

The Relation Among Thought Suppression, Forgetting, and Mental Health

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Declaration

This thesis is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Preface and specified in the text. I further state that no substantial part of my thesis has already been submitted, or, is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text. It does not exceed the word limit of 60,000 words (excluding the bibliography, tables/figures, and appendices) as prescribed by the Degree Committee for the Faculties of the Schools of Clinical Medicine and Veterinary Medicine.

Abstract

Title: *The Relation Among Thought Suppression, Forgetting, and Mental Health*

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Things are known by their opposites. If we want to dive deeper into how we remember, we must not forget about forgetting. Even after more than a decade of research on forgetting having an adaptive and active function in our lives beyond a passive role as a failed attempt to remember, it is still not widely studied in its own right. Not only can forgetting be an adaptive gateway for learning new things and regulating our emotions, but also be a critical opening for dealing with the traumas that haunt us, the worries that consume us, or the thoughts that just never seem to stop. Our ability to forget should not only be studied as a *reaction* – a failure to remember, a symptom in patients, or a response to unprocessed trauma. Rather, forgetting can and has been increasingly studied through its *acts*. At its core, this thesis is intended to put forth an appeal to urge and inspire research efforts to move beyond seeing the water in the half-full glass only after half of it is gone, but to take hold of the glass and drink from it! For instance, we passively experience decay through observing the changing colours of leaves in nature; however, this does not preclude our knowledge of a very active force behind the cycle of decay, indeed for the purposes of nothing other than renewal. Similarly, forgetting can feel passive experientially, but there could be very active forces that bring about this seeming decay, perhaps to bring out the light that shines on life. In this way, this thesis will examine one aspect of this mighty force – motivated forgetting – our capacity to actively block out distressful thoughts and render them less memorable or intrusive. Just as discipline is the root of building virtuous character, controlling our thoughts is perhaps the beginning of disciplining our minds in this arduous walk of life. Active forgetting can be a tool, which in times of difficulty can allow us to get up and step back into walking in life, rather than letting life walk all over us.

Indeed, when the COVID-19 pandemic happened, it felt like life was getting out of control, and anxiety started to walk over everyone, especially the most vulnerable of us. Although decades of research have “hinted” and “suggested” that suppression “may” promote resilience in facing difficulties of life,

we were all too afraid to truly affirm this with conviction because of an even longer line of work going back to Freud that engraved suppressing of thoughts as fundamentally maladaptive into the public mind. Thus, the pandemic actually presented an opportunity to put these competing theories to test and for the first time *causally* investigate the impact of suppression training on mental health. This research study forms the heart of this thesis and will be discussed in detail in Chapter 3. Of course, our conviction in the beneficial impact of suppression would not have been as strongly present if not supported by existing research as well as personal experiences of everyday people using suppression to overcome life's challenges. With this in mind, Chapter 1 will highlight existing research that gave us the extra confidence to grab hold of that glass of water, so to say. It will also walk us through how the pandemic specially brewed so much anxiety amongst the population that in a way made everyone parched for some sort of relief. However, we must also recognize that research into motivated forgetting has been around for some time now, the resistance of its applicability is stickier than one may think. Hence, Chapter 2 is dedicated to a detailed discussion of the theories and experiments that have been proposed to showcase an ironic heightening of memory for the supposedly suppressed information, and will offer alternative explanations for why such efforts may be misdirected. Then, we will swiftly move into the suppression training study in Chapter 3 and conclude with some heart-warming reflections from many people who learned to suppress their fears and intuitively integrated the technique into their own lives in the midst of the pandemic. It seems that we have not only found water, but sweet fragrant rosewater! Having tasted its sweetness, we wanted everyone to enjoy it, moving us into Chapter 4 where we present our translation of the suppression training from a remote testing procedure into an accessible app, hoping for a future where we all taste the sweetness of relief from intrusive thoughts. This then prompts us to think: how can we find more people who know what this drink tastes like? Such a question shall lead us into Chapter 5 in which we provide a novel tool for investigating the phenomenon of selective forgetting and its relevant phenomena such as distinct suppression strategies and prevalence of recovered memories. With that, we conclude this writing, having equipped wayfarers with signposts to find out more about the quality of this precious glass of rosewater that we seem to all possess but many do not yet know how to find or drink from.

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Lastly, thank you to whoever is reading this work. Please excuse its numerous deficiencies. Like the unpredictability of the landing for an arrow unleashed from its bow, I can only intend good for this undertaking to contribute to beneficial knowledge, and submit to its unfolding, be it as a benefit to a self or the world, however much or little, in whatever shape or form.

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Abbreviations

ACC	anterior cingulate cortex
aINI-T	app-based INI training
AM	autobiographical memory
ANOVA	analysis of variance
ATapp	Attention Training app
BBTS	Brief Betrayal Trauma Survey
BDI-II	Beck Depression Inventory II
CD-RISC-10	Connor-Davidson Resilience Scale 10-Item
CFI	Cognitive Flexibility Inventory
CBT	Cognitive Behavioural Therapy
COVID-19	Coronavirus disease 2019
DASS	Depression, Anxiety and Stress Scale
DF	directed forgetting
DLPFC	dorsolateral prefrontal cortex
DMN	default mode network
DS	direct suppression
EEG	electroencephalogram
EFA	Exploratory Factor Analysis
EFT	Episodic Future Thinking
FPN	frontoparietal network
GABA	gamma aminobutyric acid
GAD	General Anxiety Disorder
GNG	Go/No-Go
HAI	Health Anxiety Inventory
HSAM	Highly Superior Autobiographical Memory
IES-R	Impact of Events Scale-Revised
IIF	imagination-induced facilitation
INI	Imagine/No-Imagine
INI-T	Imagine/No-Imagine Training

IPT	Ironic Processing Theory
ISI	interstimulus interval
IUS	Intolerance of Uncertainty Scale
LGCM	latent growth-curve modelling
MHapps	mental health apps
mHealth	mobile health
MIL	Meaning in Life Questionnaire
Mini-SAM	Mini version of Survey of Autobiographical Memory
MRC CBU	Medical Research Council, Cognition and Brain Sciences Unit
OCD	Obsessive-Compulsive Disorder
PCL-C	PTSD Checklist - Civilian version
POMP	percent of maximum possible
PTSD	Post-traumatic stress disorder
PTSS	Post-Traumatic Stress Symptoms
RIF	retrieval-induced forgetting
SDAM	Severely Deficient Autobiographical Memory
SIF	suppression-induced forgetting
STAI	State-Trait Anxiety Inventory Form Y-1
TCAQ	Thought Control Ability Questionnaire
TNT	Think/No-Think
TS	thought substitution
TSI-R	Thought Suppression Inventory - revised
UPPS-P	Urgency, Premeditation, Perseverance, Sensation Seeking, and Positive Urgency Impulsive Behaviour Scale
UX	user experience
vINI-T	videoconferencing-based INI training
vmPFC	ventromedial prefrontal cortex
WBSI	White Bear Suppression Inventory
WEMWBS	Warwick-Edinburgh Mental Well-being Scale
WHO	World Health Organization

Forgetting in Our Times

1.1. Motivated Forgetting & Its Virtues

Introduction to Motivated Forgetting

Your heart throbs in pain. You feel a rush of intense mix of frustration and sadness as images of your ex-partner pass in your mind's eye. You then shake your head. You need to get them out of your mind! You frantically go around the house and go through your phone, removing any remaining reminders of them.

Such is a scenario of heartbreak that many people are all too familiar with. It is a clear illustration of how people can be very motivated to forget memories from their past. When an unpleasant thought, often a memory from the past, surfaces to mind, we tend to try our best to get it out of our mind. Aware of such tendencies, a body of research has focused on investigating the causes, mechanisms, and effects of motivated forgetting. In everyday life, motivated forgetting may occur actively/intentionally or passively/unintentionally. Although an important and fascinating field of study in its own right, passive forgetting will not be the focus of this thesis. Instead, moving forward, we will focus exclusively on the active forgetting branch of motivated forgetting and its various virtues, with occasional mention of passive forgetting when appropriate.

Active forgetting itself can be organised into inhibition of different aspects of memory. Recently, a three-factor model of active forgetting has been proposed whereby active forgetting may be achieved through 1) inhibition of the distracting prepotent memory representations (i.e., memory inhibition) by selectively retrieving a weaker competing memory (i.e., retrieval-induced forgetting, RIF) or by stopping the automatic retrieval of a target memory when triggered by a strong reminder (i.e., suppression-induced forgetting, SIF), 2) global disruption of the processing of the target memory (i.e.,

process inhibition), or 3) purging of the mental context (i.e., context inhibition) (M. C. Anderson & Hulbert, 2021). More specifically, memory inhibition can either be achieved through selective retrieval (i.e. retrieving a particular memory given a cue associated with multiple competing memory traces) or retrieval stopping (i.e. suppressing recall of a memory when a reminder begins to elicit automatic retrieval). Process inhibition disrupts a memory process (e.g. episodic encoding, consolidation, or retrieval processes) needed for remembering that memory, which can have a systemic impact. Context inhibition makes a memory inaccessible by inhibiting the mental context necessary for its retrieval through replacement of its context with new experiences.

To illustrate, in the above-mentioned heartbreak example, we might try to reduce the pains of heartbreak by one or a combination of the following: trying to remember other memories of activities that did not include our ex-partner during the time of our relationship together (selective retrieval via memory inhibition), or actively blocking out any memory of our ex-partner whenever such an image or thought intrudes our mind (retrieval stopping via memory inhibition), or proactively removing all reminders of our ex-partner in our environment to prevent triggers for recollecting a memory (process inhibition), or actively creating new experiences in the places we used to go with our ex-partner and the activities we used to do together with completely new people (context inhibition). Indeed, these efforts may not immediately cause us to forget those memories completely, but it will most likely help us manage various emotional outbursts that may bubble up in the aftermaths of a bad breakup, and render the memories of our ex-partner less accessible through the images of those memories becoming less vivid and their emotional impacts less salient over time, eventually allowing us to enter a state of balance in which we are no longer emotionally triggered with such memories if they happen to arise in the future.

Emotional homeostasis is a strong motivating factor for active forgetting. Research has shown that active forgetting can be emotionally beneficial by reducing access to unpleasant memories (M. C. Anderson & Hanslmayr, 2014; Engen & Anderson, 2018). Beyond affect reduction (Gagnepain et al., 2017; Harrington et al., 2020; Legrand et al., 2018), benefits of active forgetting have been demonstrated to include conflict reduction, which was initially introduced by Anderson & Hulbert (2021) to capture

previous observations of “a beneficial reduction in response conflict and cognitive control costs resulting from actively forgetting overly accessible and disruptive memories” (p. 8) (see also Bekinschtein et al., 2018; Benoit et al., 2015; Ferreira et al., 2014; Gagnepain et al., 2017; Hanslmayr et al., 2010; Harrington et al., 2020; Hellerstedt et al., 2016; Johansson & Johansson, 2020; Kuhl et al., 2007; Legrand et al., 2018; Levy & Anderson, 2012; Mary et al., 2020; Staudigl et al., 2010; van Schie & Anderson, 2017; Wimber et al., 2011, 2015). Additional benefits include reduced perceptual distraction (Gagnepain et al., 2014; P. T. Hertel et al., 2018; K. Kim & Yi, 2013; Mary et al., 2020), as well as facilitation of learning (Pastötter et al., 2012, 2018). Such an ability can then override habitual and potentially compulsive responses to facilitate goal-directed control over behaviours. In this way, it is widely proposed that thoughts or images of memories can then be forgotten as a result of inhibitory control acting on the representations of those memories to facilitate the underlying goal which is often restoration or maintenance of emotional homeostasis.

Motivated Forgetting as Capacity for Emotional Regulation

Forgetting is often understood as an *inability* to remember something that was once recallable. However, at least in the realm of emotions, forgetting can perhaps be understood not as an inability but rather a *capacity* to discard memories to unburden our mind. Although most often discussed in terms of forgetting unwanted negative memories (M. C. Anderson & Hanslmayr, 2014; Engen & Anderson, 2018; Nørby, 2018), forgetting of positive but distracting thoughts can also occur if the goal at the present moment is to complete a task rather than engage in reminiscence. In this way, motivated forgetting can be seen as a goal-driven capacity to recruit mechanisms to control present or future expression of a thought if it is needed by the individual (M. C. Anderson & Hanslmayr, 2014; Conway, 2005; English et al., 2017) or meets environmental demands (Hirst & Yamashiro, 2017; Nairne & Pandeirada, 2008; Schooler & Hertwig, 2005). In this way, forgetting has been proposed as a graded phenomenon in relation to the content, context, and temporality of a memory (Nørby, 2020). Given that memory retrieval is a constructive process (Conway & Loveday, 2015; Loftus & Loftus, 1980;

Yonelinas et al., 2019), it has been proposed that a decoupling occurs such that emotions are forgotten while declarative knowledge is retained (Nørby, 2020). This is commonly observed with resilient survivors of trauma such that the emotional trigger is no longer present when recalling the trauma. In addition, theories such as the context change theory (Sahakyan & Kelley, 2002) emphasise the mechanism by which a target memory is forgotten due to intentional or unintentional removal of oneself from contextual cues that sustain support of remembering a particular experience. Furthermore, forgetting may occur due to interference from events with similar contexts happening before or after the acquisition of an experience (McGeoch, 1932; Tomlinson et al., 2009; Underwood, 1957; Yonelinas et al., 2019). This interference effect may be revoked due to passing of time as time often allows for a wider range of stimulus variability such that a cue may re-trigger the once-forgotten memory (R. Bjork & Bjork, 1992; Estes, 1955). Similarly, memories that were once forgotten through employing active forgetting mechanisms may also resurface if that inhibitory control is let go, either through passing of time or through a compromised system. Indeed, one can see the parallel between the graded theory of forgetting with the above-mentioned three-factor model of active forgetting. Thus, similarly, the graded nature of forgetting can be illustrated by the previous example of a bad breakup: one might counter upsetting memories of the ex-partner by trying to 1) forget select moments that are particularly emotionally salient, 2) move to a new city and start a new life, and 3) allow time to pass. However, the capacity to do so effectively rests on factors that manifest itself as individual differences in people's ability to forget.

A severely compromised capacity to control one's thoughts seems to affect both remembering (i.e. unable to selectively recall a positive experience) and forgetting (i.e. unable to selectively forget a negative experience) processes, both of which can cause psychological distress. Individual differences in the capacity to forget unwanted, emotional, and intrusive thoughts can be driven by the strength of an individual's cognitive control ability. A few factors have been repeatedly studied and discussed in the motivated forgetting literature as core contributors to individual differences, namely, metacognitive beliefs, cortisol reactivity, genetics, ageing, and one's goal state. As will be discussed in later chapters, the

most directly relevant factors to our experiments are metacognitive beliefs, genetics, and goal state; therefore, those factors will be briefly mentioned below.

Individual differences in metacognitive beliefs (Wells, 2011, 2013) can be influential in motivated forgetting capacity such that negative beliefs about one's ability to control may inadvertently weaken cognitive control. According to the self-regulatory executive function model, a negative metacognition (negative thoughts and beliefs about oneself or the world) may diminish attentional control (Villalobos et al., 2021). This loss of control may then result in repetitive negative thoughts or inability to retrieve a wanted memory, both of which are manifestations of a compromised capacity to forget. In addition, one's orientation towards time is related to the extent to which they exhibit the fading affect bias (Kensinger & Ford, 2020). The fading affect bias is the phenomenon that negative emotions tend to fade faster than positive emotions (Walker et al., 1997). An individual who is past-oriented is less likely to exhibit the fading affect bias when compared to those with either present- or future-oriented outlook in life (D. Wheeler et al., 2009). In other words, those who tend to focus on the past to construct meaning about their lives and the world are more prone to holding onto negative emotions, which could be a result of a weakened emotion regulation due to metacognitively induced weakening of cognitive control.

Individual differences in genetics seem to also play an important role such that the highly heritable traits of cognition and affect converge in superior frontal cortical thickness (Kraljević et al., 2021). Importantly, the superior frontal gyrus, the region of convergence for association between affect and cognition as found by Kraljević and colleagues, includes the dorsolateral prefrontal cortex (DLPFC). The DLPFC has previously been established as the hub for higher cognitive functions such as cognitive control (Boisgueheneuc et al., 2006; Corbetta & Shulman, 2002) and motivated emotional regulation (Engen & Anderson, 2018; Frank et al., 2014; Okon-Singer et al., 2015). In addition, the left superior frontal gyrus has been found to be important in self-awareness and introspection (I. I. Goldberg et al., 2006), which is relevant to both the role of metacognitive belief as mentioned above as well as its genetic implications in psychiatric disorders of self-awareness such as schizophrenia (P. H. Lee et al.,

2016). Specifically, there have been observations of neuroanatomical correlates in schizophrenics (Weng et al., 2022) and PTSD patients (L. Li et al., 2022), reflecting the neural network coupling between affective experience and cognitive abilities in the human brain (Barrett, 2017; Pessoa, 2008), which suggests a shared genetic basis between cognition and affect. In addition, research in genetics of forgetting in animal models points to the neurobiological underpinning of such network processes and the need for a deep understanding of memory suppressor molecules and their processes (Noyes & Davis, 2022).

Perhaps the most dynamic of individual differences lies in the goal state, such that just as goal state at the time of recalling something affects how prominently its emotional aspects are incorporated into a memory (Holland et al., 2010; Kensinger & Ford, 2020), the degree to which an individual can effectively set and commit to a goal at the time of motivated forgetting can influence its impact. One way to consider how goal state may drive differences in people's capacity of motivated forgetting is to look at the memory function. The functions of memory are typically summarised broadly into three categories: maintenance of self-image, direction of present and future behaviour, and facilitation of social bonding (Bluck & Alea, 2002). Any one or combination of these functions of memory can underlie an individual's goal state at any given moment in time. In this way, alterations in any one of these functions can also influence one's goals which can improve or worsen one's motivated forgetting capacity of memories related to a particular goal. For instance, two immigrants with similar background experiences may display different capacities for forgetting their past: while one may desperately want to integrate into the new society and thus readily avoid and forget memories that are incoherent with their new identity (i.e. highly motivated to forget the past), the other may intend to return to their home country as soon as possible and experience intrusive homesickness and avoid mingling with the local population (i.e. unmotivated to forget the past and may even experience rumination).

Any combination of the above factors may be at play at any given moment to influence an individual's capacity to actively forget unwanted, emotional, and intrusive thoughts. Therefore, a treatment that aims to restore motivated forgetting capacity for various psychological disorders that

seemingly manifest deficiency must be able to have an impact above and beyond these stable and dynamic factors of individual differences in the clinical population.

Mechanisms of Active Forgetting

The focus of this thesis is on memory inhibition (as opposed to process inhibition or context inhibition), and specifically inhibition through retrieval stopping (as opposed to selective inhibition). At first glance, retrieval stopping may seem passive as it is inherently a reaction to an unwanted reminder. However, it is not the need to react, but the act that follows which determines the intentionality of activity and the level of effort involved. To illustrate, let's return to the example of the breakup: a song playing in a restaurant may trigger a memory of the ex-partner, and now all of a sudden, we feel our heart beating faster and we could feel ourselves getting distracted from the conversation we are presently having with our friend. Here, we can choose to: 1) let our thoughts go back to that moment and reminisce in those memories and be completely distracted in our thoughts and feelings, 2) ignore our thoughts and just try to focus on what our friend is saying at the moment while still feeling the tension triggered by the memory, or 3) take a moment to actively block that image of the past by clearing our mind and letting go of our sensations and then return to the conversation we were having. The first strategy would be an example of a passive reaction. Out of the latter two active reactions, the last one is clearly more effective in maintaining emotional stability; however, it is also more effortful and requires awareness of such an ability followed by intentional repeated practice to learn how to do it effectively.

Neuroscience research in motivated forgetting has provided evidence of forgetting arising from retrieval suppression mechanisms mediated by the prefrontal cortex, which adapts our memory to align with our cognitive and emotional goals (for a review, see Anderson & Hulbert, 2021). Cortical patterns indicating processes involved in active forgetting have been revealed through methods such as multivariate functional magnetic resonance imaging (fMRI) and electroencephalogram (EEG). The prefrontal control hypothesis sees the right DLPFC (rDLPFC) as a source that initiates a top-down inhibitory control signal over inhibition sites (e.g. hippocampus) which are regions that support the to-

be-controlled representations or processes. As formally proposed by Anderson and Hulbert (2021), this hypothesis was inspired by much research pointing to the concept of inhibitory control as a putative domain-general control mechanism (M. C. Anderson et al., 2016; Aron et al., 2004, 2014; Banich & Depue, 2015; Bari & Robbins, 2013; Boucher et al., 2007; Diamond, 2013; Eysenck et al., 2007; Joormann & Tanovic, 2015; Lipszyc & Schachar, 2010; Logan et al., 1984). Recently, evidence emerged which showed stopping actions and thoughts as recruiting common regions in the right dorsolateral and ventrolateral prefrontal cortex to suppress task-specific content, via dynamic targeting of the motor cortex or the hippocampus (Apšvalka et al., 2022; Depue et al., 2015; Schmidt et al., 2023). Furthermore, simultaneous EEG-fMRI recordings tracking interactions among dorsal anterior cingulate cortex (dACC), rDLPFC, and hippocampus during suppression suggest a model in which dACC acts as a detector to signal the need to suppress by triggering top-down inhibitory control (Crespo-García et al., 2022). In addition, animal models of active forgetting have also been demonstrated to establish causal necessity of the prefrontal cortex (M. C. Anderson et al., 2016; Bekinschtein et al., 2018; Eichenbaum, 2017; F. T. Gallo et al., 2022). Further neurobiological research has also advanced our understanding of the nature of neural inhibition in the hippocampus as being vital to successful forgetting via inhibitory control mechanisms. For example, it has been demonstrated that how effectively the prefrontal cortex initiates hippocampal downregulation can be dictated by inhibitory gamma aminobutyric acid (GABA) neurotransmitters local to the hippocampus (Castillo Díaz et al., 2021; Schmitz et al., 2017; for a discussion in animal models, see Noyes & Davis, 2022). Moreover, by integrating human and animal research on extinction and retrieval stopping, novel hypotheses have been proposed to argue that retrieval suppression recruits extinction circuitry to achieve emotional regulation, potentially shedding light on how humans may cope with intrusive thoughts (M. C. Anderson & Floresco, 2022). In a way, the essential thorn of intrusive thoughts for the person experiencing them is the seeming inability to get rid of them at will, in other words, to just forget about them.

As can be seen, there could be several ways to actively suppress retrieval and cause SIF of a memory trace. In other words, SIF effects (M. C. Anderson & Huddleston, 2012; P. Hertel & McDaniel, 2010) act as an indicator for someone being able to successfully suppress a specific thought,

be it in the past as in memories, or in the future as in fears. There are two main strategies of suppression that have been widely studied to show SIF effects: thought substitution (TS) and direct suppression (DS). Thought substitution is when we retrieve an alternative thought, image, or idea to substitute an unwanted thought and thus suppress further unfolding of the intruding thought (Benoit & Anderson, 2012; Bergström et al., 2009; P. T. Hertel & Calcaterra, 2005). Direct suppression, on the other hand, is to stop the retrieval of anything altogether by focusing our attention to block out any thought instead of diverting it to another thought, image, or idea (Benoit & Anderson, 2012; Bergström et al., 2009; Gagnepain et al., 2014). For instance, in the example above, TS demonstrates how we can avoid retrieval of the memory trace by replacing the thought of the ex-partner with another thought (i.e. what our friend is saying). DS requires us to acknowledge the intruding thought of the ex-partner surfacing to our mind and then immediately actively try to block it from occupying our thoughts by restoring a blank mind to be able to focus back to the present moment.

In the laboratory, the effects of these two mechanisms can be tested by giving explicit instructions for the suppression task. In terms of their application, both retrieval stopping strategies have been shown to cause forgetting of the suppressed material (Benoit & Anderson, 2012; Bergström et al., 2009; P. T. Hertel & Calcaterra, 2005), and capacity to reduce distress from aversive memories (Nishiyama & Saito, 2022). However, results from several studies have showcased dissociations between DS and TS on an electrophysiological (Bergström et al., 2009), hemodynamical (Benoit & Anderson, 2012), behavioural (Hulbert et al., 2016; Y. Wang et al., 2015), and mechanistic (L. C. Marsh & Anderson, 2022) levels (see Supplementary Materials section of Anderson & Hulbert, 2021 for a summary of their dissociations). In addition, while a body of literature seems to show evidence for comparable rates of forgetting of laboratory-devised items (Sahakyan & Delaney, 2003; Sahakyan & Kelley, 2002), recent evidence suggests that DS may be more effective for successful suppression and the subsequent forgetting of individual items relative to TS (Hubbard & Sahakyan, 2021). In this way, both strategies are examples of inhibiting intrusive thoughts during retrieval stopping, but they may undergo different mechanisms for achieving the SIF effect.

Importantly, direct suppression seems to reflect a more robust top-down inhibitory control mechanism. For instance, while stopping actions and thoughts share a domain-general inhibitory control effect by recruiting common regions in the PFC to suppress diverse content (Apšvalka et al., 2022), such regions have been shown to only be engaged during tasks explicitly recruiting mechanisms of direct suppression, not thought substitution (Hubbard & Sahakyan, 2023). However, SIF has recently been demonstrated to vary with the exact suppression mechanism employed, such that for healthy individuals, the effect sizes were considerably larger with specified instructions for either mechanism than when they were unspecific (Stramaccia et al., 2021). A meta-analysis found that for SIF in studies with healthy participants, those with direct retrieval suppression instructions have a slightly larger effect size (ES=0.66, 95% CI [0.42, 0.90]) than those of thought suppression (ES=0.59, 95% CI [0.40, 0.77]), although this slight advantage for the direct suppression strategy was not statistically significant (Stramaccia et al., 2021). It is important to note, however, compared to the number of studies explicitly using direct suppression instructions, the number is relatively fewer for thought substitution.

Hence, if direct suppression can induce forgetting as observed by the SIF effect, by studying the patterns of inhibitory control unfolding in active forgetting procedures, we can venture into identifying how the neural circuitry responds when eliciting direct suppression in people struggling with emotional regulation when experiencing intrusive thoughts, and eventually work towards restoring function. Therefore, direct suppression presents itself as potentially a promising paradigm for tapping into alleviating the debilitating effects of intrusive thoughts, manifesting often as rumination, perseverative worry, or obsessive thoughts.

Testing Active Forgetting Via the Think/No-Think Procedure

The intentional forgetting of the suppressed thought, as indicated by the SIF effect, is most often investigated in the laboratory using either variations of the think/no-think (TNT) procedure (M. C. Anderson & Green, 2001), or the list-method directed forgetting (DF) procedure (R. A. Bjork et al., 1968). The two methods differ such that the TNT procedure focuses on suppression of specific details

in memory (rather than whole lists) at the step of memory retrieval (rather than encoding). Therefore, for a closer adaptation to real-world circumstances, the TNT procedure is often preferred as a method of studying suppression. The original version of the TNT procedure broadly included three phases: learning, TNT, and testing.

The learning phase required healthy participants to learn pairs of words (e.g. Ordeal – Roach), such that when shown the Cue Word (Ordeal), they should be able to retrieve the target Response Word (Roach). During the TNT phase, participants are then shown a subset of the Cue Words with instructions to do two different tasks depending on the associated information that accompanies (or precedes) the displayed cue in each trial (e.g. colour or sound). For instance, some cues may be displayed in green, for which the participants would need to covertly rehearse the associated target word (i.e. Think items); on the other hand, for red cues, participants need to prevent the associated target word from coming to mind (i.e. No-Think items). More specifically, if they were given explicit instruction for direct suppression (as opposed to thought substitution), they would need to stop any thought or image from coming into their mind during the trial. In order to robustly practise the effortful process of suppression, each cue will be presented several times. Some of the cues that were not displayed during this phase would serve as Baseline items to assess baseline memory performance during the testing phase. During the testing phase, participants will once again be shown each of the Cue Words (e.g. Ordeal), and need to recall its corresponding Response Word (e.g. Roach). The testing phase is used to typically measure the percentage of correctly recalled targets of suppressed cues relative to that of the non-suppressed baseline items (% accuracy of Baseline – No-Think items). Thus, this below-baseline memory accuracy is used as an index of the SIF effect. Since its inception, beyond the typical differences in timing of tasks and additions of quality checks when adapting procedures, different variations of the TNT procedure have been developed, especially around the use of different stimuli.

In an effort to delineate and diversify the application of this paradigm to study motivated forgetting, the TNT procedure has been modified in its stimuli type and the content of the presented material. The material of stimuli that participants had to suppress has most often been word pairs, as

was the original TNT study; however, since then, pictorial material has also been used. Studies with DS instruction have used pictures (often with negative valence) as stimuli in healthy, subclinical, and clinical populations (Catarino et al., 2015; Küpper et al., 2014; Marzi et al., 2014; Nishiyama & Saito, 2022; Waldhauser et al., 2018; D. Zhang et al., 2016). Some studies have combined words and pictorial material as stimuli by pairing word cues with picture targets (for an example, see Wimber et al., 2015). In other words, TNT studies investigating retrieval stopping have examined word pairs, face-scene pairs, word-scene pairs, word-face, and word-object pairings (for reviews, see Anderson & Hanslmayr, 2014; Anderson & Hulbert, 2021; Marsh & Anderson, 2022).

In the attempts to understand the interplay between suppression and one's mental well-being, studies have also differed the valence of the to-be-suppressed material. Besides the typical negative stimuli which many pictorial stimuli use, there have been some studies with positive stimuli (Joormann et al., 2005; Marzi et al., 2014), neutral stimuli (P. T. Hertel & Gerstle, 2003; K. Kim et al., 2007; Nemeth et al., 2014; Ryckman, 2015; Sacchet et al., 2017; Salamé & Danion, 2007; I. Wessel et al., 2020), and mixed stimuli (Noreen et al., 2020; Noreen & Ridout, 2016; Stephens et al., 2013). Another important variation has been the content of the material. Most studies use materials developed in the laboratory and thus are carefully controlled for its characteristics across conditions. The theoretical view that memory suppression is motivated for emotional regulation inspires studies involving autobiographical memories which people would be much more motivated to suppress relative to laboratory-derived material. To date, there has only been a handful of published studies that used the TNT procedure with autobiographical memories as stimuli (F. Lu et al., 2023; Noreen et al., 2016; Noreen & Macleod, 2013; Satish et al., 2022; Stephens et al., 2013). Research investigating memory control in the real-world remains limited and the field will benefit much from innovative ways of exploring not just stimuli content, but move beyond memory to explore prospective thinking, which will be discussed in more detail later (see *1.2. Thinking about the Future*).

Motivated Forgetting in Clinical Populations

A key benefit of motivated forgetting as can be seen from its intimate connection with emotional regulation is its effect of reducing access to unpleasant memories (M. C. Anderson & Hanslmayr, 2014; Engen & Anderson, 2018) which can in turn reduce emotional distress upon later recalls as well as the degree of their intrusiveness. This emotional benefit has inspired researchers to investigate the effectiveness of laboratory-developed procedures of active forgetting in both subclinical and clinical populations. For instance, there have been large efforts of using working memory training as a method to transdiagnostically improve cognition and emotion regulation in healthy and clinical populations (e.g. General Anxiety Disorder - GAD, PTSD, eating disorders) (for a review, see Barkus, 2020). Significant outcomes from such training have shown gains in mood as well as decreases in use of maladaptive emotion regulation strategies and reduction in the frequency of intrusive thoughts. Similarly, a unified protocol for the transdiagnostic treatment of emotion disorders has been proposed and includes in its core modules cognitive flexibility, and has been showing encouraging results with improvement in anxiety and depressive symptoms (for a review, see Osma et al., 2021). Although occurring in parallel to the developments in the field of motivated forgetting, such results suggest a convergence of methods that target cognitive control to influence affective states, which aligns with theories supporting the shared mechanisms between motivated forgetting and emotion regulation as discussed in previous sections.

Indeed, procedures of both intentional forgetting and incidental forgetting have been tested within subclinical and clinical populations to investigate differential capacities of active forgetting in these populations (for a summary, see Table 1). As can be seen, although there are a few studies that have found no differences between clinical and healthy control samples, the majority of the findings suggest a clear impact of motivated forgetting capacity in clinical and subclinical populations (for a review, see Stramaccia et al., 2021). Together with studies suggesting emotional regulatory benefits of adaptive forgetting (for a summary, see Anderson & Hulbert, 2021; Visser et al., 2020), these results point to the need for future works investigating therapeutic interventions specifically targeting training of motivated

forgetting capacity in clinical and subclinical populations. Indeed, the following chapters will address the various projects in this thesis aimed precisely to contribute to this goal.

Table 1.

Motivated forgetting in clinical & subclinical populations.

	Intentional Forgetting						Incidental Forgetting		
	Directed Forgetting			Suppression-Induced Forgetting			Retrieval-Induced Forgetting		
	Diff?	Details	Sources	Diff?	Details	Sources	Diff?	Details	Sources
PTSD	Yes	Deficit in encoding non-trauma-related words	(Baumann et al., 2013; Cottencin et al., 2006; Mary et al., 2020; McNally, 1998)	Yes	Deficit to suppress emotional & neutral pictures	(Catarino et al., 2015; Mary et al., 2020; Sullivan et al., 2019; Waldhauser et al., 2018)	Yes		(Amir et al., 2009)
	No	No deficit in retrieval (i.e. similar forgetting rates as healthy controls)	(Baumann et al., 2013; Cottencin et al., 2006; DePrince & Freyd, 2004; McNally, 1998)	Yes	Positively correlated with symptom severity	(Catarino et al., 2015; Waldhauser et al., 2018)			
Depression	Yes	Deficit of DF effect in patients with severe diagnosis of MDD	(Power et al., 2000; Wingefeld et al., 2013)	Yes	Difference in suppression strategy use from fMRI	(Sacchet et al., 2017)	Yes	reduced RIF effect for MDD patients	(Groome & Sterkaj, 2010)
	Yes	Deficit of DF effect in subclinical sample	(Xie et al., 2018)	Yes	Deficit in subclinical sample; positively correlated with symptom severity	(Noreen et al., 2016, 2020)			
	No	No deficit in patients with moderate diagnosis of MDD	(Kuehl et al., 2017)	No		(Groome & Sterkaj, 2010)			
Schizophrenia	Yes	Deficit of DF effect for neutral & emotional words	(Alderson-Day et al., 2019; Müller et al., 2005; Patrick et al., 2015; Patrick & Christensen, 2013; Racsmány et al., 2008; Sahakyan et al., 2020)	N/A			No		(AhnAllen et al., 2007; Nestor et al., 2005; Racsmány et al., 2008; Soriano et al., 2009)
	No	No deficit for negative pictures	(Okruszek et al., 2019)						
OCD	Yes	Deficit only for disease-related stimuli	(Bohne et al., 2005; Tolin et al., 2002; Wilhelm et al., 1996)	N/A			Yes	Deficit in RIF for neutral words in patients with comorbidity with depressive symptoms	(Demeter et al., 2014)
	Yes	Deficit at encoding, but no deficit at retrieval	(Konishi et al., 2011; Moritz et al., 2012)				Yes	Deficit in RIF for salient OCD-relevant words	(Jelinek et al., 2012)

1.2. Thinking about the Future

Motivation to Investigate Future Thinking

Thinking about the future has been fruitfully developing as an area of scientific inquiry from its roots in early studies of discussing it in the context of the nature of the human mind (Suddendorf & Corballis, 1997; Tulving, 1985b) to its contemporary place of a proper subfield of scientific inquiry (Seligman et al., 2013). Its relevance to this thesis will become clearer in Chapter 3 when we discuss the application of motivated forgetting in the context of future thoughts. However, before diving straight into its application, it is important to review the layers of research that led to future thinking becoming relevant as an area of research primarily in understanding how we remember, and subsequently in more recent inquiries into forgetting.

Various terminology has emerged from the umbrella of investigating how we think about the future in order to fine tune the characteristics of this phenomenon: namely, prospection (Buckner & Carroll, 2007), episodic future thinking (Atance & O'Neill, 2001; Szpunar et al., 2014), episodic foresight (Martin-Ordas et al., 2012; Suddendorf, 2010), episodic simulation (D. L. Schacter & Addis, 2007), mental time travel (Klein, 2013; Suddendorf & Busby, 2005; M. A. Wheeler et al., 1997), and prospective memory (Brandimonte et al., 2014; Kliegel et al., 2007), with the first four used interchangeably and the latter two used more as specialised subcategories of future thinking. It is natural for multiple terms to emerge to refer to a shared underlying phenomenon given that researchers may choose to place emphasis on different aspects when defining an observation. Since the topic of this thesis revolves around motivated forgetting enacting in personally relevant future events in a specific time and place, and given the prevalence and the more specialised nature of the term in relevant existing research, we will adopt “episodic future thinking” (EFT) here to describe a person’s ability to mentally generate and imagine specific self-relevant events contextualised in one’s future. Although the emphasis of the discussions henceforth will be on EFT, we will also present relevant research on future thinking where appropriate even if the authors did not explicitly define the topic of their inquiry as EFT.

The motivation for research into EFT lies in its intuitive relevance to our daily life: predicting our behaviour, planning and, informing decision-making, facilitating problem-solving, achieving goals, and influencing psychological well-being (for reviews, see Du et al., 2022; Miloyan & McFarlane, 2019). Moreover, four subtypes of adaptive functioning (i.e., a learned set of conceptual, social, and practical skills used in everyday life; Schalock et al., 2010) have been identified and verified with predictive validity for EFT. They are decision making, goal processing, problem solving, and coping, all of which reflect recommendations often given by clinical neuropsychologists (Ward, 2016). As outlined by Ward (2016), there has been extensive research conducted on the relationship between adaptive functioning and EFT. This line of work is important because the potential of EFT as a predictor of adaptive functioning may lead to having better predictors of health which in turn can help clinicians and their patients and loved ones better plan for potential future health decline.

Moreover, whenever people are not engaged in the activities of the present moment, most of their time is spent thinking about the future, a phenomenon also known as mind-wandering (Baird et al., 2011; Baumeister et al., 2016; Killingsworth & Gilbert, 2010; Stawarczyk et al., 2013). Studies of EFT mostly involve tasks whereby participants are prompted with a question, cue word or a sentence that provides a specific context in order to generate a description of a future event. In this way, individuals with average to above-average capacity of EFT are able to “prelive” the future event, provide coherent contextual details (e.g., time and place, people present), and simulate sensory experiences and emotions that may come up during the said future event (Ward, 2016). Beyond the functional roles it plays in our daily life, episodic future thinking can also be a powerful adaptive tool in emotional regulation.

Episodic Future Thinking and Emotion Regulation

It is a widely shared experience that people can temporarily release emotional tension associated with an upcoming stressful event by simulating positive scenarios of how the event may hypothetically unfold. For instance, someone is more likely to start packing their things in order to prepare for moving

out in the midst of a very busy schedule if they are able to imagine the satisfaction they will feel once everything is over and the relaxing day-off they will have after the move. More specifically, emotional episodic future simulations can inform a host of cognitive processes such as memory, attitudes, emotional response, plausibility, prosociality, self-schema, and decision-making, each with potential adaptive and maladaptive consequences (for a review, see Wardell et al., 2022). Notably, adaptive consequences are not exclusively future simulations with positive affective content. Negative simulation can also result in prevention of detrimental outcomes, as is often experienced when assessing the cost and benefit of a potentially risky future endeavour. Perhaps more convincing than simulated representations of future events are our daily thoughts that come and go. Indeed, as many as 60% of future-oriented thoughts in daily life are characterised with affective content (D'Argembeau et al., 2011), pointing to our intuitive desire to have a pre-feeling of emotional responses to future scenarios (Boyer, 2008).

Importantly, there is a differential effect of valence in our future-oriented thoughts. Positive future thoughts tend to be more frequent, more specific, and manifest in one's mind more as visual images than negative future-oriented thoughts in both real-life (Barsics et al., 2016; D'Argembeau et al., 2011; de Vito et al., 2015; Finnbogadóttir & Berntsen, 2011) and simulated representations of future events (Acevedo-Molina et al., 2020; D'Argembeau & Van der Linden, 2004; de Vito et al., 2015; MacLeod & Byrne, 1996; Newby-Clark & Ross, 2003; Painter & Kring, 2015; Puig & Szpunar, 2017; A. S. Rasmussen & Berntsen, 2013). In addition, negative future simulations are more frequently manifested as inner speech while positive future simulations are more frequently accompanied with mental imagery (Barsics et al., 2016; for a review, see Wardell et al., 2022). The more specific and frequent characteristic of future-oriented thoughts with positive emotional content is consistent with existing research showing that most people tend to be optimistic and thus conceive a favourable future in a favourable light (Harris & Hahn, 2011; Sharot et al., 2007; Taylor & Brown, 1988; Weinstein, 1980). On the other hand, while there is evidence showing difference in the phenomenology and frequency between emotional and neutral simulations of future events (Acevedo-Molina et al., 2020; D'Argembeau et al., 2011), further investigations are needed to compare and understand how neutral

future events may be distinctly contextualised and imagined in the future (Wardell et al., 2022). Furthermore, the effect emotional simulations may have in the present moment, as observed in positive emotional simulations promoting one's motivation to engage in the simulated behaviour (Ji et al., 2021; Renner et al., 2019), can be the key in the differential profile of valence. This is especially relevant when designing an experiment to investigate the effect of valence in EFT, which indeed is one of the undertakings for the experiments that will be discussed in later chapters.

Given the interaction of valence with mental imagery in its manifestation in future-oriented thoughts, it is important to consider individual differences in imagery in characterising a person's EFT. For example, individuals with aphantasia seem to experience a reduction of emotional expression as indicated by a lowered physiological response when imagining emotional future scenarios (Blackwell, 2020; Wicken et al., 2021). On the other hand, like a double-edged sword, such individuals may be protected from some of the maladaptive effects of imagining future events with negative emotional content (Dawes et al., 2020).

The functional adaptive role of emotions in EFT can be further seen in the detrimental decisions made by people with an impaired ability to integrate affective information into future thoughts (Bechara & Damasio, 2005; Feinstein et al., 2011; Gupta et al., 2011). So, not only are such people deprived of being able to ease tensions by installing versions of the future with positive affect, but also have a compounded problem of often making decisions with negative consequences precisely because they cannot anticipate the negative emotions such an action can eventually bring about. In this way, if, as a result of a compromised EFT, someone projects a disproportionate negative emotion to an anticipatory otherwise not-so-catastrophic future episodic event, then they may at best become hesitant in working towards the otherwise neutral event or at worst become debilitated at the present moment out of perceived inability to emotionally regulate, and this can transform the future thought into a preservative worry. This catastrophizing of feelings when imagining the future, resulting in various emotional and psychological dysfunction, is indeed the target for applying active forgetting procedures in future thoughts.

This cautious tone is also conveyed in studies involving simulations of emotional episodic future events that are stressful or threatening, especially when the participants do not possess appropriate emotional regulation strategies. Indeed, future representations of worrisome events are intimately connected to pathological worry and thus serve as an essential component of threat-management and emergence of anxiety disorders (for a review, see Bulley et al., 2017). In addition, one can imagine how negative metacognitive beliefs such as low self-worth and justification of maladaptive behaviours can further encourage unhealthy behaviours in the present moment (Wardell et al., 2022). On the other hand, anticipation of strong positive emotions in simulated future events, as opposed to resolving of a present negative emotion or avoidance of a future negative worry, can also act as the key component that actively initiates a simulation of future in one's mind. In sum, all of these points to the centrality of emotions in potentially playing a role in both the causes and effects of EFT.

Episodic Future Thinking and Episodic Memory

Importantly, converging evidence from neuroscientific inquiry into the mechanisms of EFT and clinical studies involving neurological populations with deficits in future thinking suggests a core neural network of EFT. This core neural network includes the medial temporal lobe, the parahippocampus and hippocampus, the medial prefrontal cortex, the posterior cingulate cortex, the retrosplenial cortex, anterior and lateral temporal lobe, precuneus, and posterior parietal lobe (for a review, see Addis, Pan, et al., 2009). Closely resembling this is the default mode network (DMN), a select group of neural regions that experience increased activity during rest and decreased activity when engaged in a cognitively demanding behaviour (Raichle et al., 2001; Shulman et al., 1997), which includes the medial prefrontal cortex, the posterior cingulate cortex, retrosplenial cortex, inferior parietal lobe, lateral temporal cortex, and hippocampal formation (Buckner et al., 2008). In other words, the DMN underlies both episodic processes, whether temporally set in the past or the future. This overlap of EFT and memory is further supported by converging evidence from behavioural data in cognitive and neuropsychological research (for reviews, see D. Schacter et al., 2012; D. L. Schacter, 2012;

Ward, 2016). Furthermore, as one of the five main cognitive processes involved in EFT, (the rest being semantic memory, executive functioning, self-referential processing, and imagery), episodic memory is intimately linked to EFT (Ward, 2016).

Indeed, other cognitive functions besides episodic memory are also necessary for future thinking (for a review, see D. Schacter et al., 2012). This is especially important when considering how semantic memory is critically implicated in episodic simulation (D'Argembeau & Mathy, 2011; Irish et al., 2012a; Irish & Piguet, 2013; Wardell et al., 2022). In other words, since episodic details from the past have some relative degree of certainty to construct a future episode, the vagueness around the larger context of what will happen in the future would rely more on semantic memory. This can be observed in clinical cases such that patients with semantic dementia, despite possessing relatively intact episodic memory, display similar lack of internal details of imagined future episodes as patients with Alzheimer's Disease who are expected to have low internal detail (Irish et al., 2012a). In this way, it has been proposed that semantic information works hand-in-hand with episodic information in supporting future simulations of episodic scenarios, perhaps by providing a framework to store the to-be-used episodic content (MacLeod, 2016). Other differences between EFT and episodic memory include the observation that we think about the present in a much more detailed and concrete way than we do about the future (Addis et al., 2008; Anderson & Dewhurst, 2009; Berntsen & Bohn, 2010; D'Argembeau et al., 2010; Hill & Emery, 2013). In addition, neuroimaging studies also shed light on distinct qualities between thinking about the episodic events in the future and recalling episodic events from the past; for example, future thinking engages a wider neural network than does recalling of past memories (Addis et al., 2007). On the other hand, brain regions often involved in contextual and visual information such as the parahippocampal cortex and the posterior visual cortex seem to be more activated during remembering events of the past than imagining them in the future (Addis, Sacchetti, et al., 2009; Gilmore et al., 2016; for a review, see MacLeod, 2016). All of these combined shows the intimate link between future thinking and autobiographical memory which suggests that manipulation of one may also result in observable impact in the other. In other words, this opens the way to potentially indirectly target one phenomenon through manipulation of processes in the other; for instance, targeting emotional reaction

to certain autobiographical memories through manipulating one's reaction to similar future simulated events.

Behavioural, cognitive, clinical, and neuroimaging research all have been contributing and subsequently shaping the progress of contemporary research on future thinking. For example, Ingvar's early hypothesis that linked future thinking to memory largely relied on neurophysiological evidence which was then extended by Tulving based on clinical work (Ingvar, 1985; Tulving, 1972, 1985b, 1985a, 2002; J. M. Williams et al., 1996). From that point onwards, more theories steadily developed as researchers designed experiments that used modified measures of existing memory procedures to study future episodic events (e.g., autobiographical interview, Addis et al., 2008; Levine et al., 2002). This eventually led to the development of the constructive episodic simulation hypothesis which posits that episodic simulation of future events is possible due to a mechanism of recombining episodic details from past events into novel scenarios in the future, with the emphasis being placed on this future simulation being an essential function of episodic memory (D. L. Schacter & Addis, 2007). Therefore, if people were to have difficulties retrieving episodic details, as is the case with people suffering from neurological disorders or psychological distress as well as those in old age, then their performance on EFT would also be compromised (for a review, see MacLeod, 2016). Drawing from these lines of shared patterns, an alternative theory, the remembering-imagining system, has also been proposed to integrate episodic thoughts from the past, current and the future in relation to seeking attainment of one's goals (Conway et al., 2016). Indeed, this resonates with the foregoing discussion of goal state as an important factor in determining individual differences in motivated forgetting. Alternative theories, such as centrality of the mental construction of a scene (Hassabis & Maguire, 2007, 2009), have also been proposed to integrate processes potentially involved in both reminiscing of the past and imagining of the future.

In terms of relevance to emotions, evidence of participants rating imagined future episodic events as more positive, self-referential, and important than past episodic memories seems to suggest a prioritisation of emotional past memories to facilitate EFT with emotional content (Berntsen & Bohn, 2010; Wardell et al., 2022). Another significant piece of evidence arises from the fact that emotion

regulation strategies are shared across temporal dimensions such that they are effectively applied in response to both reminiscence of past memories as well as imagining of future simulated events (Benoit et al., 2018). If simulations of emotional future events share similar behavioural characteristics and neural networks as those of emotional past memories, then it is plausible that they would also share the cognitive constructs that gate their output. For example, just as we would want to be able to control intrusive triggering images of past traumas, we would also want to be able to control the incessant anxiety-inducing images of worries and fears in the future. Indeed, the inhibitory thought control mechanisms engaged during motivated forgetting to suppress intrusive past memories seem to be shared when one intentionally suppresses future events (Benoit et al., 2016). Moreover, the same brain regions that support memory retrieval and episodic simulation are implicated in suppression of imagined fears (Addis et al., 2007; Benoit & Schacter, 2015; Hassabis et al., 2007; D. L. Schacter et al., 2017), namely downregulation of the ventromedial prefrontal cortex (vmPFC) and hippocampus by the rDLPFC (Benoit et al., 2016). Importantly, despite the increased difficulty to forget details of familiar contexts due to their relatively vivid nature (Hirst & Phelps, 2016), stronger downregulation correlates with successful suppression of event elaboration, which may cause subsequent forgetting of key details in successfully suppressed imagined events (Benoit & Anderson, 2012; Gagnepain et al., 2014). Such observations of downregulatory activity could be investigated further by probing the limit, if any, of the threshold for the degree of intrusiveness any imagined future feared scenario can possess before a person is rendered unable to benefit from the suppression-induced forgetting of its details. Another significant aspect of such an investigation into suppression of future simulations of worrisome events is its subsequent impact on the quality of how one experiences the events post-suppression, as well as their overall mental health state as a result of suppression. To date, there is only one published paper indicating reduced apprehension for the future fears following suppression (Benoit et al., 2016).

On the other hand, in contrast to the adaptive effects of suppression, there is also evidence suggesting that vivid episodic simulation of future worries is related to adaptive emotion regulation strategies (Jing et al., 2016). This does not necessarily contradict findings of suppression as both may be appropriate avenues to mitigate future worries and fears, depending on the severity of the emotional toll

as well as the mental state of the person at the time of imagining these future fears. For example, while engaging with simulated fears may prepare us to cope with what may come, the degree of intrusiveness of future worries and fears may require directly suppressing these future-oriented thoughts and images to emotionally regulate more effectively and to decrease their intrusiveness in the future. Indeed, such intrusive thoughts surged during the coronavirus disease 2019 (COVID-19) pandemic, which then became the backdrop of our attempt to apply motivated forgetting on EFT (see Chapter 3).

Episodic Future Thinking in the Realm of Clinical Populations

Given the strong link between episodic future thinking and emotions as discussed above, there is a large body of work investigating how this link may be differentially expressed and experienced in people with neurological conditions and mental health problems. EFT has been found to be impaired in many neurological populations as an underlying symptom: Alzheimer's disease (Acevedo-Molina et al., 2023; Addis, Sacchetti, et al., 2009; El Haj et al., 2015, 2019; El Haj & Antoine, 2021; Irish et al., 2012a, 2012b, 2013; Moustafa & El Haj, 2018; Strikwerda-Brown et al., 2022), Parkinson's disease (de Vito, Gamboz, Brandimonte, et al., 2012; Ernst et al., 2017), semantic dementia (Irish et al., 2012a, 2012b; La Corte et al., 2021; Strikwerda-Brown et al., 2022; Viard et al., 2014), fronto-temporal dementia (Fusi et al., 2021; Irish et al., 2013), mild cognitive impairment (Gamboz, De Vito, et al., 2010; Niedźwieńska & Kvavilashvili, 2018; for a review of future thinking in the dementias, see Irish & Piolino, 2016). Similarly, EFT has also been impaired in populations with memory-related problems, such as amnesia (Andelman et al., 2010; De Luca et al., 2018; Hassabis et al., 2007; Klein et al., 2002; Kurczek et al., 2015; Liu et al., 2021; Race et al., 2011; Rosenbaum et al., 2005; Zeman et al., 2013), and transient global amnesia (Juskenaite et al., 2014). Relatedly, people with highly superior autobiographical memory (HSAM) seem to only have superior imagination of future scenarios when they are personally relevant with rich episodic details, but not general scene construction (Gibson et al., 2022).

In addition to research on patients with memory-related deficits, there have also been clinical studies showing compromised EFT in patients with damage in specific brain regions: prefrontal cortex

damage (Berryhill et al., 2010; Bertossi, Aleo, et al., 2016; Bertossi et al., 2017; Bertossi, Tesini, et al., 2016; Ciaramelli, Anelli, et al., 2021; Ciaramelli, De Luca, et al., 2021; Kurczek et al., 2015; K. W. Rasmussen & Berntsen, 2018), left temporal resection (Manning et al., 2013), posterior parietal cortex damage (Berryhill et al., 2010), thalamic damage (Weiler et al., 2011), multiple sclerosis (Ayala et al., 2022; Ernst, 2020; Ernst, Blanc, et al., 2015; Ernst, Noblet, et al., 2015, 2016; Ernst, Sourty, et al., 2016), and traumatic brain injury (Coste et al., 2015; Phillips et al., 2018; K. W. Rasmussen & Berntsen, 2014). Given its implication in a wide array of neurological conditions, EFT's potential as a diagnostic tool naturally comes to mind. However, due to several reasons such as a severe lack of reported effect size in published studies, small sample sizes due to case study nature of the reports, as well as a lack of formal investigation into the convergence between the various episodic future thinking tasks used, the diagnostic potential of EFT currently remains uncertain.

