolgd door een onprettig filmpje. Een dag later kregen de participanten weer plaatjes te zien, ditmaal van de gele en blauwe lamp in een boekenkast. De plaatjes werden niet gevolgd door het onprettige filmpje, waardoor de angst voor de lampen kon uitdoven (extinctieleren). Direct daarna werden aan de helft van de participanten de lampen nogmaals in de boekenkast getoond, terwijl de andere helft de lampen weer op het bureau te zien kregen. De participanten die de lampen weer op het bureau te zien kregen, lieten terugkeer van angst zien, gemeten door subjectieve verwachtingen en fysiologische angstmaten, terwijl de andere participanten geen terugkeer van angst lieten zien. Het paradigma is dus geschikt om terugkeer van angst te onderzoeken.

In **hoofdstuk 3** werd vervolgens onderzocht of het maken van oogbewegingen tijdens het ophalen van de herinnering aan het onprettige filmpje de mentale representatie van de film minder onaangenaam kon maken en de terugkeer van angst kon verminderen. Dezelfde procedure werd gevolgd als in hoofdstuk 2 met de toevoeging van een interventiefase voorafgaand aan extinctieleren op Dag 2. Participanten werden toegewezen aan één van drie interventies: de duale-taak groep, de alleen-ophalen groep en een groep die geen interventie kreeg. De duale-taak groep haalde de herinnering aan de onprettige film op terwijl zij oogbewegingen maakten (16 x 24 seconden). De alleen-ophalen groep haalde enkel de herinnering aan de onprettige film op zonder het maken van oogbewegingen. De derde groep had geen interventie en begon direct met extinctieleren op Dag 2. Zoals verwacht lieten de resultaten zien dat de onaangenaamheid en levendigheid van de herinnering aan de onprettige film het meeste afnamen in de duale-taak groep, in mindere mate in de alleen-ophalen groep en het minste in de groep die geen interventie had. Er waren echter geen verschillen in de angstreactie direct na de interventiefase of in de terugkeer van angst. De interventies waren dus niet effectief om terugkeer van angst te verminderen.

In **hoofdstuk 4** werd onderzocht of het maken van oogbewegingen tijdens het ophalen van een herinnering aan onprettige filmpjes invloed had op het verminderen van terugkeer van angst en op het ontwikkelen van intrusieve herinneringen aan de filmclips. Intrusieve herinneringen zijn beelden die spontaan opkomen zonder dat iemand moeite doet om zich deze te herinneren. Zulke intrusieve herinneringen kunnen een rol spelen bij het ontstaan en in stand houden van angst en kunnen erg verontrustend zijn. Ditmaal werd participanten geleerd om twee gezichten te associëren met onprettige filmclips, terwijl één gezicht nooit gevolgd werd door de onprettige filmclips. Deze gezichten werden getoond op een blauwe achtergrond. Daarna volgde de interventiefase met de drie verschillende groepen, die gelijk waren aan die in hoofdstuk 3. Vervolgens kregen de participanten de gezichten nogmaals te zien zonder de onprettige filmclips op een gele achtergrond (extinctieleren). Participanten rapporteerden vervolgens twee dagen in een dagboek of zij intrusieve herinneringen aan de filmclips ervaarden. Na 48 uur kwamen de participanten terug naar het laboratorium en werden aan de participanten de gezichten weer met een blauwe achtergrond getoond. In de duale-taak groep en de alleen-ophalen groep was de herinnering aan de filmclips minder onaangenaam aan het einde van Dag 1 in vergelijking met de groep die geen interventie kreeg. De verschillen waren echter verdwenen op Dag 3. Bovendien lieten de drie groepen geen verschillen zien in angstreactie direct na de interventie, in terugkeer van angst of in het aantal intrusieve herinneringen.