In terms of various mental health conditions manifesting deficits in EFT, there have been investigations conducted in people suffering from depression (Gamble et al., 2019; Hallford et al., 2018, 2020), anxiety (Du et al., 2022; Miloyan et al., 2017; Moustafa et al., 2019), bipolar disorder, schizophrenia (Hallford et al., 2018; Lyons et al., 2016), and PTSD (Brown et al., 2014; Hallford et al., 2018; Kleim et al., 2014). Broadly, a less positive outlook of the future has been associated with depression (L. Marsh et al., 2019; Strunk & Adler, 2009) and anxiety (Hoerger et al., 2012; J. Q. Wu et al., 2015). Furthermore, as expected, positive future events tend to be less vivid in one's imagination in individuals with dysphoria (Hallford et al., 2018; for a review, see Wardell et al., 2022). As highlighted by MacLeod (2016), the significance of research investigating positive outlook of the future comes to full force when considering how its lack (i.e., hopelessness about the future) is the active ingredient in suicidal depression, predicting repetition of deliberate self-harm 6 months later (Petrie et al., 1988) and completed suicides up to 10 years later (Beck et al., 1990). The relevance of EFT comes in given that suicidal patients show difficulty thinking of specifically future episodic events with a positive valence (Hunter & O'Connor, 2003; MacLeod et al., 1993). Furthermore, people with depression tend to engage more in negative prospection (MacLeod & Cropley, 1995) and show reduced specificity when prompted to imagine positive future events, but not for negative or neutral events (Gamble et al., 2019).

Furthermore, the intimate connection between episodic future thoughts with negative valence and depressive symptoms is underscored by the proposal that negative prospection is perhaps not merely influencing but actually acting as a core causal element of depression (Roepke & Seligman, 2016). In the case of anxiety, negative prospection has been proposed to act as a mechanism by which EFT acts to manage potential future threats such that it allows people to take more advanced precautionary measures (Boyer & Linard, 2006; Miloyan et al., 2016; Stein & Nesse, 2011).

On the other hand, in the case of people actually suffering from anxiety, EFT is not an adaptive strategy, but rather a seeming deficit. For example, while individuals tend to consider positive future simulations as more likely to occur than negative simulations (Acevedo-Molina et al., 2020; Barsics et al., 2016; Szpunar & Schacter, 2013), the opposite is observed in anxious people (J. Q. Wu et al., 2015). As with people with depression, anxious individuals tend to have a negative belief that the negatively-valenced future events are likely to actually occur. Moreover, generating negatively-valenced personally relevant future episodes seem to be easier for clinically anxious people than non-anxious controls (Raune et al., 2005; for a review, see Wardell et al., 2022). In addition, valence of the future-oriented thought may be differentially processed and experienced by people on the two ends of the spectrum, both within a mental illness, and across mental health conditions. If we take the case of anxiety, we see that higher anxiety is associated with greater EFT specificity for negatively-valenced cues and with fewer EFT specificity for positively-valenced values (Du et al., 2022). Across mental health conditions, anxious people show a distinct valence profile of imagined future events when compared to depressed people, such that people experience increased negative thoughts in anxiety and decreased positive thoughts in depression (MacLeod, 2016). This differential feature of EFT specificity is important to consider when interpreting results from populations that like have comorbidity of depression and anxiety.

Research showcasing characteristics of episodic future thinking's manifestation in clinical populations also affirms the link between episodic simulation and episodic memory. For example, the degree to which someone is anxious can moderate the probability of that person's recall of the details of emotional simulations versus neutral simulations (Montijn et al., 2021). Significantly, the distinct

valence profile of imagined future events in the future-thinking task (MacLeod et al., 1993; MacLeod & Byrne, 1996; Moore et al., 2006) is the same profile for the past memory version of the task (MacLeod, 2016). This gives further support to the interdependence between EFT and episodic memories. Furthermore, the observation of reduced specificity in EFT is shared with reduced specificity for past memories in patients suffering from depression (Belcher & Kangas, 2014), schizophrenia (D'Argembeau et al., 2008), PTSD (Brown et al., 2013), severe grief (Maccallum & Bryant, 2011; Robinaugh & McNally, 2013), and people with autism spectrum disorder (Lind et al., 2014; Lind & Bowler, 2010; Ye et al., 2023). The strong correlation between how specific someone's descriptions of their past events are to how specific they are able to imagine future events further provides evidence for a shared mechanism underlying EFT and episodic memory. Taken together, given its implications in many types of psychopathology, there is potential for EFT to be considered as a transdiagnostic treatment strategy for many mental health conditions.

1.3. The Hidden Pandemic

Global Mental Health Crisis: the Hidden Pandemic

The COVID-19 pandemic originated with a highly infectious disease of the SARS-CoV-2 strain, which was initially detected in Wuhan, Hubei, China. First reported towards the end of 2019 (C. Huang et al., 2020), COVID-19 was then officially declared as a pandemic by the World Health Organization (WHO) in March 2020. To this day, the pandemic has been infecting over 700 million people, resulting in over 6 million deaths (WHO COVID-19 Dashboard, 2023). Perhaps too familiar to all of us, the pandemic has been affecting not just the physical health of over 9.5% of the global human population, but also the psychological well-being of every single person, albeit to varying degrees (Fiorillo & Gorwood, 2020; Jakovljevic et al., 2020; Parola et al., 2020). As early as 2020, studies have called for classifying the COVID-19 pandemic as an urgent event with such traumatic nature that it may lead to long-lasting complex psychological response at both an individual and collective level (Horesh & Brown, 2020; Masiero et al., 2020; Parola et al., 2020). Under the shadow of the global COVID-19 pandemic, the looming, much-dismissed, and invisible mental health crisis came to light. In a way, the COVID-19 pandemic brought forth the hidden pandemic of mental health into the spotlight.

COVID-19's impact on mental health includes manifestation of 1) common mental health conditions like symptoms of depression, anxiety, and post-traumatic stress, 2) behaviour-related psychological distress such as panic attack, irrational anger, impulsivity, and suicidal behaviour, as well as 3) other dysfunctional disorders such as somatization disorder and sleep disorders (Dragiotti et al., 2022; Fountoulakis et al., 2022; Hossain et al., 2020). To illustrate the wide range of prevalence that can be observed across studies due to a variety of factors, Dragiotti and colleagues found an increase between 9% and 31% in the prevalence rates of anxiety, depression, stress, and sleeping problems before and after the pandemic, all based on six studies with longitudinal data. (Dragiotti et al., 2022). In addition, there have been limited reports of some of these concerns becoming long-term, extending beyond the pandemic (for a review of long-term effects, see Pandey et al., 2021). On the other hand, a notable observation is that the rise in mental health issues appears to have slowed by late 2022, not only in high-

income European countries, but also across the world (N. Ahmed et al., 2023; Robinson et al., 2022). However, given that the world is still seeing new cases every day, albeit substantially fewer, it is too soon to come to a conclusive statement regarding the long-term impacts of COVID-19 on mental well-being.

These detrimental effects are not limited to those affected with the virus. The groups of people that have been most observed by mental health researchers have been primarily of 3 categories: 1) patients who affirmatively contracted the virus, 2) healthcare workers, and 3) the general public who may or may not have contracted the virus at the time of study. However, there have been a handful - and hopefully more upcoming - studies specifically focusing on vulnerable populations (for a review, see Li et al., 2023). For example, a review paper found that the epidemiological distribution of mental health problems and their associated factors were heterogeneous among COVID-19 patients, healthcare workers, and the general public (Hossain et al., 2020). On the other hand, the impact of COVID-19 on mental health can also be organised into subgroups not based on proximity to virus contraction, but on the type of impact it has on an individual: direct and indirect. Direct impact would include any observations about mental health changes in the population as a direct result of contracting the virus. Indirect impact would encompass demographic, psychosocial, environmental, and socio-political factors. Given that all of the work reported in this thesis was conducted during the course of the pandemic, as well as mental health indices being a core outcome measure of the experiments described in subsequent chapters, we will proceed to discuss some impacts of the hidden pandemic menacing beyond the COVID-19 pandemic.

Direct Impact of COVID-19 on Mental Health

This deadly disease is characterised primarily with respiratory distress symptoms (Fu et al., 2020). Importantly, there is some medical research which indicates that the SARS-CoV-2 virus acts on the brain through its neurotrophic properties (E. A. Troyer et al., 2020); however, exactly how this impacts brain functioning is still awaiting further elucidation. Significantly, the effects of COVID-19 on patients cross beyond neurological symptoms, sometimes resulting in psychological and

neuropsychiatric manifestations. In a meta-analysis, Dragioti and colleagues (2022) found prevalence of over 20 mental health outcomes from 173 COVID-19 related studies recorded of 502,261 participants spread across 32 countries.

What follows is a brief summary of the psychological and psychiatric conditions reported among patients with COVID-19. However, due to discrepancy in sample size and geographical location, only statistically significant prevalent conditions are listed with their supporting citations while omitting the actual statistics reported in each of the studies (for reviews, see: Dragioti et al., 2022; Vindegaard & Benros, 2020). There are a few mental health concerns that are consistently observed in high levels in COVID-19 patients: post-traumatic stress symptoms (PTSS; Bo et al., 2021; Chen et al., 2020; Qiu et al., 2020; Zhang et al., 2020), depression (Bo et al., 2021; Lei et al., 2020; L. Yang et al., 2020; J. Zhang et al., 2020), anxiety (Lei et al., 2020; L. Yang et al., 2020), psychosis related symptoms like impaired consciousness and confusion (Bo et al., 2021; Y. Chen et al., 2020; Qiu et al., 2020), and sleep problems (Dragioti et al., 2022). Importantly, patients with pre-existing psychiatric disorders reported worsening of psychiatric symptoms (Bo et al., 2021; Fernández-Aranda et al., 2020; Tsamakidis et al., 2020; J. Zhang et al., 2020; Zhou et al., 2020). Notably, the most prevalent symptoms experienced by COVID-19 patients (in contrast to caregivers, healthcare providers, the general population) were stress (84%), sleeping problems (63%), and PTSS (94%) (Dragioti et al., 2022). Interestingly, it has been previously observed that people with mental health difficulties also tend to be more prone to infections. Notably, an alternative proposal behind observations of severe neuropsychiatric symptoms in COVID-19 patients has been the patient's inability to prevent infection and their lowered levels of self-control (Pandey et al., 2021).

Regarding long-term impact of psychological issues resulting from virus contraction, evidence does not yet seem to be conclusive. For instance, some longitudinal studies concluded in favour of detrimental long-term psychological impacts of COVID-19 on patients (for a review, see Pandey et al., 2021), while others found that patients' symptoms at longer term did not deviate significantly from the general population (Bourmistrova et al., 2022). However, there are many factors of individual differences that may be at play and require further investigation. Therefore, in a way, the non-

conclusiveness of existing research further points to the potentially central role of indirect effects of COVID-19 in agitating and sustaining further deterioration of psychological distress across the population.

Indirect Impact of COVID-19 on Mental Health

Indirect impacts of COVID-19 may include elevated levels of distress due to: physical health disturbances (e.g., exacerbation of cardiovascular and diabetic chronic conditions), psychosocial factors (e.g., loneliness), addiction-related behaviour (e.g., increased consumption of alcohol), environmental shifts (e.g., social distancing), familial aggression (e.g., domestic abuse), or occupation (e.g., being a healthcare provider). All of these could detrimentally affect an individual's mental health state, regardless of whether or not the individual has contracted the virus. For example, some of the psychosocial factors that have been found to be associated with increased mental health problems in COVID-19 include demographic features (age, gender, marital status), socioeconomic disposition (education, occupation, income), interpersonal environment (place of living, close contact with COVID-19 patients), comorbid conditions (physical and psychological), news and media exposure, and metacognitive beliefs (Hossain et al., 2020; Kaczorowski & Grande, 2021; Mansfield et al., 2021).

Another way to probe COVID-19's indirect impact on mental health is to consider people who are not considered a COVID-19 patient while participating in the study. For instance, the large body of work on the mental health state of healthcare providers and frontline workers would all come under such indirect impacts of COVID-19. This is important to consider because indirect impacts are experienced differentially across specific groups, especially across COVID-19 patients, healthcare workers, and the general public (Holmes et al., 2020; Pappa et al., 2020; Walton et al., 2020). An example to illustrate the diversity of the category of issues as well as the impacted population can be seen from the synthesised observation that prevalence of mental health issues can range from 1% for stress in the general population to 94% for PTSD symptomatology in COVID-19 patients; moreover, common

symptoms of distress such as depression, anxiety, stress, and sleep problems were observed with prevalence ranging from 8% to 63% across different population subgroups (Dragioti et al., 2022).

At the beginning of the pandemic, the general population experienced increased levels of distress, depression, and anxiety symptoms (for a review, see Manchia et al., 2022). Significantly, it was found that relative to pre-pandemic times, it was more than 40 times more likely for anyone in the general public to develop depression during the COVID-19 pandemic (Fountoulakis et al., 2022). This could be in part due to the increased exposure and consumption of COVID-19 related social media contents or mass media news (Drouin et al., 2020) as a result of lockdowns, boredom, and decreased physical activity (Brooks et al., 2020), which were all associated with mental health problems (P. J. Chen et al., 2021; Drouin et al., 2020; Hou et al., 2020; Y. Huang & Zhao, 2020; Ni et al., 2020), especially to the detriment of sleep quality (P. J. Chen et al., 2021; Janati Idrissi et al., 2020; Nagata et al., 2020; Xiao et al., 2020).

Given the state of overwhelming cases in hospitals around the world, healthcare providers became a highly exposed group, facing challenges both in and out of their work environment as they dealt with direct threat of virus contraction continuously for themselves and their loved ones. This mental toll is reflected in the multitude of papers repeatedly showing that especially at the onset of the COVID-19 pandemic, healthcare providers suffered severe anxiety and depression, PTSS, fatigue, burnout, and sleep problems (for a review, see Dragioti et al., 2022). Specifically, in healthcare providers, the most prevalent secondary outcomes was fear, at 71% (Dragioti et al., 2022), which mirrored what had been previously reported about the level of fear found in the aftermath of previous epidemics (Chong et al., 2004; Kisely et al., 2020; Tsamakidis et al., 2020). Similarly, in working populations who are not in the healthcare profession, fear was also the most prevalent symptom, albeit much lower in intensity, at 29% (Dragioti et al., 2022). This is important to note as fear is often a feature of future thinking, an emotion that can range from simply feeling a bit worried to becoming paranoid to succumbing to absolute debilitation out of being petrified of a future outcome. Notably, although highest in COVID-19 patients, PTSS was still significantly elevated in the general population (Dragioti et al., 2022). Taken together, these results show that the mental health toll indirectly caused by the

COVID-19 pandemic was so high that it virtually did not spare anyone in the population. In fact, the data support our lived reality that many people in the general population experienced more difficulty in dealing with mental health problems than perhaps some of the COVID-19-infected patients. Furthermore, the high prevalence of mental health struggles differentially expressed in populations across COVID-19's development suggests that there are certain underlying factors that may make one person more susceptible to mental health decline than another.

Risk Factors for the Hidden Pandemic

Some of the most obvious risk factors for an individual include 1) being from an at-risk population, 2) having an existing psychiatric, neurodevelopmental, or mental health condition, 3) belonging to occupations with high risk of daily exposure such as healthcare workers, and 4) inherent socio-demographic risks like old age (for reviews, see Manchia et al., 2022; Vindegaard & Benros, 2020). Importantly, social distancing measures may have exacerbated the vulnerabilities of already quite vulnerable populations, due to anything from loneliness to food insecurity to widened inequality in access to health services (for a review, see Li et al., 2023). A dire result of becoming more vulnerable whilst already being a part of a vulnerable group is the increased risk of suicide. Indeed, shifts in rate of suicide during the COVID-19 pandemic varied significantly across subgroups of the population depending on geographic location and timepoint of pandemic policies, such that markers of minoritisation and social disadvantage played a clear and significant role in suicide variation (for a review, see Martínez-Alés et al., 2023).

In terms of worsening symptoms of psychological distress, one of the most important risk factors for being affected in mental well-being indirectly by the pandemic is to have a history of mental health conditions (G. Li et al., 2020; Mazza et al., 2020; Özdin & Bayrak Özdin, 2020; C. Wang et al., 2020; W. Zhang et al., 2020). For instance, having a history of any mental health disorder, self-harm behaviour, or suicidal tendency was a risk factor for developing depression, whereas rate of suicidal thoughts did not deviate from what was previously found in the general population (Fountoulakis et

al., 2022). However, there also have been studies showing no significant change in mental health symptom severity in adults with pre-existing mental health conditions which the authors acknowledge as surprising and discuss as potentially a result of large variations in the experiences and environmental context of people living with mental health conditions (N. Ahmed et al., 2023).

Amongst changes in the environment relative to pre-pandemic quality of life are those factors that restricted movement such as social distancing measures, quarantine, and lockdowns. Prior to the COVID-19 pandemic, there had already been studies that showed a correlation between presence of quarantine (in the context of the SARS outbreak) with heightened levels of depression (Hawryluck et al., 2004), PTSS (P. Wu et al., 2009), sleeping problems (S. Lee et al., 2005), stress (Bai et al., 2004), and maladaptive behaviours (Marjanovic et al., 2007). As such, reports of high levels of negative mental health outcomes (e.g., depression, anxiety, and sleep problems) have been associated with the COVID-19 pandemic (M. Z. Ahmed et al., 2020; Brooks et al., 2020; Cellini et al., 2020; Galea et al., 2020; Gupta et al., 2020; Y. Huang & Zhao, 2020; Hwang et al., 2020; Parola et al., 2020; Rossi et al., 2020; Salles & Mascarenhas Barbosa, 2020; Usher et al., 2020; Venkatesh & Edirappuli, 2020; Xiang et al., 2020; for a review, see Pandey et al., 2021). Importantly, as in the case discussed above relating to pregnant women, not only did pandemic regulatory measures like lockdowns potentially intensify existing risk factors, but further unintentionally exacerbated the mental health toll by restricting access to in-person therapeutic, familial, and community support. Closely linked to the power of governmental policies to differentially impact a person's living conditions is their socioeconomic disposition (Nicola et al., 2020). Understandably, financial insecurities such as distress from changing to work-from-home to unemployment altogether, are all risk factors for negative mental health outcomes during the COVID-19 pandemic (Kawohl & Nordt, 2020; Patel & Rietveld, 2020; Probst et al., 2020; J. M. Wilson et al., 2020).

One major underlying psychological theme driving a lot of the risk factors is the feeling of uncertainty. It has been shown that uncertainty can act as a trigger for negative mental health outcomes such as stress (Greco & Roger, 2003) and anxiety (Grupe & Nitscrerke, 2013), and is more broadly associated with worsened mental health, in particular depression, anxiety, distress, PTSD, and stress

across different populations (Phillimore & Cheung, 2021; Santacroce, 2003; Stewart & Mishel, 2000; D. Wu et al., 2020; for a review, see Massazza et al., 2023). Having been labelled as a “pandemic of uncertainty” (Rogoff, 2020), the COVID-19 pandemic resulted in a surge of worry in the general population (Pandey et al., 2021). This uncertainty was also fuelled by information overload as well as misinformation, further exacerbating mental well-being (Verstraelen et al., 2018). For some, uncertainty of the future led to an increase in alcohol and drug use to maladaptively cope with stress and anxiety (Grossman et al., 2020; Pollard et al., 2020). This is important to consider in the above-mentioned context of heightened fear in the general population which could be driven by multifaceted uncertainty of one’s future in the age of the pandemic. Notably, uncertainty can also present itself as an opportunity, as supported by research associating uncertainty with hope and optimism in face of adversity (Brashers, 2001; Gill & Morgan, 2011). This is interesting given that there is some data suggesting building of resilience as a result of the pandemic such that some people reported doing better during the pandemic relative to before it, perhaps as a result of reconnecting with family and friends and an absence of some pre-pandemic stressors (N. Ahmed et al., 2023; Manchia et al., 2022; Murphy et al., 2021; Sheridan Rains et al., 2021).

In sum, it is clear that the hidden pandemic of worsening mental health came into full swing as a result of a variety of risk factors, with some not yet immediately adjustable, while others more manageable and perhaps even preventable. Moreover, the multifaceted nature of these risk factors also gives hope that there are many avenues through which mental health service providers and professionals can provide support in this hidden pandemic. Before discussing how we can do our part, sometimes it is more apt to first remove the obstacles in the way. In this spirit, the next chapter will re-examine major theoretical ideas and their accompanying studies that have become roadblocks in the way of applying more than a decade of research showcasing the *adaptive* role of controlling one’s thoughts as an intervention for mental health support.

Dusting the Lens of Ironic Processing

2.1. Revisiting Thought Suppression

Introduction to Ironic Processing

Since the inception of the ironic processes model of mental control (Wegner, 1994), the field of psychology has seen an explosion of experiments pursuing the application of this theory in various aspects of the human experience. Wegner (1994) posits the availability of mental capacity as the discerning variable for the criterion of successful control, which if reduced temporarily in face of mental loads would lead to ironic effects - “mental states that go beyond “no change” to become the opposite of what is desired” (p. 35); moreover, as succinctly described in the abstract of the seminal paper, the ironic processing theory (IPT) conceptualises two processes underlying the availability of mental capacity: “(a) an operating process that promotes the intended change by searching for mental contents consistent with the intended state and (b) a monitoring process that tests whether the operating process is needed by searching for mental contents inconsistent with the intended state” (p. 34); therefore, “when mental capacity is undermined and the operating process is limited” due to mental load, people’s “intentions to control the mind unleash a monitoring system that not only searches for the failure of mental control but then tends itself to create that failure” (p. 35). In this way, according to Wegner (1994), “processes that undermine the intentional control of mental states are inherent in the very exercise of such control,” (p. 34) such that “[d]esired happiness becomes sadness, desired relaxation becomes anxiety, desired interest becomes boredom, desired love becomes hate, and so on” (p. 35).

The IPT came into fruition following a series of experiments conducted in the 1980s now widely known as the “white bear” experiments. As the authors succinctly summarised in the abstract of their work, the experiment and its observations are as follows: “subjects verbalizing the stream of

consciousness for a 5-min period were asked to try not to think of a white bear, but to ring a bell in case they did. As indicated both by mentions and by bell rings, they were unable to suppress the thought as instructed. On being asked after this suppression task to think about the white bear for a 5-min period, these subjects showed significantly more tokens of thought about the bear than did subjects who were asked to think about a white bear from the outset” (Wegner et al., 1987, p. 5). One may be curious to ask why white bears? It seems from popular accounts that Wegner was inspired by Fyodor Dostoevsky’s challenge to his readers to not to think of a polar bear without the idea coming into mind repeatedly afterwards. Wegner seemed to have taken this challenge head-on and developed the white bear experiment, results of which have since shaped the discourse of suppression in psychology.

Crystallised in the IPT of mental control, the impact of the white bear experiments has since extended the concept of suppression beyond thoughts into subfields of emotions, memory, interpersonal processes, psychophysiological reactions, and psychopathology (Wenzlaff & Wegner, 2000). As we dive into these studies in this chapter, one may notice that the chapter structure will resemble the natural flow of how we understand a new concept in our field. This was an intentional effort to be able to first probe IPT’s relevant concepts and findings, then to understand the impact and limits of its underlying theory, to then be able to discuss application of its use. In other words, this chapter will first delineate the findings and conclusions that form the backbone of the IPT, especially those that are relevant to the topic of this thesis - thought suppression. Then, we will probe the IPT with a more vigilant eye, and finally summarise and challenge the impact of the theory in the field as well as in larger society. This is critical because many studies stemming from the inception of IPT often comment on clinical and subclinical populations which can result in attitude shifts in practitioners and the general public, impacting the availability and appeal of future treatment options. Hence, in this next section, let us first revisit the critical paper that permanently pinned the scarlet letter on thought suppression.

The Dust of Confounding Instructions

“One obvious recommendation for individuals plagued by unwanted thoughts is to abandon thought suppression in favor of alternative, more effective methods of mental control” (Wenzlaff & Wegner, 2000, p. 83). This is the conclusion and recommendation reached at the end of Wenzlaff and Wegner’s influential paper “Thought Suppression”. The call for abandoning thought suppression has since been widely accepted both by clinicians and the wider public, especially in the age of popularising self-expression and authenticity such that we inadvertently think that we should never suppress our thoughts. However, I agree with the authors that “our knowledge of the intricacies and idiosyncracies of thought suppression is far from complete” (Wenzlaff & Wegner, 2000, p. 84), and hopefully this thesis is a step towards a more detailed and precise picture.

The intention behind these chapters is to remove the dust accumulating atop suppression studies that potentially veiled people from drawing from the benefits of suppression; in other words, it is not an attempt to completely dismiss the observations in these studies, nor is it a sweeping call to endorse suppression for everyone regardless of circumstances. Indeed, benefits of suppression would depend upon on the context for intentional forgetting. What is needed in the literature, and hopefully executed in this chapter, is to re-balance the scale of outlook on suppression back to a more neutral vantage point by challenging some of the claims vilifying its use, so as to be able to appreciate its benefits as well. Thus, what follows is a brief revisiting of the various ideas and findings presented in Wenzlaff and Wegner’s paper and an attempt to reconsider some of these arguments in a different light and reinterpret some of the findings with an alternative understanding. For the sake of ease in simplicity and flow, the following discussion will be categorised by theme, so it may not necessarily follow the order with which the statements appeared in the article.

The post-suppression rebound effect refers to the observation of an increase in the frequency of the suppressed content coming to one’s mind when prompted to express the suppressed content following a period of suppression. This was first demonstrated with the 1987 white bear experiments.

Critical lens: A fundamental assumption of any human-subject based laboratory experiment is that participants understand the terminology being used in an instruction as the experimenter intends. A closer look at the white bear instructions reveals that the term “suppression” is not defined in any way to be able to confirm that the participant is actually engaging meaningfully with an active form of suppression. Here are the instructions for the original white bear experiment: “In the next five minutes, please verbalize your thoughts as you did before, with one exception. This time, try not to think of a white bear. Every time you say “white bear” or have “white bear” come to mind, though, please ring the bell on the table before you” (Wegner et al., 1987, p. 7). There are three major issues with this instruction: 1) the mode of suppression is unclear from “*try not to think,*” 2) the phrase “*every time*” presupposes that it will most certainly return which may elicit a supposedly expected response, and 3) the outcome is conflated as a measure of prevalence of intrusions rather than the intended measure of the ability to suppress thoughts. Moreover, the first two issues are related to perception of task instructions which will be discussed in this section of the chapter, whereas the last issue is related to interpretation of task outcome which will be discussed in the next section of the chapter.

A core problem highlighted by the first of the above-mentioned three main issues is that people can try to not think about something by using a variety of strategies, be they adaptive or maladaptive. A closely relevant example could be emotion regulation strategies, such as acceptance of emotions, reappraisal, problem-solving, rumination, avoidance, and suppression (Prefit et al., 2019). Importantly, avoidance could be further delineated to cognitive avoidance (A. D. Williams & Moulds, 2007), behavioural avoidance (Naragon-Gainey et al., 2017), and distraction (Kalisch et al., 2006); similarly, suppression could be further categorised to expressive suppression (Goldin et al., 2008), emotion suppression (Tull et al., 2010), and thought suppression (Höping & de Jong-Meyer, 2003). Firstly, it is important to notice that suppression stands in distinction from avoidance. Secondly, within either suppression or avoidance, there are further subcategories of distinction. Thirdly and perhaps most importantly, each of the subcategories maps differentially to the possible involvement of either direct suppression or thought substitution in its mode of emotion regulation. Specifically, in the category of suppression, neither DS nor TS are involved in expressive suppression, and only DS is involved in

emotion suppression and thought suppression (Engen & Anderson, 2018). In the category of avoidance, neither DS nor TS are involved in either cognitive or behavioural avoidance, and only TS is involved in distraction (Engen & Anderson, 2018). Therefore, since a lot of the inquiry in research into further applications of the IPT reside in the context of suppressing one's thoughts that are associated with particular emotions upon encountering a trigger, it is vital to clarify what is the actual phenomenon a task like the white bear task is intending to elicit in the participants.

However, if one were to make the case that thought suppression need not be solely for the purposes of emotion regulation, then a further inquiry into the nature of suppressing any thoughts would be warranted. Generally, in the field of neuroscience, suppressing thoughts would imply an active effortful act that engages with the thought in some way to make it temporarily or enduringly inaccessible, whereas avoiding thoughts could be passive or not-as-effortful and could even be achieved without any engagement with the thought at all. This distinct pattern could be seen in the nature of the tasks that are often used to test suppression versus avoidance. Furthermore, the distinction can be gleaned from the etymology of the words “suppress” and “avoid”. “Suppress” comes from the Classic Latin verb *supprimere*, meaning “to press down, to weigh down, to hold back, to stem the flow of, to stop, check, to stifle, to keep, detain, to withhold from circulation, to refrain from disclosing” (Oxford English Dictionary, 2023b). “Avoid” comes from the Old French verb *évuider*, meaning “to empty out, clear out, quit, get quit of, banish” (Oxford English Dictionary, 2023a). Here, one can see that the roots of suppression revolve around an act of actively and perhaps even forcefully stopping something that is ongoing, continuous, or flowing, whereas the roots of avoidance carries with it a sense of disengaging and a sort of getting rid of things quickly in one go. Moreover, the existence of an alternative term “repression” in classical psychology, albeit not unanimously agreed upon, to imply a more inactive or unconscious process of rendering thoughts inaccessible also implies that suppression is perhaps a more conscious, intentional, or effortful process. Therefore, when directed with the instruction of “*try not to think*”, it is unclear whether participants actually engaged suppression of intruding thoughts of a white bear (e.g., through DS), or if they simply avoided the thought of a white bear by self-distraction (e.g., through TS). In other words, the task is prompting participants to simply try not to think about

something, but do not give instructions as to *how* they should “not think”, which means they could be engaging in some direct suppression, some thought substitution, some self-distracting, some mind-wandering, and some perhaps actually thinking about the target words/phrases. Hence, the overall intended effect of suppressing the thought would actually be expected to be convoluted at best and perhaps reverse at worst. In other words, the critical problem here is that the nature of the task also lends itself to interpret its seemingly paradoxical effects to be not necessarily a result of “voluntarily relinquished” mental control. This is because there are no subsequent measures that check whether participants were actually continually engaging in an effortful intentional inhibitory suppression that can qualify as mental control throughout that time frame.

Regarding the second issue, perhaps it is easiest to convey through a simple example. Consider the following scenario: before you go to a foreign country, a friend may want to inform you of the meaning of certain customs of the place that may be foreign to an outsider by saying something like “every time you see someone do this, then...” It is understood that the act the friend is informing you of is common and you should be prepared to know what to do, or else the friend wouldn’t have made it a point to mention it. This is qualitatively different from the friend saying “*if* you see someone do this,” which would have implied that it is something that may or may not happen. Grammatically, “every time” implies frequency, whereas “*if*” implies conditionality or possibility. So, rather than giving an open-ended possibility that the thought of a white bear may or may not come, stating “every time” in the instructions implies that such thoughts will come generally, and the experimenter is interested in capturing the frequency of the intrusions. Such an implied understanding can indeed shift the intensity of one’s allowance of the thoughts to come, which when combined with the possibility that the prompt is triggering an avoidance response, can heavily affect the frequency of observed intrusions.

The Dust of Confounding Outcomes

Since the third issue with the instruction for the white bear task is related to an outcome measure, we shall first discuss the outcome measure which was subsequently developed as a result of the

white bear experiments - the White Bear Suppression Inventory (WBSI; Wegner & Zanakos, 1994). The 15-item WBSI was intended as a self-report measure probing one's tendency to suppress unwanted thoughts and has since been investigated to show that some of its items appear to assess intrusive thinking rather than thought suppression (Muris et al., 1996). Moreover, an earlier study found that instead of the intended thought suppression factor, there are two additional factors that may be underlying the WBSI: Unwanted Intrusive Thoughts and Self-Distraction (Blumberg, 2000). Similarly, a more recent study identified a two-factor solution of WBSI's underlying structure, namely, Unwanted Intrusive Thoughts and Thought Suppression (Höping & de Jong-Meyer, 2003). More specifically, the authors argued that the central assessment WBSI is making is thought intrusions, and that "[i]n addition to unwanted intrusions, they appear to assess something like a low self-efficacy expectation concerning attempts at thought suppression by either implying fruitless efforts in the past, as in Item 3 and 4, or by implying that future attempts at thought suppression would be unsuccessful, as in Item 6, 7, and 12" (Höping & de Jong-Meyer, 2003, p. 1053). This is important to note because it reveals that if the validation of an instrument is not specific enough, it can result in misinterpretation of the underlying phenomenon driving the observed outcome. Now, returning back to the white bear task's experimental procedure itself rather than the WBSI which was developed later, one can see that the issue of thought intrusions versus thought suppression becomes clearer when contrasting the results of the addition as opposed to absence of a load within the procedure.

If one were to ignore the issues mentioned above, post-suppression rebound would seem to suggest thought suppression as the driver behind the rebound effect by increasing the accessibility of the target (i.e., meant to be suppressed) thoughts in one's mind (Higgins, 1989), which led to experiments of adding a load (i.e., additional cognitive demands) to investigate potential enhanced accessibility of suppressed content during the attempted suppression time frame (Wenzlaff & Wegner, 2000). Without load, the white bear task did not consistently produce an immediate enhancement of target thoughts, which the author noted as "it is not clear why" (Wenzlaff & Wegner, 2000, p. 64). However, we can understand and perhaps even expect this result if we were to take into consideration the potential for the participants to disengage in the intended process. Echoing the discussion about the first issue above,

in the absence of added cognitive demands, the task is prompting participants to simply try to suppress something without a measure to investigate the degree to which they are suppressing; therefore, it makes sense for a few studies to observe an increase in intrusion (i.e., supposed enhanced accessibility) if the participants were actually meaningfully engaging to suppress, and for most studies to not observe any enhancement due to the high probability that participants are simply avoiding or distracting themselves or not engaged in suppression.

The research on conducting the white bear experiment with load showed evidence of “a load-induced surge of suppression-related material” as a result of the added cognitive demand disabling thought suppression (Wenzlaff & Wegner, 2000, p. 65). A closer look at those very experiments claiming this point, however, reveals that the nature of the task with load is in essence assessing task switching rather than looking at the effects of suppressing or controlling the emergence of unwanted thoughts. For instance, Wegner and Erber’s 1992 experiment asked participants to come up with word associations to word prompts as they try to either suppress thinking about a target word (i.e., the suppression condition) or concentrate on thinking about that target word (i.e., the concentration condition), and found that under load, participants gave the target word as a response to the association prompt during suppression more often than during concentration (experiment 1) and the reaction times to name the colours of the words was greater for the suppression condition (experiment 2). When looked through the lens of task switching, the interpretation of these observations as the hyperaccessibility of suppressed thoughts would require re-examination.

To illustrate, the suppression condition has 3 tasks in this procedure: A) to not think about a target word, B) listen to words that are either related or unrelated to the target word, and C) give word associations to those prompted words. The initial effect of task switching is such that when a task is switched ($A \rightarrow B$), the previous task A would be inhibited (Mayr & Keele, 2000), which in the case above means that the act of suppressing the target word (A) is beginning to be inhibited when the participant hears a word prompt (B). Importantly, because this inhibition continues until the next task, when the next task is the previously inhibited task A ($A \rightarrow B \rightarrow A$), then this inhibition would need to be overcome, and the cost of this overcoming (i.e., the cost of deinhibition) often manifests as the

behavioural effects of the task (Arbuthnott & Frank, 2000; Costa & Friedrich, 2012; Grange & Houghton, 2010; Mayr & Keele, 2000; for review, see Chen et al., 2022). In the above task, when word associations are given (C), it is in reality still continuing suppression (A). Therefore, this overall procedure would induce deinhibition costs which can manifest behaviourally in slower reaction times and increases in frequency of errors. Indeed, this is what was observed as the effect. What is described as an immediate enhancement of accessibility with load, could in reality reflect the deinhibition costs as the participants begin to become less successful in attempted suppression (i.e., the errors) and take longer to do the task (i.e., the longer reaction time). In addition, there is a different aspect of task switching that can also account for the seeming enhancement of accessibility with load, namely the competing presence of relevant and irrelevant content in working memory during task switching. Previous research has found that task switching can lead to impairment in working memory for task-relevant information and an enhancement in memory for unattended, task-irrelevant items (Richter & Yeung, 2012). In the present case, task C is when measurement is taken and the task is to come up with word associations, and so task-relevant information would be alternative associated words for the prompted word, and the task-irrelevant information would be the target word because it was meant to be suppressed and thus should be irrelevant to this task. The results reflect the working memory enhancement of task-irrelevant information whereby the target words are used more than other alternative words in the suppression condition.

Even if one were to assume that participants actually engaged in suppression (i.e., dismissing the first issue with the white bear instructions), still an alternative explanation is unveiled for the perceived immediate enhanced accessibility with load when one takes a closer look at the other observations that are seen alongside the increased recall of the target word. Regarding the same experiments by Wegner and Erber (1992), the IPT is invoked to explain the enhanced accessibility of suppressed content by describing how “relatively effortless monitoring process is released to sensitize the person to the unwanted thought” when “the effortful operating process...is hampered by time pressure” (Wegner, 1994, p. 42). However, this experiment could be interpreted from a completely different angle. Specifically, the time pressure did not “release” the “relatively effortless monitoring process”, rather it

prompted an even more effortful search for the correct target word because there is a motivation to perform well and accurately under time pressure (Lepine et al., 2005). So, at least some if not all of the heightened performance accuracy in the time-pressured group can be attributed to wanting to be a good participant, which is in fact a competing goal-directed behaviour. This potential confounding factor will become important a later section when rebutting the arguments originally presented against the goal interruption model to be in favour of IPT. In addition, Wenzlaff and Wegner themselves mentioned in their paper that previous works have shown that enhanced recall of information is observed when attention capacity becomes depleted (Macrae et al., 1997; Wenzlaff & Wegner, 2000), which should naturally lead one to consider the possibility that with depleted attention capacity, participants are not even completing the task anymore. One may then ask: if it is true that the participants didn't complete the suppression process, then why did they especially cling onto the suppression-relevant themes as was observed in its increased frequency of recall? Perhaps an everyday example would resolve this seeming contradiction. Consider the following scenario:

Your friend calls to ask you to look for a Beatles vinyl he accidentally left at your house because he urgently needs it and will come pick it up from your house in 30 minutes. Just as you started looking for this vinyl in the house, you got a phone call from your partner asking if you have booked the hotel for your trip abroad next week. You realised that you haven't, so you immediately start looking for options online after finishing that call. After 15 minutes or so, the doorbell rings, and you instantly realise that you still haven't found the vinyl yet. So, you open the door already with words of apology only to realise that it was misdirected, because the person who rang the bell was not your friend but just the mailman dropping off a package.

The critical point here is that you *assumed* that the doorbell is from your friend, and you would only assume that because you were still mindful of the task (i.e., find the Beatles vinyl) in the background whilst engaging in another presenting task (i.e., book a hotel for next week). Hence, this example is illustrating both arguments presented: 1) the measuring of task switching effects instead of the intended thought suppression, and 2) the observation that just like searching for something, prior to a suppression attempt completing successfully, the act of suppressing is simply a cognitive task whose true effect can

only be seen if the attempt is successful. Hence, the intended measure of the effect of thought suppression is perhaps not observed because it was not allowed to fully unfold. Moreover, the finding that suppression of personal successes or failures led to increased accessibility of those thoughts (Wegner et al., 1993) can be understood from the same perspective, such that the participant in the study would try hard to suppress personally relevant content. Therefore, when such an effort is cut short, the image or content becomes even more pertinent and raw in the mind's eye, manifesting in more accessibility of those thoughts, or in other words, more intrusions.

A counterargument to the point mentioned above could be the potential of having perfect participants who engage in direct suppression and are successful in their attempts, and yet still results in observation of an increase in rebound specifically in the suppressing group relative to the nonsuppressing group, but only when there is a cognitive load in the task. So, one may ask: what can possibly be the cause if not for the rebound effect? The answer may lie in understanding the difference between the nonsuppressing and suppressing groups. For instance, "nonsuppressing" could mean that the participants are not engaging in any inhibitory control, but they could still be engaging in distractions or focusing their attention (as was the case when people were assigned to be in the concentration group). Importantly, there is no conflict in what they were doing prior to the recall test and during the recall test, as everything is coherent. On the other hand, the suppressing group, when there is a load, is facing more than usual intrusions because direct suppression needs multiple repetitions for it to be truly successful enough in lowering the number of intrusions, as demonstrated by experiments showing the number of intrusions decreasing as a function of repetition of trials (Benoit et al., 2014; Gagnepain et al., 2017; Hellerstedt et al., 2016; Levy & Anderson, 2012). Hence, when there is a load introduced, a task switching happens which means that the multiple repetitions are not present; in other words, the participant may very well be at the beginning of the suppression attempt process where there are high intrusions when they are tested. In fact, frequency of intrusions decreasing only with repeated attempts of suppression also applies to suppression attempts of autobiographical memories (Satish et al., 2022). This observation is also in line with the clinical observations of heightened intrusive thoughts across mental health conditions as discussed previously in Chapter 1.

From this, it seems that the same experiment of the suppression of personal successes or failures (Wegner et al., 1993) have confounding variables as a result of task switching. The instructions of the task were as follows: “The task called for the subject to press keys to indicate whether words presented on screen were red or blue and at the same time to remember a number presented before the word and report it after seeing the word. The numbers were either two digits or six digits, so as to give the subject either a low or high cognitive load during color naming. Words appearing on screen were either relevant to the mood-related event (e.g., *success* or *failure*) or were irrelevant to it (e.g., *telephone*)” (Wegner et al., 1993, p. 1098). Here, by asking participants to recall the number prior to the word that is meant to be suppressed, the procedure is disrupting the suppression process. In the trials that have longer words, the mental load increase also means that the participant is spending more effort and energy to try to remember the longer number which means their attention is focused on the screen; therefore, the participant is more likely to be prompted to have instances of focused attention on the screen, then seeing a red word, they realise that they shouldn’t concentrate on the word any more. This is the opposite of the cognitive task they were just performing a few seconds ago, so this switch in cognitive task creates instead a heightened awareness of conflict detection which may then actually increase awareness of the object that is in conflict. In this experiment, task-irrelevant information would be a distractor which actually is the red or blue word on the screen. Because the task is to recall the number, so the word becomes a distraction. When the task switching happens, as expected from the cognitive costs of task switching (Richter & Yeung, 2012), memory for the task-relevant information gets impaired while memory for the task-irrelevant information (i.e., cue words on the screen) actually improves. Importantly, this switching only occurs during the “suppression” trials which involves task switching, whereas the task during the “concentration” trials is the same as the main task without any detection of conflict (i.e., to concentrate on the number in order to be able to recall it accurately). In addition to the breakdown of issues relating to the instruction, procedure, and interpretation of the results of the white bear task as presented above, more can be gleaned from revisiting the various theoretical accounts the authors presented to understand the seemingly paradoxical effects of thought suppression, namely

distractor associations, goal interruption, the role of metacognition, and of course, the ironic processing theory itself.

The Dust of Considering “Goal Interruption” Theory

Since the authors have already highlighted the various weaknesses in the alternative theories as a way of supporting ironic processing theory as the more coherent theory underlying the evidence of post-suppression rebound effect, there is no need to further delineate what each of these theories lacks in detail here. However, one point of contention that warrants revisiting is the various reasons put forth by the authors to illustrate the deficiencies of the goal interruption thesis. Specifically, the first claim is that “a goal-completion motive cannot explain the context dependent effects involving suppression rebound” (Wenzlaff & Wegner, 2000, p. 67). Just like how there is amnesic shadow when there is successful suppression due to the impact suppression has on the “context” of the to-be-suppressed content (Hulbert et al., 2016; Zhu et al., 2022; Zhu & Wang, 2021), it would not be surprising to see that when this suppression attempt is cut short as a result of adding cognitive load, the “goal” that is interrupted is within a particular context and thus will resurface along with that context. And this is reflected for instance in the observation that the reinstatement of the mood state at the initiation of suppression shows a post-suppression rebound effect (Wenzlaff et al., 1991).

The second claim to revisit is that the goal interruption thesis “has difficulty explaining both the attenuating effects of focused self-distraction and the intrusion-promoting effects of cognitive load” (Wenzlaff & Wegner, 2000, p. 67). Regarding the first part on attenuating effects, it is important to note that the rebound effect is attenuated upon using a single distracter explicitly during the attempted suppression time frame because the single distracter has become “the other thought” for participants to engage in thought substitution. Being one type of suppression techniques as discussed in Chapter 1, thought substitution could bring about at least temporary relief of intrusiveness which would be observed as an attenuation effect. Similarly, changes in environmental or mood context resulting in an attenuation in the post-suppression rebound effect also makes sense because once the context changes,

the “goal” will be in the background of the new context. Therefore, since the goal would have been changed, any lingering need to complete the goal would no longer be present which would mean the usual increased intrusions would also attenuate, especially in the context of laboratory-produced stimuli. The counterargument for the second part about “the intrusion-promoting effects of cognitive load” (Wenzlaff & Wegner, 2000, p. 67) is in essence that it is not the cognitive load that is promoting intrusions. It is important to still keep in mind that the suppression process has a timeline, especially when on laboratory-produced materials. A participant would have to be familiarised with the stimuli (e.g., word pairs) enough to remember them, suppress them upon intrusion, which then leads to disassociation of the previously formed associations, which can then possibly render forgetting.

Critically, one cannot suppress something if it does not intrude into one’s awareness. If a participant is instructed to suppress the image of “aq iyiq” every time it comes to their mind, they would have no idea what to do and in fact would probably do nothing and let their minds wander. They will not recruit suppression because they did not know that “aq iyiq” means “white bear” in the Uyghur language. So, only upon first knowing the to-be-suppressed content enough for it to become somewhat intrusive can a person then make it an object of suppression. In the context of lab stimuli, there is a learning period at the beginning precisely for this reason, to introduce intrusions, in a way, for suppression to then take effect. So, even if this was not an explicit step in the procedure as is the case with Wegner’s experiments, the participants are still learning during the reading of the instructions. Given that suppression is an effortful process when done correctly, it is very likely that at the time when participants are called to switch the task to retrieval of the number (i.e., the cognitive load), they are just beginning to be familiar enough with the stimuli to have intrusions. In other words, in order to perform intrusion effectively, they had to have had intrusions of the to-be-suppressed item multiple times. So, when the time is called to switch, they are in the middle of the suppression process which pre-supposes intrusions, and that is exactly what they are reporting.

On a similar note about the nature of what is required for suppression to initiate, consider the experiment in which participants were asked to recall either a sad or happy life event and write down their reminiscing thoughts of the event while *trying to not be sad* or *try to be happy* accordingly (Wegner

et al., 1993). Wegner (1994) claimed that the “results of this study also were largely consistent with the predictions of the theory regarding the differential effectiveness of trying to create a mood versus trying to suppress a mood. Subjects under load who were trying not to feel sad or trying not to feel happy were clearly unsuccessful, whereas those under load who were trying to feel happy or trying to feel sad were only marginally unsuccessful” (p. 43). However, a key missing perspective here is once again the nature of effortful suppressing, trying to *not* feel requires the feeling to emerge first. It requires effort for the participant who is supposed to *not feel* a particular emotion to first feel it to then suppress it; whereas the instruction *to feel* something starts with whatever feeling they have at that moment so it is less effortful, thus yielding seemingly more success. In summary, it is not the cognitive load that is “intrusion-promoting” but 1) the retrieval process that is initiated by the cognitive load task bringing back temporarily more recent items in working memory, and 2) the nature of the suppression process to require intrusions of the to-be-suppressed material. Perhaps here lies the irony of apparently the “most crucial” point of contention for the authors in not accepting goal interruption as a coherent explanation, namely that “the theory is unable to account for the return of intrusive thoughts during suppression” (Wenzlaff & Wegner, 2000, p. 67). Intrusive thoughts must return for suppression to initiate!

Contextualising Results for Interpretation

To further illustrate the nuance that is required in interpreting results, let’s revisit a key experiment in the clinical population the authors included to lend support for their impactful statement that “thought suppression may prolong or worsen depression by strengthening mood-relevant associations” (Wenzlaff & Wegner, 2000, p. 83). The study in question is conducted in a depressed sample over a 4- to 6-week period, where on completion of the three sets of scrambled sentences while suppressing, participants had to respond to the following questions which acted as indirect measures of suppression ability: “In the past month how often have you tried to suppress (i.e., keep out of mind) unwanted negative thoughts?” (1 = never, 7 = all the time) and “In the past month how successful have you been in suppressing unwanted negative thoughts?” (1 = not at all successful, 7 = very successful) (Wenzlaff & Bates, 1998, p. 1563). Specifically, the results showed that people who are at-risk (i.e.,

previously depressed) reported employing suppression moderately more frequently than depressed people (ratings of 4.64 vs. 3.74) and were significantly more successful at suppressing those thoughts (ratings of 4.77 vs. 2.61). So, this shows that both by subjective report and by the fact that they are no longer clinically depressed, perhaps people in the at-risk group have acquired an ability to suppress. This shows in their indirect suppression task of having lower negative statements than depressed participants when prompted with positive/no instructions.

The increase that was observed when the cognitive load task is administered (i.e., remember digits), once again reflects the task switching effect. Given that when two tasks are associated with a stimulus type, suppression prompt would cause the stimuli to be processed by brain areas associated with both tasks (G. R. Wylie et al., 2004), we would then expect brain regions involved in both suppressing of the suppressed items as well as the continuous retrieval of the cognitive load stimuli to be all engaged. In other words, when the at-risk participants are experiencing load, the stimuli of the suppression task and the retrieval task are competing, such that intrusions are occurring while the brain is trying to retrieve the number and keep it in working memory at the same time. Therefore, negative sentiments may also then get retrieved but without the actual need to suppress anything since there is no explicit instruction to suppress. When taken under this light of elucidating the underlying phenomenon that may have led to the various results, the statement reached by the authors that “by exacerbating negative cognitions, thought suppression may represent a cognitive risk factor for depression” (Wenzlaff & Wegner, 2000, p. 83) seems too premature to conclude from the existing data.

Just as the authors rightly pointed out that metacognitive beliefs can create individual differences in one’s ability to suppress, in a subtle irony, perhaps it is the authors’ conceptualization of suppression that has resulted in a lot of the oversight of the issues mentioned above. Specifically, the authors seemed to have a notion of suppression as a willful ability with a binary-like execution - either successful or not. Indeed, only with such an assumption can they then have the idea to entertain what emotional content “may undermine suppression” (Wenzlaff & Wegner, 2000, p. 70). On the other hand, suppression as understood from the perspective of motivated forgetting is an acquired and learned skill, and once learned, it has a spectrum of strength like any cognitive skill. It is not going to be just

cancelled or undermined but rather will need to be strengthened based on the quality of the object of suppression. To illustrate, once someone has learned how to play the violin (like having learned how to suppress), we wouldn't ask "which composer may undermine her ability to play the violin" (just like how we shouldn't ask "what emotional aspects of the target may undermine suppression"), because it is not the composer (qualitative aspects of the target), but the preference for the style (what motivates one to practise suppression) and the familiarity with the level of the technique required (experience using suppression) that determine how well someone can play a particular composer's pieces (how well one can suppress unwanted thoughts).

On the other hand, the authors seem to equate suppression to avoidance, as can be seen from statements such as "the tendency to avoid thinking about traumatic or anxiety-producing topics may prompt the return of those topics to mind" (Wenzlaff & Wegner, 2000, p. 81). This is essentially what was argued above as the first issue regarding the white bear instructions, because avoidance is most probably what is being measured a lot of the time in these studies involving the white bear task, and especially in clinical contexts given the added motivation factor of avoidance being the easiest though likely temporary method of emotional relief. Moreover, in clinical cases, the tendency to avoid thinking about the traumatic topic prompts the return of those topics precisely because patients are simply avoiding the thought rather than engaging their attention to it to properly suppress it because they are compromised in their ability to suppress properly or do not have yet the training to do so. In a way, all that is being observed could be the cycle of "trigger → intrusion → avoidance" and then back to the trigger. For instance, when investigating the post-suppression rebound effect in patients with PTSD and OCD, PTSD participants experienced more intrusive thoughts during suppression phase than non-PTSD participants (Shipherd & Beck, 1999), whereas OCD participants seem to have more intrusive thoughts than control regardless of whether they were suppressing (Janeck & Calamari, 1999). This may be because the way intrusive thoughts manifest in PTSD patients is that it is a response to being triggered by something on occasion, whereas for OCD patients, the intrusive thoughts are self-manifesting and hence always there in the background. So, while the suppression phase is creating somewhat of a triggered environment for people with PTSD to avoid these thoughts, it is not creating the same for the

OCD patients because it is the same for OCD patients whether or not the instructions mention the need to think or not think about these thoughts, since the thoughts are so obsessive that the patients are already constantly telling themselves to not think about them but don't have the right strategy to suppress or deal with them. Hence, this reinforces the critical point that the instruction for the white bear task may more often than not actually fail to prompt suppression, and in the cases that it does, it elicits thought substitution rather than direct suppression. Indeed, although "deliberate attempts to remove thoughts from consciousness" (Rassin et al., 2000, p. 974) was termed as "thought suppression" by Wegner (1989), interestingly it was actually first described by William James as a way to control one's stream of consciousness by shifting one's attention from one thought to another, so more avoidance than active suppression (James, 2007; Rassin et al., 2000).

This is how Wenzlaff and Wegner (2000) opened their influential paper on "Thought Suppression", with a quote from Lewis Carroll's *Curiosa Mathematica*:

Again and again I have said to myself, on lying down at night, after a day embittered by some vexatious matter, 'I will not think of it any more! . . . It can do no good whatever to go through it again. I will think of something else!'

Ironically, as we now return in full circle, it is quite clear from this opening that what the authors thought of as representative for "thought suppression" to qualify it as an opening is what we would specify as "thought substitution". More concretely, the narrator here wants to "not think" by "think[ing] of something else". This is experientially and mechanistically different from someone who attempts to "not think" by "not thinking anything at all" or perhaps by "blocking out everything that comes to mind". Indeed, these are some ways an experimenter may explain direct suppression to participants, while emphasising that they should not think of anything else. While acknowledging differences between the authors and the field of cognitive control specialists in the conceptualisation of suppression, it is still important to have revisited the highly cited work on "Thought Suppression" by Wenzlaff and Wegner (2000). By discussing issues embedded in the instructions of the original white bear task as well as other major early experiments, we highlighted three major critiques against the post-

suppression rebound effect: 1) equating of avoidance with suppression leading to ambiguity when interpreting results, 2) oversight of task switching effects as a cause for the increase in intrusiveness of suppressed materials, and 3) misinterpretation of presence of intrusions as uniformly maladaptive due to a lack of nuanced understanding of the process of effortful suppression. Given how the post-suppression rebound effect is the core of IPT, we will next revisit the theory itself for further delineations that may challenge some of its conclusions in real-world applications.

2.2. Reconsidering Ironic Processing Theory

Confronting Intuitive Challenges

When reading through Wegner's (1994) thesis on the ironic processing theory of mental control, one may feel some resistance to certain statements as ideas can surface to mind almost intuitively to challenge some of these notions. It is important to at least tune in to these intuitive confrontations as they may hold keys to unlocking more rigorous investigations into the reasons for such hesitations. In the spirit of tuning in, for a few pages, I would like to entertain the readers in some of the intuitive hesitations one may experience upon engaging with IPT.

The use of metaphors and anecdotes in scientific writing is essential to carry the message across and make the findings relatable. However, the accuracy of representing a phenomenon can become hindered by the limitations of the metaphor to describe it. Wegner (1994) first traces the history for the origin of the idea of control requiring two processes back to the development of the study of cybernetics (Wiener, 1948) which Wegner tried to explain using the metaphor of a thermostat: "Just as thermostats find a favorite temperature by operating the furnace and testing to see when it is warm enough, control theories suggest that people approach goals by performing goal-oriented behaviors and testing to see whether their goals are met" (Wegner, 1994, p. 37). For anyone who takes a moment to reflect upon the complexity of the human brain, they can immediately sense the distorted reductionism in this unjust metaphor. How can the brain be like a thermostat? There are competing goals, complex emotions, genetic makeup, and lessons of past traumas, all integrated in the manifestation of behaviours. In other words, the brain does not simply generate out of thin air, but receives and communicates in an integrated manner. Indeed, brain imaging studies on control processes and specifically on task switching seem to be clear in their position that control is not actualised through a simple gating mechanism that executes control by simply turning on task-relevant areas and turning off task-irrelevant areas of the brain (Allport et al., 1994; Sohn & Anderson, 2003; G. Wylie & Allport, 2000; G. R. Wylie et al., 2003, 2004). If it is simply a testing system like a thermostat, then how does one explain its receptive quality, one that

yields to insight, eureka, and wisdom? This reductionism is also seen in the various simplifications of goal states.

As mentioned in the previous section, Wegner (1994) explains the ironic effect by illustrating how emotional states can become reversed under mental load such that “[d]esired happiness becomes sadness, desired relaxation becomes anxiety, desired interest becomes boredom, desired love becomes hate” (p. 35). A simple pause in reflecting upon these mental states can reveal the faulty assumptions under this statement. How can what is desired become its opposite simply as a result of a faulty in-between mechanism? Hate is an extremely effortful emotional state, and similarly, anxiety and sadness are not only emotionally but also physically draining. Therefore, these must have causes beyond a simple reversal caused by seemingly a few minutes of suppression. Indeed, perhaps “this oppositional quality that always seems to haunt attempts to direct our minds” feels like an “agony” (Wegner, 1994, p. 34) because we are not reminding ourselves of the natural heightened activation energy required to initiate something that goes against our habits and perhaps even lower desires. Regarding the actual two processes posited by the IPT (i.e., operating and monitoring processes), it is interesting to note that Wegner (1994) himself describes the operating process as a form of thought substitution such that the search initiated by the operating process “turns to distracters in the attempt to provide mental control” (p. 37). Furthermore, this shows that given the orientation of the theory underlying the white bear experiments, the experiments at best probe suppression in the form of thought substitution if not avoidance. Similarly, when describing the monitoring system, Wegner (1994) states that “[a] monitor searching for failure during thought suppression would search for the to-be-suppressed thought (cf. Wegner, 1992), and the presence of this thought in consciousness (even as part of a monitoring process) would certainly disallow the possibility of any meaningful sort of suppression” (p. 39). However, while he perhaps intended for this to showcase the ineffectiveness of intentional mental control, it actually inadvertently also reveals how this view has completely ignored the fact that suppression is not a searching process, but a downregulating stopping process. Therefore, it is precisely the “presence of this thought in consciousness” that gives motivation for repeated effortful suppression leading to eventual disassociation and forgetting. Indeed, this is the entire premise of exposure therapy. In other words,

IPT's application or reach to the usage of direct suppression related research is very limited, if at all relevant. This is an important point to note and revisit when considering the findings that will be presented in the upcoming chapters.

In addition, another critical quality of the operating process is that it is “seldom continuous, and rather, it occurs cyclically in response to the monitor's signal of operating process failure” (Wegner, 1994, p. 38). Two questions can be posed to challenge this: 1) If the operating process is not continuous, then what is it doing when not being activated by the monitoring process? 2) What accounts for the ability of the operating process to reset and how does it happen? Regarding the first question, it is not dismissible that neuronal ensembles involved in the operating process would simply remain idle while the monitoring process takes place in the background. If the conflict monitoring theory were to be insisted, then alternative uses for the operating process must also be proposed, which leads into the second question. Regarding the second question, it seems highly unrealistic in relation to the lived experiences of people where resetting is almost never an option, unless fate causes one to face an incredible trauma that renders one to completely forget and start anew. Indeed, more comprehensive models have since been proposed to connect conflict monitoring to cognitive control (Botvinick et al., 2001). However, the conflict monitoring hypothesis is more relevant in the control of behaviours resulting from attention switching, error detection and processing, which are often observed in tasks like the Stroop and the flanker task (Griggs et al., 2023; Marly et al., 2023; Möde et al., 2023; Viviani et al., 2023), rather than motivated control solely at the level of cognition and emotion.

Perhaps a more intuitively perceived incompleteness in the model describing the dynamic between the two processes is the idea that “mental control is not likely to be attempted when it is already successful” (Wegner, 1994, p. 38). This is counterintuitive when considering some situations when our attention becomes fully captured in a state of satisfaction to pursue even further *after* experiencing success in reaching a goal. For instance, when someone learns to ride a bike, their attention and relatedly arousal would likely not plummet but rather potentially become even higher at the instance when they finally get the hang of it and start riding the bike for longer distances. Indeed, if attention was not so centrally linked with the aftermath of attaining goals, no learning would unfold in our experiences.

Beyond metaphors and examples for the processes underlying IPT, there are also some uneasiness embedded in the various hypothetical examples used to illustrate the potential reach of the theory. For instance, Wegner (1994) suggests that IPT can explain the reasons behind failed attempts to quit smoking by showing that the attempt to quit smoking “normally institutes a monitoring process that focuses on cigarettes smoked and so undermines the attempt to quit” (Wegner, 1994, p. 39). The problem here is that it is highly unlikely that any nicotine addict who sincerely wishes to quit would be focusing on the number of times they failed by relapsing into smoking a cigarette rather than focusing on the success of sustaining the streak of sobriety. Similarly, when describing the application of IPT to depressed patients, an alternative perspective of the lived experience of the depressed person is not considered. Moreover, the rumination of the depressed person is likely not because the monitoring process is scanning and evaluating whether the person is depressed and then initiating the operating system to control the sadness as proposed by the much reductionist model of IPT, but perhaps rather due to the inherent intrusiveness of their ruminative thoughts and yet not being equipped with the appropriate strategy to deal with them.

In sum, what has been mentioned as intuitive resistances when confronted with the various statements made in support of the IPT are in actuality a reflection of the same issues discussed previously when revisiting IPT’s role in thought suppression. Moreover, the reductionist interpretation of the theory seems shaky to hold ground when considering research in inhibitory control showcasing its vital value to maintaining function and well-being, which is further reflected in the dearth of brain imaging evidence to support the seemingly popular IPT. It is important to note that our intention here is not to completely dismiss the conflict monitoring hypothesis, but rather to highlight some of its incongruity in how it has been applied in IPT and interpreted in the various studies following IPT’s inception.

Reviewing Appropriateness in Application

After having examined the core experiments that lent support to the ironic processing theory and reconsidered many of its claims, it is also important to review the application of IPT within

psychology and beyond. Ideally, a theory should only be widely accepted if it can withstand rigorous scientific scrutiny; however, in the age of social media and sensationalising of research, theories gain traction for many non-scientific reasons. Therefore, this section will carefully review the claims made by researchers when reporting results of the IPT being applied in a particular context, and investigate its limits drawing from existing research across various topics.

To begin, we will turn first to the most relevant topic to this thesis, the ironic effects observed in thought suppression. At the very end of the section of his writing on the evidence for the ironic effects of thought suppression, Wegner (1994) claims that “[c]ognitive busyness or time pressure could interfere with processes of self-presentation, deception, or self-control that depend on thought suppression for their success and so promote social blunders, unintentional disclosures of deceit, or self-control lapses that are not entirely random. Rather, because the most unwelcome thoughts are typically chosen as targets for suppression, these very thoughts are the ones that are ironically exposed when the processes of suppression are disrupted” (p. 42). In other words, here are the three everyday examples listed by Wegner as being able to be explained by IPT: 1) social blunders, 2) unintentional disclosures of deceit, and 3) self-control lapses that are not entirely random. Regarding the first phenomenon of social blunders, research seems to point to something completely different than suppression as the cause of its occurrence. Specifically, as “inadvertent violations of normative standards of behavior” (Moscovitch et al., 2015), social blunders are a fear that especially prevails in socially anxious populations who imagine themselves behaving in a socially unacceptable manner leading to atrocious consequences during social events (Chiupka et al., 2012; Hofmann, 2007). However, it is certainly not the case that every socially anxious person would have a high probability of having social blunders simply because they are trying to avoid it. In fact, presence or absence of social blunders seem to have nothing to do with suppression, but rather more relevant to one’s personality and the present circumstance. In other words, anxious people who are *intending* to avoid social blunders are not suppressing something they are trying to say, and even if they were, they are not suddenly falling into social blunders everywhere they go. Similarly, the second phenomenon of unintentional disclosure of deceit also need not necessarily depend on suppression but rather be a result of underlying human morality as well as inexperience in

lying. When someone is not used to lying, they may either be so inexperienced that they accidentally end up revealing the fact that they lied, or feel guilty and become morally obliged to eventually reveal the truth. To understand the former more, consider the following example:

Your routine is to eat dinner with your partner at home after work. Today, out of the blue, a couple of friends called you to meet up right as you were about to leave work. You could call your partner and tell them the truth but they may get irritated. So, you determine that you can avoid potentially displeasing your partner if you just grab a quick bite and spend less than an hour with your friends so you can still go home in time. After a quick catch-up with your friends, as you are about to step out of the restaurant to go home, your partner calls. You lie and say you were caught up at work for a bit but that you're about to be home very soon. You make your way home, have dinner with your partner, and everything goes as planned. Except, the next day, you blurted out something your friend mentioned to you from the night before, which consequently led you to inadvertently disclose the fact that you lied the day before.

In this everyday example, there was no sign of active suppression occurring. Indeed, the unintentional disclosure happened precisely because there was no impending urgency that required being on guard about the small lie from the preceding night. This was an example in which one may disclose a lie without much underlying guilt. In the cases where there is a strong sense of guilt, the lie becomes unearthed eventually due to either the need to relieve oneself of the moral burden of overwhelming guilt or to rid oneself of its psychological side-effects of intrusive thoughts. This guilt is a motivation above and beyond any supposed confessions emerging from a reversal of the one's need to keep suppressing the urge to reveal their deceit. Wegner's third example is non-random self-control lapses which essentially excludes involuntary tics or muscle movements. The irrelevance of suppression to this phenomenon can also be illustrated from a quick imaginative scenario: you might be working on not having a foul mouth when you speak, but from time to time, you end up blurting out a word or two. Such a lapse is not due to thought suppression going wrong because there is no suppression of thought. In fact, it is precisely because you are not actively monitoring when you are speaking all the time that old speaking habits can sneak in when the context is familiar for its manifestation. Moreover,

such a lapse can happen when you are simply having a normal conversation, which stands in contrast to the explanation that the environment becoming overloaded is what supposedly causes the monitoring process to take over as proposed by IPT. Rather, you have temporarily lost track of the goal to keep tabs on your language when you speak as other more salient goals took over (e.g., to have a conversation with someone who happens to use a lot of foul language). As such, each of the three phenomena listed as fertile grounds for the application of IPT as its underlying cause seem to be questionable in its scope of relevance.

With thousands of citations since its presentation to the world, the ironic processing theory has gained a lot of traction in academic research. It has since been applied to investigations in emotion regulation, trauma, sleep, mental health disorders, memory, pain, hypnosis, resilience, etc. Now, we will unpack a few of these studies to simply illustrate some of the pitfalls in interpretation of results, potentially due to carrying forward of the missing pieces in the theory or addition of confounding variables in the task. For example, in a study of suppressing a trauma film with load, researchers found evidence contrary to IPT whereby “cognitive processes did not undermine thought suppression success” (Nixon et al., 2009, p. 252). In other words, the suppression group did not show an increase in intrusions as would be expected by IPT. However, the conclusion cannot merely stop at a failure to demonstrate the post-suppression rebound effect; rather, a closer look at the procedure shows that all participants except the control group were listening to an audio tape. This means that they were all distracted by another thought throughout this task (i.e., thought substitution). This implies that they were inadvertently engaging in passive suppression! Hence, given that the suppression group with added load would have the double effect of both task switching and passive thought substitution, one would expect the observed results of this group showing less intrusions than the control group. Beyond procedural mishaps, misinterpretations can also arise from not having perceived the presence of a confounding variable or the nuance in the underlying cognitive process.

Application of IPT in clinical and subclinical populations requires a close examination as interpretations of results from such studies often carry weight in the therapist’s room. For instance, a study investigating the rebound effect of suppressed anxious thoughts in the context of an aversive

threat did not observe any ironic effects during the time frame of suppressing thoughts, but the participants reported an increase in anxiety and frequency of anxious thoughts after the suppression time window (Koster et al., 2003). The core significance of this study leading to a seeming null result of the rebound effect is the fact that the cue in the study was an imminent threat that is present in the room. Because the threat is imminent, there is a higher incentive to actually directly suppress since the cue is right in front of the participant, much like the cues on the computer screen during the TNT procedure. Hence, the rebound was not present immediately after suppression due to the typical suppression-induced reduction of intrusion effects. However, the intrusions came back in the third phase of the experiment when the participants were told to think of anything else. This is because people who were suppressing were already occupied with the need to control that thought, and now the being-suppressed thought got cued with the retrieval of that thought as a result of thinking of anything else. Hence, once again, the retrieval cue has caused intrusions to manifest. Indeed, the fact that participants reported increased anxiety in the third phase actually supports the proposal that they are engaged in retrieving, not suppressing.

On the other hand, as mentioned above, not noticing the nuances in instructions can really skew the interpretation of a given observation. For instance, a study on patients with an eating disorder was interested in probing the ironic rebound effects of forming negative implementation intentions in this population, and found both cognitive and behavioural ironic rebound effects (Adriaanse et al., 2011). However, since the negative implementation intention has a structure that essentially gives an exception to not follow this rule for any occasion other than this one particular occasion, then the statement actually allows for all other occasions during which participants can break the rules (e.g., eat chocolate). In other words, it is much easier to rationalise lapsing on this form of intention when exceptions are easily available, which can then account for the apparent observation of behavioural rebound. This caution with words in the instructions is not superfluous as it can easily become a confounding variable. Take, for instance, the application of IPT in pain management, whereby the instruction for suppression is “to suppress any emotions” versus its control condition where participants are told to “deal with any emotions you experience” (Quartana et al., 2007, p. 458). The rebound effect observed in the form of

increased cognitive accessibility of anger has two confounding variables: 1) method used to measure pain, and 2) suppression instruction bias. Regarding the first point, the pain was administered as ice water, and indeed the angrier or emotionally charged one feels, the more heated they may feel and thus there is a potential that they would feel the ice-cold quality of the water more. Regarding the second point, the suppression instruction is to not feel *any* emotions, which goes beyond anger suppression to dissociation or detachment. Unnaturally forced dissociation can be maladaptive if not initiated by the body itself, much like a pressure cooker that will eventually explode. Suppression of destructive emotion requires redirection of that emotion in terms of its outlet, not complete disconnect from one's body as that would be extreme. Hence, here, since there is no presence of a salient motivating factor, all this exercise would lead to is the participant's frustration for the interruptions in the task (i.e., what causes the anger to arise as part of the task manipulation) and then being reminded of the fact that they can't feel frustrated which just adds on the frustration. It is unclear whether there is any suppression happening in reality since the extent of suppression is neither evaluated nor specified. A more specific suppression would have been suppressing specifically the emotion of anger. Hence, multiple factors may render such a study's results uninterpretable.

The reach of IPT in the realm of extreme psychological distress manifests in its investigations into suicidal thoughts. Specifically, research has found that suppressing suicidal thoughts, as measured by the White Bear Suppression Inventory — Suicidal Revision (WBSI-SR), may lead to an increase in suicidal ideation (Pettit et al., 2009). It is important to recognize here that the measure for suicidal thoughts was through WBSI-SR which can itself induce intrusions of suicidal thoughts by virtue of someone responding to the survey. Moreover, these two concepts, namely suicidal thoughts and suicidal ideation, are inherently entangled. Indeed, it would be odd if there were lots of suicidal thoughts without it becoming ideation and vice versa. In sum, both the measurement tool and the outcome measure can be confounding factors in artificially increasing the apparent rebound effect.

In the area of sleep research, some researchers found the rebound effect in the form of “paradoxical wakefulness” for participants who were trying to fall asleep quickly under a high mental load (Ansfield et al., 1996). Again, this need not be interpreted as rebound, rather, from the fact that

low mental load participants slept quicker, we know that this is fundamentally not about suppression. Rather, the low load participants, who are hearing sleep-inducing sounds, are simply pursuing goal-directed behaviour. For the high load participants hearing sleep-inhibiting sounds, they are literally disrupted from their sleep because of the type of noise! Therefore, the difficulty of falling asleep could simply be an effect of the experimental design. Almost reflecting an opposite protocol, a recent sleep study showed that using imagery to distract oneself prior to sleep can “lead to reduced discomfort associated with unwanted pre-sleep cognitive activity and with reduced sleep onset latency” (Harvey & Payne, 2002, p.275). This may seem counterintuitive at first but is actually a reflection of the effects of thought substitution. Indeed, authors cite the intriguing result that there is an increase in intrusion without load but a decrease in frequency of intrusions “when suppression instructions were accompanied by instructions to replace the target thought with a specific engaging task” (Harvey & Payne, 2002, p. 268). This shows that it is actually thought substitution that is at play for the “imagery distraction” condition such that the suppression actually has an effect.

On the other hand, this also alludes to the now much-repeated probability that the white bear experiments are essentially triggering avoidance, the effects of which are quite maladaptive and unhelpful as Wegner and many others have highlighted. Similarly, in the realm of dreaming, Wegner and colleagues (2004) observed highest “intrusions” in the suppression group in which the participant was told right before going to sleep to write down their stream of thoughts after being told “try not to think of the [target] person”. If this was truly suppression at work, then the valence and arousal of the to-be-suppressed content should matter, yet the results do not show a differential pattern in regards to the participant’s emotional attraction to the target to-be-suppressed person. For instance, it has been recently found that unpleasant thoughts are in fact more prone to rebound in dreams than pleasant thoughts (Malinowski et al., 2019); therefore, things that are more emotionally charging should be harder to suppress and thus lead to more intrusions in dreams and in waking, which points to the underlying concern of confounding variables other than suppression being truly at play in this study. In addition, brain imaging evidence from sleep studies seem to suggest that weakly encoded information tend to be the object of reactivation in sleep (Schechtman et al., 2021), which is indeed the case here

when only a few minutes are given to weakly encode thoughts about the target person which can prompt resurfacing in sleep state in order to be prioritised for consolidation. Indeed, this resurfacing is further strengthened by the possibly compromised activity of inhibitory control in dream state as supported by significant hypoactivity of the DLPFC during REM sleep (Desseilles et al., 2011). In other words, during REM sleep, direct suppression attempts are at best affected and at worst compromised, which may lead to more intrusions. Therefore, it seems more plausible that what is observed by Wegner and colleagues (2004) after suppression induction is not a rebound effect caused by suppression which is often accompanied by valence differentiation and the use of DLPFC. Rather, since the “crush” and “noncrush” of the participants as specified in the experiment are both new information that is introduced right before sleeping, their representations are renewed during sleep for memory consolidation. In other words, the differential effect of suppression instruction (i.e., try not to think of this person) versus expression instruction (i.e., think of anything), can be interpreted as the difference upon reorientation of one’s focus on a particular thought that gets flagged as a particularly “new” information which then prompts resurfacing in the form of “intrusions” in order to consolidate into memory during sleep.

Perhaps a more intricate and nuanced example lies in studies involving hypnosis. Interestingly, a classic study using different instructions for suppression, namely amnesia suggestions versus mind blanking found that “[h]ighly hypnotizable participants reported successful thought suppression, only when given an amnesia suggestion” and that “[b]lank-mind instructions did not prevent paradoxical effects for thought suppression” (King & Council, 2008, p. 309). It is important to note that hypnosis can cause decoupling in inhibitory control processes (Egner et al., 2005), which would then imply that highly hypnotizable people would not be engaging in direct suppression under the “blank-mind” instruction since it would require the inhibitory control processes to be active. However, participants might still be hypnotised alternatively for amnesia suggestion, which is exactly what the results found. Moreover, this shows that “blank-mind” or DS is a qualitatively different form of thought suppression, that is unlike avoidance and TS. Furthermore, although this study cannot answer the question as to why

different instructions for thought suppression produced different effects, it can still indicate the observation that different strategies were employed.

Another interesting area of application that is relevant to emotion regulation has been probing IPT in relation to appraisal. Appraisals refer to “direct, immediate, and intuitive evaluations made on the environment in reference to personal well-being” (Yap & Tong, 2009, p. 1209). The blatantly clear conflation between suppression and avoidance that got carried over from the origin of IPT can be seen from the discussion on indirect support for the appraisal rebound effect: “For example, people who try to *avoid* stereotypic responses toward members of a social group are more likely to make the same responses toward them later [italics emphasis is inserted]” (Yap & Tong, 2009, p. 1209). Similarly, the suppression instructions for the task was “to refrain from thinking about how unfairly this person was treated” (Yap & Tong, 2009, p. 1211), which does not signal DS but rather avoidance. Indeed, the result depends on whether or not the researcher who apparently wasted the participant’s time (by arriving 25 minutes late as part of the manipulation) is then rated with unfair feedback. This can introduce ambiguity in the result, not only because suppression is not explicitly tested, but also because there is a confounding variable of frustration introduced due to the additional instruction given to the suppression group only. To illustrate, consider someone getting intrusions while sitting there, attempting to avoid those intrusive thoughts; hence, the concept of fairness would be easily accessible in their working memory as a nature of the task. Then, of course the person would recruit that concept when they talk about their frustration with the researcher.

Perhaps the far-reaching and somewhat alarming impact of IPT is its application in topics that have nothing to do with the original thesis of application in mental control. For instance, a recent paper on performance setting found that anxious participants made more ironic errors (Gorgulu et al., 2019); however, in reality, this experiment had nothing pertinent to do with suppression. As can be seen from all of the examples above, a careful examination can reveal loopholes in wordings of instructions, design of experimental procedure, and interpretation of results, which may all lead to conclusions that are at best incomplete and at worst erroneous. Putting aside the obviously problematic conclusions that have hindered a full appreciation of the application of suppression in improving wellbeing, it is important to

acknowledge that like any intervention, suppression is not going to be effective in all circumstances across all populations, and may lead to opposite results to what is intended. For instance, for someone who is worrying about something they cannot do anything about (e.g., death of a loved one), suppression may be really beneficial; however, for someone who just experienced a really salient event, processing what had happened may be more appropriate to undergo first prior to suppressing in order to acknowledge the experience, much like how acknowledgement precedes suppression in a direct suppression experiment. Similarly, for someone who is worried about something they need to actually act upon, suppressing it would not be practically useful even if it is temporarily relieving of cognitive and emotional stress, which is distinct from the circumstances of someone who ruminates on certain thoughts for prolonged periods of time that result in wasting of time and energy. Therefore, especially given the evidence in the upcoming chapters regarding its beneficial impact on mental state, our intention is to open the path for suppression to be available as an approach in people's toolkit, to be selected when appropriate. The efforts in this chapter attempts to remove the obstacles that have historically and methodologically obstructed such a path from being visible to those who need it most.

Keep Calm & Carry On with Suppression Training

3.1. Imagine/No-Imagine Training: Event-Specific Outcomes

Contextualising the Imagine/No-Imagine Training

Suppressing upsetting thoughts may promote mental health during adversity and this capacity may be trainable. Historically, thought suppression has been considered maladaptive because of the century-old Freudian proposal that suppressed content persists in the unconscious mind, resurfacing indirectly through symptoms and dreams (Freud, 1953, 1957). According to modern theoretical accounts, even when thought suppression succeeds fleetingly, the suppressed content rebounds in accessibility and emotional intensity, amplifying a person's distress (Wegner, 1994, 2009). These clinical views remain unreconciled with neurobiological evidence that suppressing thoughts helps to maintain mental health (M. C. Anderson et al., 2004; Depue et al., 2007; Engen & Anderson, 2018; Fawcett & Hulbert, 2020; Gagnepain et al., 2017; Mary et al., 2020; Nørby, 2018). For example, engaging the right lateral PFC to suppress intrusive thoughts is associated with greater resilience to developing PTSD after violent trauma (Mary et al., 2020), decreased anxiety about feared events (Benoit et al., 2016), fewer distressing intrusions after viewing a traumatic film (Streb et al., 2016), and a tendency to forget suppressed content on both explicit (M. C. Anderson & Green, 2001; M. C. Anderson & Hulbert, 2021) and implicit memory tests (Gagnepain et al., 2014; Y. Wang et al., 2019). Despite these potential benefits, direct causal evidence for how thought suppression affects mental health is lacking. This is because the presumed risk of asking vulnerable populations to suppress distressing thoughts has discouraged experimental studies to determine its effects (Holmes et al., 2007). If thought suppression improved mental health by reducing distressing thoughts and their emotional impact (Benoit et al., 2016; Gagnepain et al., 2017; Harrington et al., 2020; Legrand et al., 2020; Nishiyama & Saito, 2022), these discoveries could alter how we should treat anxiety, depression, and PTSD — a radical departure

from current treatments which often strive to eliminate thought suppression (Gortner et al., 2006; Hayes et al., 2011; McEvoy, 2019; H. Murray & El-Leithy, 2021; *Post-Traumatic Stress Disorder: NICE Guideline [NG116]*, 2018).

We challenge the view that thought suppression worsens mental illness. We hypothesised, in contrast, that training people to suppress unpleasant thoughts in response to reminders would improve their mental health, even in people with anxiety, depression, and PTSD. People with these conditions suppress thoughts less effectively on laboratory measures, mirroring their intrusive symptoms in daily life (Catarino et al., 2015; P. T. Hertel & Gerstle, 2003; Mary et al., 2020; Marzi et al., 2014; Stramaccia et al., 2021; Waldhauser et al., 2018). Such difficulties are often attributed to ineffective inhibitory control over memory and emotion, originating from structural, functional, or neurochemical deficiencies in the prefrontal cortex or the hippocampus (Aupperle et al., 2012; Bishop, 2009; De Raedt & Koster, 2010; DeGutis et al., 2015; Etkin et al., 2013; Eysenck et al., 2007; Joormann & Gotlib, 2010; Menon, 2011; Schmitz et al., 2017). However, it remains unclear the extent to which thought suppression deficits also reflect modifiable factors, including inexperience with the concept of suppression, ineffective use of suppression strategies, or metacognitive beliefs about the impossibility of thought suppression discouraging its use, which are all factors that may be remediated by repeated training and reveal suppression's utility to the individual. Indeed, studies of lesions in the prefrontal cortex suggest that it is the ability to self-initiate use of effective memory strategies, and not the ability to use or benefit from the use of effective memory strategies that are impaired in patients (Kirchhoff, 2009). Such finds give the alternative explanation that deficits in thought suppression observed in clinical populations are perhaps due to an inability to self-initiate suppression, which presents the possibility that through training, suppression could become a cognitive skill that bears fruits in mental well-being for even clinical populations. We therefore causally tested how thought suppression affects mental health by training people to suppress their distressing thoughts about feared future events. We targeted participants' fearful thoughts given the dramatic rise in anxiety, depression, and post-traumatic stress in the Covid-19 pandemic (*Mental Health and COVID-19*, 2022; T. Wu et al., 2021; Xie et al., 2022), and the potential benefit of ameliorating a key symptom of these conditions.

Our study took place via individualised videoconferencing, anticipating a future with safe and accessible treatment delivery to participants worldwide. Before training, 120 adults from 16 countries listed feared future events of current concern to them, each with a cue word that reminded them of the event (Fig. 1; see Tables 2A-2C for participant and event characteristics). They briefly described each fear and listed a single word denoting a central detail of what they typically imagine (see Procedure below). Via this procedure, participants also generated neutral and positive future events (i.e., “hopes”). During training, participants practised the Imagine/No-Imagine (INI) task (Benoit et al., 2016), which requires retrieval stopping (M. C. Anderson et al., 2004; M. C. Anderson & Green, 2001; M. C. Anderson & Hulbert, 2021), a particular form of thought suppression. Moreover, the idea to use future feared events instead of past distressful memories stemmed primarily from safeguarding concerns as the sessions were not conducted in-person in a facility with on-site mental health professionals to be able to handle cases of triggered reactions of severe distress. Secondly, given that there was already one study demonstrating possibility to suppress future fears, we thought to replicate that study (i.e., Benoit et al., 2016). However, this present study is entirely unique in being a multi-day training, with different procedural timings and instructions, and being carried out on a video-conferencing platform. In fact, even the idea of using future events was arrived independently and the existence of previous research simply solidified our intention to carry it forward. In other words, only the concept of the INI task and some basic parameter considerations were derived from the previous study.

The training task was repeated for 3 days. On each trial of this task, participants confronted the cue to a future event for four seconds and depending on the type of trial indicated by the colour of the cue word, we asked them to imagine the event vividly (“Imagine” items) or to stop themselves from imagining it (“No-Imagine” items). Specifically, for No-Imagine trials, we asked participants to first recognize the feared event signified by the cue, but thereafter to suppress retrieval of any thoughts or imagery about it. Participants practised thought suppression extensively: across 3 days, they suppressed every No-Imagine (or imagined every Imagine) event 36 times. After the final training session and following a 3-month delay, we tested how repeated thought suppression had affected the suppressed events. We evaluated risks of clinical concern by scrutinising whether suppression promoted paradoxical

increases (hereinafter termed ironic increases; Wegner, 1994) in memory or affect for participants' fears or had instead enabled people to successfully forget these unwelcome thoughts.

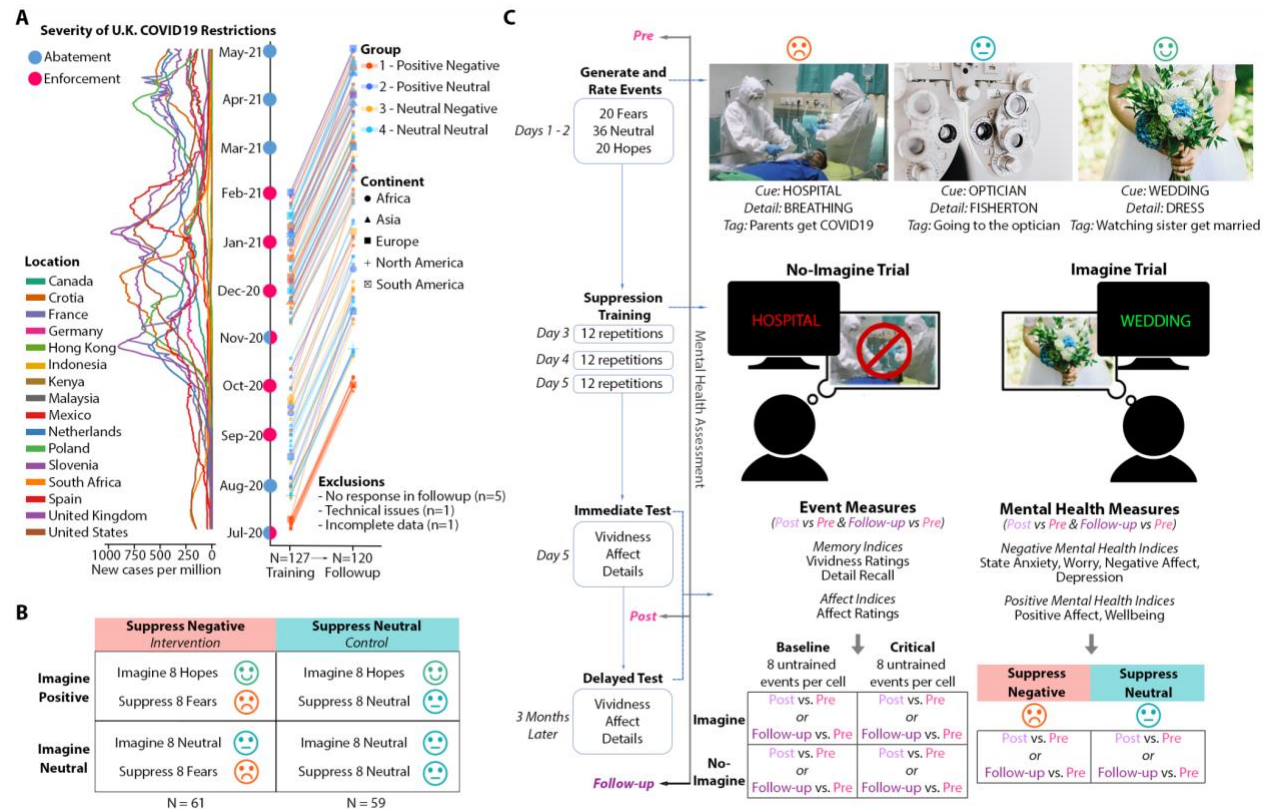


Fig. 1. Experimental design and procedure.

(A) 120 participants from 5 continents participated in online suppression training and a follow-up assessment three months later during the Covid-19 pandemic. (B) We randomly assigned participants to suppress their fears (primary intervention, Suppress-Negative, $N = 61$) or neutral events (control, Suppress-Neutral, $N = 59$), with half of each group assigned to also imagine Positive or Neutral future events. (C) Participants first generated 20 fears, 36 neutral events and 20 hopes (over 2 days) each with a cue, a key detail, a short tag line, and a brief description with more details (images in figure are for illustration only). They then rated event characteristics, and had their mental health assessed; 3 days of retrieval suppression practice ensued, each session was composed of 12 No-Imagine and 12 Imagine repetitions in response to No-Imagine and Imagine cues, respectively. No-imagine cues (appearing in red) required participants to attend to the cue whilst suppressing retrieval of any imagery or thoughts; Imagine cues (appearing in green) required participants to imagine the event. Immediately after the final training session, we tested memory and affect for generated events, and assessed mental health; we repeated these assessments after 3 months. Analyses of event measures focused on changes in memory and affect for each event after training compared to before (post vs pre; or follow-up vs pre), as did measures of mental health. Event analyses permit assessment of the effects of imagination (Imagine row) or suppression (No-Imagine row). For more details regarding experimental design, participants, remote testing structure, experimental procedure, and statistical analyses, see *Section 3.4. Materials & Methods*.

Table 2.*A. Demographic Characteristics of Participants*

	Suppress-Negative		Suppress-Neutral	
	n	%	n	%
Gender				
Female	51	83.61	42	71.19
Male	10	16.39	14	23.73
Missing	0	0.00	3	5.09
Ethnicity				
Any other White background	21	34.43	11	18.64
Any other ethnic group	0	0.00	1	1.69
Arab	1	1.64	0	0.00
Asian / Asian British	7	11.48	11	18.64
Black / African / Caribbean / Black British	2	3.28	6	10.17
Mixed / Multiple ethnic background	3	4.92	3	5.08
White British	27	44.26	25	42.37
Missing	0	0.00	2	3.39

Note. $N = 120$ (Suppress-Negative: $n=61$, Suppress-Neutral: $n=59$). Participants were on average 27.41 years old ($SD = 10.21$), and participant age did not differ by group. No significance was found from independent t-tests between Suppress-Negative and Suppress-Neutral groups across measures.

B. Participants' Mental Health Characteristics Prior to Training

Baseline characteristic	Suppress-Negative		Suppress-Neutral	
	μ	SD	μ	SD
Positive Mental Health Indices				
Positive Negative Affect Schedule - Positive	31.93	7.80	32.58	8.89
Warwick-Edinburgh Mental Well-being Scale	46.87	9.52	48.00	10.30
Negative Mental Health Indices				
State Trait Anxiety Inventory - State	36.43	10.74	36.31	11.15
Penn State Worry Questionnaire	21.54	15.53	22.75	15.28
Positive Negative Affect Schedule - Negative	19.43	6.97	18.97	6.59
Beck's Depression Inventory II	12.54	9.79	11.34	9.29
Predictors of Training Response				
State Trait Anxiety Inventory - Trait	42.72	12.18	43.44	12.65
Impact of Events Scale Revised	22.87	14.69	24.17	17.37

Note. Positive and Negative Mental Health Indices contributed to the main indices of mental health and were also measured post-training and at followup. Here we display raw questionnaire scores, though in most figures and analyses we used POMP scores (percentage of maximum point, see section on *Statistical Analyses*). No significance was found from independent t-tests between Suppress-Negative and Suppress-Neutral groups across measures.

C. Event Characteristics

<i>To-Be Suppressed Events</i>	Suppress-Negative				Suppress-Neutral			
	Baseline		No-Imagine		Baseline		No-Imagine	
	μ	SD	μ	SD	μ	SD	μ	SD
Current Source of Concern	3.17	0.69	3.13	0.67	2.34	1.02	2.37	1.11

Distance in the Future	2.77	0.59	2.85	0.70	1.94	0.60	1.88	0.65
Emotional Intensity	2.56	0.75	2.53	0.83	5.52	0.57	5.52	0.69
Frequency of Thought	3.09	0.66	3.00	0.61	2.48	0.88	2.44	0.95
Likelihood of Occurrence	2.73	0.55	2.71	0.60	4.19	0.58	4.20	0.61
Long-term Impact	3.54	0.55	3.49	0.65	2.28	0.76	2.23	0.84

<i>To-Be Imagined Events</i>	Imagine-Positive				Imagine-Neutral			
	Baseline		Imagine		Baseline		Imagine	
	μ	SD	μ	SD	μ	SD	μ	SD
Current Source of Concern	3.17	0.75	3.20	0.75	2.25	0.89	2.28	0.91
Distance in the Future	3.26	0.67	3.27	0.71	1.70	0.50	1.80	0.49
Emotional Intensity	7.43	0.73	7.37	0.78	5.58	0.73	5.54	0.68
Frequency of Thought	3.15	0.60	3.15	0.65	2.43	0.84	2.43	0.85
Likelihood of Occurrence	3.54	0.65	3.38	0.71	4.30	0.55	4.23	0.52
Long-term Impact	3.55	0.60	3.51	0.62	2.23	0.87	2.25	0.87

Note. All reported event rating measures were collected prior to suppression training and were used algorithmically to assign events so as to match Baseline and Imagine or Baseline and No-Image conditions prior to training. **Current Source of Concern:** the extent to which the event is a source of current focus of one's thoughts, where 1 is not at all, 3 is to some extent, and 5 is most definitely. **Distance in Future:** how far in the future one imagines the event happening, with 1 being very soon and 5 being further in the future, with the maximum being 2 years away. **Emotional Intensity:** how strongly the event makes one feel, where 1 is very unpleasant and 9 is very pleasant (Manikin scale wherein 5 is neutral). **Frequency of Thought:** how often one tends to think about the event, with 1 being rarely and 5 being very often. **Likelihood of Occurrence:** how likely the event is to actually happen to the person, with 1 being a very unlikely event and 5 being almost certain to happen. **Long-Term Impact:** how much long-term impact (aversive or beneficial) the event will have on one's physical and/or psychological well-being if the event were to come true, such that: 1-none at all, 2-negligible, 3-small, 4-moderate, 5-large/formidable. No significant differences were found in independent t-test between Baseline and No-Imagine (or Baseline and Imagine) conditions in any of the rating scales for any group.

Our central focus, however, was on whether training participants to suppress distressing thoughts causally affected their mental health. Worsening or improvement in mental health should be measurable as changes on clinical indices of depression, anxiety, worry, affect, and well-being (see section on Materials). We quantified such changes by measuring these clinical features before and after thought suppression training and after 3-months. To detect mental health effects unique to suppressing distressing thoughts, we compared changes in our indices for a group that suppressed feared events (the Suppress-Negative group, $N = 61$) to changes in a control group that suppressed neutral events (the Suppress-Neutral group, $N = 59$). Mental health changes in the Suppress-Neutral group provide a rigorous control against which to assess the unique effects of suppressing unpleasant content by quantifying general changes arising from other factors: from participants generating positive, negative, and neutral events at the study's outset; from receiving thought suppression training in general; from placebo effects, or from socially interacting with an experimenter. If suppressing feared events harms or

benefits participants, mental health changes for the Suppress-Negative group should exceed those in the Suppress-Neutral group. In a complementary manipulation, we juxtaposed the mental health effects of suppressing fearful thoughts with those induced by positive imagery about hopeful future events. On Imagine trials, half of the participants imagined positive future events (Imagine-Positive), and half, neutral events (Imagine-Neutral), within each of the two Suppress groups (Fig. 1B). This manipulation enabled us to evaluate the mental health impact of thought suppression in relation to the effects of a popular approach to enhancing mood: positive thinking (Blackwell et al., 2013; Holmes & Mathews, 2005; A. D. Williams et al., 2013). However, for most of the analyses in this chapter, the data is not presented in the structure of four groups (Fig. 1B), but rather is collapsed into two groups differing by the valence of suppressed content (i.e., suppression of negative events vs. neutral events). This is because no effects of interest (either with respect to mental health change or with respect to SIF on our event measures) interacted with the Imagine-Positive/Imagine-Neutral manipulation. Specifically, using our mental health change latent variable values as a dependent measure (i.e., factor from principal component analysis factor, PCA, will be discussed in section 3.2.), in a 2 x 2 between-subjects design with valence of suppressed content (Suppress-Negative vs Suppress-Neutral) and valence of imagined content (Imagine-Positive, Imagine-Neutral) as factors, we observed no interaction, $F < 1$. Thus, observations of significant difference between Suppress-Negative and Suppress-Neutral conditions, as will be illustrated in the rest of this chapter, did not vary as a function of what people imagined. So, the conclusions based on the main effect of valence of suppressed content (Suppress-Negative vs. Suppress-Neutral) are representative of the data.

Impact of Thought Suppression on Feared Events

We first tested how thought suppression training affected memory for the suppressed events. We sought evidence for ironic increases in accessibility of suppressed content to quantify the risk of training people to suppress their fears. In healthy individuals, suppressing retrieval typically reduces later recall of the suppressed content, at least for simple words and images (M. C. Anderson & Green, 2001; M. C. Anderson & Hulbert, 2021; Stramaccia et al., 2021). This SIF effect is established by showing that

the final recall of suppressed items is lower than that of Baseline items that were also encoded initially, but that were neither suppressed nor retrieved after encoding. Consistent with this pattern, after suppression training, participants recalled the key detail of their personal events less often. Participants recalled fewer No-Imagine (i.e., suppressed) than Baseline items overall, $F(1,118) = 8.31$, $p = .005$, $\eta_p^2 = 0.066$, and this effect did not vary across the Suppress-Negative and Suppress-Neutral groups, $F_s < 1$ (Table 3; Fig. 2). We also tested whether suppression altered events' phenomenological quality by quantifying changes in reported vividness (1 = not vivid / not much detail, 5 = very vivid / as if experiencing it now) observed after training compared to before training. Suppressed events showed larger reductions in vividness (relative to pre-training) than did Baseline events, $F(1,118) = 6.61$, $p = .01$, $\eta_p^2 = 0.053$, and this effect did not vary across the Suppress-Negative and Suppress-Neutral groups, $F < 1$ (Table 3; Fig. 2). Thus, as with laboratory stimuli, suppression reduced access to feared and neutral personal events, at least on a retention test immediately after suppression.

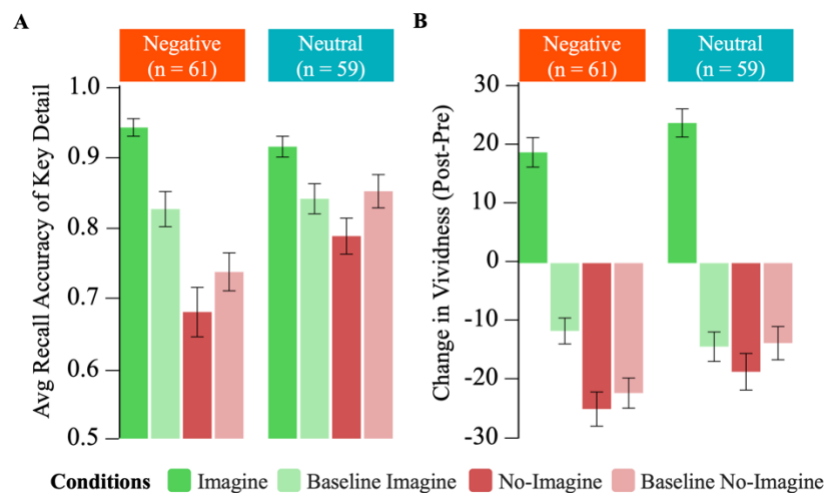


Fig. 2. Impact of imagination and suppression on event memory.

(A) Imagining future events increased the probability of recalling events' key details (dark green bars), relative to the probability of recalling the key details in matched Baseline events that did not receive repeated imagination trials during the 3-days of training (light green bars). In contrast, suppressing thoughts of future events reduced the probability of recalling events' key details (dark red bars) relative to the probability of recalling key details for matched Baseline events (light red bars). Half of the participants suppressed feared events (left half), and half suppressed neutral events (right half). Notably, within the Negative group (left half), the events in the No-Imagine and Baseline-No-Imagine conditions are uniformly negative, whereas within the neutral group (right half), those same conditions concern uniformly neutral events. In contrast, within the Negative group (left half), half of the participants imagined Positive events and half, Neutral events (with corresponding Positive and Neutral Baseline-Imagine events); in the Neutral group, the same was true (see Fig. 1B for a design overview). (B) The increase in the vividness of events post training, compared to pre-training, was greater when participants repeatedly imagined those events during training (dark green bars) compared to the vividness changes observed for Baseline

events that were not repeatedly imagined during training (light green bars). In contrast, the reduction in vividness of events post-training, compared to pre-training, was greater when participants repeatedly suppressed those events during training (dark red bars), compared to changes observed for Baseline events that were not repeatedly suppressed (light red bars). The organisation of Panel B is analogous to Panel A, with half of the participants suppressing Negative events (left half) and half suppressing Neutral events (right half). Instead of plotting changes in the vividness rating scale directly, scores in Panel B are computed as POMP scores. Error bars reflect standard errors.

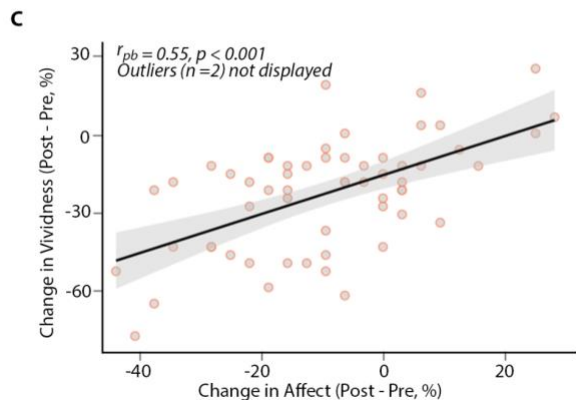
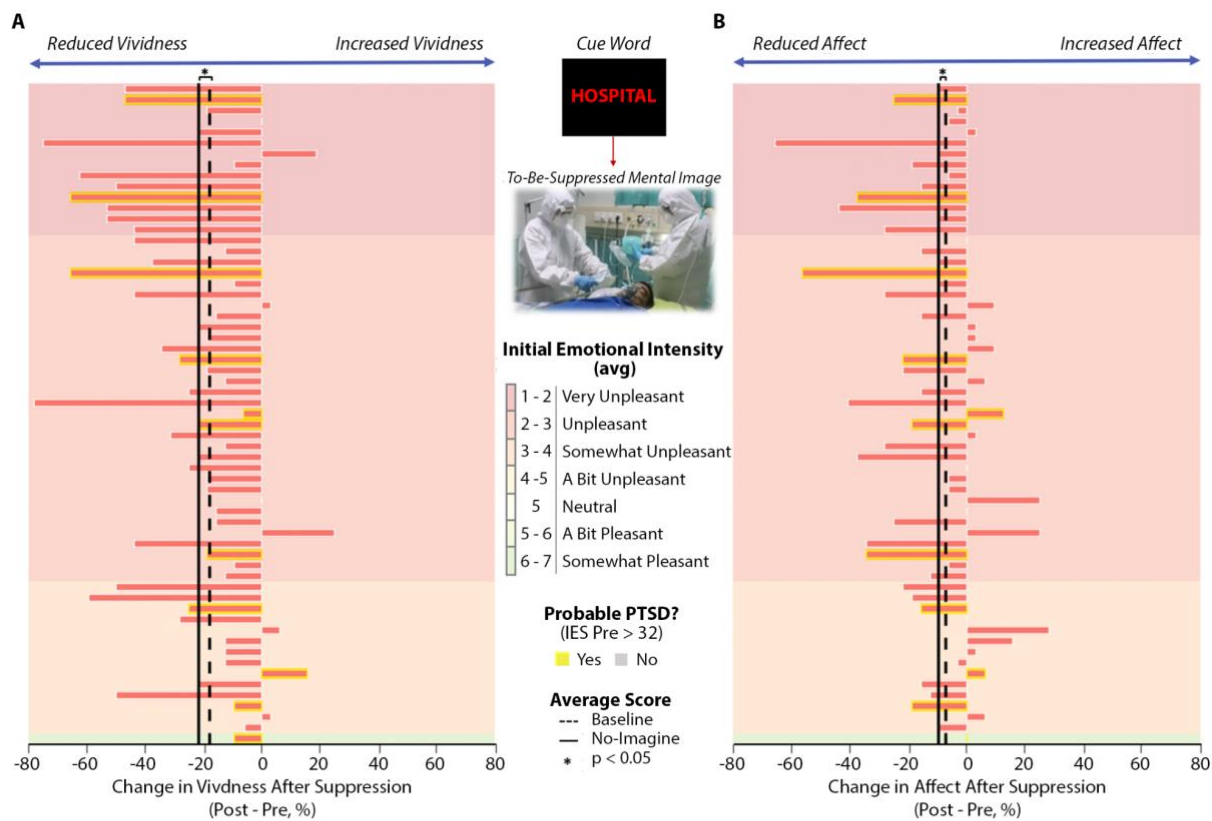
Table 3.*Immediate Effects of Suppression & Imagination on Key Detail Recall and Vividness*

	Suppression						Imagination					
	Baseline		No-Imagine		SIF		Baseline		Imagine		IIF	
	μ	SD	μ	SD	μ	SD	μ	SD	μ	SD	μ	SD
Key Detail Recall												
Suppress-Negative	0.74	0.21	0.68	0.27	0.06	0.26	0.83	0.19	0.94	0.10	0.12	0.19
Suppress-Neutral	0.85	0.18	0.79	0.20	0.06	0.19	0.84	0.16	0.91	0.11	0.07	0.17
<i>Overall</i>	0.79	0.20	0.73	0.24	0.06	0.23	0.83	0.18	0.93	0.11	0.10	0.18
Vividness												
Suppress-Negative	-0.88	0.80	-0.99	0.91	0.11	0.60	-0.46	0.69	0.75	0.78	1.21	1.07
Suppress-Neutral	-0.54	0.87	-0.74	0.95	0.19	0.68	-0.57	0.77	0.95	0.73	1.52	1.04
<i>Overall</i>	-0.72	0.85	-0.87	0.94	0.15	0.64	-0.51	0.73	0.85	0.76	1.36	1.06

Note. SIF: suppression induced forgetting, IIF: imagination induced facilitation. Key Detail recall reflects the percentage of items correctly recalled. Vividness reflects the change in rated vividness after suppression compared to before it (post-pre).

The preceding findings show that training people to suppress the retrieval of fearful thoughts does not lead those thoughts to rebound ironically on average. However, group-level memory declines for suppressed content could mask ironic effects for some individuals. Rebound effects could precipitate adverse events of clinical concern. To address the likelihood of rebound effects, we sought individual participants for whom the accessibility of suppressed details or fearful imagery increased on the post-training measure compared to the pre-training measure. If ironic rebound effects are a serious concern, such post-suppression increases should be common. Across the whole sample of 120 participants, No-Imagine items were associated with lower key detail recall ($F(1,118) = 109.4, p < .001, \eta_p^2 = 0.481$) and reduced vividness ($F(1,118) = 103.608, p < .001, \eta_p^2 = 0.468$) after, compared to before training. Only 1 person out of 120 showed higher detail recall for suppressed items post-training. Of the 61 participants that suppressed fears, 6 reported increased vividness for No-Imagine items post-training (Fig. 3A); of the 59 participants who suppressed neutral events, 15 reported increased vividness. Critically, however, these cases are unlikely to reflect ironic rebound effects: a similar number of

participants reported increases for Baseline events (for Baseline items in the Suppress-Negative and Suppress-Neutral groups, 5 and 14 participants, respectively, showed increased vividness, and 1 and 4, respectively increases in detail recall). We performed a relative risk analysis assessing the chance of increased accessibility after suppressing fears or neutral events, relative to their respective baselines (Table 4A). Suppressing fearful or neutral thoughts did not increase the relative risk of ironic effects in either vividness or key detail recall (Fig. 3D, Table 4A). Even when we examined individual feared events, the number of fears (per participant) showing increased vividness did not vary across the Baseline and No-Imagine conditions in any group (see Table 4B).



D

	Suppress Negative (N=61)		Suppress Neutral (N=59)	
	Increase	No Increase	Increase	No Increase
Vividness				
No-Imagine	6.0	55.0	15.0	44.0
Baseline	5.0	56.0	14.0	45.0
Affect				
No-Imagine	15.0	46.0	13.0	46.0
Baseline	15.0	46.0	15.0	44.0
Relative Risk of Ironic Increase, CI				
Vividness	1.2 [0.4, 3.7]		1.1 [0.6, 2.0]	
Affect	1.0 [0.5, 1.9]		0.9 [0.5, 1.7]	

Fig. 3. Changes in fear, vividness, and emotion after suppression reveal benefits, not ironic rebound.