In deze drie studies is gepoogd om conditioneringsparadigma's te verbeteren door het gebruik van complexe stimuli (onprettige filmclips) in plaats van veelgebruikte eenvoudigere stimuli zoals elektrische schokjes. Het nieuwe paradigma heeft echter nog steeds een aantal nadelen die het lastig maken om te onderzoeken of een duale-taak interventie terugkeer van angst kan verminderen. Zo zijn de stimuli die gebruikt worden in conditioneringsonderzoek niet te vergelijken met ervaringen in het dagelijks leven. De herinnering aan de onprettige filmpjes werd bijvoorbeeld snel minder onaangenaam na verloop van tijd. Bovendien zijn dit soort stimuli uiteraard weinig persoonlijk relevant, terwijl juist het veranderen van de emotionele en cognitieve reacties op herinneringen mogelijk belangrijk zou kunnen zijn voor de effectiviteit van een duale-taak interventie. De duale-taak interventie is een model voor de oogbewegingen-component van *eye movement desensitization and reprocessing* (EMDR), een behandeling voor posttraumatische stressstoornis, terwijl andere onderdelen van EMDR mogelijk ook bijdragen aan de effectiviteit. Een andere beperking is dat gedrag niet werd onderzocht. Participanten hadden een passieve rol, terwijl mensen in het dagelijkse leven ervoor kunnen kiezen om situaties te vermijden of juist aan te gaan wat een rol speelt bij terugkeer van angst. Gezien de beperkingen van conditioneringsparadigma's zijn in het tweede deel van dit proefschrift mensen met bestaande angstklachten onderzocht bij wie een andere interventie werd getest om negatieve mentale beelden te veranderen en exposure bereidheid te vergroten.

Het veranderen van negatieve mentale beelden om exposure bereidheid te vergroten

In **hoofdstuk 5** werd bij mensen met sociale angst onderzocht of *imagery rescripting* van een beangstigende sociale herinnering een rampscenario voor een beangstigende toekomstsituatie kon veranderen. Mensen met sociale angst werd gevraagd om zich een sociale situatie in te beelden die mogelijk in hun toekomst zou plaatsvinden en die hen beangstigde. Vervolgens werd een herinnering aan een sociale situatie opgehaald waarbij zij dezelfde negatieve gevoelens en gedachten ervaarden. Participanten kregen vervolgens *imagery rescripting* of progressieve relaxatie als interventie. Tijdens *imagery rescripting* werd participanten gevraagd om de herinnering levendig voor zich te zien vanuit hun jongere zelf. Vervolgens werden zij aangemoedigd om als hun huidige zelf in te grijpen in de herinnering en de herinnering positiever te maken. Daarna werd de herinnering opnieuw ingebeeld vanuit het perspectief dat zij destijds hadden, met de veranderingen van hun huidige zelf erbij. In de progressieve relaxatie groep werden participanten begeleid bij het aan- en ontspannen van spiergroepen. Voor en na de interventiefase beoordeelden de participanten hun nare herinnering. Een dag later werd participanten gevraagd om zich de beangstigende toekomstsituatie nogmaals in te beelden zoals zij deze nu ervaarden. De resultaten lieten zien dat beide interventies leidden tot veranderde betekenisgeving aan de herinnering: zij waren minder overtuigd van hun negatieve cognities, ervaarden minder negatieve emoties en voelden meer controle over de herinnering. Bovendien leidden beide interventies tot een minder negatieve beschrijving van de beangstigende toekomstsituatie en bevatte de beschrijving zelfs meer positieve elementen. Ook ervaarden participanten minder angst en vermijding ten opzichte van de toekomstsituatie. *Imagery rescripting* leidde tot een grotere toename van positieve emoties geassocieerd met de herinnering en tot zowel minder negatieve als meer positieve emoties geassocieerd met het toekomstbeeld in vergelijking met progressieve relaxatie. Veranderingen in de betekenisgeving van de herinnering waren gerelateerd aan veranderingen in de betekenisgeving van de toekomstige situatie een dag later. Deze bevindingen tonen aan dat het ingrijpen in nare herinneringen ook kan leiden tot veranderingen in de wijze waarop mensen met sociale angst zich de toekomst inbeelden. Het is echter onduidelijk of mensen daardoor de beangstigende situaties ook sneller aan zullen gaan.

In **hoofdstuk 6** is onderzocht of het zich positief inbeelden van de toekomst het makkelijker maakt voor mensen met spreekangst om beangstigende situaties ook daadwerkelijk aan te gaan. De helft van de participanten kreeg een audiofragment te horen waarin zij een presentatie gaven die goed verliep. Participanten moesten zich dit scenario zo levendig mogelijk inbeelden terwijl zij het hoorden. De andere helft kreeg niets te horen. Daarna werd participanten gevraagd om een presentatie te geven in een *virtual reality* omgeving als exposure oefening. Participanten werd verteld dat zij moesten proberen zo lang mogelijk te presenteren of totdat hun verteld werd dat zij mochten stoppen. Uit de resultaten kwam naar voren dat participanten die zich het positieve scenario hadden ingebeeld, minder anticipatie-angst rapporteerden en ook minder angst ervaarden tijdens de exposure oefening dan participanten die geen audiofragment te horen kregen. Er was echter geen verschil in de bereidheid om de presentatie te geven tussen de twee groepen. Bovendien maakte 91% van de participanten de vijf minuten presentatietijd vol, waardoor verschillen in uitval tussen de groepen niet konden worden geanalyseerd. Een verklaring hiervoor is dat participanten niet erg angstig waren. Samengevat liet deze studie zien dat een gestandaardiseerde positieve toekomstgerichte inbeeldingsoefening potentie heeft om angst te verminderen. Een nadeel van een gestandaardiseerde oefening is dat juist het zich inbeelden van situaties die binnen iemands persoonlijke toekomst kunnen passen, een grote invloed lijkt te hebben op emoties en doelgericht gedrag. Een gepersonaliseerde oefening zou daarom mogelijk effectiever kunnen zijn.