(A) Suppressing fears reduced their vividness on an immediate test for nearly all participants, irrespective of the initial emotional intensity of those fears or participants' post-traumatic stress status; horizontal bars are individual participants' average change in vividness (post – pre; POMP scores). Participants are sorted vertically by the average emotional intensity of fears pre-training from least (bottom bars, light orange background) to most intense (top bars, darker red background); yellow highlights on bars indicate participants with probable PTSD. Across negative and neutral events, vividness reductions were significantly greater for No-Imagine than for Baseline items and did not vary reliably by event valence (mean changes indicated by solid black vs dotted vertical bars; see text for statistics) and are greater for participants whose events are initially more intense ($r = .28$, $p = .027$). (B) Suppressing feared events reduced their affective tone for most participants (1 = not anxious at all, 5 = extremely anxious), irrespective of initial emotional intensity (as assessed on a separate 9-point scale-see Supplementary Methods) and PTSD status; affect reductions were greater for No-Imagine than for Baseline items (solid black vs dotted vertical bars). (C) In the Suppress-Negative group, the more that suppression training reduced fear vividness, the greater the reduction in perceived fear intensity. (D) Suppressing future events rarely increased vividness or affect post-training compared to pre-training and the frequency of increases never exceeded those observed for baseline events that were never suppressed, irrespective of event valence. The relative risk of an adverse event (a suppression-related increase in their fears' vividness or affective intensity) was near to 1.0 (no increase in risk) for both the Suppress-Negative and Suppress-Neutral conditions (confidence intervals [in brackets] spanning 1.0 reflect non-significant changes in risk).

Table 4.

A. *Relative Risk of Increased Accessibility (Reversals) after Training (post – pre) for Suppressed Events Compared to Baseline Events in the Suppress-Negative and Suppress-Neutral groups.*

	Suppress-Negative			Suppress-Neutral		
	# Subj With Reversals	# Subj Without Reversals	Absolute Risk (%)	# Subj With Reversals	# Subj Without Reversals	Absolute Risk (%)
Key Detail Recall						
No-Imagine	1.00	60.00	1.64	0.00	59.00	0.00
Baseline No-Imagine	1.00	60.00	1.64	4.00	55.00	6.78
Relative Risk [95% CI]	1.00 [0.06, 15.63]			Undefined		
Vividness						
No-Imagine	6.00	55.00	9.84	15.00	44.00	25.42
Baseline No-Imagine	5.00	56.00	8.20	14.00	45.00	23.73
Relative Risk [95% CI]	1.20 [0.39, 3.72]			1.07 [0.57, 2.02]		

Note. Relative risks are “undefined” if a calculation resulted in division by zero. If the relative risk = 1, or if the 95% confidence interval includes 1, then there is no significant difference between the groups.

B. *Average Number of Fears Per Participant that Show Increased Accessibility (Reversals) After Training Compared to Before (post – pre) for the No-Imagine and Baseline Conditions, separately for the Suppress-Negative and Suppress-Neutral Groups. Reversals Shown for Both Key Detail Recall and Vividness.*

	Suppress-Negative		Suppress-Neutral	
	μ	SD	μ	SD
Key Detail Recall				
No-Imagine	0.02	0.13	0.00	0.00
Baseline No-Imagine	0.02	0.13	0.07	0.25

Vividness				
No-Imagine	0.10	0.30	0.25	0.44
Baseline No-Imagine	0.08	0.28	0.24	0.43

We considered the possibility that ironic rebound effects only arise for emotionally intense fears of great concern to participants. To address this, we examined whether the degree to which suppression training reduced vividness or detail recall for No-Imagine fears varied according to participants' initial emotional intensity ratings for those fears. Contrary to such concerns, greater fear intensity was associated with larger suppression-related reductions in vividness after training compared to before training, $r = .283$, $p = .027$ (Fig. 3A). Initial emotional intensity was not associated with declines in detail recall, $r = -.068$, $p = .604$.

The foregoing findings only address the impact of suppression immediately after training. Suppression might briefly benefit participants yet trigger hazardous hyper-accessibility of suppressed thoughts at longer delays. Indeed, SIF was not detected after 3-months: at the follow-up, No-Imagine items were no longer recalled more poorly than were Baseline items, nor did they show greater declines in vividness compared to Baseline ($F < 1$ in all cases; Table 5). One interpretation of this pattern is that suppression dissipated over the delay, causing an ironic rebound in fear accessibility. Contrary to this rebound effect, both memory for key details of No-Imagine items ($F(1,118) = 1731.8$, $p < .001$, $\eta_p^2 = 0.936$), and the vividness of No-Imagine items ($F(1,118) = 27.74$, $p < 0.001$, $\eta_p^2 = 0.19$) remained far lower, not higher, after 3 months than they were prior to suppression, with no indication of any special resurgence of these suppressed items. For example, after 3 months, in the Suppress-Negative group, numerically fewer participants showed increased vividness for No-Imagine events (follow-up - pre > 0 , $N = 14$) than showed such increases for Baseline events ($N = 21$); the Suppress-Neutral condition showed no difference ($N = 15$ and $N = 13$ in the No-Imagine and Baseline conditions, respectively). As a result, for fears, the relative risk of ironic increases in vividness of suppressed events, relative to Baseline events suggested decreased, not increased risk, though this reduction was not significant (Table 6A). Even when we examined individual events, the number of fears (per participant) that increased in accessibility did not differ between No-Imagine and Baseline conditions for any measure or group ($F_s < 1$; Table 6). These findings suggest that suppression does not trigger rebound processes.

Table 5.*Delayed Effects of Suppression & Imagination on Key Detail Recall and Vividness at 3 Months*

	Suppression						Imagination					
	Baseline		No-Imagine		SIF		Baseline		Imagine		IIF	
	μ	SD	μ	SD	μ	SD	μ	SD	μ	SD	μ	SD
Key Detail Recall												
Suppress-Negative	0.17	0.21	0.18	0.20	0.00	0.19	0.21	0.20	0.25	0.19	0.04	0.20
Suppress-Neutral	0.19	0.17	0.18	0.18	0.00	0.20	0.25	0.21	0.31	0.22	0.06	0.22
<i>Overall</i>	0.18	0.19	0.18	0.19	0.00	0.19	0.23	0.21	0.28	0.20	0.05	0.21
Vividness												
Suppress-Negative	-0.61	0.84	-0.57	0.76	-0.04	0.66	-0.31	0.75	-0.12	0.75	0.19	0.75
Suppress-Neutral	-0.22	0.78	-0.18	0.80	-0.04	0.65	-0.16	0.64	0.05	0.73	0.22	0.66
<i>Overall</i>	-0.42	0.83	-0.38	0.80	-0.04	0.65	-0.24	0.70	-0.03	0.74	0.20	0.71

Note. SIF: suppression induced forgetting, IIF: imagination induced facilitation. Key Detail recall reflects the percentage of items correctly recalled. Vividness reflects the change in rated vividness after suppression compared to before it (post-pre).

Table 6.

A. Relative Risk of Increased Accessibility (Reversals) after Training (followup – pre) for Suppressed Events Compared to Baseline Events in the Suppress-Negative and Suppress-Neutral groups.

	Suppress-Negative			Suppress-Neutral		
	# Subj With	# Subj	Absolute	# Subj With	# Subj	Absolute
	Reversals	Without Reversals	Risk (%)	Reversals	Without Reversals	Risk (%)
Key Detail Recall						
No-Imagine	0.00	61.00	0.00	0.00	59.00	0.00
Baseline No-Imagine	0.00	61.00	0.00	0.00	59.00	0.00
Relative Risk [95% CI]		Undefined			Undefined	
Vividness						
No-Imagine	14.00	47.00	22.95	21.00	38.00	35.59
Baseline No-Imagine	14.00	47.00	22.95	26.00	33.00	44.07
Relative Risk [95% CI]		1.00 [0.52, 1.92]			0.81 [0.52, 1.26]	

Note. Relative risks are “undefined” if a calculation resulted in division by zero. If the relative risk = 1, or if the 95% confidence interval includes 1, then there is no significant difference between the groups.

B. Average Number of Fears Per Participant that Show Increased Accessibility (Reversals) After Training Compared to Before (followup – pre) for the No-Imagine and Baseline Conditions, separately for the Suppress-Negative and Suppress-Neutral Groups. Reversals Shown for Both Key Detail Recall and Vividness.

	Suppress-Negative		Suppress-Neutral	
	μ	SD	μ	SD
Key Detail Recall				
No-Imagine	0.00	0.00	0.00	0.00
Baseline No-Imagine	0.00	0.00	0.00	0.00

Vividness				
No-Imagine	0.23	0.42	0.36	0.48
Baseline No-Imagine	0.23	0.42	0.44	0.50

Finally, we tested whether people reporting higher trait anxiety or pandemic-related post-traumatic stress suppressed event details or imagery less well. Participants reporting mental health symptoms may be especially vulnerable to rebound effects. We tested whether indices of mental health collected before training predicted declines in vividness, and key detail memory for No-Imagine fears in the Suppress-Negative group. Contrary to rebound concerns, suppression-related declines in vividness were greater, not smaller, the higher the reported trait anxiety ($r = -.264$, $p = .04$), and the higher the reported depression ($r = -.324$, $p = .011$) with the effect of depression surviving statistical correction (Benjamini & Hochberg, 1995). Vividness declines were not reliably related to pandemic-related post-traumatic stress ($r = -.11$, $p = .41$; Fig. 3A). For memory of key details, neither higher trait anxiety ($r = -.116$, $p = .372$) nor depression ($r = -.074$, $p = .57$) predicted smaller declines in recall, and higher post-traumatic stress scores marginally predicted larger, not smaller, declines in recall ($r = -.25$, $p = .052$). Similar though weaker relationships arose after 3 months (e.g., $r = -.21$, $p = .10$, when relating pre-training trait anxiety to suppression-related declines in vividness), providing no evidence of increased vulnerability.

Together, these findings provide no indication that training people to suppress distressing thoughts of feared events triggered ironic rebounds in the accessibility of those thoughts on either an immediate or delayed test. Ironic effects were absent even for participants reporting high anxiety, depression, or post-traumatic stress, who instead often showed greater suppression-related declines.

Reduced Affective Responses to Feared Events

Suppression training could intensify emotional responses to the suppressed content even if it fails to trigger ironic rebound effects in memory. If suppressed thoughts grow more distressing (Koster et al., 2003; Quartana & Burns, 2007; Wegner, 2009), adverse psychological events may occur. Theories of clinical disorders often posit escalating emotional responses to suppressed content, especially when

thought suppression failures trigger negative self-appraisals (Koster et al., 2003; McEvoy, 2019; Quartana & Burns, 2007). On the other hand, suppressing the retrieval of aversive pictures reduces later affective responses on both subjective and psychophysiological measures of emotion (Benoit et al., 2016; Gagnepain et al., 2017; Harrington et al., 2020; Legrand et al., 2020; Nishiyama & Saito, 2022). To evaluate suppression training's effect on subjective emotion, we tested whether participants' ratings of their affective responses to suppressed events changed after suppression training compared to before training (post – pre). If suppression triggers ironic rebounds, affect ratings should grow more negative for suppressed events after training. However, affect ratings for No-Imagine events were lower compared to before suppression, $F(1,118) = 37.018$, $p < .001$, $\eta_p^2 = 0.239$ (Fig. 3B). As with laboratory findings (Harrington et al., 2020; Legrand et al., 2020; Nishiyama & Saito, 2022), declines were greater for No-Imagine than for Baseline events, $F(1,118) = 4.136$, $p = 0.044$, $\eta_p^2 = 0.034$, and this affective SIF did not vary across Suppression groups, $F < 1$ (Table 7). Consistent with our memory indices, suppression-specific reductions in affective responses were not detected at 3-months, with no differences observed for No-Imagine and Baseline items, $F < 1$ (Table 7). However, at 3 months, affective ratings of No-Imagine events remained lower compared to pre-training, ($F(1,118) = 32.89$, $p < .001$, $\eta_p^2 = 0.218$), establishing that time's passage did not ironically increase subjective emotions to suppressed future fears. Importantly, for feared events, suppression-related reductions in affect and vividness were robustly associated, suggesting that rendering thoughts less accessible weakens their capacity to instill anxiety (Fig. 3C).

In the Suppress-Negative group, few participants ($N = 15$) reported more anxiety about suppressed fears after training, and the number was the same for non-suppressed baseline fears ($N = 15$). Given this pattern, the relative risk of a rebound in anxiety about suppressed fears was 1.0, indicating that the risk was no different than when no suppression had occurred (Fig. 3D; Table 8). A similar pattern arose after suppressing neutral events (Fig. 3D; Table 8). After 3-months, similar results arose for both groups, with no increased risk of ironic effects (Table 8). Higher post-traumatic stress did not reliably predict smaller suppression-related affect declines (post-traumatic stress, $r = -.07$, $p = .62$), and both higher trait anxiety ($r = -.232$, $p = .07$) and depression ($r = -.32$, $p = .01$) prior to training showed

trends towards steeper declines in affect for suppressed fears, not smaller declines. Pre-training anxiety and depression were not reliably related to the decline in affect that fears showed after 3 months ($r = -.002$ and $r = -.019$, respectively). Finally, the average emotional intensity of a participant's fear at the study's outset (as indexed by a distinct measure from that used to assess affect reductions—see Supplementary Methods) did not predict the suppression-related affect reduction measured on immediate or delayed tests (immediate; $r = .007$, $p = .94$; delayed; $r = .171$, $p = .062$). Together, these findings show that suppression training caused no measurable rebound effects on emotional responses to feared events regardless of their initial intensity, and often reduced affective responses on immediate tests. Suppression-related reductions in perceived fear were more prominent for people reporting higher trait anxiety and depression.

Table 7.*Effects of Suppression & Imagination on Subjective Affect*

	Suppression						Imagination					
	Baseline		No-Imagine		SIF		Baseline		Imagine		IIF	
	μ	SD	μ	SD	μ	SD	μ	SD	μ	SD	μ	SD
Immediate (Post - Pre)												
Suppress-Negative	-0.34	0.68	-0.45	0.74	0.11	0.51	-0.19	0.48	0.07	0.57	0.26	0.55
Suppress-Neutral	-0.25	0.75	-0.33	0.65	0.09	0.55	-0.09	0.54	0.28	0.57	0.37	0.52
<i>Overall</i>	-0.29	0.71	-0.39	0.70	0.10	0.53	-0.14	0.51	0.17	0.58	0.31	0.53
Delayed (Followup - Pre)												
Suppress-Negative	-0.59	0.73	-0.57	0.70	-0.01	0.56	-0.29	0.57	-0.20	0.56	0.09	0.47
Suppress-Neutral	-0.17	0.68	-0.17	0.72	0.00	0.58	0.00	0.73	-0.01	0.63	0.00	0.53
<i>Overall</i>	-0.38	0.73	-0.37	0.73	0.00	0.57	-0.15	0.67	-0.11	0.60	0.04	0.50

Note. SIF: suppression induced forgetting, IIF: imagination induced facilitation. Scores for subjective affect reflect the change in affective rating after suppression (either Post – Pre in the Immediate condition, or Followup – Pre in the Delayed condition).

Table 8.

Relative Risk of Increased Affect (Reversals) after Training (Post-Pre or Followup – Pre) for Suppressed Events Compared to Baseline Events in the Suppress-Negative and Suppress-Neutral Groups.

	Suppress-Negative			Suppress-Neutral		
	# Subj With Reversals	# Subj Without Reversals	Absolute Risk (%)	# Subj With Reversals	# Subj Without Reversals	Absolute Risk (%)
Immediate (Post - Pre)						
No-Imagine	15.00	46.00	24.59	13.00	46.00	22.03
Baseline No-Imagine	15.00	46.00	24.59	15.00	44.00	25.42
Relative Risk [95% CI]		1.00 [0.54, 1.86]			0.87 [0.45, 1.66]	
Delayed (Followup - Pre)						
No-Imagine	12.00	49.00	19.67	24.00	35.00	40.68
Baseline No-Imagine	10.00	51.00	16.39	19.00	40.00	32.20
Relative Risk [95% CI]		1.20 [0.56, 2.57]			1.26 [0.78, 2.04]	

3.2. Imagine/No-Imagine Training: Mental Health Outcomes

Immediate Effects of Suppression on Mental Health

Detrimental thought suppression effects could emerge on measures of mental health, despite their absence on explicit memory tests. As Freud suggested, suppressing distressing content may preserve it in the unconscious, where it could shape participants' moods, perceptions, and actions (Freud, 1953, 1957). If suppressed content persists perniciously, mental health indices should reveal the symptoms it creates. To test this possibility, we calculated changes in reported depression, state anxiety, worry, positive and negative affect, and well-being from pre-training to post-training. We did this separately for the Suppress-Neutral and Suppress-Negative groups to isolate unique effects of suppressing fears, beyond those of training suppression more generally.

The six inventories used to investigate various mental health states consist of four negative indices and two positive indices. The negative indices were: State portion of the State-Trait Anxiety Inventory Form Y-1 (STAI) (Spielberger et al., 1983), Penn State Worry Questionnaire-Past Day (PSWQ-PD) (Joos et al., 2012), Beck's Depression Inventory II (BDI-II) (Beck et al., 1996), and the negative component of the Positive and Negative Affect Schedule (PANAS) (Watson et al., 1988). We modified the BDI-II to exclude a single item referring to suicidal thoughts due to ethical concerns about triggering suicidal ideation. The positive indices were: Warwick-Edinburgh Mental Well-being Scale (WEMWBS) ('The Warwick-Edinburgh Mental Well-being Scale (WEMWBS)', 2006) and the positive component of the Positive and Negative Affect Schedule (PANAS) (Watson et al., 1988). Given our focus on post-traumatic stress and anxiety during the pandemic, and given a priori concerns about ironic mental health effects, we measured pandemic-related PTSD and trait anxiety to scrutinize our intervention's effect on these vulnerable populations, via the Impact of Events Scale-Revised (IES-R) (Weiss & Marmar, 1997), and the trait portion of the State-Trait Anxiety Inventory Form Y-1 (STAI) (Spielberger et al., 1983). In order to examine mean-level differences between groups, the raw scores from the various mental health scales are transformed with the POMP (percent of maximum possible) method (Cohen et al., 1999) for the figures presented in this chapter. However, for a detailed look at the

raw scores, possible allocation to (sub)clinical ranges, as well as example of sample items, please see Appendix A.

Mental health improved on most measures after training people to suppress distressing thoughts (Fig. 4A). In contrast, training people to suppress neutral thoughts did not improve most measures, except worry and negative affect, which showed comparable gains in both groups (Fig. 4A). To compare mental health benefits across training groups, we conducted a principal component analysis (PCA) on change scores (post-pre) for all 6 measures to derive a latent construct reflecting broad mental health. The rationale behind conducting a PCA is primarily for the purposes of reducing the dimensionality of our data. Given that we had 6 measures, each with its own set(s) of dimensions, we needed to find the maximum variance of our data with fewer dimensions, which in this case projected onto a single subspace or factor since all scales were highly correlated constructs of mental health. This is also the measure used for the latent growth-curve modelling (LGCM) analysis which will be discussed later in relation to the sustained benefits of the training. Using the PCA factor, participants trained to suppress fears were observed to have experienced more improvement in mental health than did those trained to suppress neutral events, $t(118) = -2.012$, $p = .045$ (Fig. 4B). Greater improvement for the Suppress-Negative group cannot be attributed to pre-existing group differences on mental health measures, the nature of the positive, neutral, or negative events generated, or to the amount of SIF they exhibited (see Tables 2A, 2B, 3). This effect suggests that training the suppression of distressing events benefitted participants more than did training suppression itself. Supporting this interpretation, the extent to which training reduced affect for suppressed fears predicted more negative scores (better outcomes) on our mental health latent variable, $r = .27$, $p = .034$.

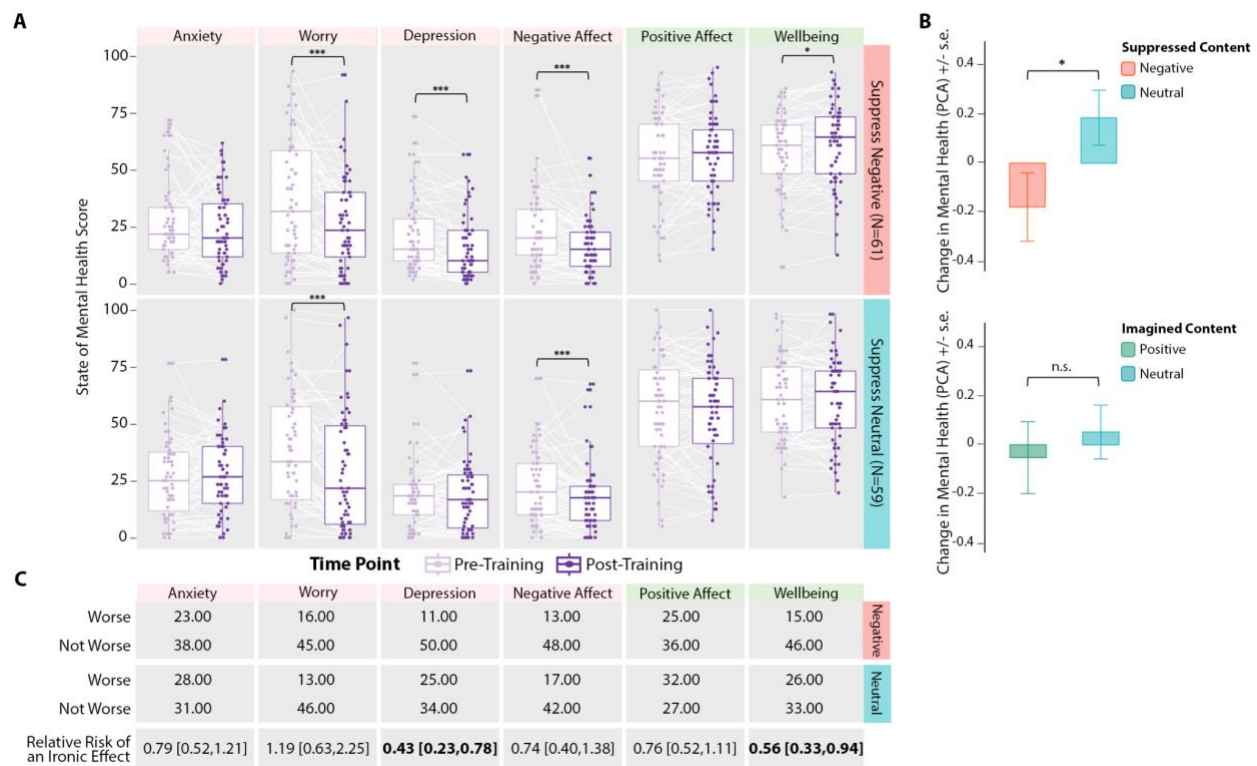


Fig. 4. Suppressing fears both improves and protects mental health.

(A) Training participants to suppress fears (upper half, red label) significantly reduced worry, depression and negative affect, and increased well-being post-training (right-hand bar within each panel) compared to pre-training (lefthand bar within each panel); training at suppressing neutral events (lower half, blue label) reduced worry and negative affect. Individual participants are indicated by dots connected by white lines; boxes reflect interquartile range, and lines reflect median scores. (B) A principal components analysis on change scores (post – pre) for our 4 negative and 2 positive measures yielded a latent variable that revealed more mental health improvement (more negative scores) in the Suppress-Negative than the Suppress-Neutral group; an analysis contrasting participants who imagined positive future events versus neutral events revealed no reliable difference in mental health changes on this latent variable. (C) Suppressing fears generally reduced the chances of an adverse event (a worsening of mental health; i.e., post>pre for negative indices; post< pre for positive indices) compared to suppressing neutral events on nearly every mental health index, significantly so for depression and well-being which exhibited 57% and 44% decreases in the chances of an adverse event, respectively (confidence intervals [in brackets] spanning 1.0 reflect no change in relative risk; significant reductions indicated in boldface).

To be sure that overall training benefits did not disguise ironic effects in the Suppress-Negative group, we quantified how often mental health declined after training for individual participants. In relative risk analyses, no mental health index showed significantly greater risk of ironic effects after suppressing fears than after suppressing neutral thoughts, with most measures indicating numerically less frequent adverse changes for the former (Fig. 4C; Table 9). Strikingly, suppressing fears reduced the risk of an ironic decline in well-being by 44.2% (95% CI = [.33 .94]) and of a worsening of depression by 57.4% (95% CI = [.23, .78]), relative to suppressing neutral events (Fig. 4C). This finding demonstrates

that suppressing unpleasant thoughts plays an important role in protecting people from declining mental health (not simply improving it), aiding in resilience to adverse conditions.

Table 9.

A. *Summary of Relative Risks, Based on Calculations in Detailed Table Below. Significant reductions in risk of ironic worsening were observed for depression and well-being on the immediate test (bold).*

	Immediate	Delayed
State Trait Anxiety Inventory – State	0.79 [0.52, 1.21]	1.25 [0.84, 1.85]
Penn State Worry Questionnaire	1.19 [0.63, 2.25]	1.83 [1.17, 2.85]
Positive Negative Affect Schedule - Negative	0.74 [0.40, 1.38]	0.85 [0.54, 1.33]
Beck's Depression Inventory II	0.43 [0.23, 0.78]	0.67 [0.40, 1.14]
Positive Negative Affect Schedule - Positive	0.76 [0.52, 1.11]	0.93 [0.64, 1.36]
Warwick-Edinburgh Mental Well-being Scale	0.56 [0.33, 0.94]	0.68 [0.47, 1.00]

Note. Relative risks are bolded if statistically significant. Brackets denote the 95% confidence intervals. If the relative risk = 1, or if the 95% confidence interval includes 1, then there is no significant difference between the groups.

B. *Relative Risk of Ironic Worsening (Reversals) in Mental Health After Training the Suppression of Fears, Relative to Training the Suppression of Neutral Events*

	Immediate			Delayed		
	# Subj With Reversals	# Subj Without Reversals	Absolute Risk (%)	# Subj With Reversals	# Subj Without Reversals	Absolute Risk (%)
State Trait Anxiety Inventory – State						
No-Imagine	23.00	38.00	37.70	31.00	30.00	50.82
Baseline No-Imagine	28.00	31.00	47.46	24.00	35.00	40.68
Relative Risk [95% CI]		0.79 [0.52, 1.21]			1.25 [0.84, 1.85]	
Penn State Worry Questionnaire						
No-Imagine	16.00	45.00	26.23	34.00	27.00	55.74
Baseline No-Imagine	13.00	46.00	22.03	18.00	41.00	30.51
Relative Risk [95% CI]		1.19 [0.63, 2.25]			1.83 [1.17, 2.85]	
Positive Negative Affect Schedule - Negative						
No-Imagine	13.00	48.00	21.31	22.00	39.00	36.07
Baseline No-Imagine	17.00	42.00	28.81	25.00	34.00	42.37
Relative Risk [95% CI]		0.74 [0.40, 1.38]			0.85 [0.54, 1.33]	
Beck's Depression Inventory II						
No-Imagine	11.00	50.00	18.03	16.00	45.00	26.23
Baseline No-Imagine	25.00	34.00	42.37	23.00	36.00	38.98
Relative Risk [95% CI]		0.43 [0.23, 0.78]			0.67 [0.40, 1.14]	
Positive Negative Affect Schedule - Positive						
No-Imagine	25.00	36.00	40.98	28.00	33.00	45.90
Baseline No-Imagine	32.00	27.00	54.24	29.00	30.00	49.15

Relative Risk [95% CI]	0.76 [0.52, 1.11]			0.93 [0.64, 1.36]		
Warwick-Edinburgh Mental Well-being Scale						
No-Imagine	15.00	46.00	24.59	24.00	37.00	39.34
Baseline No-Imagine	26.00	33.00	44.07	34.00	25.00	57.63
Relative Risk [95% CI]	0.56 [0.33, 0.94]			0.68 [0.47, 1.00]		

Unlike suppressing fears, training participants to imagine positive and joyful future events conferred little unique benefit. We compared mental health changes after training participants to imagine hopeful future events ($N = 60$) to those after training participants to imagine neutral events ($N = 60$). Because half of each group suppressed negative and half suppressed neutral events, positive imagery's impact can be examined with suppression valence held constant. Although practice at imagining positive events reduced worry and negative affect after training, comparable benefits arose when people practiced imagining neutral events, suggesting that improvements did not stem from positive imagery. Our PCA latent variable for mental health change yielded no reliable advantage for the Imagine-Positive over the Imagine-Neutral group, $t(118) = -.57$, $p = .569$ (Fig. 4B). Moreover, increased positive affect for Imagined scenarios was not related, across participants, to mental health improvement (as indexed by the PCA component) for either imagination group ($r = -.04$ and $-.13$ in the Imagine-Positive and Imagine-neutral groups respectively). The lack of specific benefits of positive imagination cannot be attributed to an ineffective manipulation: Imagined events showed robust increases in detail recall ($F(1,118) = 34.20$, $p < .001$, $\eta_p^2 = 0.225$; interaction with valence, $F < 1$), vividness ($F(1,118) = 197.26$, $p < .001$, $\eta_p^2 = 0.626$, interaction with valence, $F < 1$) and subjective ratings of affect ($F(1,118) = 43.62$, $p < .001$, $\eta_p^2 = 0.27$; interaction with valence, $F(1,118) = 7.73$, $p = .006$, $\eta_p^2 = 0.062$; see Fig. 5). These increases in vividness, memory and affect for specific positive future events, however, did not uniquely improve participants' mental health beyond imagining neutral events.

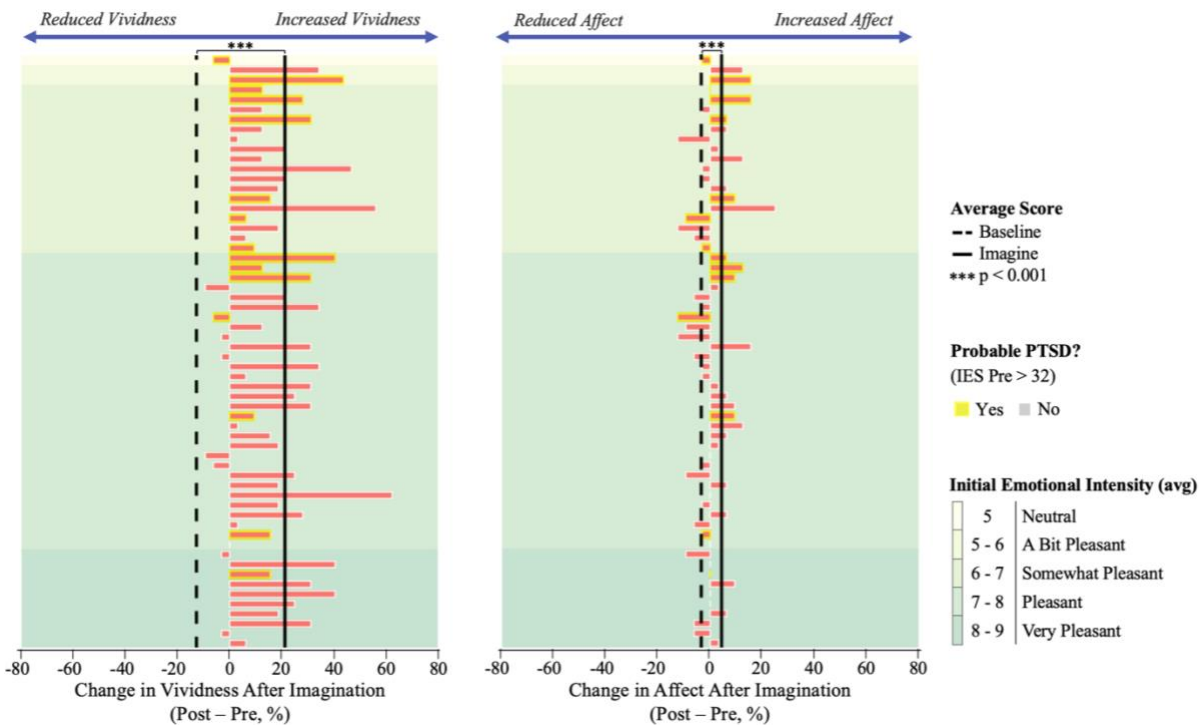


Fig. 5. Impact of imagination of vividness and affect for hopeful events.

Imagining hopeful events increased their vividness on an immediate test for nearly all participants, irrespective of the initial emotional intensity of those hopes and post-traumatic stress status; horizontal bars are individual participants' average change in vividness (post – pre; POMP scores). Participants are sorted by the average rated emotional intensity of their hopes pre-training from most pleasant (bottom bars, darker green background) to neutral (top bars, yellower background); yellow highlights on bars indicate participants with probable PTSD. Vividness facilitations are significantly greater for Imagine than for Baseline items (mean changes indicated by solid black vs dotted vertical bars). In the Imagine-Positive group, imagination increased positive affect for the imagined hopes, as seen by the greater increase in affect (post – pre) for imagined events (solid black bar) compared to baseline events (dotted bar).

Suppression-Training Effects in Anxious and Traumatized Participants

Despite the mental health benefits in our full sample, suppression training may harm those with anxiety, depression, and post-traumatic stress. Pathological worry, rumination, and intrusive memories in these conditions are often attributed to neurobiological deficiencies that may be difficult to rectify with training (Aupperle et al., 2012; Catarino et al., 2015; De Raedt & Koster, 2010; DeGutis et al., 2015; Etkin et al., 2013; Mary et al., 2020; Menon, 2011; Schmitz et al., 2017). People with these conditions may suffer ironic rebound effects. To address this possibility, we tested whether pre-training trait anxiety and pandemic-related post-traumatic stress predicted mental-health improvement (post-training – pre-training).

Contrary to the foregoing concerns, participants reporting higher trait anxiety and post-traumatic stress benefitted the most from suppressing their distressing thoughts. After correcting for multiple comparisons, higher trait anxiety predicted larger reductions in worry, negative affect, and depression and larger increases in positive affect and well-being ($r = -.48, -.61, -.30, .32,$ and $.3$, respectively, significant after Benjamini-Hochberg Correction (Benjamini & Hochberg, 1995); see Fig. 6A). Trait anxiety also predicted larger reductions in state anxiety ($r = -.26, p = .04$) although this did not survive statistical correction. Participants who reported greater pandemic-related post-traumatic stress showed similar though weaker relationships for most mental health indices, and only the benefits to well-being ($r = .34, p = .007$) survived statistical correction (Fig. 6B). Higher trait anxiety ($r = -.52, p < .00001$, Fig. 7A) and post-traumatic stress ($r = -.35, p = .0068$) predicted greater improvement (more negative scores) on our PCA-derived mental-health change latent variable. These correlations did not occur in the Suppress-Neutral group: trait anxiety or post-traumatic stress did not correlate with most individual measures (Figs. 5A and 5B), or with our mental health change latent variable ($r = -.22, p = .1$ and $r = -.22, p = .1$ for trait anxiety [Fig. 7B] and post-traumatic stress respectively). Importantly the correlation between trait anxiety and mental-health improvement (Fig. 7A) was greater for those suppressing negative than neutral content (1-tailed, Fisher's $Z = 1.894, p = .029$), showing that the former correlation is not the inevitable result of participants with the highest scores regressing to the mean, as the opportunity for this was equivalent in both groups. Thus, people suffering from higher trait anxiety or post-traumatic stress benefitted more from suppression training, but only if trained to suppress distressing content.

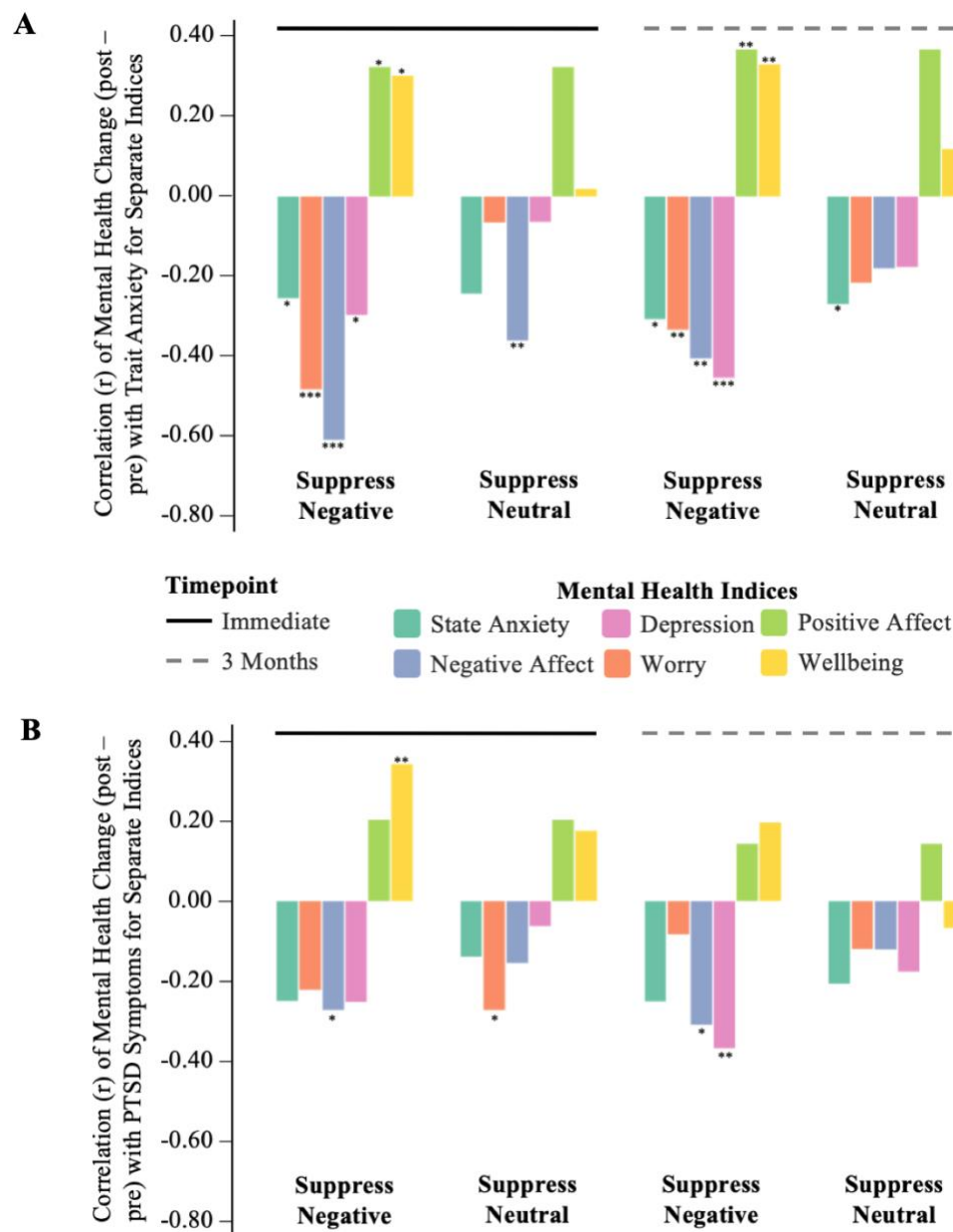
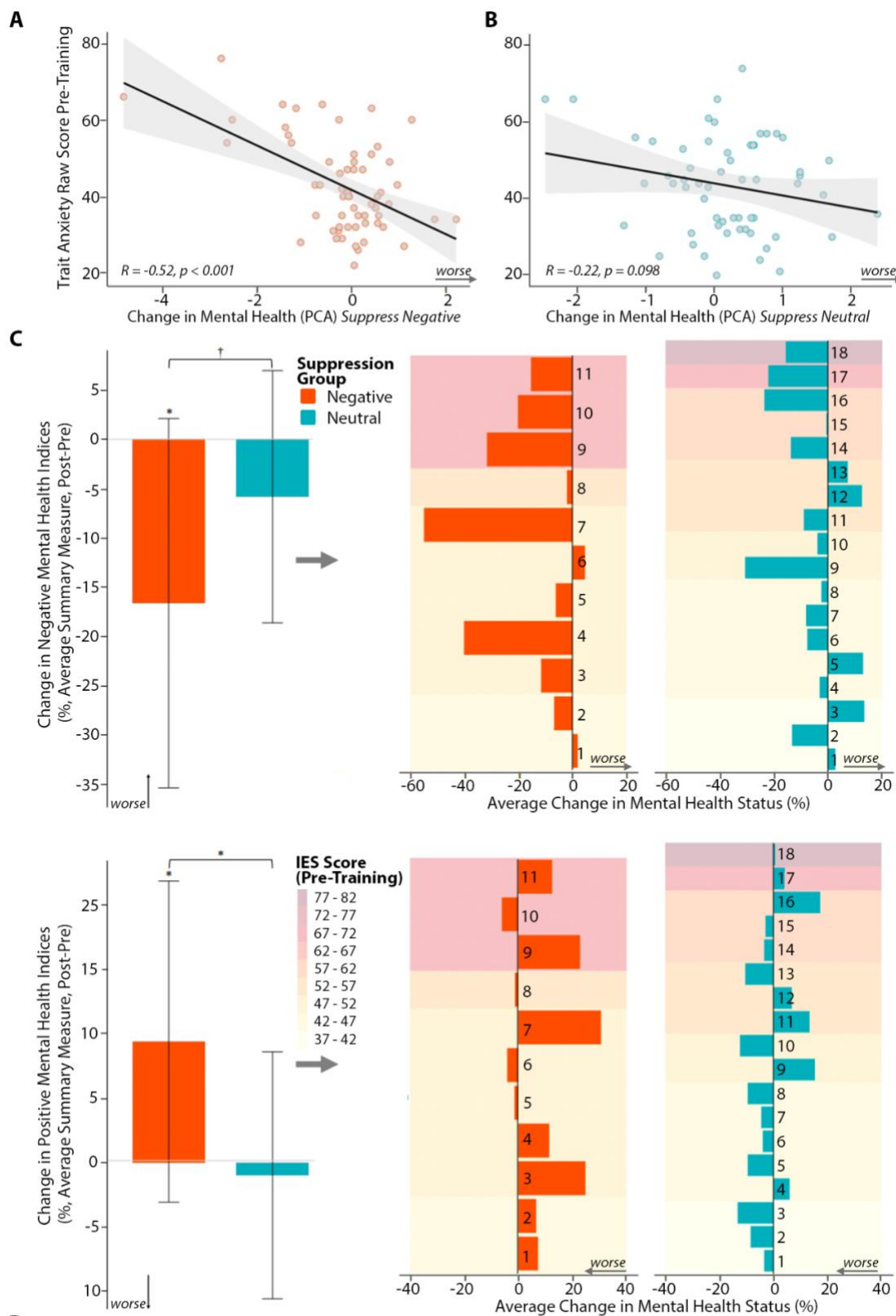


Fig. 6. Pre-Training Trait Anxiety and Post-Traumatic Stress status predicted improvement on individual mental-health measures, but mainly when participants suppressed fears and not neutral events.

(A) Correlations (r values) are plotted on the y-axis; significance is indicated by asterix (** $< .001$; ** $< .01$; * $< .05$). Trait anxiety levels prior to training predicted whether participants showed significant improvements on negative mental health indices (extending downward) and positive indices (extending upwards) arising on the immediate test (post – pre; bars below solid lines) and the 3-month follow-up (follow-up – pre; bars below dotted lines). Trait anxiety predicted improvement (i.e., for all six measures of mental health state) for those who suppressed fears (Suppress-Negative), more so than for those who suppressed neutral events (Suppress-Neutral). (B) Post-traumatic stress scores predicted improvement (post – pre) on some negative mental health indices (negative affect and depression) and positive indices (well-being) on the immediate test (bars

below solid lines) and the 3-month follow-up (follow-up – pre; bars below dotted lines). Such correlations were significant after suppressing fears (Suppress-Negative), but generally not after suppressing neutral events (Suppress-Neutral).



D

Relative Risk of Ironic Worsening	All Subjects	Post-Traumatic Stress	Anxiety	Depression
Negative Indices	1.10 [0.60, 1.99]	0.65 [0.15, 2.81]	0.81 [0.26, 2.53]	0
Positive Indices	0.81 [0.54, 1.99]	0.60 [0.25, 1.41]	0.49 [0.23, 1.05]	0.62 [0.21, 1.79]

Fig. 7. Mental health benefits of suppression training in symptomatic participants.

(A) Higher pre-training trait anxiety scores (STAI-Trait) predicted greater mental health benefits for participants in the Suppress-Negative group on our PCA-derived mental health change latent variable. (B) Trait anxiety did not predict mental health changes in the Suppress-Neutral group. (C) Participants with likely pandemic-related PTSD (IES score > 32) showed mental health improvement on both negative mental health indices (state anxiety, depression, worry, negative affect) and positive indices (well-being and positive affect) after training to suppress fears (Suppress-Negative group) compared to participants trained to suppress neutral events (Suppress-Neutral group). Left panels indicate POMP scores averaged over the negative scales (top) and positive scales (bottom). Right panels show individual participants with likely PTSD in the Suppress-Negative group (left, red) and the Suppress-Neutral group (right, blue), sorted by IES score (least to greatest, from bottom to top) to illustrate that benefits occurred irrespective of PTSD symptom severity. (D) The relative risk of adverse events (a worsening of mental health after training) was never greater after suppressing fears compared to suppressing neutral events whether considering all subjects, or subgroups with likely PTSD (IES > 32), substantial anxiety (STAI-trait > 44), or depression (BDI > 19) (confidence intervals [in brackets] that include 1 indicate no increased risk). * $p < .05$, † $p \sim .05$

Despite the foregoing associations, truly severe anxiety or post-traumatic stress might put participants at elevated risk of ironic rebound effects. To test this possibility, we isolated 23 participants in our Suppress-Negative group with trait anxiety scores warranting clinical concern (STAI Trait > 44) (Bunevicius et al., 2013), and 11 participants with Impact of Event Scale scores that reflect likely post-traumatic stress disorder (IES > 32). On every mental-health measure except state anxiety, participants in the Suppress-Negative group with high trait anxiety showed significant benefits (see Table 10A) with the index for worry dropping, on average, 17 points (a 44% reduction). Participants with high post-traumatic stress scores showed similar benefits (Table 10B; see Fig. 7C for an analysis based on summary measures). Similar subgroups in the Suppress-Neutral condition showed few of these benefits (Tables 10A, 10B; and Fig. 7C) with depression, well-being, and positive-affect showing the most reliable differences across the Suppress-Negative and Suppress-Neutral groups (Tables 10A, 10B). These findings suggest that benefits arose from suppressing negative content. A relative risk analysis indicated that participants high in trait anxiety or with likely post-traumatic stress disorder had numerically lower risk of ironic reversals on most mental health indices after suppressing negative content, compared to neutral content (see Fig. 7D for an analysis based on summary measures), with significantly reduced risks for reversals in well-being and positive affect (Tables 11A, 11B). Training the suppression of worries thus protected participants with likely PTSD or anxiety disorders from declines in well-being or positive affect, in striking contrast to ironic rebound predictions.

Table 10.*A. Training Benefits on our Immediate Test for Participants with High Trait Anxiety.*

Mental Health Questionnaires	Suppress-Negative		Sig. Time	Suppress-Neutral		Sig. Time	Sig. Group
	μ	SD		μ	SD		
State Trait Anxiety Inventory - State	-4.93	20.96	ns	-2.74	13.69	ns	ns
Penn State Worry Questionnaire	-18.19	26.77	**	-8.27	18.45	*	ns
Positive Negative Affect Schedule - Negative	-15.33	16.59	***	-8.57	13.68	**	ns
Beck's Depression Inventory II	-8.12	13.48	**	0.00	13.12	ns	*
Positive Negative Affect Schedule - Positive	7.72	13.52	*	-2.86	14.67	ns	*
Warwick-Edinburgh Mental Well-being Scale	7.30	9.95	**	-0.26	9.51	ns	**

Note. Participants are included as having high anxiety if they scored > 44 on the pre-training baseline measure of the Trait portion of the State Trait Anxiety Inventory. Scores reflect the change in mental health state after training relative to baseline measures prior to training (post – pre; POMP scores). Significance of Time reflects a paired samples student t-test between pre and post training. Significance of Group is derived from independent samples student t-tests between Suppress-Negative and Suppress-Neutral groups on the post-pre values. The p-value is indicated as such: <0.001(***), <0.01(**), <0.05(*), <=0.1(†), >0.1(ns).

B. Training Benefits on our Immediate Test for Participants with Likely PTSD

Mental Health Questionnaires	Suppress-Negative		Sig. Time	Suppress-Neutral		Sig. Time	Sig. Group
	μ	SD		μ	SD		
State Trait Anxiety Inventory - State	-10.61	20.59	†	-1.02	17.73	ns	ns
Penn State Worry Questionnaire	-19.24	25.78	*	-14.91	22.96	*	ns
Positive Negative Affect Schedule - Negative	-12.95	23.90	*	-6.67	12.98	†	ns
Beck's Depression Inventory II	-8.94	19.07	†	-1.02	12.25	ns	†
Positive Negative Affect Schedule - Positive	1.82	14.50	ns	-1.53	18.55	ns	†
Warwick-Edinburgh Mental Well-being Scale	3.90	10.19	**	2.68	10.18	ns	*

Note. Participants are included as having likely PTSD if they scored > 32 on the pre-training baseline measure of the Impact of Event Scale Revised.

Table 11.*A. For High Trait Anxious Participants Only, the Relative Risk of Worsening Mental Health After Training (Post-Pre or Followup – Pre) in the Suppress-Negative Condition Compared to the Suppress-Neutral Condition on Immediate and 3-Month Assessments (significant reductions in bold).*

	Immediate	Delayed
State Trait Anxiety Inventory – State	1.22 [0.65, 2.28]	1.11 [0.57, 2.13]
Penn State Worry Questionnaire	1.22 [0.50, 2.97]	1.35 [0.66, 2.76]
Positive Negative Affect Schedule - Negative	0.73 [0.19, 2.74]	0.89 [0.43, 1.83]
Beck's Depression Inventory II	0.43 [0.18, 1.03]	0.56 [0.25, 1.24]
Positive Negative Affect Schedule - Positive	0.46 [0.21, 0.98]	0.73 [0.39, 1.35]
Warwick-Edinburgh Mental Well-being Scale	0.28 [0.09, 0.87]	0.50 [0.25, 1.00]

Note. Relative risks are bolded if statistically significant. Brackets denote the 95% confidence intervals. If the relative risk = 1, or if the 95% confidence interval includes 1, then there is no significant difference between the groups.

B. *For Participants with Likely PTSD Only, the Relative Risk of Worsening Mental Health After Training (Post-Pre or Followup – Pre) in the Suppress-Negative Condition Compared to the Suppress-Neutral Condition on Immediate and 3-Month Assessments.*

	Immediate	Delayed
State Trait Anxiety Inventory – State	0.47 [0.12, 1.86]	0.47 [0.12, 1.86]
Penn State Worry Questionnaire	1.23 [0.34, 4.48]	1.31 [0.44, 3.85]
Positive Negative Affect Schedule - Negative	0.65 [0.15, 2.81]	0.33 [0.04, 2.45]
Beck's Depression Inventory II	0.33 [0.09, 1.23]	0.27 [0.04, 1.97]
Positive Negative Affect Schedule - Positive	0.55 [0.23, 1.27]	0.73 [0.29, 1.80]
Warwick-Edinburgh Mental Well-being Scale	0.18 [0.03, 1.25]	0.16 [0.02, 1.11]

Note. Relative risks are followed by brackets denoting the 95% confidence intervals. If the relative risk = 1, or if the 95% confidence interval includes 1, then there is no significant difference between the groups.

Sustained Benefits of Suppression After 3 Months

Improved mental health after training may be transient. Indeed, suppression-induced forgetting of suppressed fears on indices of memory, vividness, and affect were not detected at the 3-month delay. However, suppressed fears may remain less intrusive after 3 months, even if they are voluntarily recallable. To examine the durability of mental health benefits, we first examined changes on each of the six individual indices 3-months after training.

After 3 months, participants trained to suppress their fears continued to show reduced depression ($F(1,60) = 11.3, p < .001, \eta_p^2 = 0.158$) and a trend towards reduced negative affect ($F(1,60) = 2.982, p = 0.089, \eta_p^2 = 0.047$), relative to pretraining levels (Fig. 8). Those trained to suppress neutral events showed neither of these effects (depression: $F(1,58) = 1.473, p = 0.23, \eta_p^2 = 0.025$; negative affect: $F(1,58) = 2.042, p = 0.158, \eta_p^2 = 0.034$); they did, however, show reduced worry, as they had immediately after training ($F(1,58) = 9.059, p = 0.004, \eta_p^2 = 0.135$). Neither group showed reliable benefits on state anxiety, positive affect, or well-being ($p > .25$ in all cases). A PCA on change scores (followup – pretraining) for our 6 mental health indices revealed a latent variable like the one derived based on our immediate assessment. The Suppress-Negative and Suppress-Neutral groups did not differ on this global measure ($F < 1$), suggesting training people to suppress distressing thoughts provided no sustained aggregate mental health advantage over training them to suppress neutral thoughts, when considering all participants (Fig. 8).

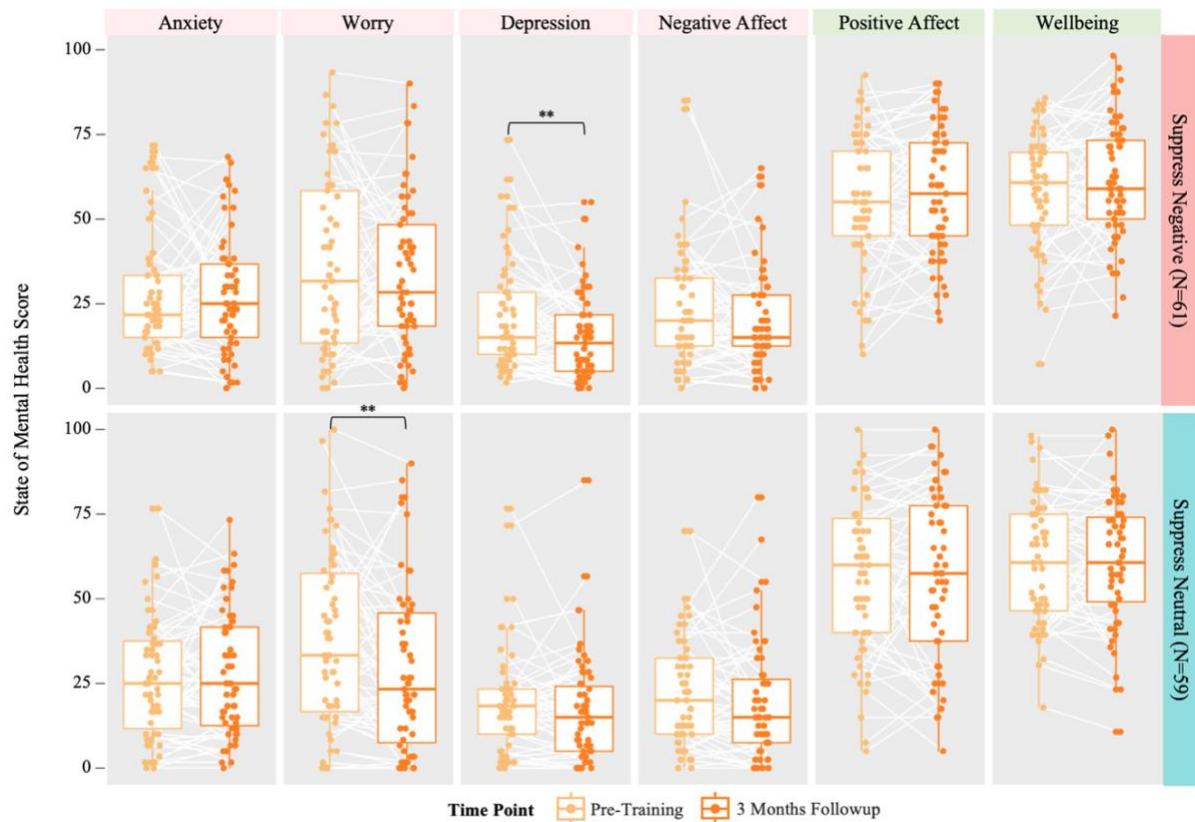


Fig. 8. Mental health changes after a 3-month delay in our whole sample.

Training at suppressing fears (upper half, red label) significantly reduced depression after 3 months compared to pre-training; training at suppressing neutral events (lower half, blue label) reduced worry after 3 months. Individual participants are indicated by dots connected by white lines; boxes reflect interquartile range, and lines reflect median scores.

The foregoing analysis of the entire sample includes many participants with good initial mental health and may obscure durable improvement in symptomatic participants, who had shown the largest gains after training. To address this possibility, we correlated trait anxiety and post-traumatic stress indices prior to training with mental health improvement after 3 months. After correcting for multiple comparisons, higher trait anxiety prior to training (indicated by STAI-Trait scores) was associated with larger reductions in worry, negative affect, depression, and state anxiety, and larger increases in positive affect and well-being ($r = -0.33, -0.41, -0.46, -0.31, 0.37, \text{ and } 0.33$, respectively significant after Benjamini-Hochberg correction (Benjamini & Hochberg, 1995); see Fig. 6A and Fig. 9A for analyses based on summary measures). Pandemic-related post-traumatic stress prior to training (IES) showed similar associations, although only depression remained significant after statistical correction (Fig. 6B and Fig. 9A). Both higher trait anxiety ($r = -0.49, p < .0001$) and post-traumatic stress ($r = -0.28, p =$

0.028) predicted greater improvement on our PCA-derived mental health change latent variable at 3 months. In contrast, in the Suppress-Neutral group, correlations were not significant for either individual indices (Figs. 5A and 5B; and Fig. 9A), or for our PCA-derived latent variable ($r = 0.05$, $r = 0.08$ for trait anxiety and post-traumatic stress respectively). Importantly, these correlations were again significantly lower than in the Suppress-Negative condition (1 tailed, Fisher's $z = -3.13$, $p < .001$ for Anxiety, $z = 1.96$, $p = 0.025$ for PTSD), showing that the latter correlations are not the inevitable result of participants with the highest scores regressing to the mean, as the opportunity for this was equivalent in the Suppress-Neutral group.

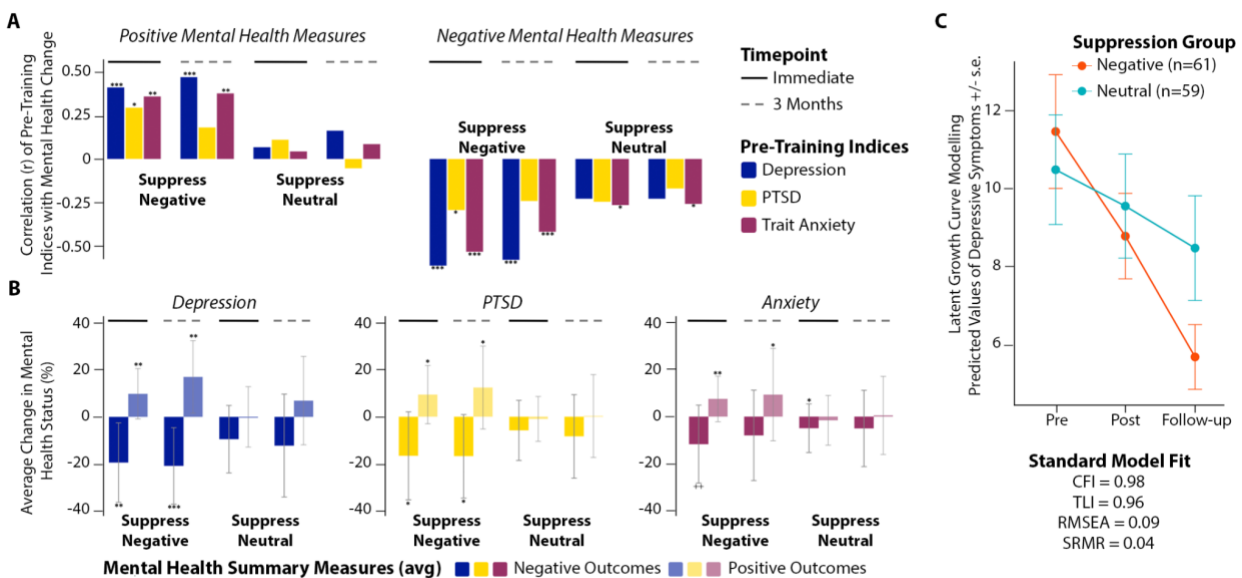


Fig. 9. Depression, anxiety, or post-traumatic stress symptoms prior to training predict mental health benefits of fear suppression immediately after training and after 3 months.

(A) Greater pre-training trait anxiety (maroon bars), pandemic-related post-traumatic stress (yellow bars), and depressive symptoms (dark blue bars) predicted larger improvements in positive mental health indices (left half of the panel) and negative mental health indices (right half of the panel) on our immediate assessment post-training (solid line above bars) and three months later (dashed line above bars), but only when people were trained to suppress fears (Suppress-Negative) and not neutral events (Suppress-Neutral). Correlations (r values) are plotted on the y-axis; significance is indicated by asterisks ($*** < .001$; $** < .01$; $* < .05$). Positive mental health is a composite of well-being and positive affect (averaged POMP scores); Negative mental health is a composite of the average POMP scores of the negative indices. (B) Subgroups with higher depression symptoms, likely PTSD, or anxiety showed significant improvements on negative mental health indices (darker shades, extending downward) and positive indices (lighter shades, extending upwards) during the immediate test (post – pre; bars below solid lines) and the 3-month follow-up (follow-up – pre; bars below dotted lines). Improvements occurred only after suppressing fears (Suppress-Negative), not after suppressing neutral events (Suppress-Neutral). (C) A LGCM analysis across our three time points (Pre, Post, and Follow-up) revealed greater improvement in depression after suppressing fears than after suppressing neutral events during training (y-axis values are predicted values of depressive symptoms based on the LGCM model).

The foregoing findings suggest that people with likely post-traumatic stress disorder or high trait anxiety continue to reap benefits from suppression training after 3 months, but only if they suppressed distressing content. Indeed, in the Suppress-Negative group, the overall mental health benefit gained after 3 months (PCA-derived latent variable) was predicted by how much suppression had reduced negative valence for fears immediately after training completed, $r = 0.34$, $p < 0.006$. Thus, successfully suppressing affect for fears was linked to enduring benefits. Participants qualifying for a provisional PTSD diagnosis (IES score > 32 , $N = 11$) showed significant mental health benefits 3 months after suppressing fears: after correcting for multiple comparisons (Benjamini-Hochberg correction), they showed improved depression ($F(1,10) = 15.306$, $p = 0.003$, $\eta_p^2 = 0.605$), negative affect ($F(1,10) = 7.822$, $p = 0.019$, $\eta_p^2 = 0.439$), anxiety ($F(1,10) = 7.443$, $p = 0.021$, $\eta_p^2 = 0.427$) and well-being ($F(1,10) = 7.379$, $p = 0.022$, $\eta_p^2 = 0.425$) (see Table 12A; and Fig. 9B for analyses based on summary measures). No significant improvements arose for a similarly composed group ($N = 18$) who suppressed neutral scenarios (see Table 12A; and Fig. 9B), with the amount of mental health improvement on our latent variable greater after suppressing fears than neutral events ($p < .05$). Participants reporting high anxiety (STAI-Trait, >44 , $N = 23$) also showed improved depression ($F(1,22) = 8.051$, $p = 0.01$, $\eta_p^2 = 0.268$) and positive affect ($F(1, 21) = 6.41$, $p = 0.019$, $\eta_p^2 = 0.226$) and similar trends on other measures if they suppressed fears (see Table 12B; and Fig. 9B). Neither group of vulnerable participants showed a significant increase in ironic reversals after suppressing fears compared to suppressing neutral events, and in most cases, this risk was reduced (Tables 11A, 11B).

Table 12.*A. Training Benefits on our Delayed Test for Participants with High Trait Anxiety*

Mental Health Questionnaires	Suppress-Negative		Sig. Time	Suppress-Neutral		Sig. Time	Sig. Group
	μ	SD		μ	SD		
State Trait Anxiety Inventory - State	-7.32	20.23	ns	-0.89	16.27	ns	ns
Penn State Worry Questionnaire	-8.91	23.38	ns	-3.57	18.75	*	ns
Positive Negative Affect Schedule - Negative	-6.63	19.98	ns	-0.80	15.03	ns	ns
Beck's Depression Inventory II	-9.06	16.42	**	-1.85	14.65	ns	†
Positive Negative Affect Schedule - Positive	7.72	20.56	*	-1.79	15.45	ns	†
Warwick-Edinburgh Mental Well-being Scale	5.75	18.42	†	-1.40	14.21	ns	ns

Note. Participants are included as having high anxiety if they scored > 44 on the pre-training baseline measure of the Trait portion of the State Trait Anxiety Inventory. Scores reflect the change in mental health state 3 months after training relative to baseline measures prior to training (follow-up – pre; POMP). Significance of Time is derived from paired samples student

t-tests between pre-training and follow-up. Significance of Group is derived from independent samples student t-tests between Suppress-Negative and Suppress-Neutral groups. The p-value is indicated as such: <0.001(***), <0.01(**), <0.05(*), <=0.1(†), >0.1(ns).

B. Training Benefits on our Delayed Test for Participants with Likely PTSD

Mental Health Questionnaires	<u>Suppress-Negative</u>			Sig. <i>Time</i>	<u>Suppress-Neutral</u>			Sig. <i>Group</i>
	μ	SD			μ	SD	<i>Time</i>	
State Trait Anxiety Inventory - State	-13.03	23.47	*	-1.67	15.37	ns	ns	
Penn State Worry Questionnaire	-5.91	24.54	ns	-8.89	17.07	†	ns	
Positive Negative Affect Schedule - Negative	-9.55	24.18	*	-3.89	15.39	ns	ns	
Beck's Depression Inventory II	-17.88	18.56	**	-6.48	13.57	†	†	
Positive Negative Affect Schedule - Positive	10.68	19.97	ns	-2.22	16.62	ns	ns	
Warwick-Edinburgh Mental Well-being Scale	13.47	19.91	*	-1.29	14.74	ns	†	

Note. Participants are included as having likely PTSD if they scored > 32 on the pre-training baseline measure of the Impact of Event Scale Revised. Scores reflect the change in mental health state 3 months after training relative to baseline measures prior to training (follow-up – pre; POMP scores). Significance of Time is derived from paired samples student t-tests between pre-training and follow-up. Significance of Group is derived from independent samples student t-tests between Suppress-Negative and Suppress-Neutral groups. The p-value is indicated as such: <0.001(***), <0.01(**), <0.05(*), <=0.1(†), >0.1(ns).

Estimating suppression training's long-term impact on mental health is challenging because adverse events can arise during the 3-month delay, especially given the global pandemic's multiple waves. Because we ran the Suppress-Negative and Suppress-Neutral groups concurrently, variability introduced by such events should be similar across groups. Nevertheless, estimates of how training effects changed over time should consider this variable impact across participants and time points. To characterise how training affected mental health over time, taking this variability into account, we conducted latent growth curve analyses on individual measures. In these analyses, we included estimates of the pandemic's recent impact on participants both prior to training and at our 3-month followup via Impact of Event Scale scores. Given the number of parameters to be estimated by each model, only the model for our depression index converged. This model revealed that, over time, depression declined over the three time-points for both the Suppress-Negative and Suppress-Neutral groups but that it did so more rapidly for the Suppress-Negative group (one-sample t-test of the predicted values of the latent variable Slope, based on Group, $t = -6.1608$, $df = 107$, $p\text{-value} = 1.296e-08$; Fig. 9C). These findings suggest that training people to suppress fearful thoughts benefitted depression over time more than did training them to suppress neutral thoughts. More broadly, our delayed assessment suggests durable

benefits of suppression training on multiple indices for symptomatic participants, contrary to concerns over ironic rebound effects.

Perceived Effects of Suppression

Participants' subjective reactions could determine whether they adopt thought suppression skills into their lives. We asked about participants' experiences with suppression, during and after training, focusing on those trained to suppress fearful content.

During training, participants reported improved ability to control fearful thoughts in response to reminder cues. They reported slight to moderate success during the first training session ($M = 2.7$ on a 5-point scale); by the end of training on Day 3, they reported being extremely effective ($M = 4.5$), a significant improvement, $F(1,50) = 221.7$, $p < 0.001$, $\eta_p^2 = 0.816$, with 57% of the participants selecting the maximum rating. No participant showed an ironic decline. Seventy-three percent of participants rated themselves as surprised or very surprised by this ability, and on a free report question about major insights derived from training, 67% of comments remarked that the benefits of suppressing their thoughts was the biggest discovery, with only 10% of participants commenting on the value of positive imagination during Imagine trials.

These perceptions translated into participants' use of thought suppression during the 3-month delay, despite receiving no instructions to do so. After 3 months, 82% of all participants reported having used thought suppression for the trained fears and 80% for novel fears, a pattern that was true for both healthy and symptomatic participants (Fig. 10A), including those with probable post-traumatic stress disorder due to the pandemic (81% for trained fears; 100% for novel thoughts). Indeed, increased symptom severity prior to training (reflecting a composite of trait anxiety, post-traumatic stress symptoms, and depression symptoms) predicted spontaneous use of suppression over the 3-month delay ($r = 0.27$, $p = 0.01$; Fig. 10B) and suppression use robustly predicted how much mental health had improved after this delay on our PCA-derived mental health measure ($r = -0.32$, $p < 0.001$, Fig. 10B). At the follow-up, 87% of all participants reported finding suppression useful. Amongst participants with

probable post-traumatic stress disorder, 82% reported reduced anxiety and 63% reported improved mood that they attributed specifically to learning thought suppression (Fig. 10C), with 27% reporting that they had “much better mood” and were “much less anxious” because of the training. No participants with likely post-traumatic stress disorder or with clinically concerning anxiety reported ironic worsening of mood or anxiety during the delay period. These findings are the opposite to what should arise according to conventional wisdom about paradoxical suppression effects and indicate high participant endorsement for the benefits of suppressing distressing thoughts (see Table 13 for verbal reports from all 61 participants in the Suppress-Negative condition about their experiences with suppressing fears over the 3-month delay).

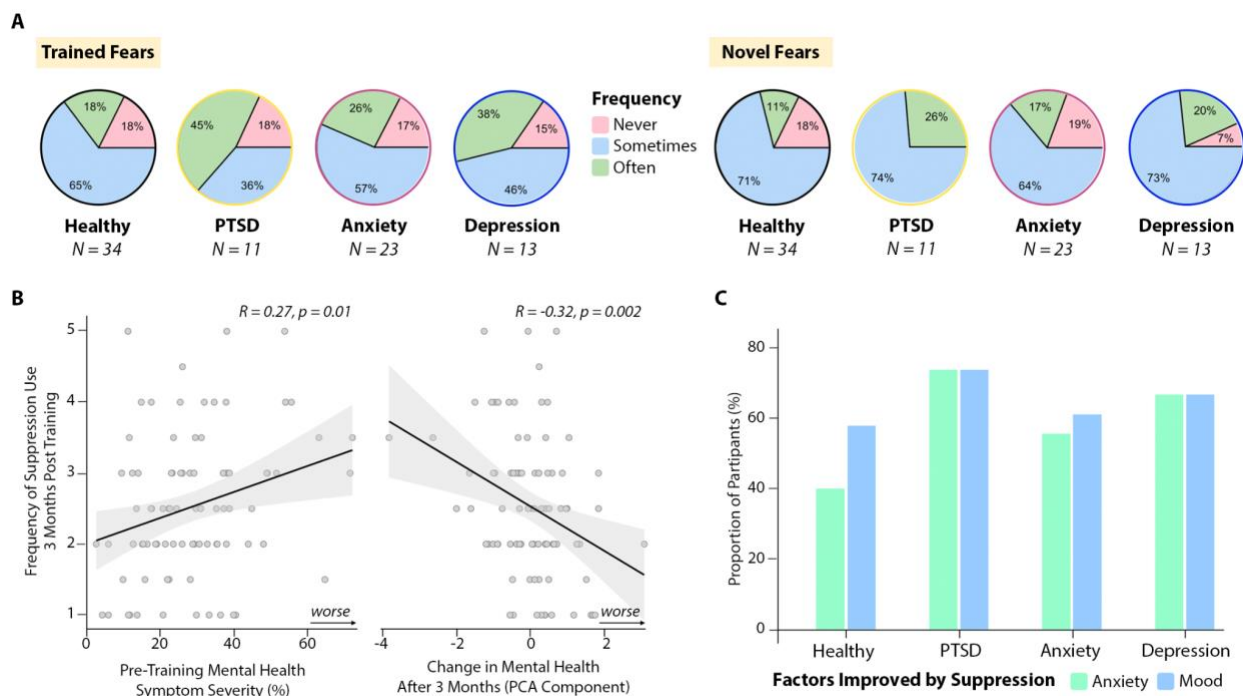


Fig. 10. Participants spontaneously suppressed fears over the 3-month delay, concluding that it improved their mood and anxiety.

(A) Most participants in the Suppress-Negative group reported using suppression over the delay both for trained (left side) and novel fears (right side), irrespective of whether pre-training indices suggested good mental health or pandemic-related PTSD, anxiety, or depression. Values reflect the percentage of people claiming to use suppression either Never (pink), Sometimes (light blue) or Often (green). (B) Pre-training mental health symptom severity (x-axis, composite based on the average of Trait Anxiety, BDI, and IES) predicted the frequency with which participants reported using suppression during the delay (left); suppression use predicted increases in mental health benefits (right). (C) Healthy and symptomatic participants reported improved mood and anxiety that they directly attributed to suppression, with the largest improvements in highly symptomatic participants.

These subjective impressions are intended to supplement and confirm the data presented in previous sections. It is no exaggeration that as the experimenter, I personally found the follow-up sessions to be incredibly rewarding and humbling as I was able to see and hear how much participants benefited from this study. Indeed, it was the subjective reports during my follow-ups with participants that sparked the idea to carry the work further into making it more accessible through an app (see Chapter 4). However, it is also important to note a few limitations. On the one hand, our comparison of Suppress-Negative vs. Suppress-Neutral groups is a crucial design feature to isolate benefits specific to suppressing negative content, since by comparing against people who suppressed neutral content, we can control for plausible benefits that are present in both groups such as placebo effects, social interaction with experimenters in the time of isolation during the pandemic, and the fatigue or distress that may be present from the mere act of generating, positive, neutral, and negative events at the outset.

On the other hand, it is possible that there were some factors such as individual differences and demand characteristics that were inevitable. For instance, in the midst of a pandemic with varied levels of social isolation measures, many hours of interaction time with an experimenter will unavoidably influence one's mood state in addition to the impact of various pandemic-related factors on the day of the session. We tried to capture just how varied people's circumstances were in terms of the number of COVID-19 cases in their respective countries as well as UK-specific governmental policies on social isolation (since majority of participants were UK-based) in Fig. 1A. In addition, we noticed that being observed online definitely made a difference in how closely participants followed instructions. This was especially apparently in the app study (Chapter 4) as the same event task with the same instructions required much more efforts of monitoring and more edit suggestions from the experimenter in the app experiment in absence of the context of a seemingly more controlled environment of video-conferencing. In addition, although we cannot dismiss the demand characteristics of self-report measures such that participants may implicitly feel the need to report scores that would indicate improvement since they obviously underwent a purposeful training program for three days, the impact would still be minimal as we purposefully made the event ratings task quite fast-paced and gave a suggested completion time for the post-experimental questionnaires. Importantly, not only does the

self-reported subjective responses not contradict the quantitative data presented in previous sections, but rather strengthens and adds life to the positive impact the training made in people's life during a very difficult time.

Table 13.

Subjective Reports About the Experience of Suppressing Fearful Thoughts Over 3 Months, as a Function of Post-Traumatic Stress Symptoms. Participants are sorted from highest pandemic-related IES Score to lowest, and divided into quartiles to illustrate that perceptions of usefulness and likelihood of future use were greatest in the most symptomatic participants.

PTSD/Depression/Anxiety: Pre-training (POMP scores) for IES-R, BDI-II, and STAI-Trait respectively.

Usefulness: Do you think that the suppression (mind-blanking) strategy you learned through the course of the training was useful or helpful to use outside the lab in your own life?

Reusability: How likely are you to re-use the suppression (mind-blanking) strategy you learned to decrease your anxiety or thoughts about the negative events in your life?

Rating Scale: Very unlikely - 1; Unlikely - 2; Neutral - 3; Likely - 4; Very likely - 5

Impact: In your own words, please elaborate on your opinion about re-using the suppression (mind-blanking) strategy in the previous question.

ID	PTSD	Depress.	Anxiety	Useful?	Reusa.?	Impact
234	69.32	53.33	71.67	Yes	3	Need to remember to do it in the moment
158	68.18	28.33	38.33	Yes	3	I like the method but often I find it difficult to remember that I can use it for situations outside of the ones I wrote down
80	67.05	33.33	66.67	Yes	5	The mind-blocking is able to prevent someone from concentrating on negative events and just focus on positive and neutral events
128	55.68	35.00	71.67	Yes	5	it's very useful when trying to get to sleep, because I can easily stop over-thinking
18	51.14	25.00	30.00	Yes	4	Sometimes it just feels impossible to stop thinking if something is worrying you, or you are taken by surprise by a bad event. But if something just begins to creep in you can actively decide to stop.
191	51.14	61.67	76.67	Yes	4	it can definitely help me in having more control over my anxious responses that randomly appear throughout the day
178	50.00	73.33	93.33	Yes	3	help to relax myself for a little while, but anxiety grows later again
61	50.00	45.00	66.67	Yes	5	In practise I couldn't believe how effective it was and it made me realise how powerful my brain can be. I always thought that just dismissing thoughts would make things worse, like 'brushing it under the carpet' however, it's a useful tool as it can put some distressing irrelevant thoughts to bed.
216	47.73	36.67	60.00	Yes	4	I think it has been useful when I have used it in diverting my attention and changing my mood (increase)

106	44.32	5.00	18.33	Yes	3	If a negative effect is strong, the think-blocking is working with other strong thinking so I put my focus on the other thought. The mind-blanking is working just with small negative situations
36	43.18	15.00	48.33	Yes	4	Using the blank mind technique helps to quell the initial panic of a negative thought.
10	35.23	30.00	56.67	Yes	4	It's more useful to do for unlikely events but for events that could happen it is more useful to deal with them head on rather than ignoring them
202	35.23	10.00	33.33	Yes	5	It is a really powerful tool to block worrying thoughts, I will definitely intend to use it again.
209	35.23	15.00	20.00	Yes	4	I think it is useful to do when I have no control over the event and it numbs out the anxiety (anxiety is still there, just less intense)
192	34.09	11.67	21.67	Yes	4	-

First Quarter Summary

PTSD: 49.17 Depression: 31.89 Anxiety: 51.56 Usefulness: 100% Reusability: 4.00

197	32.95	10.00	21.67	Yes	4	I think it would be worth trying again in stressful situations. I'm not sure how good I'd be at it though, I think I've forgotten quite a bit since training!
221	32.95	13.33	25.00	Yes	4	I think it was helpful in approaching my stresses and anxieties about potential events in a different way and did help me manage the way I thought about hypothetical/future events
226	32.95	18.33	33.33	Yes	4	It feels to me like I did not "practice" enough yet as my daily job was quite intense, full of meetings and with very little personal time to think about pleasant or unpleasant things. I don't always block fears because they are usually related to something that I can act on. I "push back" only things I cannot do anything about i.e. death of a friend
215	31.82	10.00	36.67	Yes	3	I think it is a good strategy but it is so easy to forget about it when you're in a low mood
218	30.68	23.33	35.00	Yes	5	It is a great way to prevent bad thoughts and make me feel better, as well as not wasting time worrying about something before it even happens.
8	29.55	6.67	10.00	Yes	4	It's worth trying if I'm having negative thoughts but it doesn't work if I'm feeling really sad or worried about something
134	28.41	28.33	20.00	Yes	5	Since having the training, I have used the strategy a lot and found it to be very effective in stopping me thinking about negative or disturbing ideas or situations
180	28.41	5.00	11.67	Yes	4	Not sure if it is quite the same, but I am quite good at compartmentalizing things and manage to separate home and work (so can blank out things when I am not in work or home mode)
3	27.27	21.67	45.00	Yes	4	Mind blanking - helps to focus on the day-to-day activities rather than worrying on events.
7	26.14	11.67	25.00	Yes	4	I think the method of using mind-blanking is a very effective 'circuit breaker' to limit the likelihood of myself or an individual spiralling into negative thoughts. Thus, I wouldn't be able to say as to whether I consciously use it however, I hope and feel that the method encourages

						me to pause and think more rationally when I am experiencing negative or worrying thoughts.
239	26.14	6.67	38.33	Yes	4	I think it might be a good strategy to use, if one can remember to do it in the "heat of the moment"
145	26.14	16.67	66.67	No	2	I have never applied it before, so I just don't do it now. I usually deal with my fears by talking about them.
15	25.00	56.67	73.33	Yes	4	I use it to stop me dwelling on it at the time although thoughts do sometimes come back but is useful in the present moment
176	25.00	53.33	38.33	Yes	4	I think it could be useful, since I have a tendency to let negative thoughts take over my mind. Using this technique, I try to stop my negative thoughts before they spiral out of control.
135	22.73	23.33	43.33	Yes	3	a good technique, but doesn't feel natural

Second Quarter Summary

PTSD: 28.41 Depression: 20.33 Anxiety: 34.89 Usefulness: 93% Reusability: 3.87

170	22.73	26.67	55.00	Yes	5	There are certain events that I worry about, triggered by situations. I have frequently, in those situations, used the suppression strategy to good effect. Eg. overtaking cars on the highway is always stressful, but visualizing a car crash is not exactly helpful in that moment, and this helps to keep my mind clear and on the road. Suppression doesn't work well when I'm worrying about something like getting a paper published (or not), because I feel like the worry should help me to work towards my goal, not be suppressed.
225	22.73	11.67	28.33	Yes	4	It is a way to do not worry about future events we do not have any control. The example than members of my family are going to die for age will happens and thinking about that is not going to change the sadly fact, another negative effects I can affect the outcome and blocking them it is not useful because we can act about them and change the outcome
210	21.59	15.00	13.33	Yes	4	The strategy could be accompanied by self-talk aimed at telling oneself not to worry unnecessarily.
26	21.59	18.33	48.33	Yes	3	I tried using the strategy a few times soon after the initial study but have not used it much since
88	21.59	15.00	48.33	Yes	5	I think that it was a good strategy to learn and try to apply, but outside the lab I found it hard to make myself really do that and remind myself of the strategy
140	21.59	18.33	28.33	Yes	4	It worked well to stop negative thoughts becoming intrusive
168	20.45	40.00	51.67	Yes	4	I know there are things which could very well happen, but thinking about them doesn't do me any good, e.g. I know worrying about deadlines doesn't make me do more work. So, it's better for me to just force myself to not think about it.
173	20.45	8.33	45.00	Yes	4	For temporary cases it works to suppress immediate emotions but if the source of anxiety is still there it will come back until the source is dealt with. It's not a long-term fix to getting rid of anxiety but it may help you feel not feel anxious as much of the time.
233	20.45	21.67	35.00	Yes	3	I think it's important to be aware of the problem and understand and accept how you feel about it, because I don't believe that suppress the

						emotions is good to solve the problems. If you understand and accept how you feel first then yes you want to stop your mind from starting a loop of negative emotions that won't lead you anywhere
149	19.32	15.00	23.33	No	3	I think I don't have a ton of negative thoughts in general, and so I sort of forgot to use the strategy. There are a few specific negative thoughts that I have that are recurrent, and it might be a useful technique to deal with these
190	19.32	31.67	63.33	Yes	4	I think this technique is useful for things out of your control, but may not be the best approach for worries that require solutions. Some problems need to be confronted in order to be overcome
154	18.18	10.00	25.00	Yes	5	By using suppression, negative thoughts can be prevented from being brought to the conscious mind so it is quite useful for future negative events which I am not even sure would happen or not.
46	18.18	25.00	25.00	Yes	4	When negative thoughts enter my mind, I am more likely to actively try to suppress or 'blank' them
147	15.91	41.67	56.67	Yes	4	I was able to do this and I could tell the anxiety decreased so I will use - when I remember to and it is remembering to that is the issue... I need to connect the anxiety triggers with the resource of blanking and putting that in place.
203	15.91	10.00	20.00	No	3	Potentially it could help but I have forgotten to try it! I will try to use it more and see.

Third Quarter Summary

PTSD: 20.00 Depression: 20.56 Anxiety: 37.78 Usefulness: 87% Reusability: 3.93

174	14.77	3.33	30.00	Yes	4	good strategy. another tool in my tool belt.
141	13.64	6.67	15.00	Yes	4	I think it's a great way to learn to control bad thoughts you have about life and to help improve mood.
111	12.50	11.67	18.33	Yes	4	I think it is a useful strategy and it has been good to have this reminder as I will now use it more
29	11.36	6.67	35.00	Yes	4	I think it is a useful task to control negative thoughts and stop them escalating.
153	11.36	10.00	45.00	Yes	3	-
235	10.23	10.00	33.33	Yes	3	It was useful tool to stop bad thoughts from coming to mind
56	10.23	8.33	11.67	Yes	5	I think I could use it to help with food cravings or negative self-image thoughts rather than using it to block anxiety about events occurring.
2	9.09	6.67	20.00	No	3	I hadn't really thought about it over the past 3 months. I don't tend to dwell on too many negative events that much, and when I do I tend to think through them quite a lot rather than blanking them out. If in the future my worries are becoming more problematic (constant), then I might use the suppression strategy.
94	9.09	5.00	15.00	Yes	4	It is a useful skill in not over-thinking issues, particularly during a pandemic when lots of things are out of our control.
11	7.95	3.33	23.33	No	1	I don't think suppression of thought is a good thing as I feel you need to be honest with your feelings even if they are detrimental to your mental health.
126	6.82	35.00	51.67	Yes	4	I caught myself sometimes utilizing the mind-blanking when irrational worries arose. This gave me a short-lived alleviation of the anxiety.

144	3.41	1.67	3.33	Yes	4	Helpful, but more of a supplementary tool for me as I already dealt with anxiety well.
162	1.14	15.00	25.00	Yes	3	It's a very interesting process, but it is not automatic to put it in place and I feel that thinking a little about negative events is sometimes important, at least to think of solutions and alternatives. I think it is a very good solution for recurrent, nagging negative thoughts.
16	0.00	8.33	33.33	No	3	did not use it
17	0.00	5.00	13.33	No	4	Useful for worries for things for which I have no control over such as worrying about things that haven't happened yet (e.g. deaths in the family) or things that might not happen (e.g. another lockdown), however potentially not productive to completely mind-blank on the issue because there could still be actions that I could take - such as spend more time with my grandparents, try to look for another job/take provisions for possible lockdown etc. So, I think I could use it to some extent but not completely mind-blank on issue/subject of worry.
167	0.00	46.67	73.33	No	3	I find it wouldn't be very helpful for me since I prefer to think through problems rather than blank them out.

Fourth Quarter Summary

PTSD: 7.60 Depression: 11.46 Anxiety: 27.92 Usefulness: 69% Reusability: 3.50

3.3. Discussion

The mnemonic and affective patterns we observed after training participants to suppress distressing thoughts support a role of thought suppression in protecting and enhancing mental health, in which suppression reduces (i) immediate awareness of distressing content, (ii) later voluntary access to details and imagery of feared scenarios, and (iii) the subjective distress associated with feared scenarios. When successful, these regulatory impacts prevent suppressed content from driving worrying, rumination, and other forms of repetitive thinking that amplify anxiety, depression, and post-traumatic stress. Such reductions, coupled with increased perception of control over their thoughts (Table 13), improved people's well-being. Participants voluntarily applied suppression to their targeted fears and to new fears during the 3 months after initial training, yielding enduring mental health gains for symptomatic participants.

The current findings challenge the pervasive view that thought suppression plays a key role in the pathogenesis of mental health disorders. We observed no evidence that training people to suppress distressing thoughts increased the risk of paradoxical rebound effects on any of our mnemonic, affective, or mental health indices. Contrary to concerns, risk did not increase the affective intensity of feared events, or participants' level of trait anxiety, depression, or post-traumatic stress at the outset of training, regardless of delay. The negative assessment of thought suppression amongst clinical psychologists originated in the historical Freudian view that suppressed contents persist in influencing us unconsciously (Freud, 1953, 1957), which has since been continued by theoretical claims about the ironic effects of thought suppression (Wegner, 1994, 2009). As discussed extensively in Chapter 2, clinical concern about ironic effects has been motivated by data from the white bear thought suppression task, which, unlike retrieval suppression, requires participants to remember and monitor for a specific forbidden thought (i.e., white bears) as they strive to suppress that very thought. Our data indicate that retrieval-suppression, which instead seeks to interrupt the progression from cues to unwelcome thoughts, does not carry this rebound risk. Unlike the white bear experiments, our task explicitly measures direct suppression; in addition, we suggest that our task better captures thought

suppression as it occurs naturally (Engen & Anderson, 2018; Visser et al., 2021). We hypothesise that retrieval suppression succeeds by recruiting inhibitory control mechanisms (M. C. Anderson & Green, 2001; M. C. Anderson & Hulbert, 2021; Apšvalka et al., 2022; J. R. Wessel & Aron, 2017) in tandem with the circuitry underlying fear extinction, to inhibit mnemonic and affective responses in parallel (M. C. Anderson & Floresco, 2022; Benoit et al., 2016; Engen & Anderson, 2018; Gagnepain et al., 2017; Visser et al., 2021). By training people to persistently confront reminders that reactivate their fearful thoughts (a key precursor to memory disruption, see Khalaf et al., 2018) and then driving them to suppress awareness of the associated memory, our protocol combines active forgetting of distressing imagery (Benoit et al., 2016; Brewin et al., 2010; Meyer & Benoit, 2022; Phelps & Hofmann, 2019), with the controlled recruitment of extinction circuitry, believed critical in adjusting emotional responses to threat (M. C. Anderson & Floresco, 2022; Craske et al., 2022; Dunsmoor et al., 2022; Maren, 2011; Milad & Quirk, 2012; Sevenster et al., 2018; Y. Wang et al., 2021). Indeed, in a classical fear extinction paradigm involving electrical shocks, asking people to suppress retrieval of the fearful shock during extinction learning benefits the durability and generalisation of extinction (Y. Wang et al., 2021).

Whatever mechanisms underlie the current benefits, our experiment shows that suppression training can improve mental health for those suffering from symptoms of anxiety and PTSD. In doing so, we provide an alternative lens on the origins of persistent intrusive thinking in these disorders. If participants high in trait anxiety or post-traumatic distress had suffered from structural or neurochemical deficits in the prefrontal cortex or other brain structures needed for thought suppression, it is unlikely that a 3-day training regimen would have improved control over their symptoms to the degree that it did. The training's clearest impact was to increase participants' awareness of the possibility of thought suppression and to vividly illustrate its value in regulating their most distressing fears. Thus, our training may have eliminated a metacognitive gap or instead may have altered false beliefs about the dangers of thought suppression that had previously limited its use, revealing latent abilities our participants possessed but didn't use. Our work sheds light on a potential explanation for the literature showing seeming "impairments" related to suppression in clinical disorders such as PTSD, namely that vulnerable populations may have never been properly exposed to let alone being trained in

suppression as an option to alleviate their distress, especially given the widespread scepticism against suppression brewed by the ironic processing theory literature (see Chapter 2). Indeed, many participants reported surprise at their ability to suppress, and how much it improved their mood. The ability of our short suppression training intervention to significantly improve mental health in those with high anxiety or post-traumatic stress raises doubts about emphasis on anatomical deficiencies in these conditions and suggests that the fraction of psychiatric disorders arising from behaviourally treatable causes is higher than clinical neuroscientists typically assume. Deficient prefrontal cortex activation in brain imaging studies of psychiatric disorders can be misinterpreted as a neurobiological deficiency when it may often simply indicate a treatable failure to engage intact abilities. Identifying patients that strongly benefit from suppression training could better isolate non-responsive individuals with true neurobiological deficits, improving scientific study of these conditions and enabling targeted interventions tailored to individual needs. More broadly, the substantial and durable mental health benefits, safety, high endorsement, spontaneous use, and accessible delivery make suppression training a promising and scalable intervention on its own, or as a neurobiologically grounded complement to standard treatments such as exposure or cognitive behavioural therapy (CBT).

3.4. *Materials & Methods*

Experimental Design

To determine how suppressing distressing content affected mental health, we manipulated the negativity of the content that participants suppressed during No-Imagine trials. We randomly assigned participants to suppress one of two types of content: fears (primary intervention, Suppress-Negative, $N = 61$) or neutral future events (control, Suppress-Neutral, $N = 59$). As a secondary variable, we manipulated the positivity of the events that participants imagined during Imagine trials. We randomly assigned half of the participants to imagine positive (Imagine-Positive, $N = 60$) or neutral (Imagine-Neutral, $N = 60$) future events. Thus, our intervention constituted a 2 x 2 between-participants design with valence of suppressed content as the primary manipulation.

To implement this design, participants first generated 20 fears, 36 neutral events and 20 hopes in the future (over 2 days), each with a cue, a key detail, a short tag line, and a brief description with more details. They then rated event characteristics, and had their mental health assessed; 3 days of retrieval suppression practice ensued, each day composed of 12 No-Imagine and 12 Imagine repetitions in response to No-Imagine and Imagine cues, respectively. No-imagine cues (appearing in red) required participants to attend to the cue whilst suppressing retrieval of any imagery or thought; Imagine cues (appearing in green) required participants to imagine the event (see Fig. 1 for illustrations). Immediately after the final training session (and again after 3 months), we tested memory and affect for generated events, and assessed mental health.

Participants

One hundred and twenty-seven people took part initially, of whom we excluded 7 participants – 5 because of not being able to contact for follow-up, 1 because of issues connecting to Zoom, and 1 because of incomplete questionnaire data. The final sample included the 120 participants for whom we had complete data in the immediate and follow-up sessions (93 females, Age: $\mu = 27.41$, $SD = 10.21$; see Table 2A for further demographic characteristics of participants).

We randomly assigned participants to conditions which differed in the valence of the events participants needed to suppress during training (i.e., Suppress-Negative or Suppress-Neutral), each of which further differed in events participants needed to imagine during training (Positive or Neutral events). We assigned participants via blocked randomization, such that we ran each condition once for every four participants, ensuring that we matched the number of participants in groups as we ran the study. We determined the sample size for each of the 4 groups based on a-priori power analysis with G* Power 3.1 software (Faul et al., 2009) ($f = 0.27$ (Ashton et al., 2020), $\alpha = 0.05$, $1-\beta = 0.8$, Number of groups = 1, Number of measurements = 2, correlation amongst representative measures = 0.49 (Benoit et al., 2016)) using data from Benoit, Davies & Anderson (2016) as a basis. This indicated a required sample of 30 participants per experimental group, resulting in 120 participants for the entire experiment. Primary analyses focused on comparisons between the Suppress-Negative and Suppress-Neutral groups.

We recruited participants from the MRC Cognition and Brain Sciences Unit (CBU) participant panels with the constraint that they had no prior participation in research involving the TNT or the INI paradigms. We also recruited a small set of participants via online study advertisements on Facebook and Twitter and via word-of-mouth from previous participants. We paid participants according to the rates set for behavioural experiments at the MRC CBU (£6/hour). Exclusion criteria included a history of attention deficit disorder, reading disability, or lack of English fluency. Non-native English speakers could participate if they were fluent in English from early childhood, and scored above 90% on the Cambridge General English Assessment (General English Assessment, 2021). The Cambridge Psychology Research Ethics Committee approved the study, with all participants providing informed consent digitally.

Remote Testing

To allow international participation during the Covid-19 pandemic, we conducted the study online via the videoconferencing platform Zoom (Zoom Video Communications Inc, 2021). Because Zoom meetings are accessible via a web-browser, no software installation was required. For one

participant, we used Skype instead due to technical difficulties. Videoconferencing allowed the experimenter to share their screen during training. To mimic laboratory studies, we required that participants use a desktop or laptop for all sessions except for the first session. Because this introductory session did not involve experimental tasks, we allowed participants to use an iPad or a smartphone if they wished. We required all participants to remove distractions from their environment and to keep their cameras on during all the sessions.

Materials

Each participant generated 76 future events on three Microsoft Excel spreadsheet templates: 20 negative events (i.e., fears and worries), 20 positive events (i.e., hopes and dreams), and 36 neutral events (i.e., routines and mundane hypothetical scenarios). Participants completed four cells for each event: 1) a tagline in less than eight words describing the essence of the event, 2) a more elaborate description of details which the experimenter used to verify the event's compliance with the rules, 3) a Cue Word – an obvious reminder which was used to evoke the event during training, 4) a Key Detail – a single word expressing a central event detail not mentioned in the tagline and obvious only to the participant which was used to assess event recall during the immediate and delayed tests.

Although all participants generated the same amount and types of events at the outset, we drew selectively from these events to construct the stimuli set which differ in the 4 groups. Specifically, we used only 40 out of the 76 events generated initially as stimuli for each participant (32 critical events for the training, 4 events for practice, and 4 events for context-reinstatement during the recall test). Participants generated more material than we used for their training because (a) everyone need to generate an equal number of events in the negative, neutral, and positive conditions to avoid any biases, and (b) the INI task for each of our four groups required materials with different valences. Thus, we selected a subset of critical events according to the condition to which participants had been assigned. When we assigned participants to suppress negative events and imagine positive events, we set neutral events aside and used only the positive and negative events; when we assigned them to suppress negative and imagine neutral events, we set aside positive events and used negative events and neutral events;

when we assigned them to suppress neutral events and imagine positive events, we set aside negative events, selecting positive and neutral events; and when we assigned participants to suppress and imagine neutral events, we set aside all positive and negative events, focusing exclusively on neutral events. For each participant, we allocated 8 events to each of four conditions: Imagine (I), No-Imagine (NI), Baseline Imagine (BI), and Baseline No-Imagine (BNI). For example, in the Suppress-Negative, Imagine-Positive group, I and BI would each be composed of 8 positive events, and NI and BNI, 8 negative events. Within a condition pair (e.g., I and BI; or NI and BNI), we assigned events to conditions algorithmically to match a given manipulation with its baseline as closely as possible. For example, through an automated matching algorithm, we maximised the average similarity of six ratings of event characteristics (mood, vividness, likelihood of occurrence, distance in the future, frequency of thought, degree of current concern; see Procedure for details) across the NI and BNI conditions, and between the I and BI conditions.

We administered mental health questionnaires either once or multiple times (pre-training, post-training, follow-up) using the secure online survey tool Qualtrics (Qualtrics, 2005). We measured our six target mental health indices at all three time points. The positive and negative indices are computed simply by averaging over the POMP scores separately for the positive and negative mental health scales. The IES-R was administered pre-training and at follow-up to estimate dynamic changes in pandemic-related circumstances over the 3-month delay, which were then incorporated in the LGCM analysis (see Fig. 9). Finally, we included exploratory scales, the results of which will not be extensively discussed in this chapter, but some will be briefly mentioned in Chapter 5. The data, however, is uploaded to Dataverse (Mamat & Anderson, 2023) for anyone to view. The scales included the Optimism Pessimism Instrument (OPI) (Dember et al., 1989), Health Anxiety Inventory (HAI-18) (Salkovskis et al., 2002), Intolerance of Uncertainty Scale (IUS-12) (Carleton et al., 2007), Five Facets of Mindfulness (FFMQ) (Michalos, 2014), Cognitive Flexibility Inventory (CFI) (Dennis & Vander Wal, 2010), Meaning in Life Questionnaire (MIL) (Steger et al., 2006), Metacognitive belief questionnaire (MCQ-30) (Wells & Cartwright-Hatton, 2004), and Short UPPS-P Impulsive Behaviour Scale (SUPPS-P) (Cyders et al., 2014).

Procedure

The experiment includes a set of initial training sessions and a follow-up session 3 months later. Here we describe the procedures of these two segments. The initial stage of the study was conducted in 3 phases conducted over 5 days: introduction, training, and testing (see Fig. 1C). In the introductory session (day 1), we briefly introduced the study, collected verbal consent, administered pre-experimental questionnaires, and then provided instructions for the event generation task. The event generation phase (days 1-2) consisted of two tasks: listing events and then rating them on several scales. These two tasks were repeated 3 times, once for each event valence category (negative, neutral, positive). We emailed the event generation spreadsheet template to participants for a given valence (e.g., negative) and once returned and completed, the next event generation spreadsheet would be sent, and this would continue until all 3 valence categories (76 events) had been completed. We randomised the order in which the negative, neutral, and positive events were generated for each participant.

Each event needed to comply with 6 rules which were clearly explained to participants. Specifically, events needed to 1) be genuinely positive (i.e., a future hope that brings incredible joy), negative (i.e., a feared future event that has caused and continues to cause worry), or neutral (i.e., routines and mundane tasks), 2) be something that the participant can and has vividly imagined from their first-person perspective, 3) concern possible developments in the participant's life that could take place within the next two years, 4) be a specific episode with a particular time and place, 5) only last between a few minutes to one day, and 6) be current concerns or recurrent fears (i.e. thought of at least three times in the past six months) in the case of negative events. Upon completion of each template, the experimenter checked to ensure 1) each event followed the six rules, 2) no repeats of words are present for Cue Word and Key Detail across all templates, 3) Key Detail words do not appear in the tag-lines, and gave feedback by email if any edits were required. Once all events complied with the rules, the experimenter emailed the participant the ratings task in html generated via PsyToolkit (Stoet, 2017) which consisted of 8 ratings per event: vividness, likelihood of occurrence, distance in the future, level of anxiety about the event (for positive events - joy), frequency of thought, degree of current concern,

long-term impact, and emotional intensity. The ratings were all rated on a 5-point scale, except for emotional intensity which is on a 9-point scale (see Table 2C. for event characteristics and see the Notes of this table for details on each of the rating scales). Note that the Anxiety rating (on a 5-point scale) for each event was a core “event” dependent variable measured before and after training (and at follow-up) (Fig. 1), whereas emotional intensity (on a 9-point scale) was used as a distinct one-time pretraining predictor measure (see, e.g., Fig. 3, where participants are sorted by this measure). The same sequenced procedure, event generation, experimenter checks, and participant ratings, repeated for the next two templates during the time between the introduction session and the first day of training.

After participants completed the event generation phase, they proceeded to the first day of training (day 3; see Fig. 1C.). The first day consisted of a brief questionnaire (given daily during training), a criterion test, practice at the suppression task on filler items, and finally the Imagine/No-Imagine training (INI-T). The brief daily questionnaire recorded: 1) occurrence of any mood-altering experiences since the day before, 2) overall mood and arousal based on Self-Assessment Manikin (SAM) (Palombo et al., 2013), 3) hours of sleep on the preceding night (1-11 scale), and 4) degree of tiredness (1-10).

The main experimental tasks then ensued. During these tasks, all stimuli were presented via screen-sharing during videoconferencing from scripts written in Matlab with Psychophysics Toolbox extensions (Brainard, 1997; Kleiner, 2007). We began with a criterion test that ensured that participants could remember the associations between their Cue Word and Key Detail for each of the 40 events prior to suppression training. For each event, we presented the Cue Word and tested whether the participant could remember the Key Detail, after which we gave feedback about the correct Key Detail that they had originally listed. During this test, we required 3 verbal responses for each item, when presented with its Cue Word (600ms inter-stimulus interval): whether 1) they could silently remember the personal event associated with the Cue Word (yes/no, 5s), 2) they could recall the Key Detail by saying it aloud (5s), 3) the event they were thinking of in response to the Cue Word during the first “yes/no” response was indeed the right event (3s), given the feedback provided (2s). To calculate the accuracy of participants’ responses, the experimenter coded each trial upon hearing the 3 verbal responses. If the

participant gave no response, that event was coded as incorrect; if they responded, we considered an event as accurately recalled if the participant stated that they could recall the event (yes/no), recalled the correct Key Detail, and confirmed that the Key Detail went with the event they had recalled. We repeated the criterion test up to three times to ensure that participants achieved above 90% accuracy. We displayed events in the criterion test such that no more than two consecutive trials were from the same condition. On the first test, we picked events randomly from the condition set without replacement (aside from the aforementioned constraint on condition repetition), and we followed the same order for the repeated criterion tests.

Following the criterion test, participants practised the INI task and then underwent the training. Each trial first showed a fixation cross for 500 ms followed by a Cue Word for 4s (600ms isi) in either green or red font depending on whether it was an Imagine or No-Imagine trial, respectively. For Imagine trials, we instructed participants to do the following for as long as the green Cue Word remained on the screen: 1) read the Cue Word silently and recognize the event to which it referred, 2) recall the associated Key Detail to mind silently, 3) imagine the future event in vivid detail, 4) add a novel feature to the event each time the Cue Word repeated. For the two groups that imagined positive events on Imagine trials, we further asked them to create a positive and hopeful feeling each time they imagined the event. This was a novelty in our design, added in order to accentuate the supposed effects of positive thinking and to keep their attention engaged on the task to match the intensity of attention engagement during the suppression trials which can be quite difficult initially and are certainly attention-demanding. For No-Imagine trials, we instructed participants to do the following for as long as the red Cue Word remained on the screen: 1) read the Cue Word silently and recognize the event to which it referred, 2) stop any further imagination of the event by blocking the event and any associated details out and keeping it out of mind. To ensure that participants engaged direct suppression and not thought substitution (Benoit & Anderson, 2012), the experimenter urged participants not to replace the unwanted thoughts (such as the Key Detail or other specifics of the event) with something else, and to instead remain focused on the Cue Word and keep their mind blank during the No-Imagine trials. During the practice phase, we showed four filler events twice, across two blocks (i.e., 8 trials in total).

We presented Cue Words in a pseudorandom order such that the Cue Word was randomly selected from the set of items in its condition; however, the Cue Word was repeated only after all of the other Cue Words in the same condition had been shown. Following the practice phase, we verbally administered a diagnostic questionnaire that allowed the experimenter to give constructive feedback to ensure that all instructions for the INI task were followed correctly.

The training phase followed the same procedure as the practice phase. During each of the four training runs, we repeated 16 events (i.e., 8 Imagine and 8 No-Imagine) three times, yielding 192 trials. Thus, across the whole session, the 8 Imagine and 8 No-Imagine Cue Words repeated 12 times. We determined the random ordering of conditions (I or NI) over trials once at the study's outset, ensuring that no more than two consecutive trials came from the same condition; all participants followed this order. Cue Words were presented in a pseudorandom order across the blocks following the same rule as the practice phase. In between runs, we provided a short (up to 60s) break for the participant to rest their eyes. Diagnostic questionnaire was administered again verbally after the second block (i.e., halfway through the training). Trial timings matched the timings in the practice phase: fixation cross for 5s, coloured Cue Word for 4s, with 600ms isi.

At the beginning of the training phase, the experimenter always turned off her video camera, whereas the participants kept their cameras on. After a training session and before ending the activities on the first day, we told participants to not intentionally engage with the materials outside of the training sessions (i.e., to not rehearse the word pairs). On the second and third training days, participants followed the same procedure, except that we omitted the criterion test. We conducted the 3 training days consecutively and mostly at around the same time of the day.

After the INI task on the final training day, we tested participants on all 40 of the main target events in the experiment. The testing phase consisted of 1) a recall test in which a correct verbal response of the corresponding Key Detail to the Cue Word, and 2) a rating task in which vividness and affect ratings were given through html files sent by the experimenter for each of the events. During these tests, events were ordered such that no more than two consecutive trials were drawn from the same condition.

After the tests, we included a questionnaire to get a sense of the efficacy of training on the participants' suppression abilities and their impression of the training's viability to be adapted for personal future use, as well as a series of mental health questionnaires.

For the follow-up session, we contacted participants via email to schedule the follow-up session 3 months following the date of their introduction session (+/- 1 week). The follow-up session lasted around 1 hour and consisted of a recall test, vividness and affect ratings, and follow-up questionnaires. The Key Word recall test was the exact same as the testing phase on the last day of training, with only the time of stimulus display extended from 4s to 5s.

Statistical Analyses

The accuracy reported for the final Key Detail recall was not conditionalized on the criterion test from the first day of training. To put mental health questionnaires on a uniform scale, all scores included in this chapter were converted (unless otherwise stated as raw data) to percent of maximum possible (POMP) scores which is calculated as: $POMP = 100 * (raw - min) / (max - min)$. Analyses of repeated measures ANOVAs, ANCOVAs and t-tests were performed using JASP (JASP Team, 2021). Component values from PCA were derived from IBM SPSS Statistics 27 (IBM SPSS Statistics for Windows, 2020). Statistical analyses of structural equation modelling (SEM) were carried out in R using the lavaan package (Rosseel Y, 2012) for a LGCM of the questionnaire scores collected across the three time-points (Pre, Post, and Follow-up). Robust correlation analyses were conducted in R using a script that automatically gives an output for the most appropriate of the three correlation methods (Pearson's, Spearman skipped, percentage-bend) upon inspection for outliers and normality (Apšvalka, 2022).