In **hoofdstuk 7** werd een gepersonaliseerde *imagery rescripting* interventie toegepast op rampscenario's voor een beangstigende toekomstige sociale situatie om te onderzoeken of dat het makkelijker maakte om de sociale situatie ook daadwerkelijk aan te gaan. Participanten werd gevraagd om een sociale situatie te beschrijven die zij vreesden om zo hun negatieve verwachtingen van die situatie te toetsen (exposure). De helft van de participanten kreeg voorafgaand aan de sociale situatie *imagery rescripting* toegepast op de door hen gevreesde negatieve verwachting van de sociale situatie. De andere participanten hadden een pauze. De resultaten toonden aan dat bij participanten die *imagery rescripting* kregen, de subjectieve kans dat de negatieve verwachting uitkwam, en de geschatte ernst daarvan verminderden in vergelijking met participanten die een pauze hadden. Ook verminderden bij participanten die *imagery rescripting* kregen, angst en hulpeloosheid en verhoogde de bereidheid om de sociale situatie aan te gaan in vergelijking met participanten die een pauze hadden. Nadat participanten de sociale situatie waren aangegaan, werd hun gevraagd zich voor te stellen dat ze de sociale situatie nogmaals moesten aangaan. De subjectieve negatieve verwachting en hopeloosheid daalden sterker in de groep die *imagery rescripting* kreeg dan in de groep die enkel was blootgesteld aan de sociale situatie. Dit suggereert dat *imagery rescripting* ervoor zorgt dat het makkelijker wordt om de gevreesde situatie aan te gaan en bovendien mogelijk de effectiviteit van exposure versterkt.

Implicaties van de bevindingen en suggesties voor toekomstig onderzoek

De studies uit dit proefschrift geven inzicht in de wijze waarop behandeling voor angststoornissen mogelijk verbeterd kunnen worden. Uiteraard moeten deze bevindingen eerst gerepliceerd worden (ook in klinische doelgroepen). Daarbij moet ook aandacht worden besteed aan de langetermijneffecten van de interventie en aan de vraag of de positieve effecten ook generaliseren naar andere beangstigende situaties. De bevindingen in dit proefschrift hebben theoretische implicaties, potentiële klinische implicaties en bieden een aantal suggesties voor toekomstig onderzoek.

Alhoewel er aandacht is voor negatieve herinneringen bij het ontstaan van angststoornissen, is daar weinig aandacht voor binnen bestaande behandelingen. Daarnaast is er ook weinig oog voor negatieve beelden die mensen zich van de toekomst kunnen vormen. Zowel binnen de hedendaagse leertheorie als in de klinische praktijk zou er meer aandacht moeten zijn voor negatieve mentale beelden die mensen met angststoornissen ervaren. De gepresenteerde lab-studies gaven geen aanwijzingen dat terugkeer van angst verminderd kan worden met interventies gericht op het veranderen van mentale beelden. Er waren echter ook methodologische beperkingen die het lastig maken om deze bevindingen te interpreteren. Vervolgstudies met meer ecologisch valide paradigma's zouden hier uitspraken over kunnen doen. De studies gepresenteerd in het tweede deel van dit proefschrift tonen aan dat *imagery rescripting* toegepast op nare herinneringen en rampscenario's voor de toekomst het makkelijker kunnen maken om beangstigende situaties aan te gaan. De studies lieten zien dat participanten na de interventie een hogere bereidheid hadden om de sociale situatie aan te gaan. Er waren echter geen verschillen tussen groepen in het daadwerkelijk aangaan van sociale situaties. Replicatiestudies in klinische doelgroepen die minder bereid zijn om exposure aan te gaan dan de huidige participanten met lagere angstniveaus, moeten meer duidelijkheid bieden of patiënten uiteindelijk ook vaker gevreesde situaties aangaan na dergelijke interventies.