Regarding data analysis strategy and approach, in order to determine how suppression or imagination affected the events themselves, we compared indices sensitive to event memory and affect across experimental conditions with their respective control events. Control events were other events generated by the participant that had the same valence as the suppressed content, and were matched algorithmically on vividness, intensity, and other event attributes (see Materials section). To probe the

SIF effect in event memory, we computed the percentage of key details correctly recalled for No-Imagine items and No-Imagine Baseline items. We evaluated SIF as having occurred if participants recalled fewer No-Imagine items than No-Imagine Baseline items. To determine if imagination facilitated recall of imagined items, we compared key detail recall for Imagine items to Imagine Baseline items. To probe the SIF effect in vividness, we computed change scores for participants' vividness ratings (post-training – pre-training), expressing these scores as percentages (POMP scores) for No-Imagine and No-Imagine Baseline items. Similarly, we evaluated SIF as having occurred if participants reported a larger change in vividness for No-Imagine than for No-Imagine Baseline items. We performed an analogous analysis to detect suppression-induced changes in affective intensity. We computed the impact of imagination on vividness and affective intensity in analogous fashion but using Imagine and Imagine-Baseline scores instead of No-Imagine and No-Imagine Baseline scores. We conducted similar analyses on the immediate assessment and after the 3-month delay. For delayed vividness and affect analyses, we computed change scores by comparing participants' follow-up ratings after 3 months to their pre-training ratings (follow-up – pre).

Suppression Training at Your Fingertips

4.1. Research & Development of a Suppression Training App

Contextualising the World of Mental Health Apps

All of us have probably experienced a moment in time when a thought just keeps popping into our mind time and again, sometimes remaining there, playing in our minds over and over again. Wouldn't it be nice to be able to type it into an app and then do a quick training to rid ourselves of that thought and all others like it? This is indeed the practical motivation behind the development of a suppression training app - learn to control intrusive thoughts, be they of past memories, current worries, or future fears, accessible at your fingertips. In other words, an app that aids a person to control intrusive thinking. Intrusive thinking has been described in many ways; moreover, one of the most comprehensive attempts defines "unwanted clinically relevant intrusive thoughts, images or impulses as any distinct, identifiable cognitive event that is unwanted, unintended, and recurrent. It interrupts the flow of thought, interferes in task performance, is associated with negative affect, and is difficult to control" (Clark, 2004, p. 4). Although similarly experienced thematically by both clinical and nonclinical individuals as established from early studies (e.g., Clark & de Silva, 1985; Parkinson & Rachman, 1981; Rachman & de Silva, 1978), intrusive thinking take on a much more aggressive tone in clinical populations such that it is more frequent in its interruption of daily activities, has a more severe and distressing impact on the individual as it unfolds in their mind, and feels more difficult to control or dismiss.

Therefore, its maladaptive and pathological manifestation has increasingly prompted researchers to consider intrusive thinking as a transdiagnostic symptom across many mental disorders (Brewer et al., 2021; Gustavson et al., 2018; B. C. Kalivas & Kalivas, 2016; P. W. Kalivas et al., 2023;

May et al., 2015; Pascual-Vera et al., 2017, 2019; E. R. Watkins, 2008). Indeed, as detailed in previous chapters, intrusive thoughts can induce various psychiatric symptoms, often taking on additional names such as repetitive negative thinking, preservative worry, and rumination. Such symptoms subsequently can worsen one's existing conditions or even initiate psychopathology in vulnerable populations or in individuals with existing predispositions, manifesting in substance use disorders, GAD, depression, PTSD, and OCD (for reviews, see Brewer et al., 2021; Demnitz-King et al., 2021; B. C. Kalivas & Kalivas, 2016; P. W. Kalivas et al., 2023). With the onslaught of the COVID-19 pandemic, intrusive thoughts about the pandemic and its potentially imminent, dire, and consequential impact on one's life came to the forefront of public health concerns (see Chapter 1.3). Therefore, it seemed more urgent than ever to be able to help the ailing population in being able to cope with these pandemic-aggravated intrusive thoughts with an easily accessible, widely deployable, and theory-grounded tool. With this aim, in the age of pandemic where we could no longer run in-person interventions, we decided to turn to the world of web and mobile-based applications for potential openings.

At the time of the writing of this thesis, over 5 billion people, equivalent to 65% of the global population, are using the internet, with 95% of us using a mobile phone to go online (Digital 2023 Global Overview Report, 2023). Furthermore, there are over 5.7 million apps on the Apple App Store and Google Play Store, which is not too surprising given the fact we spend 85% of our time using apps when we are on our phones ('Mobile App Industry Statistics', 2023). Beyond the entertainment value, apps have been increasingly applied in the health sector due to their capacity to influence behavioural changes (Wendel, 2020), improve physical health (Fanning et al., 2012; Free et al., 2013), and elevate mental health states, in particular through digital psychotherapy (Simon & Ludman, 2009). Following precedence set by the WHO in giving a platform for mobile health (mHealth) in public health services, mental health apps (MHapps) became almost an intuitive next step (for a review, see Hwang et al., 2021). With the average smartphone owner using about 10 apps per day ('Mobile App Industry Statistics', 2023), it is not surprising that the frequency of MHapp use increased during the COVID-19 pandemic (Aziz et al., 2022). As more and more MHapps develop, there have also been vigilant voices reminding us of the efficacy, intended reach, and impact of such apps through meta-analysis of their

implementation (Lecomte et al., 2020; Linardon et al., 2019; Weisel et al., 2019). Indeed, close attention should be paid to their grounding in theory, convergence with behavioural results, and demonstration of effectiveness and reliability across target populations.

Critically, despite existing literature demonstrating cognitive control as an important area implicated in various mental health issues, there is a gap in the world of mHealth to target cognitive control as a gateway to well-being via interactive applications. Even though inhibitory control has been demonstrated as being responsive to training for increased capacity (Benikos et al., 2013; Jones et al., 2013), there have only been two mobile apps specifically designed to improve inhibitory control through training (for a review, see Vergani et al., 2019). Having established both that inhibitory control ability can be improved upon through app-delivered training sessions (Arean et al., 2016; Blackburne et al., 2016), and that suppressing intrusive thoughts can improve one's mental health state as seen from results in Chapter 3, it is only reasonable for us to take on this timely challenge to develop an app to train one's ability to suppress intrusive thoughts with the aims to ameliorate any presenting mental health issues.

With the exception of the two apps specifically developed to train and improve in cognitive control abilities, most of the health intervention apps are geared towards addressing mental health needs through self-help CBT, breathwork, meditation, and suicide prevention. Importantly, such apps have been observed to have “reduced stress, anxiety, and depression and improved well-being” (Hwang et al., 2021, p. 16). Though the results are not yet generalisable due to small samples, there are encouraging observations on the various clinical applications of training apps in areas of improving cognitive abilities as well as mental health states. There have also been innovative ways to deliver a multiplex intervention by combining app training with psychoeducational materials, specific coaching and feedback based on progress, as well as potential integration of live-people, specifically with MHapp applications in panic disorder patients (Ebenfeld et al., 2021) and veterans with PTSD and traumatic brain injury (Elbogen et al., 2019). Importantly, there has been one study that combined cognitive-emotional training with brain imaging to show a first round of evidence for training-associated changes in the short-term plasticity of neural networks within the context of patients with major depression (Hoch et al., 2019).

Furthermore, the above-mentioned clinical populations are also the same groups of people who are often implicated in having deficits in inhibitory control which manifest as heightened intrusive thinking. Taken together, these studies are paving the way forward for investigations into further research and development of more theory-centred, user-friendly, and impact-oriented web/mobile applications for training people to better cope with maladaptive intrusive thinking.

Suppression Training App: Vision, Aims, and Hypotheses

Inspired from my 3-month follow-ups with the participants who participated in the videoconferencing-based INI training (vINI-T) (see Chapter 3), the essential idea is to develop a web-app closely aligning with the INI training. Indeed, just as the use of effective encoding strategies may be an effective treatment for episodic memory impairments in individuals with deficits in self-initiated encoding strategy use (Kirchhoff, 2009), training to use effective suppression strategies may be an effective treatment for thought control impairments in individuals suffering from intrusive thoughts. Although it was quite clear from the beginning of these follow-up sessions that the training seemed to have tapped into an area of need in the general population in empowering people to learn a cognitive skill many of them didn't know they had, the idea to create an app didn't really come to fruition until one of our participants literally asked: *why don't you create an app for this?* Henceforth began a year-long (June 2022 - May 2023) process of designing and developing an app-based INI training (aINI-T) that allows researchers to deliver the core TNT training component to participants through an app, in the comfort of their own native environments. More broadly, for maximum effectiveness in administration and use, the functionality of the app needed to comply to the following three general requirements:

- 1) Flexible: capacity to support all the variants of the TNT task (as discussed in Chapter 1.1) , including different types of stimuli style (words, images), content (laboratory-derived such as word/image pairs, or user-generated such as past memories, present concerns, and future fears), and if needed, valence (positive , negative, neutral).

- 2) Comprehensive: capacity to incorporate other essential components of a typical TNT experiment beyond its core TNT phase, namely generation phase, event ratings phase, learning phase, feedback phase, recall testing phase, as well as a way to administer daily surveys, diagnostic questionnaires during the TNT phase, and pre-/post-experimental questionnaires.
- 3) Sustainable: capacity to attribute different roles to experimenters, create separate projects to allow multiple simultaneous experiments within the same lab, collaborate internationally within a team, and sufficient storage for all administration and user-generated data.

With the above functionality in mind, the first pilot of the app was executed with the following aims:

- 1) Evaluate feasibility and quality of use from 3 perspectives: *researchers* who wish to administer TNT-related experiments using the app, *research participants* who will be lab-type users of the app in a hybrid experimental environment, and *the general public* who will be the consumer-type users in the real world.
- 2) Replicate expected patterns of learning during training, with a vigilant eye on unexpected changes in behaviour, level of task compliance, and degree of interest in participation.
- 3) Develop an administrative manual for researchers with an interest in inhibitory control to be able to effectively use this as an accessible alternative tool to expand the reach of their projects, and an onboarding information sheet for users to be able quickly navigate and engage most effectively with the app.

Indeed, it was also expected that the app will go through revisions following the pilot experiment, informed by the detailed participant feedback we expected to receive as we have intentionally structured it to be an essential component of the pilot experiment. Moreover, from closely following the results obtained from the vINI-T study as delineated in Chapter 3, and with the assumption that app features will run as planned, we ambitiously hypothesised for the aINI-T study to replicate all findings from the immediate-test portion of the vINI-T study (since we did not do a follow-up portion for the aINI-T study). Specifically:

A. Impact of Thought Suppression on Feared Events

-
- a. Suppression-induced reduction in recall accuracy of key detail, and in subjective ratings of vividness and affect for the Suppressed future fearful events, more so than that of Baseline events.
 - b. No significant risk of ironic rebound in key detail recall, vividness, or affect both generally for the collective participant sample, and specifically for participants reporting high levels of pre-training anxiety, depression, or post-traumatic stress.
- B. Immediate Effects of Suppression on Mental Health
- a. Improvements in self-reported measures of depression, state anxiety, worry, positive and negative affect, and well-being from pre-training to post-training.
 - b. No significant risk of ironic rebound in mental health states both generally across participants, and specifically for people with heightened anxiety and PTSD-like symptoms.
- C. Perceived Effects of Suppression
- a. Participants improve in their self-reported ability to control fearful thoughts in response to reminder cues steadily during the course of the training.
 - b. Propensity for majority of the participants to be surprised in their ability to learn, and a desire to adopt and reuse the suppression skill in their own lives outside of the research environment.

With the above-mentioned functionality and aims in mind, we conducted some market research and finally decided to partner with Ounce Technology (2014) in June 2022 to begin the first iteration of designing and developing a web-app. In terms of contributions, the results presented in this chapter are all obtained by the web-app developed in entirety by Ounce Technology. The design and content of the application were developed from close discussions between myself, my PhD supervisor, and the team at Ounce. The initial testing of the app was then carried out by both myself and the team at Ounce. After I had completed the pilot experiment, the results of which are presented in this chapter, a manual intended to facilitate future researchers to use the web-app was compiled by PhD student Julie Lundsgaard which is included in Appendix B for reference.

A Glimpse into Transforming the Training into an App

By focusing more on integration of features, flow of the experimental procedure, and collection and organisation of data, the first iteration of the app was designed to be contextualised in the research setting, rather than a commercial product. Such a focus offers great advantages such as having an app that is theoretically grounded in all of its design and development which is central for tapping into the cognitive construct in question, but also reveals some limitations such as a less advanced user-experience design which would become more essential at a later iterative stage when the app is launched for use in the general public. In addition, in transforming the remote INI-T from being videoconferencing-based to being app-based, we also decided to develop a web-app instead of specifically a mobile app, because the former allows for use across platforms (i.e., Android, iOS, laptop, mobile, tablet) and cuts down on costs due to the administrative fees associated with app stores. Importantly, throughout the 11 months of design and iteration, there were continuous and constant back-and-forth discussions amongst the app developers and the researchers in order to best tailor to the needs of both researchers and users. Specifically, the most up-to-date version of the app at the time of the writing of this thesis is at version 1.38.1 (<https://at.ounce.ac/>) which effectively means 38 different launched renditions of the app environment. The number of revisions on the user interface's specification document and slide deck gives a glimpse of the highly iterative process involved in the development of the app (Table 14A). Indeed, there was much necessary communication between the app developer and the researcher to make sound choices for mimicking the laboratory protocol for the steps involved in each of the phases of the training, as can be seen from the example of the comments written by the developer in response to feedback from the researcher in Table 14B.

Table 14.*A. User Interface Specification – Version History Log*

General	Event Generation	Event Rating	Learning	Training	Questionnaires
2022-07-25	<i>Draft</i>	<i>Draft</i>	<i>Draft</i>	2022-07-13	<i>Draft</i>
2022-07-29	2022-07-08	2022-07-08	2022-07-11	2022-07-29	2022-07-25
2022-08-01	2022-07-11	2022-07-11	2022-07-12	2022-08-01	2022-07-29
2022-08-02	2022-07-12	2022-07-12	2022-07-29	2022-08-02	
2022-08-22	2022-07-29	2022-07-29	2022-08-01	2022-08-03	
2022-10-13				2022-08-04	
2022-11-10	<i>Signed-off</i>	<i>Signed-off</i>	<i>Signed-off</i>	2022-10-25	<i>Signed-off</i>
	2022-08-01	2022-08-01	2022-08-02	2022-10-26	2022-08-01
	2022-08-03	2022-08-03	2022-08-03	2022-10-27	
	2022-09-08	2022-09-08	2022-09-20	2022-11-01	
	2022-09-20	2022-09-20	2022-10-03	2022-11-02	
	2022-09-28	2022-10-03	2022-10-13	2022-11-11	
	2022-10-03	2022-10-11	2022-10-20	2022-11-24	
	2022-10-11	2022-10-13	2022-11-28	2022-12-07	
	2022-10-14	2022-12-07	2022-12-07	2023-01-10	
	2022-11-21	2023-01-16	2022-12-08	2023-01-16	
	2022-11-23		2022-12-12	2023-01-30	
	2022-12-07		2023-01-30		
	2023-01-20		2023-02-02		
	2023-01-30				

Note: There are eight phases in the experimental protocol for aINI-T: Pre-Training Questionnaire, Event Generation, Event Rating, Learning, Training, Recall, Vividness/Affect Rating, and Post-Training Questionnaire.

B. Example of Details from Training Task’s User Interface Specification Version History

Log Date	Comments
2022-07-13	Initial Draft Version
2022-07-29	Changed button colours. Added support for using pictures as Hints. Responded to comments in previous version.
2022-08-01	Changed Z’s comments to green (Red is my colour!) Added comments on labelling screens for different phases (see slide 3). Changed design of End of Block screen (see slide 9). Additional comments on Practice Phase complete (Slide 11)
2022-08-02	Removed resolved comments. Combined Likert and Manikin scale into just one type, as the Manikins are just an example of using image labels. Added question on Diagnostic questions (slide 10) Added navigation details at start of test. Added note about normal default in DQ Phase. Removed End of
2022-08-03	DQ Phase slide as it can just go onto Test Instructions. Removed Repeat Practice button from End of Practice. Changed titles in right of headerbars to reflect phases of task (but these can easily be changed by me later).
...	... (continues)

The app was titled the “Attention Training” app (referenced from here onwards as ATapp), changing from its original title of “TNT Training” app in order to prevent any participant from looking

up the TNT task as the recall test should be concealed. Considerations also included removal of any reference to suppression during recruitment and at the outset of training. In this way, our feasibility pilot study of aINI-T took place via a hybrid videoconferencing and at-home app procedure through the course of 5 days. Unlike the vINI-T which had 4 groups of participants depending on the valence of the suppression and imagination stimuli (see Fig. 1B), since this study was the first pilot run of the app, we decided to only have one of the four groups, namely the ‘Suppress-Negative & Imagine-Positive’ group. Closely following procedures from the vINI-T study, for the aINI-T study, 36 participants from the U.K. were invited to participate in a hybrid suppression training, whereby introductory and conclusion sessions were conducted online via Zoom with the experimenter, and the training itself took place completely on the ATapp in the participant’s own time and space (Fig. 11; see Tables 15A for participant demographics).

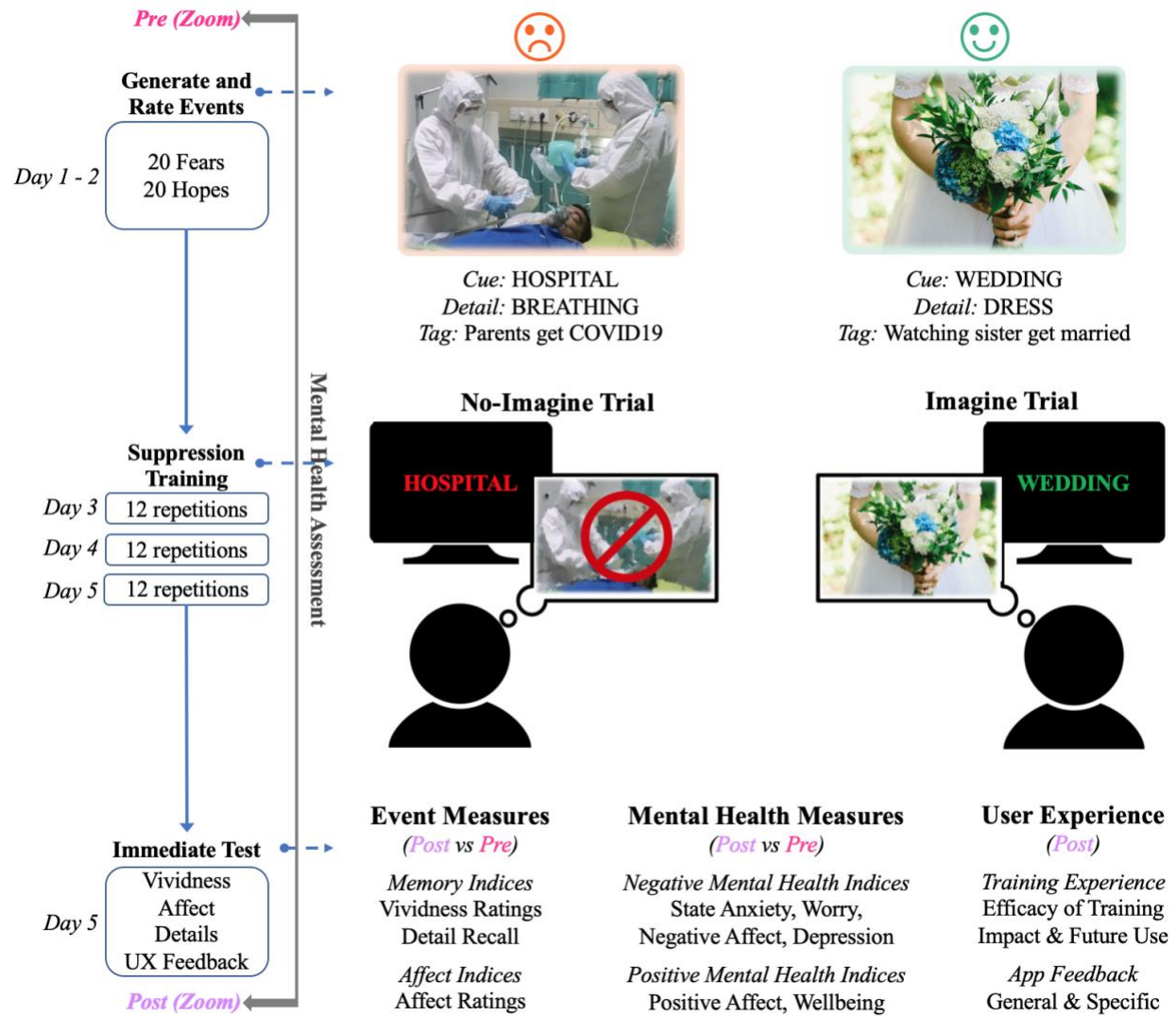


Fig. 11. Experimental procedure for the Attention Training app.

Participants were introduced to the Attention Training app (ATapp) during an introductory Zoom session, when they were registered with an account to the app, given detailed instructions for the event generation task and a brief overview for the next 4 days, and also had their mental health assessed. For the remainder of the experiment, all tasks were completed within the ATapp. For the next 2 days, participants generated 20 fears and 20 hopes each with a cue, a key detail, a short tag line, and a brief description with more details (images in figure are for illustration only, same as those in Fig. 1). After going through a few rounds of editing upon receiving experimenter feedback on the quality of their events within the app, they then rated event characteristics. 3 days of retrieval suppression practice ensued, each session was composed of 12 No-Imagine and 12 Imagine repetitions in response to No-Imagine and Imagine cues, respectively. Just as the vINI-T, No-Imagine cues (appearing in red) required participants to attend to the cue whilst suppressing retrieval of any imagery or thoughts; Imagine cues (appearing in green) required participants to imagine the event. Halfway through each training session, participants were prompted with a multiple-choice in-app instruction compliance survey that gave differential brief video feedback depending on what the participants picked as response. Immediately after the final training session, participants were tested for key detail, vividness and affect for all generated events and assessed in a survey for their perception of training efficacy. This marked the end of their engagement with the ATapp. They then met with the experimenter for a wrap-up Zoom session when they were debriefed, assessed for their mental health, and interviewed for their user experience feedback for the app.

Analyses of event measures focused on changes in memory and affect for each event after training compared to before (post vs pre), as did measures of mental health.

Table 15.

A. Demographic Characteristics of Participants

	n	%
Gender		
Female	30	83.33
Male	6	16.67
Missing	0	0.00
Ethnicity		
Asian	2	5.56
Mixed	3	8.33
White	31	86.11
Missing	0	0.00

Note. $N = 36$. Participants were on average 36.22 years old ($SD = 11.57$, range = 18 to 50).

B. Participants' Mental Health Characteristics Prior to Training

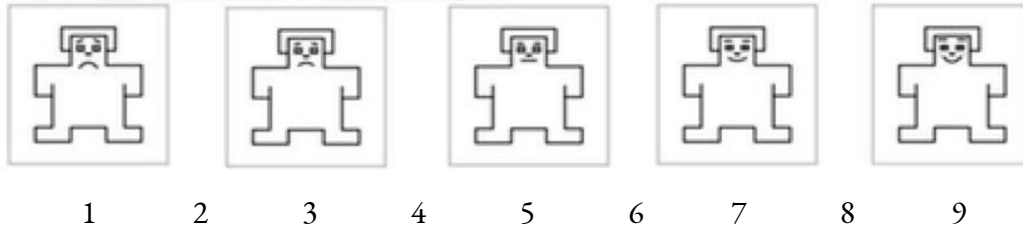
Baseline Characteristic	μ	SD	Min	Max
Positive Mental Health Indices				
Positive Negative Affect Schedule - Positive	32.25	8.80	15.00	47.00
Warwick-Edinburgh Mental Well-being Scale	46.14	8.86	26.00	61.00
Negative Mental Health Indices				
State Trait Anxiety Inventory - State	35.00	9.85	20.00	58.00
Penn State Worry Questionnaire	25.33	16.48	0.00	60.00
Positive Negative Affect Schedule - Negative	19.11	7.41	10.00	37.00
Beck's Depression Inventory II	11.92	10.68	0.00	42.00
Predictors of Training Response				
State Trait Anxiety Inventory - Trait	43.89	12.40	23.00	74.00
PTSD Checklist - Civilian	35.33	13.66	17.00	65.00

Note. Here we display raw questionnaire scores, though in most figures and analyses we used POMP scores.

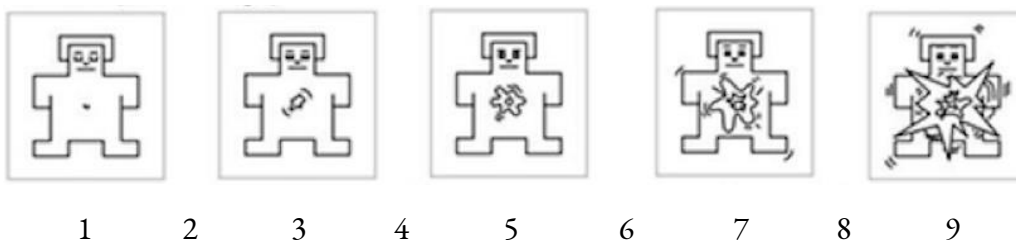
More specifically regarding participants, 88 individuals signed up (excluding 1 duplicate person who signed up twice) to participate in the study. 34 never replied to the welcome email so never began the study (39%). Out of the remaining 54 people, 18 people were excluded from the final analysis (33%): 2 participants couldn't pass the learning threshold (accuracy at only 48% and 63%), 3 individuals didn't show up to their scheduled introductory Zoom session, 6 participants showed up to the introductory Zoom session but didn't subsequently complete the Event Generation task, 6 individuals who signed up were subsequently detected to be actually non-native English speakers and thus excluded from the

rest of the study, and 1 participant's (Sub 62) training data was excluded from analysis due to previous participation in a TNT study which only surfaced during the last feedback session. In addition, 2 participants completed the study but missed the last Zoom session so have missing data for the post-experimental questionnaires and user experience (UX) feedback. The components involved in the training were essentially the same as the vINI-T except for two changes:

1. The PTSD symptomology measure was changed from IES-R to PTSD Checklist-Civilian version (PCL-C; Blanchard et al., 1996) due to the not-so-ongoing direct impact of the COVID-19 pandemic on a participant's daily life in 2023 which was the targeted trauma identified in IES-R for vINI-T
2. Addition of a daily STAR ratings (sleep, tiredness, affect, relaxation) and the self-assessment manikin's valence and arousal ratings to monitor for presence of any major shifts in self-maintenance
 - a. Sleep: How many hours did you sleep last night? (select from the dropdown menu)
[integers from 0 to 24]
 - b. Tiredness: How tired are you at this moment?
[1- much less than usual; 2 - less than usual; 3 - same as usual; 4 - more than usual; 5 - much more than usual]
 - c. Affect: How happy do you feel today?
[1- much unhappier than usual; 2 - unhappier than usual; 3 - same as usual; 4 - happier than usual; 5 - much happier than usual]
 - d. Relaxation: How relaxed do your muscles feel at this moment?
[1- very tense; 2 - tense; 3 - neither tense nor relaxed; 4 - relaxed; 5 - very relaxed]
 - e. Valence: The first picture shows a person who is clearly distressed - relevant experiences could include panic, irritation, disgust, despair, defeat, or crisis. The last picture shows a person who is obviously elated - relevant experiences could include fun, delight, happiness, relaxation, satisfaction, or repose. The remaining pictures depict intermediate states. Please select the picture that most describes how you feel right now, at this moment.



- f. Arousal: The first picture shows a person who is very calm, almost sleeping - relevant states could include relaxation, tranquillity, idleness, meditation, boredom, or laziness. The last picture shows a person who is bursting with arousal - relevant states could include excitement, euphoria, excitement, rage, agitation, or anger. Please select the picture that most describes how you feel right now, at this moment.



In addition to the notable changes above, there were also a few improvements made in the procedures to integrate the training. In vINI-T, after generating 20 negative/positive events, participants needed to email the spreadsheet to the experimenter which will then be sent back with editing requests. This was streamlined in the app by allowing the experimenter to be notified via email upon participant's submission of the events which then blocks the user from continuing onwards until the experimenter completes the review and flags any problematic entry with comments for guidance (see Appendix B: *Manual for Attention Training App*, p.14 and p.43). After the Event Generation Phase comes the Event Ratings Phase which is now integrated seamlessly to be a part of the app instead of the html task conducted via Psytoolkit (Stoet, 2017) in the vINI-T. For the Learning Phase, the threshold to indicate passing of the Learning Phase to move onwards to the Training Phase was increased to ensure more heightened attention from the participants: from vINI-T's $\geq 90\%$ accuracy with 3 allowed repeats to $\geq 99\%$ accuracy with 4 allowed repeats.

An additional change was the time duration to allow the participants to type in their response in the textbox during the criterion test prior to starting training. Previously, since it was a verbal response that gets marked by the experimenter, the time allowed for Response Word recall was 5 seconds; however, to account for the time required in typing, we've increased this to 8 seconds after some preliminary testing. On the same note, the time allowed for user response in the Recall Phase at the end of training was also changed to 8 seconds. All other timings (e.g., isi) were followed in the same way as the vINI-T. During training, participants practised the same INI task itself, with one notable modification in the process. The multiple-choice diagnostic questionnaire was administered after each practice phase and halfway through each training phase with semi-tailored video feedback to replace the online tailored verbal feedback (Fig. 12). The videos were brief (5-30 seconds) and differed based on the response choice of the participant. To ensure all directions are followed closely, participants were not allowed to move forward to the next question unless they had watched the feedback video.


After participants completed the third day of training, they proceeded to then complete the same tasks from the vINI-T, namely the Recall Task, Vividness & Affect Ratings Task, and a training experience questionnaire for efficacy of training and outlook on future use. The difference here was that all of this was completed in the app prior to their final wrap-up Zoom meeting with the experimenter, whereas all were previously a part of the final meeting for the vINI-T. The final wrap-up session thus included a short debrief, the post-experimental questionnaire with mental health measures, and a structured UX feedback in order to improve the app in future iterations. Occasionally, some participants who missed the link for the training experience survey in the app also then completed that during the Zoom session. All other elements of the training were the same as those of the vINI-T. Data analysis closely followed the vINI-T, whereby we evaluated suppression-induced effects on memory and affect, as well as presence of any suppression promoted paradoxical increases.

QuestionsTraining Pilot

RED TRIALS

2. How often did you replace the original Response Word with another word or thought?

0 Never 1 2 Half of the time 3 4 Always



Next

Fig. 12. Diagnostic questionnaire with video feedback on user screen.

The multiple-choice diagnostic questionnaire was administered after each practice phase and halfway through each training phase (i.e., after the second block) with semi-tailored video feedback for each question to replace the in-person/online tailored verbal feedback. The video feedback differed depending on which response was selected and aimed to give encouragement for continuation of the task while ensuring that instructions are followed closely. The person featured on the videos is a previous graduate student of the lab Dhruv Nandamudi.

The next section will look at the results obtained from the first pilot study of the ATapp. Due to the pilot nature of this study and the close resemblance to the vINI-T study as outlined in Chapter 3, the reporting of results will be interwoven with discussion when appropriate in order to comment effectively on the comparison between the two studies. In addition, this chapter will not repeat all of the Materials & Methods details involved as almost everything was kept exactly the same in order to replicate the vINI-T study. Indeed, whenever there is a difference, it shall be mentioned explicitly in the chapter. Needless to say, although one of the aims is to replicate the findings from the vINI-T study as summarised in Chapter 3, we still anticipated the endeavour to require a lot of ironing of wrinkles, so to say. In addition, some notable insights from the UX feedback session will also be discussed in more detail towards the end of the chapter.

4.2. *Piloting of the Attention Training App*

Impact of Thought Suppression on Feared Events

Prior to beginning any detailed reporting of the results, it is important to take account of the two errors that occurred in assigning events to conditions (i.e., No-Imagine, No-Imagine Baseline, Imagine, Imagine Baseline, Filler) that will have implications to interpretation of the ATapp pilot data. The first error is a human error whereby the “Distance in the Future” rating was unticked in the set-up of the Event Ratings task for negative events which resulted in participants never seeing this scale for the negative events during their Event Ratings task. This also meant that this scale was somehow not incorporated into the event characteristics which require matching across conditions. This then brings us to the second error: a technical bug in the matching algorithm that was not detected prior to running the pilot, which also contributed to the reason for the first error not being detected as part of the study set-up. Both of these errors have since been resolved for future use, and the minimisation function that is currently used for the matching algorithm is specified in the ATapp manual (see p. 44 of Appendix B). As a result of the error in the matching algorithm, as can be seen in Table 16, there are significant differences in various event characteristics between the No-Imagine/Imagine conditions and their respective Baselines. Moreover, to-be suppressed events were more likely to occur, more frequently on people’s minds, and more potent sources of concern than the Baseline negative events; on the other hand, to-be imagined events were more likely to occur, more frequently on people’s minds, more current in their focus, perceived to have a more long-term impact, and more pleasant than the Baseline positive events. Essentially, events in both the Imagine and the No-Imagine conditions were more memorable than the events in their respective Baseline conditions.

Therefore, in terms of interpretations of results, if suppression-induced effects are still observed, then it actually really supports the effectiveness of suppression despite the heightened memorability of the suppressed events. However, if SIF effects are not observed, then these errors can be an important explanation to be mindful of in the seeming null result due to the disadvantaged status of high memorability of the suppressed events compared to baseline from the get-go. On the other hand, since

to-be imagined events were already more potent in memorability from the start, if the results show facilitation effects, it is not really interpretable as to the attribution of its cause. If the results for the imagined events were to show unexpected reversals, however, then it could mean that the imagination procedure was not executed properly. If participants subjectively also reported the imagination procedure to be not as helpful as suppression, then given the already highly imaginability of the to-be imagined events, this lack of appeal would in turn highlight the power of suppression.

Table 16.*A. Event Characteristics of To-Be Suppressed Events*

<i>Negative Events</i>	Baseline				No-Imagine				Sig
	μ	SD	min	max	μ	SD	min	max	
Extent of Currentness	3.00	0.73	1.38	4.63	3.60	0.58	2.25	4.57	***
Distance in the Future									
Emotional Intensity	1.99	0.53	1.00	3.50	2.28	0.86	1.00	5.63	ns
Frequency of Thought	2.78	0.61	1.38	4.00	3.44	0.53	2.25	4.43	***
Likelihood of Occurrence	2.75	0.76	1.63	4.43	3.25	0.59	2.13	4.50	**
Long-term Impact	3.65	0.67	2.38	4.75	3.65	0.65	2.13	5.00	ns

B. Event Characteristics of To-Be Imagined Events

<i>Positive Events</i>	Baseline				Imagine				Sig
	μ	SD	min	max	μ	SD	min	max	
Extent of Currentness	2.91	0.79	1.13	4.75	3.52	0.60	1.88	4.75	***
Distance in the Future	3.00	0.60	2.13	4.38	3.05	0.61	1.75	4.50	ns
Emotional Intensity	7.77	0.65	6.50	9.00	8.20	0.52	6.50	9.00	**
Frequency of Thought	2.72	0.74	1.25	4.13	3.45	0.67	2.13	4.63	***
Likelihood of Occurrence	3.53	0.71	1.88	5.00	3.86	0.64	1.75	5.00	*
Long-term Impact	3.39	0.65	2.00	4.50	3.78	0.52	2.63	4.88	**

Note. All reported event rating measures were collected prior to suppression training and were used algorithmically to assign events so as to match Baseline and Imagine or Baseline and No-Image conditions prior to training. **Extent of Currentness:** the extent to which the event is a source of current focus of one's thoughts, where 1 is not at all, 3 is to some extent, and 5 is most definitely. **Distance in Future:** how far in the future one imagines the event happening, with 1 being very soon and 5 being further in the future, with the maximum being 2 years away. Due to experimenter error, this rating was not collected for negative events. **Emotional Intensity:** how strongly the event makes one feel, where 1 is very unpleasant and 9 is very pleasant (Manikin scale wherein 5 is neutral). **Frequency of Thought:** how often one tends to think about the event, with 1 being rarely and 5 being very often. **Likelihood of Occurrence:** how likely the event is to actually happen to the person, with 1 being a very unlikely event and 5 being almost certain to happen. **Long-Term Impact:** how much long-term impact (aversive or beneficial) the event will have on one's physical and/or psychological well-being if the event were to come true, such that: 1-none at all, 2-negligible, 3-small, 4-moderate, 5-large/formidable. Significance indicated (***) < .001; ** < .01; * < .05) by independent t-test between the *Baseline* and the manipulation condition (*No-Imagine* or *Imagine*).

In parallel with the vINI-T study, we first tested how thought suppression training affected memory for the suppressed events and sought evidence for ironic increases in accessibility of suppressed

content to quantify the risk of training people to suppress their fears. After suppression training, unlike the vINI-T data, participants did not have a significant reduction in accurate recall of the key detail of their personal events; moreover, there was no significant SIF or IIF effect as participants seemed to be able to recall the associating detail with the events quite readily across conditions (Table 17). Although it is clear that the heightened memorability of the events made the SIF effect for key detail recall improbable to observe, the uniform increased accuracy of recall post-training compared to before training points to a further underlying factor for the observation. One avenue of explanation could be that as a whole, all of the negative events were rated on average to be more unpleasant by participants using the app than the previous participants in the vINI-T. This could be due to the nature of the events themselves being more personally relevant which can be prompted by the added layer of privacy and comfort the app allows which was previously absent from the rigid spreadsheet listing format of the Event Generation task with the added hassle of back-and-forth emailing of the completed spreadsheets. Indeed, this was verbally mentioned by participants during the UX feedback session.

As was with vINI-T, we also tested whether suppression altered events' phenomenological quality by quantifying changes in reported vividness observed after training compared to before training. Although the suppressed negative events on average became less vivid, the effect is not significant. On the other hand, the imagined positive events were significantly more vivid than the Baseline, $F(1,64) = 10.91$, $p = 1.57 \times 10^{-3}$, $\eta_p^2 = 0.15$ (Table 17). However, as noted above, due to the heightened memorability of the imagined events prior to training, this result is not particularly interpretable. Similarly, participants felt less anxious as a whole for the negative events they suppressed compared to those not suppressed; however, the effect is not significant. For the imagined events, similarly, they felt more joyful, and while the effect seems significant, $F(1,64) = 12.55$, $p < 0.001$, $\eta_p^2 = 0.16$, the underlying sample distributions seem to suggest a violation of equal variance (Table 17). As was mentioned, given the heightened memorability of the events, and especially the fact that the suppressed and imagined events were all more currently on the participants' minds as they were more likely to occur and thus frequently thought of, it is not too surprising that these events still seem relatively similar in vividness and pleasantness to how they felt 3 days prior to training. Given that for

some, the results here may seem to resemble ironic rebound effects, we investigated the relative risks of such effects further. Specifically, as was undertaken for the vINI-T, to address the likelihood of rebound effects, we sought individual participants for whom the accessibility of suppressed details or fearful imagery increased on the post-training measure compared to the pre-training measure. If ironic rebound effects are a serious concern, such post-suppression increases should be common.

Table 17.

Immediate Effects of Suppression & Imagination on Key Detail Recall, Vividness, and Affect

	Suppression			Imagination		
	n	μ	SD	n	μ	SD
Key Detail Recall						
Baseline	35	0.91	0.12	35	0.95	0.10
Intervention	35	0.95	0.08	35	0.95	0.07
SIF / IIF	36	-0.04	0.10	36	-2.50×10^{-3}	0.12
<i>Significance</i>	$t(68) = -1.49, p = 0.14, d = -0.36$			$t(68) = 0.04, p = 0.97, d = 9.93 \times 10^{-3}$		
Vividness						
Baseline	33	-0.68	0.76	33	-0.22	0.72
Intervention	33	-0.92	0.82	33	0.33	0.62
SIF / IIF	33	0.24	0.46	33	0.55	0.83
<i>Significance</i>	$t(64) = 1.25, p = 0.21, d = 0.31$			$t(64) = -3.30, p = 1.57 \times 10^{-3}, d = -0.81$		
Affect						
Baseline	32	-2.03	0.99	33	0.04	0.43
Intervention	31	-2.22	0.76	33	0.11	0.27
SIF / IIF	31	0.17	0.69	33	0.07	0.39
<i>Significance</i>	$t(64) = 1.06, p = 0.29^a, d = 0.26$			$t(64) = -3.54, p < 0.001^a, d = -0.87$		

Note. SIF: suppression induced forgetting (Baseline – Intervention, positive values indicate more forgetting of key detail, decrease in vividness and/or affect for suppressed events), IIF: imagination induced facilitation (Intervention – Baseline, positive values indicate more recall of key detail, increase in vividness and/or affect for imagined events). Key Detail recall reflects the percentage of items correctly recalled. Vividness reflects the change in rated vividness after training compared to before it (post – pre). Affect reflects the change in rated affect (anxiety for negative events, joy for positive events) after training compared to before it (post – pre). The number of participants included in the analysis is denoted by n, to account for some missing data. Significance is calculated with Student's t-test (independent samples) with Baseline vs. Intervention as the grouping variable. *d* denotes value for Cohen's *d*. ^aBrown-Forsythe test is significant ($p < .05$), suggesting a violation of the equal variance assumption.

Across the whole sample of 36 participants, No-Imagine items were associated with lower key detail recall ($t(34) = 3.32, p = 1.09 \times 10^{-3}$, alternative hypothesis: Pre > Post), reduced vividness ($t(32) = 6.51, p < 0.001$, alternative hypothesis: Pre > Post), and reduced affect ($t(32) = 6.85, p < 0.001$, alternative hypothesis: Pre > Post). Only 1 person out of 36 showed higher detail recall for suppressed items post-training (Table 18A). Of all of the participants, 1 reported reversal for key detail, and 3

reported increased vividness for No-Imagine items post-training; critically, no one reported any increase in anxiety upon thinking about the suppressed events (Table 18A, Fig. 13A). Importantly, however, these cases are unlikely to reflect ironic rebound effects: a similar number of participants reported increases for Baseline events. Indeed, twice as many participants reported increased vividness for the negative events they did not suppress (i.e., Baseline) relative to the number of people reporting an increase for the suppressed events. Given the already higher memorability of the suppressed events, the relatively more people experiencing more vivid non-suppressed events as opposed to suppressed events actually further strengthens the power of suppression in reducing memorability of events. The relative risk of a rebound in anxiety about suppressed fears was also non-existent given that no participant reported more anxiety about any negative events, suppressed or not (Table 18A, Fig. 13B). Even when we examined individual feared events, the number of fears (per participant) showing increased recall of key detail, vividness, or induced anxiety did not vary significantly across the Baseline and No-Imagine conditions (see Table 18B). Unlike the vINI-T results, however, although one can observe a positive trend, suppression-related reductions of feared events in affect and vividness were not robustly associated (Fig. 13E). If it were significant, it would have indicated that suppression training, by potentially reducing vividness, weakened the suppressed thoughts' capacity to instil anxiety. Although observations do not robustly lead to such a conclusion, the result itself could very much be tainted by the fact that the suppressed negative events were very memorable and thus to make them less vivid may require more days of training than three 20-min sessions.

Similar to the v-INI-T, we considered the possibility that ironic rebound effects only arise for emotionally intense fears of great concern to participants. To address this, we examined whether the degree to which suppression training reduced detail recall, vividness or induced anxiety response for No-Imagine fears varied according to participants' initial emotional intensity ratings for those fears. Once again, contrary to such concerns, greater fear intensity was associated with larger suppression-related reductions in anxiety response after training compared to before training, $r = .60$, $p < 0.001$, 95% CI = [.31, .78] (Fig. 13B). Initial emotional intensity was not associated with declines in detail recall, $r = -.02$, $p = .92$, 95% CI = [-.35, .32]. Notably, greater suppression-related reductions in vividness after training

compared to before training was associated with smaller fear intensity, $r = -.37$, $p = 0.03$, 95% CI = $[-.63, -.03]$ (Fig. 13A). This makes sense as these future worries were very memorable so it is likely that the vividness would be more reducible for events that are not so unpleasant. In terms of the positive future hopes, although there is a significant difference between Imagine and its Baseline in vividness as noted above, there seems to be more reversal patterns in the imagined hopeful events (Fig. 13C & D). In addition, there is no relationship between the emotional intensity of the hopes with imagination-relation increases in detail recall ($r = .01$, $p = .94$, 95% CI = $[-.32, .34]$), vividness ($r = -.03$, $p = .86$, 95% CI = $[-.37, .31]$), or affect ($r = -.22$, $p = .21$, 95% CI = $[-.53, .13]$).

Table 18.*A. Relative Risk of Increased Accessibility (Reversals) after Training (post – pre) for Suppressed Events Compared to Baseline*

	# Subj With Reversals	# Subj Without Reversals	Absolute Risk (%)
Key Detail Recall			
No-Imagine	1	34	2.86
Baseline No-Imagine	1	34	2.86
Relative Risk [95% CI]		1.00 [0.07,15.36]	
Affect			
No-Imagine	0	31	0.00
Baseline No-Imagine	0	32	0.00
Relative Risk [95% CI]		Undefined	
Vividness			
No-Imagine	3	30	9.09
Baseline No-Imagine	6	27	18.18
Relative Risk [95% CI]		0.50 [0.14,1.83]	

Note. Relative risks are “undefined” if a calculation resulted in division by zero. If the relative risk = 1, or if the 95% confidence interval includes 1, then there is no significant difference between the groups.

B. Average Number of Fears Per Participant that Show Increased Accessibility (Reversals) After Training (Post – Pre)

	n	μ	SD
Key Detail Recall			
No-Imagine	36	0.01	0.05
Baseline No-Imagine	36	0.03	0.07
Affect			
No-Imagine	33	0.05	0.07
Baseline No-Imagine	33	0.05	0.10
Vividness			
No-Imagine	33	0.12	0.14
Baseline No-Imagine	33	0.16	0.18

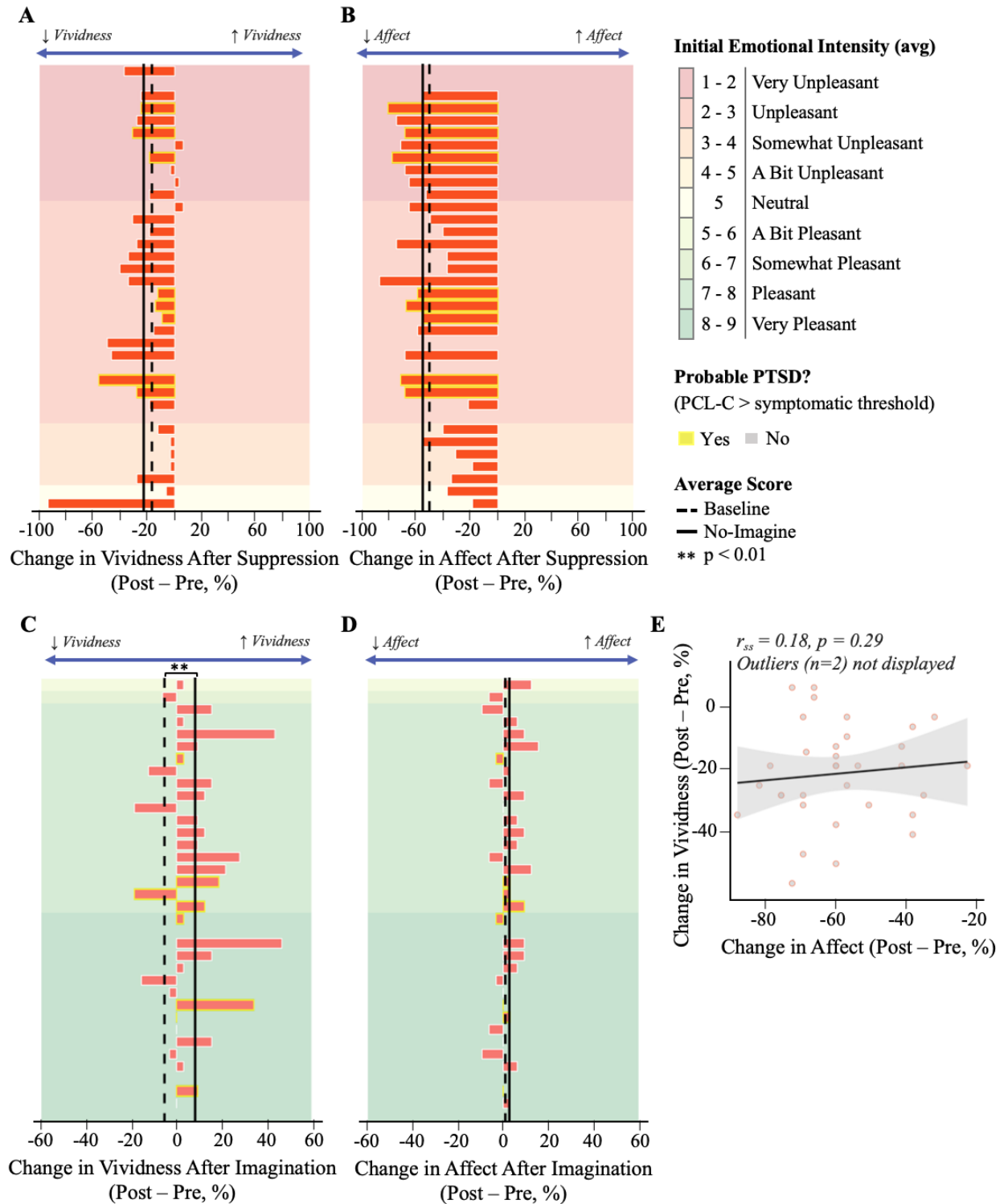


Fig. 13. Changes in vividness, and emotion after suppression reveal benefits, not ironic rebound.

(A) Suppressing fears reduced their vividness on an immediate test for nearly all participants, irrespective of the initial emotional intensity of those fears or participants’ post-traumatic stress status; horizontal bars are individual participants’ average change in vividness (post – pre; POMP scores). Participants are sorted vertically by the average emotional intensity of fears pre-training from least (bottom bars, light orange background) to most intense (top bars, darker red background); yellow highlights on bars indicate participants with probable PTSD. Although not significant, vividness reductions were

greater for No-Imagine than for Baseline items and did not vary reliably by event valence (mean changes indicated by solid black vs dotted vertical bars) and are greater for participants whose events are initially more intense ($r = .28$, $p = .027$). **(B)** Suppressing feared events reduced their affective tone for most participants, irrespective of initial emotional intensity and PTSD status. Although not significant, affect reductions were greater for No-Imagine than for Baseline items (solid black vs dotted vertical bars). **(C)** Imagining hopes increased their vividness on an immediate test, seemingly more so for relatively less pleasant events. **(D)** Imagining hopeful events did not seem to have an effect generally on the affective tone for most participants. **(E)** Reduction in fear vividness did not seem to vary significantly with reduction in perceived fear intensity.

Finally, we tested whether people reporting higher trait anxiety or post-traumatic stress suppressed event details or imagery less well. We tested whether indices of mental health collected before training predicted declines in vividness, affect, and key detail memory for No-Imagine fears. Contrary to rebound concerns, suppression-related declines in reported anxiety felt towards the fears were greater, not smaller, the higher the reported PTSD symptoms ($r = -.39$, $p = .03$, 95% CI = $[-.05, -0.66]$). Unlike the v-INI-T data, all other observed declines in vividness, affect, or key detail memory were not reliably related to high trait anxiety, depression, or post-traumatic stress (see Table 19A). With regards to imagination training, there is no significant association between increases in key detail recall, vividness, and induced joyful affect that hopeful events showed with pre-training trait anxiety, depression, or post-traumatic stress (see Table 19B). It is important to note that the sample size is almost half as much in this pilot relative to the v-INI-T study, which can introduce noise that prevent very meaningful conclusions to be drawn from null results. However, all of the observations and trends mentioned still seem to support that there is no substantial evidence of increased vulnerability of qualitative changes in the future feared events. In other words, these findings provide no indication that training people to suppress distressing thoughts of feared events triggered ironic rebounds.

Table 19.

A. Pearson's Correlations of Suppression-Related Declines with Vulnerability in Mental Health

	Suppressed Fears	Pearson's r	p-value	Lower 95% CI	Upper 95% CI
STAI-Trait <i>(Pre-Training)</i>	Key Detail Recall	-0.01	0.94	-0.35	0.32
	Vividness	0.08	0.64	-0.27	0.42
	Mood	-0.09	0.63	-0.43	0.27
BDI-II <i>(Pre-Training)</i>	Key Detail Recall	-3.10×10^{-3}	0.99	-0.34	0.33
	Vividness	0.06	0.72	-0.29	0.40
	Mood	-0.21	0.26	-0.52	0.16
PCL-C <i>(Pre-Training)</i>	Key Detail Recall	-0.02	0.93	-0.35	0.32
	Vividness	0.07	0.69	-0.28	0.41
	Mood	-0.39	0.03*	-0.66	-0.05

Note. Key detail recall measure was taken post-training, whereas vividness and mood measures reflect the change score as a result of training (post-training – pre-training). All scores used in correlations in the form of POMP scores. The p-value is indicated as such: <0.001(***), <0.01(**), <0.05(*), <=0.1(†), >0.1(ns).

B. Pearson's Correlations of Imagination-Related Increases with Vulnerability in Mental Health

	Imagined Hopes	Pearson's r	p-value	Lower 95% CI	Upper 95% CI
STAI-Trait <i>(Pre-Training)</i>	Key Detail Recall	0.27	0.12	-0.07	0.55
	Vividness	0.09	0.63	-0.26	0.42
	Mood	-0.22	0.21	-0.53	0.13
BDI-II <i>(Pre-Training)</i>	Key Detail Recall	0.18	0.29	-0.16	0.49
	Vividness	0.13	0.46	-0.22	0.45
	Mood	-0.13	0.48	-0.45	0.23
PCL-C <i>(Pre-Training)</i>	Key Detail Recall	0.21	0.23	-0.13	0.51
	Vividness	4.56×10^{-3}	0.98	-0.34	0.35
	Mood	-0.16	0.36	-0.48	0.19

Effects of Suppression on Mental Health

If one were to hold the flawed yet still influential Freudian premise that suppressing distressing content in one's mind can cause its malicious nature to manifest in maladaptive mental state and behaviour, then mental health indices can potentially act as an indirect indicator for its maladaptive persistence redirected in one's mental health state. Indeed, we challenged a lot of the assumptions underlying such ironic effects in Chapter 2, and showed evidence that mental health state actually improves with the suppression of negative fears and worries both in short-term and in long-term in Chapter 3; hence, we aimed for the pilot study of the ATapp to further contribute to this discourse. As mentioned before, the only notable difference in the pilot study in terms of mental health indices was the use of PCL-C (Blanchard et al., 1996) instead of the IES-R (Weiss & Marmar, 1997). This change was made because of the nature of the societal context coinciding with the timeline of our studies. The vINI-T study was conducted in the midst of the COVID-19 pandemic and since people's worries and fears were mostly preoccupied with the pandemic, it seemed more intuitive to tailor the post-traumatic stress symptomatology to pandemic-related stress. However, by the time that the aINI-T study began in March 2023, the effects of the pandemic had largely subsided such that it was no longer the top concern in everyone's minds; therefore, we switched the post-traumatic stress measure to PCL-C which is a widely used measure for PTSD symptomatology with reliable psychometric properties (Conybeare et al.,

2012; Ruggiero et al., 2003). In attempting to replicate the original vINI-T study, we followed the protocol closely and calculated changes in reported depression, state anxiety, worry, positive and negative affect, and well-being from pre-training to post-training.

After training people to suppress distressing thoughts, their mental health improved on average qualitatively on all measures, and significantly for worry (Fig. 14). All of the mental health measures changed in the right direction of improvement in the measured state yet this was not statistically significant. One factor could simply be the reduced power due to having missing data for 2 participants. Another factor could be some of the added frustration experienced with bugs in the app contributing a slight dent in the state of the participant when they meet with the experimenter. Even though the UX feedback session only took place after the participants completed the post-experimental mental health questionnaire, participants were still aware of the fact that they will have a UX feedback session very soon. Given that we didn't have a Suppress-Neutral group as the vINI-T study, we couldn't investigate the risk of ironic effects after suppressing fears versus after suppressing neutral thoughts. Similarly, we can't distinguish whether the improvement in mental health is definitively due to suppression of negative fears or imagination of positive hopes. However, the fact that participant's state of worry was specifically significantly reduced as a result of using the ATapp is an encouraging result that the effects are more likely a result of suppressing the very future scenarios they were worried about from coming into their minds constantly. In addition, as a pilot study, the findings are at least sufficient to demonstrate that suppressing unpleasant thoughts on the app not only does not result in maladaptive mental states, but rather shows potential for amelioration.

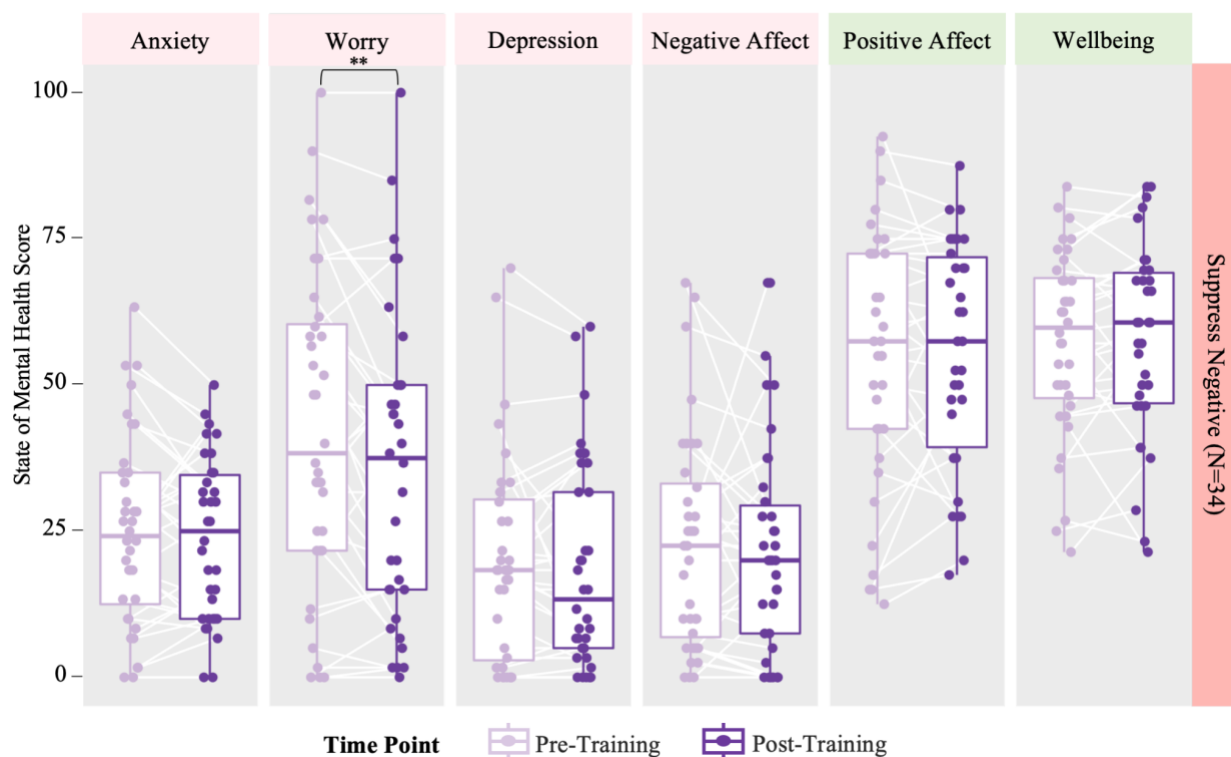


Fig. 14. Suppressing fears both improves mental health.

Training participants to suppress fears significantly reduced worry post-training (right-hand bar within each panel) compared to pre-training (left-hand bar within each panel). Individual participants are indicated by dots connected by white lines; boxes reflect interquartile range, and lines reflect median scores.

Following closely with the rationale explained in the vINI-T study regarding the analysis for people who suffer from anxiety, depression, and post-traumatic stress, we tested whether pre-training trait anxiety and post-traumatic stress predicted mental health improvement (post-training – pre-training). Contrary to Freudian and Wegnerian concerns and in line with our previous findings in the vINI-T study, participants reporting higher trait anxiety and post-traumatic stress benefitted the most from suppressing their distressing thoughts. Higher trait anxiety significantly predicted larger reductions in state anxiety ($r = -.52, p = 1.81 \times 10^{-3}$; Table 20) and negative affect ($r = -.43, p = .01$; Table 20). Participants who reported greater post-traumatic stress showed benefits to reductions in depression ($r = -.36, p = .04$; Table 20). Although higher trait anxiety and post-traumatic stress did not predict greater improvement on our PCA-derived mental-health change latent variable (Fig. 15A), they predicted greater improvement on the summary measure of the average change scores derived from the POMP scores of the four negative mental health indices, namely, STAI-State, PSWQ-PD, PANAS-NA, and BDI-II (Fig. 15B). PCA is quite sensitive to the number of participants. Therefore, given the smaller

size of our sample, it actually makes more sense to use the average of the negative mental health state questionnaires. Notably, the average of the two positive mental health state questionnaires (PANAS-PA and WEMWBS) was not significantly associated with the trait level anxiety and post-traumatic stress level of the participants prior to training. This could be due to the fact that negative constructs tend to predict perceived states in a similar valence more so than that of the opposite valence. Importantly, an alternative reason could be the fact that the effect was mainly driven by suppression of negative events rather than imagination of positive events, which would make the negative mental health state a more direct target of influence. Moreover, trait anxiety, post-traumatic stress, and depression all correlated significantly with the summary measure of the negative mental health indices (Fig. 16A). Collectively, these results show that people suffering from higher trait anxiety or post-traumatic stress benefited more from suppression training, without the adverse effects predicted by ironic processing theory.

Table 20.

Pearson's Correlations of Change in Mental Health State with Pre-Training Vulnerability in Mental Health

	Change Scores	Pearson's r	p-value	Lower 95% CI	Upper 95% CI
<i>STAI-Trait</i> <i>(Pre-Training)</i>	STAI-State	-0.52**	1.81×10 ⁻³	-0.73	-0.21
	PSWQ-PD	-0.27	0.12	-0.56	0.08
	PANAS-NA	-0.43*	0.01	-0.67	-0.11
	BDI-II	-0.18	0.32	-0.48	0.17
	PANAS-PA	0.11	0.54	-0.24	0.43
	WEMWBS	0.01	0.95	-0.33	0.35
<i>PCL-C</i> <i>(Pre-Training)</i>	STAI-State	-0.31	0.07	-0.59	0.03
	PSWQ-PD	-0.18	0.32	-0.48	0.17
	PANAS-NA	-0.26	0.13	-0.55	0.08
	BDI-II	-0.36*	0.04	-0.62	-0.02
	PANAS-PA	0.06	0.72	-0.28	0.39
	WEMWBS	0.02	0.93	-0.32	0.35

Note. Change scores are (Post – Pre) POMP scores. Significance indicated as * p < .05, ** p < .01, *** p < .001

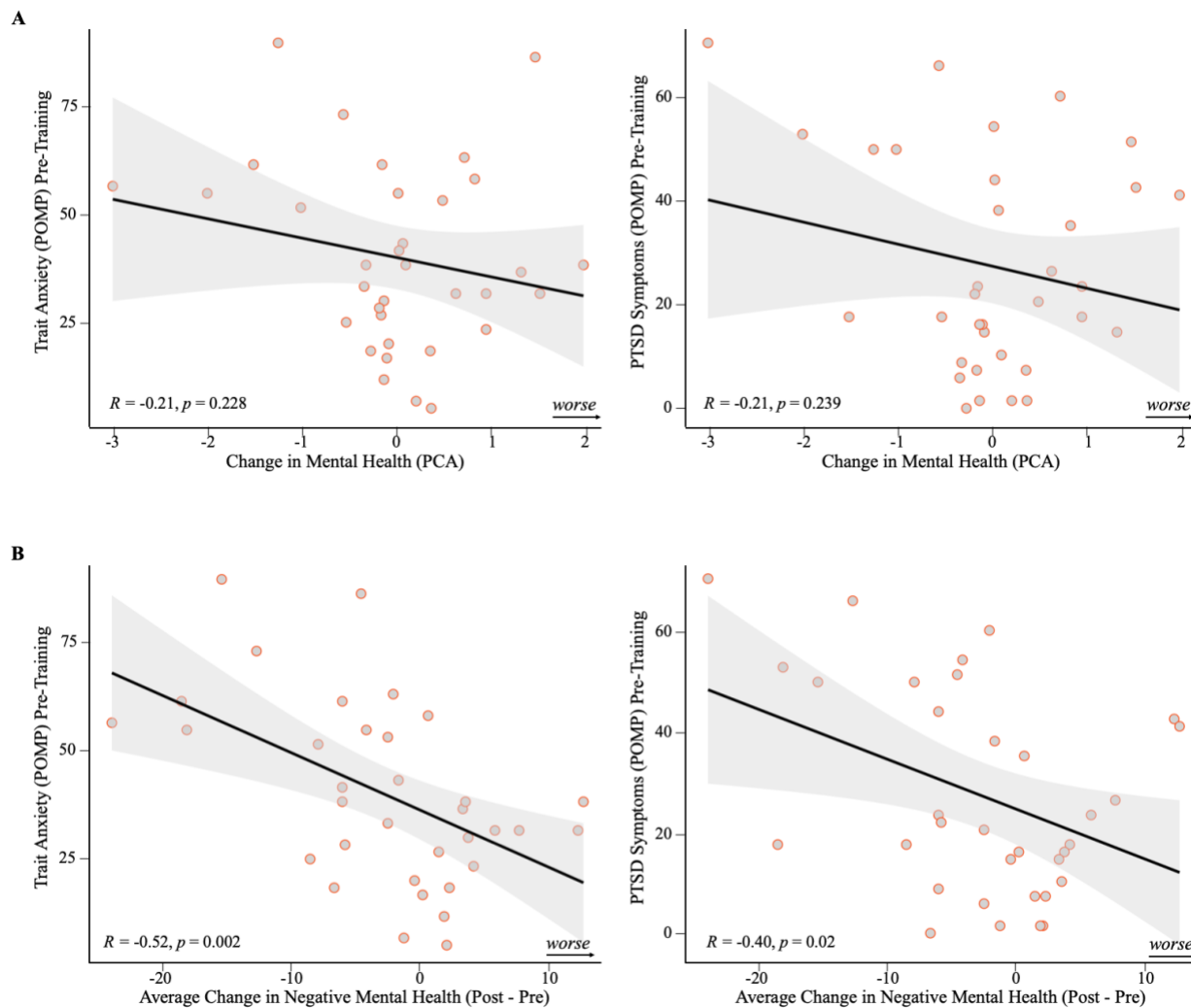


Fig. 15. Mental health benefits of suppression training in symptomatic participants.

(A) Higher pre-training trait anxiety scores (STAI-Trait) and post-traumatic stress scores (PCL-C) did not reliably predict greater mental health benefits for participants on our PCA-derived mental health change latent variable. (B) Higher pre-training trait anxiety scores and post-traumatic stress scores predicted greater mental health benefits for participants when using the average of the change scores derived from the POMP scores of the four negative mental health indices (STAI-State, PSWQ-PD, PANAS-NA, BDI-II).

Some may argue that despite the foregoing patterns of seeming benefits of the aINI-T, severe anxiety, depression, or post-traumatic stress might put participants at elevated risk of ironic rebound effects. To test this possibility, we isolated 14 participants with trait anxiety scores warranting clinical concern (STAI-Trait > 44), 7 participants with depression scores yielding clinical concern (BDI-II > 19), and 10 participants with scores that reflect likely post-traumatic stress disorder. Specifically, a participant would be considered as having PTSD symptoms if the PCL-C score pass the symptomatic threshold for DSM criteria for PTSD diagnosis. This involves first grading responses of 3–5 (Moderately

or above) as symptomatic and responses of 1–2 (below Moderately) as non-symptomatic, then 2) use the DSM criteria for a diagnosis: symptomatic response to ≥ 1 “B” item (Questions 1–5), ≥ 3 “C” items (Questions 6–12), and ≥ 2 “D” items (Questions 13–17) (Weathers et al., 2013). People with high trait anxiety showed significant benefits on state anxiety, worry, and negative affect with the index for worry dropping, on average, by 12% reduction (see Table 21A). Participants with high post-traumatic stress scores showed marginal benefit in reduction of worry (Table 21B). For people with likely depression (BDI-II > 19), we observed no notable significant benefit (Table 21C). Moreover, although these more vulnerable subgroups showed trends of improvements on both negative and positive mental health indices, only highly anxious people experienced significant improvements in negative outcome measures following aINI-T (Fig. 16B). Although not as robust as those found in vINI-T, these findings still suggest that some benefits arose from suppressing negative content via use of the ATapp.

Table 21.*A. Training Mental Health Benefits for Participants with High Trait Anxiety (N=14)*

Mental Health Questionnaires	t	Sig	p-value	μ_d	SE _d	95% CI for μ_d	
						Lower	Upper
State Trait Anxiety Inventory – State Portion	-2.99	*	0.01	-7.02	2.35	-12.10	-1.94
Penn State Worry Questionnaire – Past Day	-3.32	**	5.58×10^{-3}	-12.50	3.77	-20.65	-4.35
Positive Negative Affect Schedule – Negative	-2.72	*	0.02	-10.18	3.74	-18.25	-2.10
Beck's Depression Inventory II	-1.46	ns	0.17	-5.48	3.76	-13.59	2.64
State Trait Anxiety Inventory – Trait Portion	0.57	ns	0.58	1.31	2.28	-3.62	6.23
PTSD Checklist - Civilian	-2.12	†	0.05	-6.73	3.18	-13.59	0.14
Positive Negative Affect Schedule – Positive	0.95	ns	0.36	4.11	4.33	-5.24	13.46
Warwick-Edinburgh Mental Well-being Scale	0.62	ns	0.54	1.79	2.86	-4.39	7.96

Note. Participants are included as having high anxiety if they scored > 44 on the pre-training baseline measure of the Trait portion of the State Trait Anxiety Inventory. Scores reflect the change in mental health state after training relative to baseline measures prior to training (post – pre; POMP scores). Significance of Time reflects a paired samples student t-test between pre and post training. The p-value is indicated as such: <0.001(***), <0.01(**), <0.05(*), <=0.1(†), >0.1(ns).

B. Training Mental Health Benefits for Participants with Likely PTSD (N=10)

Mental Health Questionnaires	t	Sig	p-value	μ_d	SE _d	95% CI for μ_d	
						Lower	Upper
State Trait Anxiety Inventory – State Portion	-0.75	ns	0.47	-3.00	3.98	-12.00	6.01
Penn State Worry Questionnaire – Past Day	-2.14	†	0.06	-9.00	4.21	-18.52	0.52
Positive Negative Affect Schedule – Negative	-0.95	ns	0.37	-5.25	5.51	-17.71	7.21
Beck's Depression Inventory II	-0.58	ns	0.58	-2.83	4.92	-13.97	8.31
State Trait Anxiety Inventory – Trait Portion	1.45	ns	0.18	3.33	2.29	-1.85	8.51
PTSD Checklist - Civilian	-3.32	**	8.95×10^{-3}	-10.59	3.19	-17.81	-3.37
Positive Negative Affect Schedule – Positive	-0.74	ns	0.48	-3.50	4.70	-14.14	7.14
Warwick-Edinburgh Mental Well-being Scale	-0.44	ns	0.67	-1.61	3.64	-9.83	6.62

Note. Participants are included as having likely PTSD if the PTSD Checklist - Civilian Version (PCL-C) scores pre-training pass the symptomatic threshold for DSM criteria for PTSD diagnosis.

C. Training Mental Health Benefits for Participants with Likely Depression (N=7)

Mental Health Questionnaires	t	Sig	p-value	μ_d	SE _d	95% CI for μ_d	
						Lower	Upper
State Trait Anxiety Inventory – State Portion	-1.27	ns	0.25	-5.48	4.30	-15.99	5.04
Penn State Worry Questionnaire – Past Day	-2.03	†	0.09	-12.14	5.98	-26.79	2.50
Positive Negative Affect Schedule – Negative	-0.90	ns	0.40	-8.57	9.56	-31.96	14.81
Beck's Depression Inventory II	-2.17	†	0.07	-12.38	5.70	-26.33	1.57
State Trait Anxiety Inventory – Trait Portion	0.68	ns	0.52	2.86	4.22	-7.47	13.19
PTSD Checklist - Civilian	-1.74	ns	0.13	-9.03	5.18	-21.71	3.64
Positive Negative Affect Schedule – Positive	1.00	ns	0.35	6.43	6.41	-9.24	22.10
Warwick-Edinburgh Mental Well-being Scale	1.07	ns	0.33	5.10	4.76	-6.56	16.76

Note. Participants are included as having likely PTSD if the Beck's Depression Inventory (BDI-II) measured pre-training is greater than 19.

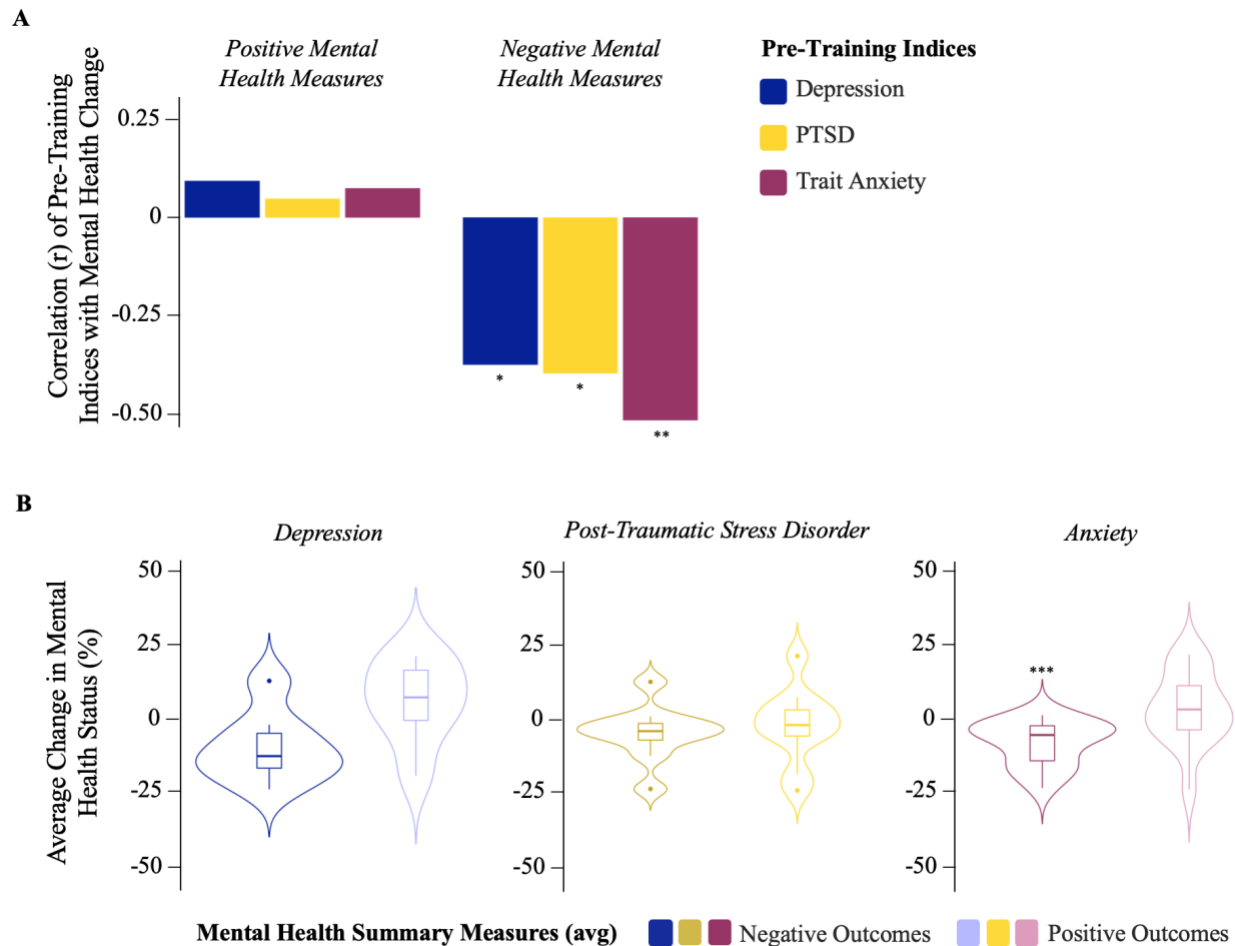


Fig. 16. Depression, anxiety, or post-traumatic stress symptoms prior to training predict mental health benefits of fear suppression after training.

(A) Greater pre-training trait anxiety (maroon bars), post-traumatic stress (yellow bars), and depressive symptoms (dark blue bars) predicted larger improvements in negative mental health indices (right half of the panel). Correlations (r values) are plotted on the y-axis. Positive mental health is a composite of well-being and positive affect (averaged POMP scores); Negative mental health is a composite of the average POMP scores of the negative indices. (B) Subgroups with higher depression symptoms, likely PTSD, or anxiety showed trends of improvements on both negative mental health indices (darker shades) and positive indices (lighter shades) following suppression training (post – pre). Significant improvements in negative outcome measures were observed for highly anxious people after suppressing their future fears. Significance is indicated by asterisks (***) $< .001$; ** $< .01$; * $< .05$).

Perception of the App-Based Suppression Training

The extremely informative and positive subjective reactions of the participants from the vINI-T study is one of the drives behind the ATapp coming into fruition. Therefore, for this aINI-T study, we similarly asked participants about their experiences with suppression, during and after training. During training, participants reported improved ability to control fearful thoughts in response to

reminder cues using the app. They reported moderate success during the first training session ($M = 2.8$ on a 5-point scale); by the end of training on Day 3, they reported being extremely effective ($M = 4.1$), a significant improvement, $t(31) = -6.84$, $p < 0.001$ (Table 22), with 28% of the participants selecting the maximum rating at the end of training.

Two participants seem to show a decline; however, both of these participants rated the suppression training as useful and their subjective free-response show how these declines do not have an ironic maladaptive nature, rather, both participants mentioned how they intend to use it in the future, affirming the effectiveness of training in real-life long-term impact. Specifically, the first participant (Sub 21) stated, “I found this task really difficult. My mind was very hard to make quiet, it will be interesting to see if I can use this method going forward the next time I have some anxiety.” Similarly, the second participant (Sub 61) who showed decline stated, “I am very surprised as to how much my mood directly impacted my thought suppression. I am eager to continue training to do so because I think it will benefit me greatly, particularly as I am an over thinker.” Eleven of the thirty-two participants who replied (34%) rated themselves as surprised or very surprised by this ability (i.e., ratings ≥ 3 from the scale: 1 = Not at all, 2 = A little surprised, 3 = Surprised, 4 = Very surprised, 5 = Astonished); in other words, 91% of the participants were at least a little surprised by this ability. In addition, on a free report question about major insights derived from training, 61% of comments remarked that the benefits of suppressing their thoughts was the biggest discovery, with only 37% of participants commenting on the value of positive imagination during Imagine trials. The degree of surprise was less than participants from the vINI-T study, even though their success rate for suppression at the beginning of training was comparable to that of the vINI-T participants (2.8 and 2.7 respectively). In a way, perhaps the pandemic era has allowed the general population to naturally acquire the ability to suppress out of necessity, thus exposing more people to the possibility of blocking out thoughts as a genuine coping strategy in times of need.

Table 22.*Significant increase in successful use of strategies from ATapp training*

Measure 1	Measure 2	t	df	p	Mean Difference	SE Difference
Suppression Success (Start - Day 1)	Suppression Success (End - Day 3)	-6.84	31	< .001	-1.22	0.18
Imagination Success (Start - Day 1)	Imagination Success (End - Day 3)	-4.10	31	< .001	-0.81	0.20

Note. For all tests (paired samples Student's t-test), the alternative hypothesis specifies that Measure 1 is less than Measure 2. For example, Suppression Success at the start on Day 1 is less than Suppression Success at the end on Day 3.

These perceptions translated into participants' use of thought suppression outside of training during the course of their participation in the aINI-T study, despite receiving no instructions to do so. In the time between the first day of training and our final wrap-up Zoom session, 84% of participants reported having used thought suppression for the trained fears and again 72% for novel fears. Similarly, symptomatic participants (i.e., probable PTSD, high anxiety, and depression), also reported to have used thought suppression for the trained and novel fears outside of the training hours (60%, 71%, 71%, respectively, same for both types of fears). Interestingly, more use of the imagination strategy outside of training was also seen with 91% of participants reporting to have used vivid imagination for both the trained hopes and novel future hopes. The finding that more people used the imagination technique spontaneously also supports the possibility that this particular cohort had particularly high imaginative skills, which is very much reflected in their subjective responses in having not been surprised with their ability to imagine. After training, 69% of participants reported finding suppression useful. Less participants found the suppression strategy useful in the app version than in the vINI-T study (69% vs. 87% respectively). This could be due to a heightened sense of commitment in the use of the app which can consequently result in a higher expectation for its usefulness. Indeed, this increase in self-motivation to engage in the app may also add to a potential decrease in engagement as there is no one there monitoring them or reminding them to do the tasks. In terms of how the suppression training directly impacted their mood and anxiety, 41% of participants reported reduced anxiety and 41% reported improved mood that they attributed specifically to learning thought suppression. No participant reported lower mood as a result of suppression training.

On the other hand, there were two participants who reported a slight increase in anxiety from the suppression training. However, upon closer look, one of them attributed the anxiety to increased awareness of the real concerns they had: “i was more aware that i was thinking negatively but not really able to stop it so more attention was drawn to the negative thoughts because i was more comprehending that they were there instead of them being hovering in the background as usual.” In contrast, upon first glance, the other participant seemed to have found the challenge of task truly anxiety-inducing, even if slightly: “The tasks were demanding on my concentration and exposed me to the fears perhaps more than normal, so I actually became a little anxious about the task itself and then struggled with being exposed to the fears more than if I’d been distracting myself (which is something the task specifically instructs not to do).” This participant was flagged for both high anxiety and probable depression, which indeed reflected in this participant having the highest combined symptom severity across all participants (derived from the average of pre-training POMP scores of STAI-Trait, PCL-C, and BDI-II).

However, before jumping to the conclusion that this is a proof of ironic rebound, it is important to see that this very same participant also eventually learned the power of suppression: “thought I wouldn’t be able to control at all my thoughts about the red events; this was the case to some extent, but the suppression technique meant that fewer details occurred in my head than I expected e.g. not catastrophising as much as if I was daydreaming and an anxiety came upon me and I did nothing about it.” This is the heart of this work! The power of this work is reflected in someone who is struggling immensely and quite sceptical of the use of suppression at the beginning to transform into eventually learning how to do it and see its benefits. Sometimes, pulling someone from the far edge a bit closer to the centre takes a lot more work than doing the same for someone already in the vicinity of the centre. Therefore, this shift from high scepticism to seeing some benefits of the technique is actually a proof for the suppression technique rather than an indication of the ironic rebound effect as intended by advocates who dismiss any beneficial use of suppression. On the other hand, as mentioned above and as can be probed from subjective reports in Table 23, participants benefited in varying degrees from the training, some even mentioning insightfully how such a skill can be effective in some circumstances and not very helpful in others.

Indeed, all of the rest of the participants, including the vulnerable participants with (even a combination of) high anxiety, post-traumatic stress, and depression, did not report a decrease in positive mood or an increase in anxiety as a result of suppressing their future fears. Therefore, as was found with the previous vINI-T study, these findings challenge conventional wisdom about paradoxical suppression effects and indicate high participant endorsement for the benefits of suppressing distressing thoughts (see Table 23 for verbal reports from participants about their experiences with suppressing fears for 3 days by using the ATapp).

Table 23.

Subjective Reports About the Experience of Suppressing Fearful Thoughts Over the Course of Training, as a Function of Average Symptoms.

Average Symptoms: Average of the three symptom diagnostic mental health indices (STAI-Trait for anxiety, PCL-C for PTSD, BDI-II for depression) measured prior to training (POMP scores)

Usefulness: Do you think that the suppression (mind-blanking) strategy you learned through the course of the training was useful or helpful to use outside the lab in your own life?

Reusability: How likely are you to re-use the suppression (mind-blanking) strategy you learned to decrease your anxiety or thoughts about the negative events in your life?

Rating Scale: Very unlikely - 1; Unlikely - 2; Neutral - 3; Likely - 4; Very likely - 5

Impact: In your own words, please elaborate on your opinion about re-using the suppression (mind-blanking) strategy in the previous question.

Note. Participants are sorted from highest Average Symptoms Score to lowest, and divided into quartiles to illustrate that perceptions of usefulness and likelihood of future use were greatest in the most symptomatic participants.

ID	Sympt.	PTSD	Depre.	Anx.	Useful?	Reusa.?	Impact
85	70.00	50.00	70.00	90.00	No	3	I've found distraction much more effective in the past, although admittedly this tends to be successful only up until a certain threshold, at which it's hard to continue distracting and the fear becomes overwhelming because you haven't actually done anything active to address it. In this way I might attempt to use the suppression strategy in a situation where distraction hasn't worked, but most of the time probably will prioritise other strategies.
02	68.17	66.18	65.00	73.33	No	2	As said above, i believe its helpful but I think it will just end up coming back worse if you are not able to challenge the thoughts rather than acknowledge and be aware that they are there.
17	56.86	70.59	43.33	56.67	-	-	-

46	56.76	60.29	46.67	63.33	-	-	-
61	54.93	51.47	26.67	86.67	Yes	5	It's something that I can see as becoming very useful and something that I am actively trying to do now, but I can also see that it's something that I have to work towards and increase in my ability to do it successfully
83	47.09	52.94	33.33	55.00	Yes	4	I would definitely try and use it at other times in life to try and reduce my anxiety
52	46.67	50.00	38.33	51.67	Yes	4	It would be good to think about doing the mind-blanking, now I know about it. It might take me a while to remember to do it.
19	46.47	54.41	30.00	55.00	-	-	-
25	37.61	41.18	33.33	38.33	Yes	4	I suffer from anxiety so this would certainly help me to control that spiraling feeling when my brain starts down a rabbit hole of thought.

First Quarter Summary

PTSD: 55.23 Depression: 42.96 Anxiety: 63.33 Usefulness: 67% Reusability: 3.67

50	37.32	35.29	18.33	58.33	No	5	Used for short periods it may be useful. Habitually could it lead to a loss in creativity? If I wake with anxiety, repeating a single word to myself to do a similar thing, sometimes allows me to go back to sleep and I certainly had to fight nodding off during the later parts of the test on all three days.
23	35.33	42.65	31.67	31.67	Yes	2	it was pretty difficult to do in a set up situation where the words were presented for you, so i think applying it to real life where everything is dependent on the context and background, it would be much harder as something will have probably ignited the thoughts so trying to clear mind won't remove whatever caused the thoughts
24	35.07	23.53	20.00	61.67	No	3	From what I have learned about mental health/anxiety etc from my own experience is that blocking out a thought isn't necessarily helpful to everyone. More that you should sit with a thought/feeling and not react to it
62	34.15	44.12	16.67	41.67	Yes	4	its difficult at times but i think could be helpful in a conscious effort to forget something
07	33.30	38.24	18.33	43.33	No	2	As mentioned above blanking doesn't help me address the root of the fear, I need to imagine the fear to see how uncontrollable the future is and how the event is a projection of my present anxieties - from there I can learn how emotions and thoughts in my current state can be addressed
12	32.55	17.65	18.33	61.67	Yes	4	Negative thoughts can grow and grow in my head until they are much worse than ever likely to happen. If I can continue to use this method I think it might help
22	31.73	23.53	31.67	40.00	No	3	I think that often pivoting to positive thoughts or potential solutions rather than trying to make my mind go blank is generally a more successful approach to trying to improve my anxiety in the moment.
08	27.97	20.59	10.00	53.33	Yes	4	As a general rule I'm not sure if it's completely helpful to blank out bad thoughts as a coping strategy, but there are times where

								it will be necessary. Particularly when those thoughts arrive at unexpected or unhelpful moments.
26	27.29	23.53	26.67	31.67	-	-	-	
68	25.49	26.47	18.33	31.67	Yes	3		I think it can be helpful in some situations, like when you're catastrophising events with low likelihood of turning negative. But if there's a valid concern or anxiety then I've found it's negatively impacted my sleep to distract myself from my feelings.
70	23.79	14.71	20.00	36.67	Yes	4		I think bringing the word to mind but not giving it detail, works in some areas. However for me, the sheer act of bringing some fears to mind (those I fear most) had the effect of me wanting to think of them.
60	21.50	16.18	18.33	30.00	Yes	4		I do think that I have recently been using this strategy even before joining this study. I have found that if something makes me anxious that is not a rational fear / not likely to be happening (i.e. my partner dating someone else) then the best strategy is to avoid thinking about it. I have had a tendency to ruminate on these things in the past which has definitely caused anxiety so it makes sense to me that mind-blanking would be an effective strategy. I do worry that it is possible that if practiced too much then it could encourage dissociation during times of stress.
34	20.88	17.65	21.67	23.33	Yes	5		I found that repeated exposure to the trigger word, and forcing my mind to ignore the feelings associate with that word, made me feel more neutral towards the trigger. I just saw it as a word, rather than associating it with a scenario.
21	20.72	8.82	15.00	38.33	Yes	3		This isn't something that I have thought about. I currently don't have too much anxiety in my life but when I do I will try to see if this method works for me.
53	19.77	17.65	16.67	25.00	Yes	5		I will try and use the suppression strategy when negative aspects or worries come into my mind in the future, to see if it helps.
89	16.80	22.06	0.00	28.33	Yes	5		I think it is a strategy to help but not entirely convinced it is the only one. I think that for me personally blanking completely puts me under pressure and causes conflict in my mind. I prefer to recognize that a negative thought has arisen, note it and then think of something positive instead (visualization). Going blank completely is hard to achieve for me at this stage of the cognitive restructuring process
41	16.57	14.71	15.00	20.00	No	3		i will try it to see how i find using it, i am open to seeing if it helps. i find it quite hard to blank my mind and tend to re-focus my mind on something else or bring my attention to something in the present moment rather than surpress the thoughts. or i will use techniques of distancing myself from the thoughts and reassuring.
82	16.21	10.29	0.00	38.33	Yes	4		I think it's useful being able to push the negative out of your mind so you spend less time focusing and worrying on it. Also imagining the positive in such vivid detail, I think is useful in real life to both focus on achieving the positive thoughts but also to reduce the negative

39	15.46	14.71	0.00	31.67	No	2	I can understand the idea, but felt this exercise was specific to suppressing thoughts following visual triggers. Whereas in reality my mind will wonder into anxious thoughts before I've necessarily realised or it will be situation specific that you cannot prevent it. I.e. Preparing for a stressful meeting, it is necessary to plan for those moments that cause you anxiety so you are fully prepared.
37	13.07	5.88	0.00	33.33	Yes	4	I can see that it would be useful in certain situations, particularly if it is a fear that is unlikely to come to fruition. Sometimes I would say it is not useful if you need to confront a fear or if doing something would help alleviate that fear rather than just ignoring it.
42	13.01	7.35	5.00	26.67	No	1	I believe that being able to face fears is a strength. If you ignore a problem, the problem doesn't disappear. Therefore I won't suppress negative events or fears but embrace them and meet them head on.
59	12.06	16.18	3.33	16.67	Yes	4	I am going to hyper focus on positive things including the vivid detail and emotions. I am going to make a point of understanding but blanking out any fears or anxiety. I am going to sit quietly or write them down and stare through them in order to become dismissive of them.
04	9.12	7.35	1.67	18.33	No	2	to push the reponse words out of my head required alot of active thought of something else so was an intensive effort
36	6.67	0.00	1.67	18.33	Yes	4	This is not a strategy I was aware of before and I definitely found it helpful and can see the benefit so I will endeavour to keep using the strategy.
86	4.38	1.47	0.00	11.67	Yes	4	Sometimes I have trouble sleeping and I end up worrying about things in the night. This may help with that process if I can shut them out.
55	2.71	1.47	0.00	6.67	Yes	5	I have very rarely before been able to just think nothing but now feel I am able to do this as well as block negative thoughts from my mind, I feel this will come in useful when I need to focus on something, at work for example and also when trying to sleep
10	2.16	1.47	0.00	5.00	Yes	4	I did not think about this as a strategy during this week, but now it has been made explicit I think I will try it out next time I am unable to get to sleep as this is when fearful thoughts are worse for me.

Last Quarter Summary

PTSD: 6.21 Depression: 1.30 Anxiety: 18.70 Usefulness: 67% Reusability: 3.33

User Experience of the Attention Training App

Given the pilot nature of this study, it was no surprise that some technical difficulties occurred. However, the overwhelmingly positive response from the participants as will be discussed shortly during the UX feedback really encouraged us to keep moving forward and also further cemented all of the

above-mentioned ameliorative function of suppressing negative thoughts rather than the conventional belief of its induction of ironic increases in distress. The app is designed such that once a participant completes their final training session, the experimenter receives an automated email which then prompts the experimenter to email the participant to schedule the final wrap-up session on Zoom if it was not scheduled during the introductory Zoom session, or simply send a reminder email if it was already scheduled. Out of the 36 participants, 34 people took part in the UX feedback session (2 participants did not come to their scheduled Zoom meeting). During this wrap-up session, participants first completed the post-experimental mental health questionnaires, then they were given a brief debrief about the nature of the study and given an opportunity to ask questions. Then, for 15-20 minutes, participants engaged in UX feedback. This involved looking at the PowerPoint slides through screen-share upon which are a series of questions related to their general and phase-specific experience of using the app. Specifically, the slides showed screenshots of each of the phases to remind the participant about that experience to prompt more detailed response of their experience. Since some of the questions inevitably reflect upon the training task besides just the technicalities of the app, participant responses to those relevant questions are also worth highlighting here. A few of the questions were also ratings which probed the degree of favourability and ease of use of the app (Table 24).

Table 24.*Quantitative User Experience Feedback*

	Mean	Std. Dev.	Variance	Min	Max
General Impression	3.76	0.78	0.61	2.00	5.00
Likelihood of Recommendation	4.21	0.84	0.71	2.00	5.00
Frequency of Use	2.59	0.86	0.73	1.00	4.00
Event Generation_Difficulty	1.50	0.86	0.74	1.00	4.00
Rating_Difficulty	1.41	0.78	0.61	1.00	4.00
Learning_Difficulty	1.97	1.14	1.30	1.00	5.00
Training_Difficulty	1.12	0.33	0.11	1.00	2.00
Diagnostic Questionnaire_Difficulty	1.32	0.68	0.47	1.00	4.00

Note. **General Impression:** How would you describe your overall impression of the app? Rate it on a scale from 0 to 5 (0 – Terrible; 1 – Poor; 2 – Fair; 3 – Good; 4 – Very good; 5 – Excellent). **Likelihood of Recommendation:** How likely would you recommend this app to a friend? (0 – Not at all likely; 1 – Very unlikely; 2 – Somewhat unlikely; 3 – Neutral; 4 – Somewhat likely; 5 – Very likely). **Frequency of Use:** How frequently would you use this app? (0 – Never; 1 – Very rarely (once per month); 2 – Rarely (2-3 times/month); 3 – Occasionally (2-3 times/week); 4 – Frequently (1-2 times/day); 5 – Very frequently (3+ times/day)). **Difficulty** (same question was used for each of the phases of training): How difficult was

it for you to complete this task using the app? (1 – Very easy; 2 – Somewhat easy; 3 – Neither easy nor difficult; 4 – Somewhat difficult; 5 – Very difficult).

In general, participants had a pretty good impression of the app as a whole, with the majority of the participants describing the app as “easy to use”, “clear”, and “functional”. When asked “Do you know anyone who would like this app?”, participant responses were unanimously affirmative, with not a single person saying no. In fact, 68% of the participants explicitly (without prompting) mentioned people with mental health problems as a target audience, with many thinking of someone they knew personally. This is really important to reflect upon as it directly challenges any lingering notions that the suppression training made people feel worse or can worsen someone’s existing mental health conditions. Here are some people who not only found benefits in the training, but *intuitively* connected the beneficial application of such a training to people who suffer from mental health issues like anxiety and depression. Indeed, many participants mentioned their own family members and friends who may find this app useful in managing their mental health challenges. To illustrate this very essential point, here are three paraphrased quotes from the participants as they were verbally responding to this question:

Sub 34: Yes, people who have been through traumatic experiences, like car crash, war, childhood trauma, who have thoughts weighing on their minds. My sister has had a bad divorce and so she'd really benefit from this!

Sub 53: A lot of people would benefit, definitely people with anxiety, intrusive thoughts, and some sort of trauma. A lot of people honestly, because most people go about their lives without thinking much about it, so most people would benefit.

Sub 59: The whole world, everyone! It is mad that it is not out there, it blows my mind how the state doesn't use it.

When asked to comment on one thing they would like to change in the app as a whole, most responses centred around three points: 1) improve the diagnostic questionnaire (Fig. 12) such that the videos were not too repetitive, 2) adjust the speed of some of the tasks as it was too quick for some people, and 3) improve the user interface to make it more aesthetically appealing to be able to compete with

commercial apps. Despite the third point mentioned regarding aesthetics, every single participant made positive comments about the interface itself and almost everyone described it as simple, clear, and easy to navigate. When asked whether they would keep using the app if they were given an opportunity to do so, all except one participant replied in the affirmative with most mentioning that it would be dependent on circumstances. This is once again a very encouraging feedback to reflect upon as it shows that participants are also attuned to the flexible nature of suppression training and how it is a skill that once learnt, can be recruited as needed. Indeed, although many found the training itself challenging at the start, on average, participants found all of the tasks easy or somewhat easy to actually execute on the app (Table 24). In other words, with the exception of a couple of bugs at the beginning, the app did not hinder the flow and execution of the tasks involved in the training. Furthermore, participants were favourable in their views for the future application of the app, with no participant stating that they would not recommend the app or never use the app in the future if given a chance to do so (see Table 24 for the distribution of ratings).

In conclusion, we demonstrated from both quantitative results and qualitative reflections that the ATapp proved effective as a tool to use in experiments investigating thought suppression through the TNT task. More testing is underway for its efficacy of use in all of the various variants of the TNT task. This aINI-T study serves a first successful replication of the main findings of the suppression training study, though not every single detail was replicated. Importantly, it showcases suppression as not only a learnable ability, but one that can be quite accessible in a simple training approach, and one that certainly empowers those who need it to harness its power in managing maladaptive impacts of life's toils on one's psyche. Perhaps it is apt to conclude with the words of one of the participants (Sub 89) who used a metaphor to summarise the suppression training:

“It is like a road sign, it used to be that I would see a negative sign ahead, and I would continue straight on driving. You have got to read the sign! You don't just go down the road... You've got the well-paved road which is anxiety and your brain automatically gets access to it... what we need to do is to pave a new road until the other road falls into a state of disrepair, so you don't use that road

anymore. I would think of this [the suppression training app] as one of the tools to pave that new road.”

“Don’t Forget Me,” Says Forgetting

5.1. Development of the Cambridge Selective Forgetting Inventory

The Need: A Tool to Capture Individual Differences in Memory

In Chapter 1, we briefly mentioned individual differences in motivated forgetting. Here, we shall focus specifically on discussions of individual differences in autobiographical memory (AM), while connecting the threads to their relevance to the phenomenon of selective forgetting. Selective forgetting is a person’s capacity to selectively forget negative, distressing, and upsetting content, either effortfully with intentionality or habitually with more ease almost semi-automatically. Moreover, selective forgetting has not been an object of serious scientific inquiry, though it has certainly been tangentially posited in many discussions. As demonstrated in the preceding chapters, motivated forgetting is driven in the real world by people’s need to rid themselves of unwanted thoughts, be they past memories or future fears. Underlying this phenomenon is a capacity to effectively suppress thoughts.

This begs the question: are there people who are so good at suppressing negative thoughts that it comes almost automatically to them? If so, what are the characteristics of their memories? If motivated forgetting has been observed to have a spectrum, then its effect - SIF - must also have a spectrum. Given individual differences in AMs have been well-established in literature (for a review, see Palombo et al., 2018), it is only reasonable to consider the possibility that there could be individual differences in the forgetting of AMs. Importantly, as discussed in Chapter 1, forgetting is *not merely* a deficiency in remembering. In what follows, we shall discuss how existing research on individual differences in AM actually hints at the need for an investigation into individual differences in forgetting, and the factors that will be relevant for a tool that attempts to face this challenge.

The topic of individual differences in AM is perhaps most strikingly presented in research showcasing extraordinary memory characteristics of people who have highly superior autobiographical memory (HSAM; Ally et al., 2013; Parker et al., 2006) and those who have severely deficient autobiographical memory (SDAM; Palombo et al., 2015), presenting a possibility of a spectrum of distribution in our ability to recollect personal events (for a review, see Palombo et al., 2018). Moreover, research on HSAM individuals seems to suggest the obsessiveness in their personality as an underlying factor beneath their superior abilities leading them to relatively easily encode and consolidate personally meaningful events (A. K. R. LePort et al., 2012). Given that obsessiveness in personality can manifest as obsessive-compulsive personality disorder (OCPD) which is suggested to be on a continuum as OCD (Marincowitz et al., 2022), and given that inhibitory control has been found to be compromised in OCD patients (Table 1), the need for a tool to reflect these various factors seems pressing to give answers to the underpinnings of such superior abilities. Indeed, it further supports the idea to mirror AM research in the study of forgetting: investigate the extreme ends of the forgetting spectrum.

Similarly, the close link between AM specificity and motivated forgetting can also be gleaned from shared networks and structures being implicated in both. For instance, brain connectivity data shows that stronger connectivity between the default mode network (DMN) and the frontoparietal network (FPN) can explain individual differences in memory ability (van Buuren et al., 2019), and that the hippocampus is highly associated with the prevalence of episodic details of AM both at a connectivity level (Setton et al., 2022) and at a structural level through the association of subfields of hippocampal volume with episodic AM (Palombo, Bacopulos, et al., 2018). Moreover, episodic AM, a person's ability to travel mentally in time to specific details of events from their past, is associated with adaptive functioning which can be seen from the brain network findings that episodic AM is potentially associated with better capacity in switching between goal-directed mental states (Petrican et al., 2020). Therefore, through research in AM, we can see a hint to the role of task switching in inhibitory control, a variable which can lead to incomplete and sometimes erroneous interpretations of thought suppression studies if not carefully examined as discussed in Chapter 2.

Furthermore, the phenomenon of selective retrieval of AM sheds encouraging light on further investigations into selective forgetting. On the one hand, selective retrieval seems to be observed in patients with a lasting inability to retrieve autobiographical events from certain time periods in their lives, which has been observed in patients with psychogenic amnesia (Brandt & Van Gorp, 2006; Brna & Wilson, 1990; Harrison et al., 2017; Kopelman, 1987; Markowitsch & Staniloiu, 2016), post-traumatic amnesia (Parker et al., 2022), and even in cases of medication-induced autobiographical amnesia (Zeman et al., 2016). In fact, functional imaging methods have been long proposed and employed to study such functional amnesic states, which can be triggered internally by acute psychological distress or externally through environmentally induced stress and trauma (Markowitsch, 2003; for a review, see Staniloiu et al., 2010). However, to what extent motivated forgetting is implicated in functional amnesia states is still an open question, a landscape in forgetting research that would greatly benefit from a tool that connects forgetting of time periods in one's life to one's engagement with suppression strategies. On the other hand, it has been shown that selectively retrieving certain memories when having conversations can even induce a forgetting effect on the unmentioned but still related memories to the retrieved memory in conversation for both the listener and the speaker (Cuc et al., 2007; Stone, Barnier, et al., 2013). Just as how selective retrieval of memories may induce forgetting of unmentioned but related memories, selective forgetting of memories may induce remembering of retained memories. Moreover, as selective forgetting is specifically related to upsetting or distressful memories, the heightened remembering of retained memories may have a more adaptive and positive outlook.

Bauer (2015) discussed how considering the role of forgetting in the development of episodic and autobiographical memory is not only lacking but incredibly needed for a complete account of how memory develops. This can be inferred from a substantial amount of research demonstrating RIF, a proposed mechanism of active forgetting (Anderson & Hulbert, 2021), taking place in everyday life as people remember autobiographical memories (Somos et al., 2023). Not only does this research support the forgetting as important for remembering, but it also calls for a need of a measurement tool that can delineate the relationship between a person's tendency to self-initiate suppression and their tendency to

selectively forget distressing memories. Furthermore, evidence in support of inhibition promoting positivity bias in AM by blocking distressing memories is further bolstered by findings of individual differences in RIF contributing to recall rates of negative AM from both childhood and recent times (Storm & Jobe, 2012). This warrants further investigations of 1) how RIF may be related to selective forgetting of time period, and 2) how inhibitory control mechanisms of thought suppression strategies can differentially influence AM. Again, to begin to investigate such inquiries, a tool that can interlink these elements simultaneously in a research effort seems to be much needed.

It is needless to state that the study of forgetting, especially motivated forgetting, is closely tied with emotional regulation (see Chapter 1.1). Indeed, the more distressing or traumatic a memory is, the more a person would be motivated to forget it, even if the attempt may not always be successful. AM is known to have a range of factors revolving around affect: fixed affect, fading affect, flourishing affect, and flexible affect, and positive and negative memories show differential associations with these variables (Hoehne, 2023). Similarly, negative memories may interact differently with forgetting mechanisms in the attempts to modulate affect. Moreover, evidence suggesting fixed affect as contributing to maladaptive emotional regulation processes (Muir et al., 2017) seems to relate to how we observed suppression training of negative fears (as opposed to neutral events) as particularly effective in improving mental health (Chapters 3 & 4). Therefore, there is high potential that any presence of selective forgetting tendencies would be intimately connected to emotional regulation. One way to probe is through people's propensity to forget negative details of events with presence of maladaptive behaviours like avoidance. Hence, there is a need for a tool to be able to capture all of those elements in an effective, accessible and practical manner.

Beyond associations with AM, there is now emerging evidence to use a functional lens to look at forgetting on its own right. A question that all of us probably asked at some point is: why can we not retain memories from early childhood? Behavioural and neuroscience evidence seem to suggest that rapid forgetting of early experiences *during* childhood reveals its functional role as an adaptive mechanism such that "infantile amnesia may start during infancy itself" (Howe, 2019, p. 120). Given all of the virtues of forgetting from emotional regulation to learning to even developmental adaptation, it

seems clear that the field of cognitive neuroscience can greatly benefit from the development of a tool that looks into prevalence of one of the most practical and transformative virtues of forgetting - the capacity to forget negative, distressing, upsetting information.

A Solution: The Cambridge Selective Forgetting Inventory

There exist currently a few surveys that investigate AM with potentially some insights to offer regarding forgetting. Specifically, they are the Survey of Autobiographical Memory (SAM; Palombo et al., 2013), the Multifactorial Memory Questionnaire (MMQ; Troyer & Rich, 2002), and the Self-evaluation of Memory Systems Questionnaire (SMSQ; Tonković & Vranić, 2011). The SAM was developed to assess individual differences in four categories of AM: episodic, semantic, spatial, and prospective (Sheldon et al., 2018), which has since been psychometrically validated using different methods (Picco et al., 2020). However, the SAM does not specifically look at forgetting, only indirectly as a deficiency in remembering AMs. The MMQ was designed with a focus on metamemory, the knowledge one has about the development and use of one's own memory, and assesses self-reported memory in 3 aspects: satisfaction with one's memory function, frequency of common memory errors over the previous two weeks, and presence of the use of internal and external memory strategies (Shaikh et al., 2021; A. K. Troyer et al., 2019; A. K. Troyer & Rich, 2002). Although some of the items in the Strategy subscale seem to tap into suppression strategies, the MMQ is largely not concerned with forgetting beyond through the lens of dysfunction in memory. Moreover, its original target group was specifically older adults which is limiting for investigation of selective forgetting tendencies in the general population. Similarly, the SMSQ was designed to assess multidimensionality of metamemory at a more comprehensive level by looking 6 aspects: subjective evaluation, episodic memory, semantic memory, memory for numbers, visuospatial memory, and reminder and aids (Tonković & Vranić, 2011). Once again, memory as understood from this survey would exclude forgetting as an active and adaptive process. Although clearly demonstrative of the lack of a self-report inventory focused specifically on active forgetting and its various aspects, these existing surveys still set precedence for

including multiple dimensions when creating a tool that is meant to represent an inquiry into a particular complex memory phenomenon.