Een andere interessante bevinding van het onderzoek is dat *imagery rescripting* voorafgaand aan exposure mogelijk de effecten van exposure versterkt. De heersende theorie over de werking van exposure neemt echter aan dat exposure effectief is wanneer de subjectieve negatieve verwachtingen zo goed mogelijk ontkracht worden tijdens exposure. Kortom, interventies voorafgaand aan exposure die deze subjectieve negatieve verwachting al ontkrachten, zouden de effectiviteit van exposure moeten verminderen. In hoofdstuk 7 werd daar echter geen bewijs voor gevonden, maar werd juist het tegendeel aangetoond. Een mogelijke verklaring hiervoor is dat mensen makkelijker hun aandacht naar buiten zouden kunnen richten wanneer zij minder belemmerd worden door negatieve beelden. Zo zouden zij beter registreren wat er daadwerkelijk gebeurt in de sociale situatie en zou op die manier hun negatieve verwachting nog verder ontkracht kunnen worden. Vervolgonderzoek zou moeten uitwijzen of een zo groot mogelijk contrast tussen de negatieve verwachting en de daadwerkelijke uitkomst essentieel is voor de effectiviteit van exposure therapie. Wanneer dat niet het geval blijkt te zijn, kunnen interventies gericht op mentale beelden voorafgaand aan exposure toegepast worden om het zo makkelijker te maken voor patiënten om exposure oefeningen te doen en hopelijk uitval tijdens behandeling te verminderen.

Een verdere aanbeveling voor onderzoek is om de actieve componenten van interventies gericht op mentale beelden te onderzoeken om deze verder te verbeteren. In het tweede deel van het onderzoek is bijvoorbeeld niet gecontroleerd voor de specificiteit van de interventie gericht op toekomstige rampscenario's. Wellicht waren de interventies niet zozeer effectief omdat mensen zich iets positiefs inbeeldden, maar puur omdat ze zich een specifieker toekomstbeeld vormden tijdens de interventie. Eerder onderzoek toonde aan dat het toevoegen van details aan een toekomstbeeld kan leiden tot minder angst, een lagere subjectieve verwachting van negatieve uitkomsten en een sterker gevoel dat iemand zou kunnen omgaan met tegenslag. Mogelijk is zowel de positieve valentie als het verhogen van het aantal details van belang voor een effectieve interventie, maar dat moet toekomstig onderzoek uitwijzen.

Conclusie

Angststoornissen kunnen een grote impact hebben op de kwaliteit van leven. Huidige behandelingen voor angststoornissen zijn effectief, maar helaas niet voor een aanzienlijk aantal patiënten. In dit proefschrift werd onderzocht of huidige behandelingen verbeterd kunnen worden door in te grijpen in negatieve mentale beelden gerelateerd aan nare herinneringen en negatieve rampscenario's voor de toekomst. Het veranderen van negatieve mentale beelden lijkt het makkelijker te maken om beangstigende situaties aan te gaan en verhoogt mogelijk de effectiviteit van exposure. Alhoewel vervolgonderzoek nodig is om de resultaten te repliceren in klinische doelgroepen en langetermijneffecten te onderzoeken, toont het onderzoek aan dat interventies gericht op negatieve mentale beelden huidige behandelingen voor angststoornissen zouden kunnen verbeteren.

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About the author

Elze Landkroon was born on December 14th 1991 in Haarlem, the Netherlands. She completed her bachelor's degree in Clinical Psychology at the University of Amsterdam (2010-2014). Afterward, she started the Research Master in Psychology at the same university with a major in clinical psychology and a minor in psychological methods, which she combined with courses and a clinical internship from the clinical psychology master. She conducted her master's thesis abroad under supervision of prof dr. Merel Kindt, dr. Ella James and prof. dr. Emily Holmes at the Medical Research Council Cognition and Brain Sciences Unit in Cambridge, United Kingdom. She obtained her master's degree (cum laude) in 2016 and started her PhD with prof. dr. Iris Engelhard, dr. Elske Salemink and dr. Katharina Meyerbröker at Utrecht University, the Netherlands. During this time, she also worked as a psychologist at Altrecht Academic Anxiety Centre for one year and completed basic training as a cognitive behavioral therapist. She also collaborated with prof. dr. Jonathan Huppert, dr. Eyal Kalanthroff, and Snir Barzilay at the Hebrew University of Jerusalem in Israel. She visited Jerusalem twice during this period as part of this collaboration. Additionally, she was a member of the conference committee of the European Society for Traumatic Stress Studies (2019) and the accreditation committee of the Dutch association for Psychotrauma (NtVP) for one year. In the summer of 2021, she started as a psychologist at Arkin BasisGGZ and as an assistant professor at Tilburg University, the Netherlands.

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