From the preceding discussions, it can be gathered that there exists a gap in existing tools available for researchers to simultaneously investigate the interactions of multiple forgetting related elements within the same individual: prevalence to forget unpleasant autobiographical memories and other unpleasant information, tendency to engage thought control strategies, as well as any existing memory profile of gaps in AM. Given this need as well as awareness of all of the preceding discussions on the connection between AM and motivated forgetting, we sought to develop a questionnaire that attempts to investigate selective forgetting in a comprehensive, accessible, and practical manner. To this end, we introduce the Cambridge Selective Forgetting Inventory (CSFI), originally designed as a 43-item inventory with 10 subscales: 1) Forgetting details of negative events - 4 items, 2) Forgetting entire negative events - 5 items, 3) Forgetting unpleasant time periods - 4 items, 4) Forgetting unpleasant tasks - 4 items, 5) Intentionality of forgetting - 4 items, 6) Forgetting by thought substitution - 6 items, 7) Forgetting by direct suppression - 6 items, 8) Avoidance of reminders - 5 items, 9) Avoidance of recall - 2 items, and 10) Recovery of forgotten unpleasant events - 3 items. The CSFI was created entirely from scratch by myself and my PhD supervisor, though some of its items may resemble some existing thought control questionnaires given their shared underlying phenomenon of interest; in addition, starting from the early stages of the item development process, we sought expert opinion from Prof. Lewis Goldberg who is known for his contributions to personality structure and assessment.

The style of the CSFI items are of the Expanded format, which practically transforms what are typically a few response options in the Likert scale into a full sentence. This format was adopted after having considered existing research demonstrating the Expanded format to have fewer and more theoretically defensible dimensionalities than scales in the Likert format, which can be especially important in development of scales that have dimensionalities of theoretical interest (X. Zhang & Savalei, 2016). Given that our inventory consisted of more than usual number of subscales in order to capture a fuller picture of the phenomenon in question, we decided to use best practices in the field and transformed our previous version of the CSFI which we had used for pilot testing to the Expanded

format. Expectedly, this led to additions, removals, and modifications to some of the items. In addition, it is perhaps apt to mention how the CSFI has been especially designed to overcome a lot of the drawbacks commonly mentioned to be associated with memory related surveys (A. K. Troyer & Rich, 2002). For instance, one criticism is that instruments are often narrowly useful for either research or clinical purposes such that either it focuses on past events or recent memory problems. This is addressed in the CSFI items such that all aspects are captured: self-evaluation of past memory ability, memory for remote events, and memory for recent events.

Another criticism is quite commonly confronted in the field of developing measurement tools - having too many items. Indeed, this concern was especially carefully considered in the development of the CSFI, given the multiple dimensions we wanted to capture. By making 10 different editions of the CSFI over the course of 3 years, we have limited the number of items from 117 to 32 (the arrival to this number will be discussed in detail shortly in this chapter). Another legitimate contention is the limited sample characteristics with most studies developing inventories which makes it hard to generalise. One way to overcome this is the commonly practised method of running subsequent studies in different populations to legitimise its broader use. As that was not feasible in this present study, we opted for participant recruitment from Prolific (<https://www.prolific.co>, 2014) for an online anonymous distributed sample inclusive of the major English-speaking countries (Table 25). As can be seen from our sample distribution, although still not extremely comprehensive, we were at least able to avoid the typical yet potentially problematic psychology research sample - young college sample. However, more future tests will be needed for use in different cultural, clinical, and global settings. In addition, multidimensionality of the construct in question is often criticised although most authors try hard to reduce dimensionality as part of their analysis. The CSFI addresses this by having multiple subscales developed under theoretical considerations, which will then be validated and confirmed for its correspondence to factor-analysis-derived dimensionality.

Table 25.*A. Demographic Information*

	Demographic	Frequency	Percent
<i>Sex</i>	Female	276	60.93
	Male	177	39.07
<i>Ethnicity</i>	Asian	31	6.84
	Black	17	3.75
	Mixed	15	3.31
	Other	4	0.88
	White	386	85.21
<i>Nationality</i>	Australia	4	0.88
	Canada	13	2.87
	Ireland	6	1.33
	United Kingdom	352	77.70
	United States of America	78	17.22

B. Descriptive Demographic Statistics

	Mean	Std. Dev	Variance	Min	Max
<i>Age</i>	35.29	8.08	65.29	21.00	50.00
<i>Sleep (hr)</i>	7.44	0.98	0.96	5.00	13.00
<i>Completion Duration (min)</i>	32.56	10.31	106.34	16.00	82.00

Note: All participants passed the following screening criteria: 1) English as first language, 2) maximum of 4 units of alcohol use per week, and 3) no previous or current diagnosis of alcohol abuse, dyslexia, cognitive impairment, Alzheimer's Disease, or psychosis.

Over the course of 3 years, beginning with its first draft in December 2019 until the launching of version 10 as the first official validation attempt in January 2023, the inventory matured from its inception of attempting to simply investigate forgetting on its own right to being inclusive in simultaneously investigating key components that tend to interact with motivated forgetting which can be central to applications in research. In what follows, we will highlight existing research that yields support to the inclusion of some of the subscales. In this way, we hope to present rationale behind the theoretical groundings of what we envisioned as we generated the items for the survey.

Rationale Behind the Subscales of the CSFI

To begin, one can see that the first two subscales are focused on forgetting of negative events, which is indeed the primary aspect of selective forgetting that we aim to measure in the CSFI. The reason for distinguishing between forgetting of details versus entire events was based on the anecdotal observation that both are present in individuals, with some forgetting only details but retaining gist of events and others forgetting whole events which can also manifest as gaps in memory. On the other hand, we also considered the possibility that the two are on a continuum such that the intensity of the experience as well as subsequent strategies to dampen its impact on one's health can be what fine tunes the level of forgetting one has. However, for the sake of exploration, we ended up deciding to include both separately. Notably, it is difficult to probe one's awareness of something they have forgotten; however, we have carefully constructed the items to reflect how someone might come to know this in the real world. For instance, such a person may be told about a shared memory from someone else and not remember it.

The rationales for the inclusion of the next subscale of forgetting time periods and the last subscale of prevalence of recovered memories are interconnected. Forgetting of time periods in one's life, be it weeks or months or years, is often studied as amnesia from a clinical lens. Indeed, the clinical view is one of the major motivations as to why we included this subscale. However, there are applications beyond clinical patients. For instance, the concept of retention interval of AM is studied widely as a factor for individual differences, especially for people at the extreme ends of the spectrum like individuals with HSAM or SDAM. Just as how the time period of recollection is shown to be important to consider in individuals with HSAM such that they show comparable episodic AM with that of the average population when recollecting from short time intervals (e.g., 1 week) but tremendously superior retention at long time intervals (A. K. LePort et al., 2016; Palombo, Bacopulos, et al., 2018), the time period of forgetting can also prove useful in investigating people who have a superior ability to forget unpleasant memories from their lives.

In addition, one can also relate gaps in memory in one's lifetime to the already much-studied concept of autobiographical memory coherence - a person's ability to construct a coherent narrative

about their personal experiences. Considered as a factor for individual differences in people's AM (McLean et al., 2019; Reese et al., 2011; Vanderveren et al., 2020; Waters et al., 2019), memory coherence is often considered an adaptive feature of AM, but has also been recently observed to have positive associations with ruminative thinking (Vanderveren et al., 2020). This begs the question: could memory incoherence feature as a resilience factor that protects some people from the perils of rumination? CSFI's subscale on forgetting of time periods can be an opening in having a tool to attempt answers to such questions. In addition, given the above-mentioned evidence that coherence in one's memory can be relatable to one's mental health issues, there seems to be a need for a tool that can simultaneously capture an individual's thought control ability (DS/TS strategies) and prevalence of incoherence in memory (forgetting of time periods & recovered memories). CSFI does exactly that, and more!

Although much contested, recovered memories do not contradict what we have uncovered thus far about how memory works (for a review, see Brewin, 2012). Firstly, there is the relevance of memory specificity such that memory specificity is different in adolescent and adults who had experienced child sexual abuse (Ogle et al., 2013). From this, we can see the relevance of investigating individual differences in suppression abilities across age ranges and their interaction with selective forgetting of past trauma, which may also lend itself to forgetting of time periods and recovered memories. Secondly, research showcasing people who spontaneously recover memories as being more prone to forgetting prior instances of remembering (for a review, Geraerts, 2012) seems to suggest that selective forgetting may be interlinked with the phenomenon of recovered memories. Moreover, there could be differences in selective forgetting abilities between the two different origins of recovered memories (suggestive therapy or spontaneous recovery). Are people who report spontaneously recovered memories superior in selective forgetting? And if so, is this a factor of employing direct suppression when suppressing distressing events from the past? CSFI can be used precisely to look at these relationships and the answers to these questions can contribute to clearing the muddy waters of recovered memories. In addition, given that absence of reminders may explain once forgotten trauma that is then later recovered (Janssen et al., 2022), CSFI may open a path of exploring the links amongst avoidance behaviour, selective

forgetting, thought control and recovered memories. It is also important to keep in mind that recovered memories can happen in both clinical and nonclinical populations. In the case of spontaneous recovery, (as opposed to therapy-induced) one can indeed recover a memory due to a confrontation with a trigger of the past trauma, but some clinicians believe that one can also spontaneously recover a memory due to the human body that detecting readiness in the present balanced state of the individual to open the door for healing from that particular traumatic memory. Thus, a nonclinical population that experiences recovered memories may reflect resilience and well-being, in contrast to what is often envisioned in narratives around memory recovery.

Research showcasing recovered memories in nonclinical individuals as being associated with fewer thoughts and lowered emotional intensity hints at the emotional regulation mechanisms at play (Chiu, 2018). Given that emotional regulation is closely connected with thought control as discussed in preceding chapters, the CSFI can become a powerful tool in probing the differential manifestation of recovered memories in both the clinical population and the general population. Additionally, there seems to be evidence for differentiation between recollection of memories for traumatic versus nontraumatic emotional events (for a review, see Sotgiu & Rusconi, 2014). With this lens, one can consider how traumatic memory can lead to forgetting of time periods and recovered memories, whereas prevalence of non-traumatic emotional memory can contribute to recruitment of thought suppression strategies and selective forgetting. In this way, CSFI can be used to ask and begin to answer questions around the differential impact of the emotional severity of one's memories on any cognitive or behavioural area of interest.

Forgetting of unpleasant tasks may at first seem irrelevant to the investigation of motivated forgetting, but one can see its importance in understanding the full picture of selective forgetting through the lens of procrastination. Quintessentially described as a self-regulatory failure (Rebetez et al., 2018), procrastination can be observed as the prevalence of voluntary and mostly irrational delay of an intended and oftentimes much-needed course of action (S. Zhang et al., 2019). By delaying unpleasant tasks beyond the time required for its completion, people who tend to procrastinate are often studied as having adopted a maladaptive behaviour that seems to provide benefits in the short-term but is

ultimately costly in the long-term. Given that self-control and impulsivity are important predictive traits of procrastination (Unda-López et al., 2022) and that there seems to be a clear link between intrusive thoughts and procrastination (Rebetez et al., 2018), one can see the rationale behind inclusion of forgetting of tasks, which can manifest as procrastination, as a relevant feature within the CSFI. Beyond behavioural findings, brain imaging studies have suggested the prefrontal cortex as an important component of neural correlates of procrastination (S. Zhang et al., 2019) as well as the top-down control of the PFC and the DMN as being implicated in procrastination (D. Zhang et al., 2016), which are all highly relevant to the discussion of motivated forgetting. Therefore, including a scale measuring one's tendency to forget executing on particularly distressing tasks contributes to painting a fuller picture when observing the phenomenon of selective forgetting.

The fifth subscale, intentionality of forgetting, arose from the almost intuitive link between intentionality and motivated forgetting. Intentionality is built into laboratory tasks such as the TNT task that seek to investigate motivated forgetting, especially its sub-branch of active forgetting. Therefore, this was sufficient at the time of developing the CSFI for us to include it as a subscale. Similarly, the next two subscales representing the two main modes of active forgetting strategies were also included as a direct reflection of their centrality to the motivated forgetting thesis. Beyond the obvious relevance of thought suppression strategies to motivated forgetting in general, one can also see the relevance of investigating a person's tendency to self-initiate thought control strategies from the literature on the important role of self-initiated encoding strategy use in episodic memory. If one were to draw a parallel with remembering and forgetting, then just as self-initiated encoding strategy use is associated with individual differences in episodic memory (Kirchhoff, 2009), self-initiated suppression strategy use could be associated with individual differences in selective forgetting. This is especially strengthened by the observation that the prefrontal cortex seems to “mediate the relationship between individuals' self-initiated encoding strategy use and their memory performance,” (Kirchhoff, 2009. p. 174). In addition, a potential future application of CSFI to give an insight of delineation can be seen from existing literature suggesting association of anxiety with AM through brooding (Ricarte et al., 2016). Given that brooding has an aspect of a lack of control over negative thoughts, future

investigations into tendencies for use of thought suppression strategies may clarify the relationship, especially since anxiety has been demonstrated as ameliorable through effective thought control (Chapters 3 & 4).

On a similar note to strategies of thought suppression is the often-used but seemingly maladaptive tendency for someone to avoid their unpleasant experiences. Indeed, one of the core arguments made in Chapter 2 against the IPT's discussion of rebound effects in thought suppression is the conflation between avoidance and direct suppression. Hence, it would be important to also include a subscale to disentangle the impact of avoidance behaviours in relation to one's profile of forgetting AMs as well as its relevance in the phenomenon of selective forgetting. A closely relevant phenomenon to selective forgetting that has been discussed in literature is overgeneral memory, which refers to a failure to remember specific personal experiences on a more global level. As can also be intuitively understood, avoidance may play a role in inducing overgeneral memory. Given that avoidance of daily hassles can reduce the richness of episodic detail when recalling autobiographical memories in the laboratory (Hallford et al., 2018), then avoidance behaviour may also shape the individual differences observed in selective forgetting, further warranting the need to include such a scale in the CSFI. Importantly, there is also evidence supporting how cognitively avoiding intrusive memories can reduce episodic components of AMs upon retrieval (Lemogne et al., 2009). Given that a reduced episodic detail in AM suggests forgetting effects, one may entertain a positive association between avoidance and selective forgetting. However, the opposite could also be true: people who tend to self-initiate effective suppression and experience selective forgetting may no longer need to avoid distressful content as much. To date, there hasn't yet been a single inventory that simultaneously investigates all of these components together. In this way, CSFI is filling an important role in overcoming methodological obstacles to initiate investigations into this fertile area of research.

In summary, since numerous considerations of the inclusion and exclusion of a particular factor potentially involved in selective forgetting occupied the majority of our discussions in determining the subscales and generating their respective items, the foregoing discussions form the backbone of the

research and development aspect of the CSFI. Next is a discussion of the first attempt of a preliminary psychometric validation study of the CSFI with 453 participants.

5.2. *Validation of the Cambridge Selective Forgetting Inventory*

Factor Structure

We performed 3 iterations of Exploratory Factor Analysis (EFA) in order to investigate item loading and to reduce the dimensionalities of the CSFI. For the first iteration of the EFA, we included all of the original 45 items (Appendix C). The subsequent iterations took place as a result of item-level analysis. The final iteration concluded with 7 factors comprising 32 items in total (Appendix D).

Importantly, we used all of the best practices in the field for dimension reduction through EFA that is most appropriate for our dataset: parallel analysis with principal axis factoring, oblique rotation, and polychoric correlation matrix. Parallel analysis was chosen because parallel analysis was determined as one of the most “accurate empirical estimates of the number of factors to retain and that scree is a useful subjective adjunct to the empirical estimates” (Watkins, 2018, p. 230). Principle axis factoring was chosen because statistical simulations have showed principle axis factoring outperforming maximum likelihood methods “when the relationships between measured variables and factors are relatively weak ($\leq .40$), sample size is relatively small (≤ 300), multivariate normality is violated, or when the number of factors underlying the measured variables is misspecified” (Watkins, 2018, p. 225). Even though not all of the above weaknesses in data apply in our case, we thought to be more cautious than risking the possibility of erroneous representation of data structure. Oblique rotation was chosen as it is often recommended by measurement specialists “that an oblique rotation be applied to allow factor intercorrelations to emerge” (Watkins, 2018, p. 233). There are different types of oblique rotation, so we chose promax as it is often the more popular option. Polychoric/tetrachoric correlation matrix was chosen as our data violates normality and since “[m]ore robust correlational methods (e.g., Spearman, phi, polychoric, tetrachoric) as well as judicious selection of EFA estimation methods would be advisable” in the case of normality violations in data (Watkins, 2018, p. 234). Kaiser-Meyer-Olkin test (KMO) was then investigated for all of the items in each iteration as it is the degree to which data reflects variance shared across all variables rather than the particular pairs. In terms of validation, values ≥ 0.7 is desirable, < 0.5 is generally unacceptable (M. W. Watkins, 2018). All items across the three iterations

qualified as desirable (Table 26). Bartlett's test of sphericity was then inspected as it measures the randomness of data. For validation, statistically significant chi-squared value is needed (M. W. Watkins, 2018). All three iterations reflect this favourably with random distribution of data (Table 27). Then, Mardia's Test of Multivariate Normality was inspected as the p-values for both the skewness and kurtosis statistics should be greater than 0.05 to conclude multivariate normality (M. W. Watkins, 2018). In the Mardia's Test, all three iterations fail to show multivariate normality (Table 28); however, this was anticipated as the Shapiro-Wilk Test was conducted in a preliminary analysis. This is also one of the main reasons for us to choose the polychoric correlation matrix for our analysis.

Table 26.*Kaiser-Meyer-Olkin test*

Item #	Iteration		
	1	2	3
Overall MSA	0.88	0.89	0.88
5.1	0.92	0.91	0.92
5.2	0.86	0.87	0.89
5.3	0.94	0.93	0.92
5.4	0.91	0.92	0.91
1.1	0.87	0.90	0.91
1.2	0.94	0.94	0.94
1.3	0.91	0.92	0.92
1.4 ³	0.96	0.96	-
1.5	0.87	0.90	0.91
6.1	0.92	0.92	0.94
6.2	0.90	0.91	0.90
6.3	0.89	0.90	0.89
6.4	0.94	0.94	0.93
7.1	0.89	0.88	0.88
7.2	0.77	0.79	0.78
7.3 ^{2,3}	0.87	-	-
7.4	0.75	0.76	0.73
8.1 ^{2,3}	0.82	-	-
8.2 ³	0.88	0.91	-
8.3 ³	0.88	0.87	-
8.4 ³	0.90	0.88	-
2.1	0.71	0.74	0.71
2.2	0.76	0.76	0.75
2.3 ^{2,3}	0.75	-	-
2.4 ^{2,3}	0.81	-	-
2.5	0.78	0.79	0.83
2.6	0.86	0.86	0.83
4.1 ^{2,3}	0.88	-	-

4.2	0.84	0.84	0.84
4.3	0.74	0.78	0.76
4.4	0.84	0.85	0.84
4.5	0.86	0.84	0.81
4.6	0.86	0.86	0.81
3.1	0.87	0.85	0.88
3.2	0.84	0.85	0.85
3.3	0.89	0.89	0.87
3.4	0.90	0.86	0.81
3.5	0.85	0.83	0.85
10.1 ³	0.87	0.86	-
10.2 ³	0.88	0.86	-
9.1	0.83	0.83	0.86
9.2	0.89	0.89	0.89
9.3	0.94	0.96	0.95

Note. ²excluded in iteration 2; ³excluded in iteration 3. A dash (-) indicates exclusion.

Table 27.

Iterations	χ^2	df	p
1	13721.87	903.00	< .001
2	11897.55	703.00	< .001
3	9554.36	496.00	< .001

Table 28.

Mardia's Test of Multivariate Normality

	Iterations	Value	Statistic	df	p
Skewness	1	255.51	19290.72	14190	< .001
	2	185.80	14027.55	9880	< .001
	3	117.53	8873.29	5984	< .001
Small Sample Skewness	1	255.51	19424.30	14190	< .001
	2	185.80	14125.23	9880	< .001
	3	117.53	8935.64	5984	< .001
Kurtosis	1	2100.70	28.35		< .001
	2	1661.29	27.27		< .001
	3	1195.93	24.62		< .001

Note. The statistic for skewness is assumed to be χ^2 distributed and the statistic for kurtosis standard normal.

Table 29.

Iterations	RMSEA	RMSEA 90% CI	SRMR	TLI	CFI	BIC
1	0.08	0.078 - 0.084	0.03	0.79	0.86	-1341.17
2	0.08	0.074 - 0.082	0.03	0.82	0.89	-1070.41
3	0.07	0.067 - 0.077	0.02	0.87	0.93	-820.49

Note. RMSEA: root mean square error of approximation; SRMR: standardized root mean square residual; TLI: Tucker-Lewis index; CFI: comparative fit index; BIC: bayesian information criterion.

After considering all of these assumption checks, we turned to the factor loadings. The first iteration yielded 7 factors (see Table 29 for fit indices). Moreover, there were 3 items that did not load with >0.4 correlation (items 1.4, 2.4, 10.2). Out of the original 10 subscales, the subscales that did not emerge were subscale 10 (avoidance of recall) and subscale 8 (intentionality). In summary, the 7 factors had the following loadings:

F1 (8 items): all 4 items in subscale 6 (time periods) + all 3 items in subscale 9 (recovered memories) + 1.1

F2 (10 items): all 5 items in subscale 3 (avoidance of reminders) + 10.1 + 2.3 (repeated in F7) + 2/4 items in subscale 8 (intentionality)

F3 (7 items): all 4 items in subscale 5 (details) + 3/5 items in subscale 1 (entire events)

F4 (6 items): 5/6 items in subscale 4 (direct supp) + 8.3

F5 (4 items): all 4 items in subscale 7 (tasks)

F6 (4 items): 4/6 items in subscale 2 (thought subs)

F7 (1 item): 8.2

Given the discrepancies in the above analysis, we took a deeper dive by correlating all items with other items within its own subscale via polychoric correlation in R (Revelle & Garner, 2022). This analysis determined that there were 5 items that were quite problematic (i.e., having < 0.5 correlation with all of the other items): 7.3 from Tasks, 8.1 from Intentionality, 2.3 & 2.4 from Thought Substitution, and 4.1 from Direct Suppression. These items were then removed from the second iteration of the EFA analysis. The second iteration of EFA also yielded 7 factors. Three items did not load with >0.4 correlation: 1.4, 8.2, 8.4. Out of the original 10 subscales, the subscales that did not emerge are: subscale 10 (avoidance of recall), subscale 8 (intentionality). The factor loadings for the second iteration were as follows:

F1 (8 items): 4/5 items in subscale 1 (entire events) + all 4 items in subscale 5 (details)

F2 (7 items): all of the 5 remaining items in subscale 4 (direct supp) + 8.3 + 10.2

F3 (6 items): all 5 items in subscale 3 (avoidance of reminders) + 10.1

F4 (4 items): all 4 items in subscale 6 (time periods)

F5 (3 items): all of the 3 remaining items in subscale 7 (tasks)

F6 (4 items): all 3 items in subscale 9 (recovered memories) + 1.1 (repeated in F1)

F7 (4 items): all of the 4 remaining items in subscale 2 (thought subs)

This time, we carefully considered the three items that did not load and examined each separately. Upon a closer look, item 1.4 may not have loaded because it seems to be a general belief about one's memory, a metacognitive type of question, whereas the other items in the Entire Events subscale imply context within the item and are more specific. Items 8.2 & 8.4 are both part of the Intentionality subscale that did not emerge in the EFA. There are two other items in the subscale, items 8.1 which was excluded from this analysis due to weak within-subscale polychoric correlation after the first iteration, and 8.3 which loaded unto F2 (i.e., direct suppression). Regarding item 8.3, it is interesting to see this emerge with direct suppression as this item looks at confidence in the positive resilient factor of suppression explicitly described as a "skill". The nonconvergence of this subscale seems to reveal the inherent inability of people in being able to be aware of their own intentions, especially since forgetting is understood as an after-effect in everyday language and mainstream media. Therefore, we decided to exclude this subscale altogether.

On the other hand, although 10.1 and 10.2 were not of the unloading items, they still didn't seem to map appropriately, which put their relevance into question. Item 10.2 is part of the Avoidance of Recall subscale that did not emerge in the EFA. Item 10.2 may not have loaded because the language use is extremely specific as the metaphor of "a mental box" may not resonate with everyone. This was a concern brought up during the item development stage as well. On the other hand, item 10.1 loaded onto the factor containing the Avoidance of Reminders subscale. Taken together, this seems to reflect multiple issues with this subscale, some of which were brought up previously during the development stage: 1) two items are too few to have for a separate subscale, 2) too specific of a type of expression (e.g., mental box) may not transfer generally to different populations, and 3) people may not be able to distinguish avoidance of recalling the event itself versus avoidance of a reminder of the event, and 4) item 10.1 technically does not exclude avoidance of the reminder if that is the strategy used to avoid recall of the event. Hence, this subscale with its two items (10.1, 10.2) was subsequently also removed.

As a result, the third iteration excluded six items mentioned in the foregoing discussion (items 1.4, 8.2, 8.4, 8.3, 10.1, 10.2). In summary, this final iteration included 32 items, with the following 11 items excluded: 1.4, 7.3, 8.1, 8.2, 8.3, 8.4, 2.3, 2.4, 4.1, 10.1, 10.2. This iteration also yielded 7 factors. The factors that emerge were clearly representative of the intended subscale structure. The only difference being that forgetting of Details vs. Entire negative experiences are now merged under one factor, which also makes intuitive sense as they both describe the general phenomenon of forgetting negative experiences. So, the 7 subscales that emerge are as follows:

F1 - forgetting unpleasant events - 8 items: 1.1, 1.2, 1.3, 1.5, 5.1, 5.2, 5.3, 5.4

F2 - forgetting unpleasant time periods - 4 items: 6.1, 6.2, 6.3, 6.4

F3 - forgetting by direct suppression - 5 items: 4.2, 4.3, 4.4, 4.5, 4.6

F4 - avoidance of reminders - 5 items: 3.1, 3.2, 3.3, 3.4, 3.5

F5 - forgetting unpleasant tasks - 3 items: 7.1, 7.2, 7.4

F6 - recovery of forgotten unpleasant events - 3 items: 9.1, 9.2, 9.3

F7 - forgetting by thought substitution - 4 items: 2.1, 2.2, 2.5, 2.6

In the final iteration of EFA, with the exception of 1 item (1.1) which loaded to two factors (F1 and F6) with > 0.4 loading, all of the other 31 items loaded uniquely to a single factor (Table 30). Eigenvalues of the seven factors ranged from 0.37 to 8.75. The range and mean of each of the factors can be inspected in Table 30. All items, adjusting for the exception of the one reverse coded item (5.4), were scored 0 to 3; therefore, all loadings are positive. The seven factors cumulatively accounted for 62% of total score variance. Factor correlations from the EFA can be seen in Table 31. Additionally, we re-tabulated scores for each of the subscales using the dimensionality and items resulting from the last EFA iteration (Table 32). The correlations from average score for each subscale corresponded well with factor correlations, indicating the validity to use averaging of scores as the approach for scoring the CSFI. Notably, the Event subscale was highly correlated with all of the subscales (Table 32A), which confirms the soundness of the various theoretical rationale underpinning the inclusion of these dimensions as relevant for the investigation of selective forgetting. Importantly, likely maladaptive features of a forgetting profile (forgetting of time periods, recovered memories, forgetting of tasks, avoidance

behaviour) were not significantly positively associated with either of the thought suppression strategies. In fact, direct suppression was significantly negatively associated with avoidance of reminders ($r = -0.16$, $p < .001$). This is an important finding as it gives support to what has been discussed extensively in Chapter 2 regarding the need to dissociate direct suppression from avoidance when it comes to instructions for thought suppression in laboratory tasks.

Indeed, a picture is emerging with direct suppression as an especially adaptive form of thought suppression while avoidance seems maladaptive with potential for ironic effects and associations with higher prevalence of having gaps in memory. Indeed, there could be an underlying factor of unprocessed trauma underlying avoidance behaviour which warrants further investigations. It is also notable that this sample of 453 participants seem to on average score quite low on all of the subscales (Table 32C). This may reflect the rarity of what we are investigating, but replications are needed before any solid conclusion.

Table 30.

Factor Loadings of the Final EFA Iteration

Item #	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Uniqueness
1.5	0.81							0.39
5.4	0.74							0.38
5.1	0.63							0.41
5.3	0.57							0.35
1.3	0.54							0.48
5.2	0.52							0.60
1.2	0.43							0.42
1.1	0.42					0.41		0.41
6.3		0.90						0.15
6.2		0.79						0.28
6.4		0.64						0.20
6.1		0.61						0.22
4.2			0.78					0.40
4.5			0.75					0.40
4.3			0.74					0.46
4.6			0.73					0.41
4.4			0.59					0.50
3.4				0.87				0.31
3.1				0.71				0.40
3.3				0.68				0.45
3.2				0.68				0.51
3.5				0.61				0.54

7.2					0.95			0.09
7.4					0.94			0.15
7.1					0.84			0.25
9.1						0.79		0.25
9.2						0.69		0.21
9.3						0.54		0.39
2.2							0.74	0.45
2.5							0.64	0.56
2.1							0.55	0.65
2.6							0.49	0.53
Mean	0.58	0.74	0.72	0.71	0.91	0.61	0.61	0.38

Note. Applied rotation method is oblimin.

Table 31.

Factor Correlations from EFA

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Factor 1	—						
Factor 2	0.60	—					
Factor 3	0.23	0.02	—				
Factor 4	0.18	0.28	-0.12	—			
Factor 5	0.32	0.28	-0.05	0.30	—		
Factor 6	0.35	0.57	-0.08	0.26	0.19	—	
Factor 7	0.06	-0.02	0.41	-0.07	-0.04	-0.04	—

Note. F1 - forgetting unpleasant events; F2 - forgetting unpleasant time periods; F3 - forgetting by direct suppression; F4 - avoidance of reminders; F5 - forgetting unpleasant tasks; F6 - recovery of forgotten unpleasant events; F7 - forgetting by thought substitution.

Table 32.

A. Summary: Pearson's Correlations of CSFI Subscales

Variable	Events	Time Periods	Tasks	Thought Subst.	Direct Suppress.	Avoid Reminders	Recovered Memories
1. Events	—						
2. Time Periods	0.66***	—					
3. Tasks	0.31***	0.26***	—				
4. Thought Substitution	0.13**	0.01	-0.02	—			
5. Direct Suppression	0.17***	-3.19×10 ⁻³	-0.07	0.43***	—		
6. Avoidance of Reminders	0.23***	0.29***	0.28***	-0.08	-0.16***	—	
7. Recovered Memories	0.51***	0.64***	0.23***	0.01	-0.08	0.31***	—

Note. * p < .05, ** p < .01, *** p < .001

B. Additional Statistics: Correlations of CSFI Subscales

Variable	Events	Time Periods	Tasks	Thought Subst.	Direct Suppress.	Avoid Reminders	Recovered Memories
1. Events	Pearson's r —						
	p-value —						

	Upper 95% CI	—						
	Lower 95% CI	—						
	Effect size	—						
	SE Effect size	—						
2. Time	Pearson's r	0.66	—					
Periods	p-value	< .001	—					
	Upper 95% CI	0.71	—					
	Lower 95% CI	0.60	—					
	Effect size	0.79	—					
	SE Effect size	0.05	—					
3. Tasks	Pearson's r	0.31	0.26	—				
	p-value	< .001	< .001	—				
	Upper 95% CI	0.40	0.34	—				
	Lower 95% CI	0.23	0.17	—				
	Effect size	0.33	0.26	—				
	SE Effect size	0.05	0.05	—				
4. Thought	Pearson's r	0.13	0.01	-0.02	—			
Substitution	p-value	6.81×10^{-3}	0.79	0.62	—			
	Upper 95% CI	0.22	0.10	0.07	—			
	Lower 95% CI	0.04	-0.08	-0.12	—			
	Effect size	0.13	0.01	-0.02	—			
	SE Effect size	0.05	0.05	0.05	—			
5. Direct	Pearson's r	0.17	-3.19×10^{-3}	-0.07	0.43	—		
Suppression	p-value	< .001	0.95	0.13	< .001	—		
	Upper 95% CI	0.26	0.09	0.02	0.50	—		
	Lower 95% CI	0.08	-0.10	-0.16	0.35	—		
	Effect size	0.17	-3.19×10^{-3}	-0.07	0.46	—		
	SE Effect size	0.05	0.05	0.05	0.05	—		
6. Avoidance	Pearson's r	0.23	0.29	0.28	-0.08	-0.16	—	
of Reminders	p-value	< .001	< .001	< .001	0.11	< .001	—	
	Upper 95% CI	0.32	0.38	0.37	0.02	-0.07	—	
	Lower 95% CI	0.14	0.21	0.20	-0.17	-0.25	—	
	Effect size	0.24	0.30	0.29	-0.08	-0.17	—	
	SE Effect size	0.05	0.05	0.05	0.05	0.05	—	
7. Recovered	Pearson's r	0.51	0.64	0.23	0.01	-0.08	0.31	—
Memories	p-value	< .001	< .001	< .001	0.80	0.09	< .001	—
	Upper 95% CI	0.57	0.69	0.31	0.10	0.01	0.39	—
	Lower 95% CI	0.44	0.58	0.14	-0.08	-0.17	0.22	—
	Effect size	0.56	0.75	0.23	0.01	-0.08	0.32	—
	SE Effect size	0.05	0.05	0.05	0.05	0.05	0.05	—

Note. Effect size is from Fisher's z. * $p < .05$, ** $p < .01$, *** $p < .001$

C. Descriptive Statistics of CSFI Subscales (N = 453)

	Mean	Std. Deviation	Variance	Range
1. Events	0.72	0.51	0.26	2.25
2. Time Periods	0.75	0.73	0.53	3.00
3. Tasks	0.73	0.66	0.43	3.00

4. Thought Substitution	1.17	0.62	0.39	3.00
5. Direct Suppression	1.19	0.60	0.36	3.00
6. Avoidance of Reminders	1.48	0.67	0.44	3.00
7. Recovered Memories	0.85	0.77	0.59	2.67

Note. These scores are the mean of all the items in a given subscale. The possible range for each subscale is 0 to 4.

Reliability

We examined internal consistency using multiple estimators of single-test reliability coefficients on the seven subscales as derived from the final iteration of the EFA. Given that Cronbach's α is known to have a tendency to underestimate true reliability (Lord et al., 1968) and the existence of some notable cautions against its use (Cho, 2016; McNeish, 2018), we decided to include alternative estimators (for a tutorial on its use in JASP, see Pfadt et al., 2023). These analyses indicated highly reliable scores on all of the subscales (Table 33). We can see that at least 69% - 88% of the total within-test score variance was due to true score variance rather than to poor item quality or item content heterogeneity.

For test-retest reliability, we used data from 182 of the 453 participants (40%) who were tested 2 weeks after the first test without any intervention in between. Correlations indicated reliable scores across all subscales (Table 34). Moreover, 67% - 83% of the total test-retest score variance was due to true variance rather than to the effects of random changes in the environment.

Table 33.

A. Summary: Frequentist Scale Reliability Statistics

	McDonald's ω	Cronbach's α	Guttman's λ_2	Guttman's λ_6	mean	sd
F1 - Events	0.85	0.84	0.85	0.84	0.72	0.51
F2 - Time Periods	0.89	0.88	0.88	0.86	0.75	0.73
F3 - Direct Suppression	0.82	0.82	0.82	0.78	1.19	0.60
F4 - Avoidance of Reminders	0.81	0.81	0.81	0.78	1.48	0.67
F5 - Tasks	0.88	0.88	0.88	0.83	0.73	0.66
F6 - Recovered Memories	0.80	0.78	0.79	0.72	0.85	0.77
F7 - Thought Substitution	0.70	0.69	0.69	0.63	1.17	0.62

Note. Mean is of participants' mean scores.

B. Additional Statistics: Frequentist Scale Reliability Statistics

		McDonald's ω	Cronbach's α	Guttman's λ_2	Guttman's λ_6	mean	sd
F1 - Events	Point estimate	0.85	0.84	0.85	0.84	0.72	0.51
	95% CI lower	0.83	0.82	0.83	0.82	0.68	0.48
	95% CI upper	0.87	0.86	0.87	0.86	0.77	0.54

F2 - Time Periods	Point estimate	0.89	0.88	0.88	0.86	0.75	0.73
	95% CI lower	0.87	0.86	0.86	0.84	0.69	0.68
	95% CI upper	0.90	0.89	0.90	0.88	0.82	0.78
F3 - Direct Suppression	Point estimate	0.82	0.82	0.82	0.78	1.19	0.60
	95% CI lower	0.79	0.79	0.79	0.75	1.14	0.57
	95% CI upper	0.84	0.84	0.85	0.82	1.25	0.65
F4 - Avoidance of Reminders	Point estimate	0.81	0.81	0.81	0.78	1.48	0.67
	95% CI lower	0.78	0.78	0.78	0.74	1.42	0.63
	95% CI upper	0.84	0.84	0.84	0.81	1.54	0.71
F5 - Tasks	Point estimate	0.88	0.88	0.88	0.83	0.73	0.66
	95% CI lower	0.86	0.86	0.85	0.8	0.67	0.62
	95% CI upper	0.90	0.90	0.90	0.86	0.79	0.70
F6 - Recovered Memories	Point estimate	0.8	0.78	0.79	0.72	0.85	0.77
	95% CI lower	0.77	0.75	0.76	0.67	0.78	0.72
	95% CI upper	0.84	0.82	0.82	0.76	0.92	0.82
F7 - Thought Substitution	Point estimate	0.70	0.69	0.69	0.63	1.17	0.62
	95% CI lower	0.65	0.65	0.64	0.58	1.11	0.58
	95% CI upper	0.74	0.74	0.74	0.69	1.23	0.67

Note. Mean is of participants' mean scores.

Table 34.

Test-Retest Reliability Analysis: Pearson's Correlations

	Events T1	Time Periods T1	Tasks T1	Thought Subs T1	Direct Supp T1	Avoid Rem. T1	Recovered Memory T1
Events_T2	0.83***	0.58***	0.36***	0.15*	0.22**	0.32***	0.55***
Time Periods_T2	0.61***	0.81***	0.29***	0.04	0.05	0.33***	0.65***
Tasks_T2	0.28***	0.15*	0.67***	-0.05	-0.03	0.31***	0.26***
Thought Subs_T2	0.18*	0.1	-0.04	0.76***	0.43***	-0.1	0.12
Direct Supp_T2	0.17*	0.07	-0.03	0.34***	0.73***	-0.08	-0.01
Avoid Reminders_T2	0.33***	0.36***	0.22**	-0.1	-0.08	0.79***	0.44***
Recovered Memory_T2	0.41***	0.58***	0.23**	0.04	-0.06	0.32***	0.77***

Note. T1 had 453 participants, and 182 of them were retested in T2. It is about a 2-week interval between T1 and T2. * p < .05, ** p < .01, *** p < .001

Construct Validity

Following the standard method for analysing construct validity, we investigated how each subscale correlates with existing surveys that may be relevant to the study of people with selective forgetting abilities. We considered convergent validity of the CSFI by examining if the subscales have high correlations with measures that are theoretically related. Similarly, we considered divergent validity by examining if the subscales have low correlations with theoretically unrelated constructs.

We probed the correlations between CSFI and 4 categories of surveys (9 questionnaires in total) and participants seem to capture the full range for almost every scale (Table 35). From their pre-training mental health indices, we can see that this sample of participants is moderately depressed and anxious. Specifically, the following scales were considered for validation purposes:

1. Thought suppression related questionnaires:
 - a. TCAQ (25 items) (Luciano et al., 2005)
 - b. TSI-R (21 items) (van Schie et al., 2016)
2. Mental health questionnaires :
 - a. Well-being: WEMWBS (14 items) (Tennant et al., 2007)
 - b. Anxiety : STAI - State & Trait (40 items) (Spielberger et al., 1983)
 - c. Depression: BDI (20 items – excluding suicide ideation) (Beck et al., 1996)
 - d. Composite: DASS (21 items) (Lovibond & Lovibond, 1995)
3. Life experience related questionnaires:
 - a. Trauma: BBTS (12 items) (L. R. Goldberg & Freyd, 2006)
 - b. Resilience: CD-RISC-10 (10 items) (Campbell-Sills & Stein, 2007; Connor & Davidson, 2003)
4. Memory related subscales: Mini-SAM (10 items) (Palombo et al., 2013)
 - a. Episodic (3 items)
 - b. Semantic (2 items)
 - c. Spatial (3 items)
 - d. Future (2 items)

Table 35.*Descriptive Statistics of the Mental Health Profile of Participants (N=453)*

			Mean	Std. Dev.	Variance	Range
Thought Control	TCAQ		46.42	18.84	354.97	93.00
	TSI-R	<i>Intrusion</i>	47.71	23.91	571.75	100.00
		<i>Suppression Attempts</i>	69.04	16.18	261.72	100.00
		<i>Effective Suppression</i>	50.88	21.70	470.81	100.00
Mental Health	STAI-State		31.35	22.06	486.83	100.00
	STAI-Trait		43.52	22.40	501.67	95.00
	WEMWBS		56.24	19.11	365.18	100.00
	BDI-II		23.30	19.66	386.63	90.00
	DASS	<i>Stress</i>	23.38	20.46	418.78	95.24
		<i>Anxiety</i>	12.23	15.53	241.08	95.24
<i>Depression</i>		24.48	25.62	656.16	100.00	
Life Experiences	BBTS	<i>High Betrayal</i>	10.67	13.88	192.74	80.00
		<i>Low Betrayal</i>	4.75	8.17	66.80	70.00
	CD-RISC-10		59.24	20.88	435.78	92.50
Memory	MiniSAM	<i>Episodic</i>	28.75	16.48	271.61	79.44
		<i>Semantic</i>	44.28	27.59	761.27	100.00
		<i>Spatial</i>	41.08	21.99	483.68	100.00
		<i>Future</i>	30.03	31.20	973.32	100.00
		<i>Total</i>	32.38	14.48	209.60	77.36

Note. Scores for the questionnaires are the POMP scores of the raw sum scores.

In terms of convergent validity, we would firstly expect high correlation of the explicitly thought control related subscales of the CSFI (thought substitution, direct suppression, avoidance of reminders) to correlate highly with TCAQ and TSI-R (Table 35). Indeed, magnitude-wise, they are all significantly correlated. However, there are some nuances that we can now see clearly with what these constructs are actually measuring given the CSFI subscales. For instance, we can see that TCAQ seems to be more positively related to adaptive thought suppression techniques and negatively associated with maladaptive strategy of avoidance of reminders. However, only effective suppression subscale of TSI-R is positively correlated with the CSFI thought suppression strategies and negatively correlated with avoidance.

On the other hand, its intrusion subscale shows the opposite pattern. Suppression attempts seem to be correlated somewhat with all three strategies but especially avoidance. This delineation once again gives clarity to what has been proposed in preceding chapters regarding what experiments that show ironic effects may actually be measuring - avoidance rather than adaptive thought control

mechanisms. The point about intrusions is also interesting to note given that the items on the intrusion subscale of TSI-R are more leaning towards a negative attitude and sometimes even an inability to control intrusions; for example: *I experience many emotions that are too intense to control*. One possible interpretation for the pattern of correlation of TSI-R's intrusion subscale with the various CSFI strategies can be due to inexperience with such techniques. In terms of divergent validity with thought control related questionnaires, it is notable to see that TCAQ did not significantly relate to selective forgetting of events, whereas the TSI-R showed a weak yet significant positive association. This is expected given that TCAQ only mentions memory-related terms once in all the items and it is actually related to not being able to recall rather than the quality of the memory itself. On the other hand, TSI-R items explicitly mention the word "memory" twice and both times it is related to suppression which indeed is highly related to selective forgetting. The rest of the correlation reveal the same pattern: TCAQ and effective suppression subscale of TSI-R seem to associate positively with adaptive CSFI subscales and negatively with maladaptive subscales (Time Periods, Tasks, Avoidance, Recovered Memories), and the opposite is true for the TSI-R subscales of intrusion and suppression attempts.

Table 36.*A. Summary: Pearson's Correlations of CSFI with Thought Control Related Questionnaires*

	Events	Time Periods	Tasks	Thought Substitution	Direct Suppression	Avoid Reminders	Recovered Memories
TCAQ	-0.04	-0.23 ***	-0.26 ***	0.37 ***	0.63 ***	-0.43 ***	-0.28 ***
TSI-R							
<i>Intrusion</i>	0.11 *	0.29 ***	0.26 ***	-0.30 ***	-0.49 ***	0.38 ***	0.35 ***
<i>Suppression Attempts</i>	0.16 **	0.22 ***	0.18 ***	0.14 *	0.06	0.43 ***	0.24 ***
<i>Effective Suppression</i>	0.11 *	-0.07	-0.09	0.40 ***	0.69 ***	-0.24 ***	-0.10 *

Note. TCAQ: Thought Control Ability Questionnaire; TSI-R: Thought Suppression Inventory - Revised. TCAQ and TSI-R are the POMP scores of the total raw scores. The CSFI subscores are average scores with a range of 0 to 4. Statistical significance is indicated as: * $p < .05$, ** $p < .01$, *** $p < .001$

B. Additional Statistics: Correlations of CSFI with Thought Control Related Questionnaires

		Time		Thought Direct		Avoid	Recov.	TSI-R		TSI-R	TSI-R	
		Events	Periods	Tasks	Subs.	Supp.	Rem.	Mem.	TCAQ	Intrus.	Sup. Att.	Eff. Sup.
TCAQ	<i>r</i>	-0.04	-0.23	-0.26	0.37	0.63	-0.43	-0.28	—			
	<i>p</i>	0.39	< .001	< .001	< .001	< .001	< .001	< .001	—			
	<i>U. CI</i>	0.05	-0.14	-0.17	0.44	0.68	-0.35	-0.19	—			
	<i>L. CI</i>	-0.13	-0.32	-0.34	0.28	0.57	-0.50	-0.36	—			
	<i>ES</i>	-0.04	-0.24	-0.26	0.38	0.74	-0.46	-0.29	—			
	<i>SEES</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05	—			
TSI-R Intrusion	<i>r</i>	0.11	0.29	0.26	-0.30	-0.49	0.38	0.35	-0.83	—		
	<i>p</i>	0.02	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	—	
	<i>U. CI</i>	0.20	0.37	0.34	-0.21	-0.42	0.45	0.43	-0.80	-0.80	—	
	<i>L. CI</i>	0.02	0.20	0.17	-0.38	-0.56	0.29	0.27	-0.85	-0.85	—	
	<i>ES</i>	0.11	0.29	0.26	-0.31	-0.54	0.39	0.37	-1.18	-1.18	—	
	<i>SEES</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	—	
TSI-R Suppression Attempts	<i>r</i>	0.16	0.22	0.18	0.14	0.06	0.43	0.24	-0.24	0.30	—	
	<i>p</i>	< .001	< .001	< .001	3.05×10^{-3}	0.21	< .001	< .001	< .001	< .001	< .001	—
	<i>U. CI</i>	0.25	0.31	0.27	0.23	0.15	0.50	0.33	-0.15	0.38	—	
	<i>L. CI</i>	0.07	0.13	0.09	0.05	-0.03	0.35	0.15	-0.32	0.21	—	
	<i>ES</i>	0.16	0.22	0.18	0.14	0.06	0.46	0.25	-0.24	0.31	—	
	<i>SEES</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	—
TSI-R Effective Suppression	<i>r</i>	0.11	-0.07	-0.09	0.40	0.69	-0.24	-0.10	0.75	-0.66	0.05	—
	<i>p</i>	0.02	0.13	0.07	< .001	< .001	< .001	0.04	< .001	< .001	0.32	—
	<i>U. CI</i>	0.20	0.02	6.54×10^{-3}	0.47	0.74	-0.16	-5.50×10^{-3}	0.79	-0.60	0.14	—
	<i>L. CI</i>	0.01	-0.16	-0.18	0.32	0.64	-0.33	-0.19	0.71	-0.71	-0.05	—
	<i>ES</i>	0.11	-0.07	-0.09	0.42	0.85	-0.25	-0.10	0.98	-0.79	0.05	—
	<i>SEES</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	—

Note. *r*: Pearson's *r*; *p*: *p*-value; *U. CI*: upper 95% Confidence Interval; *L. CI*: lower 95% Confidence Interval; *ES*: Effect Size via Fisher's *z*; *SE ES*: Standard Error of Effect Size.

In regards to the second category of questionnaires, the mental health related measures, we also see a very similar pattern, whereby the positive mental health index (WEMWBS) is positive correlated with the adaptive thought control strategies and negatively correlated with everything else except forgetting of events; the opposite holds true for all of the rest of the mental health measures as they are all negative mental health indices (Table 37). It is interesting to see a divergence between mental health related measures and forgetting of selectively negative memories, especially given convergence in all of the other measures. This requires further inquiry, though one possible interpretation could be that this particular population may not have a high enough selective forgetting tendency for us to see any reliable

	<i>Upper 95% CI</i>	0.23	0.32	0.33	-0.18	-0.25	0.49	0.35
	<i>Lower 95% CI</i>	0.05	0.15	0.15	-0.35	-0.42	0.34	0.17
	<i>Effect size</i>	0.14	0.24	0.25	-0.28	-0.35	0.45	0.27
	<i>SE Effect size</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05
DASS	<i>Pearson's r</i>	0.06	0.21	0.19	-0.27	-0.36	0.35	0.27
Anxiety	<i>p-value</i>	0.23	< .001	< .001	< .001	< .001	< .001	< .001
	<i>Upper 95% CI</i>	0.15	0.29	0.28	-0.18	-0.27	0.43	0.36
	<i>Lower 95% CI</i>	-0.04	0.12	0.10	-0.35	-0.43	0.27	0.19
	<i>Effect size</i>	0.06	0.21	0.20	-0.27	-0.37	0.37	0.28
	<i>SE Effect size</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05
DASS	<i>Pearson's r</i>	0.05	0.23	0.25	-0.31	-0.34	0.39	0.20
Depression	<i>p-value</i>	0.27	< .001	< .001	< .001	< .001	< .001	< .001
	<i>Upper 95% CI</i>	0.14	0.32	0.34	-0.23	-0.26	0.46	0.29
	<i>Lower 95% CI</i>	-0.04	0.15	0.16	-0.39	-0.42	0.31	0.11
	<i>Effect size</i>	0.05	0.24	0.26	-0.32	-0.36	0.41	0.21
	<i>SE Effect size</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Note. Scores for the mental health related questionnaires are the POMP scores of the total raw scores. The CSFI subscores are average scores with a range of 0 to 4.

We were more exploratory in our expectations regarding the two scales relevant to one's life experiences, especially adverse experiences that may shape one's metacognitive beliefs, trigger mental health conditions, or even make or break a person. We hypothesised that both resiliency and trauma would converge with more active forgetting strategies given what we know about motivated forgetting, but there was no hard-line theoretical underpinning for what may potentially diverge. Contrary to our expectation, resiliency as measured by CD-RISC-10 mimicked the above pattern of positively associating with subscales reflective of adaptive behaviour and cognition (Table 38). However, the negative associations in forgetting of events and time periods, as was the case for thought control, were not observed. In addition, high betrayal trauma actually seems to be positively associated with maladaptive concepts, perhaps because people scoring high in this scale are severely traumatised and are likely to be at the beginning stages of their healing. In this way, the data suggests selective forgetting as captured in this sample as an in-between state whereby an individual is aware of suppression strategies enough to use it effectively but may still be in a process of undergoing or healing from adverse life experiences, thereby reflecting a mental state that is still not yet fully stable or resilient. However, as with most studies around trauma and resilience, understanding its underlying factors may require longitudinal studies to be able to delineate in detail and depth.

Table 38.*A. Summary: Pearson's Correlations of CSFI with Life Experience Related Questionnaires*

	Events	Time Periods	Tasks	Thought Substitution	Direct Suppression	Avoid Reminders	Recovered Memories
BBTS_High Betrayal	0.16***	0.36***	0.11*	-0.10*	-0.19***	0.16***	0.36***
BBTS_Low Betrayal	0.13**	0.18***	0.15**	0.02	-0.03	0.07	0.24***
CD-RISC-10	0.02	-0.08	-0.20***	0.50***	0.54***	-0.30***	-0.10*

Note. Scores for the questionnaires are the POMP scores of the total raw scores. The CSFI subscores are average scores with a range of 0 to 4. Statistical significance is indicated as: * $p < .05$, ** $p < .01$, *** $p < .001$

B. Additional Statistics: Correlations of CSFI with Life Experience Related Questionnaires

		Time		Thought	Direct	Avoid	Recovered	
		Events	Periods	Tasks	Subst.	Supp.	Reminders	Memories
BBTS	<i>Pearson's r</i>	0.16	0.36	0.11	-0.10	-0.19	0.16	0.36
High Betrayal	<i>p-value</i>	< .001	< .001	0.02	0.03	< .001	< .001	< .001
	<i>Upper 95% CI</i>	0.25	0.44	0.20	-8.59×10^{-3}	-0.10	0.25	0.43
	<i>Lower 95% CI</i>	0.07	0.28	0.02	-0.19	-0.27	0.07	0.27
	<i>Effect size</i>	0.16	0.38	0.11	-0.10	-0.19	0.16	0.37
	<i>SE Effect size</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05
BBTS	<i>Pearson's r</i>	0.13	0.18	0.15	0.02	-0.03	0.07	0.24
Low Betrayal	<i>p-value</i>	5.83×10^{-3}	< .001	1.63×10^{-3}	0.63	0.55	0.13	< .001
	<i>Upper 95% CI</i>	0.22	0.26	0.24	0.11	0.06	0.16	0.33
	<i>Lower 95% CI</i>	0.04	0.09	0.06	-0.07	-0.12	-0.02	0.16
	<i>Effect size</i>	0.13	0.18	0.15	0.02	-0.03	0.07	0.25
	<i>SE Effect size</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CD-RISC-10	<i>Pearson's r</i>	0.02	-0.08	-0.20	0.50	0.54	-0.30	-0.10
	<i>p-value</i>	0.67	0.08	< .001	< .001	< .001	< .001	0.04
	<i>Upper 95% CI</i>	0.11	9.60×10^{-3}	-0.11	0.57	0.60	-0.21	-5.70×10^{-3}
	<i>Lower 95% CI</i>	-0.07	-0.17	-0.29	0.43	0.47	-0.38	-0.19
	<i>Effect size</i>	0.02	-0.08	-0.21	0.55	0.60	-0.31	-0.10
	<i>SE Effect size</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Note. Scores for the questionnaires are the POMP scores of the total raw scores. The CSFI subscores are average scores with a range of 0 to 4.

Lastly, in terms of CSFI's relatedness to survey of autobiographical memory, we hypothesised a mostly divergent observation given the fact that the miniSAM does not explicitly look at forgetting; however, there is obvious relevance of episodic memory that may negatively converge with motivated forgetting. Indeed, results show that episodic AM converges negatively onto subscales reflecting profiles of selective forgetting (Table 39). However, the clear divergence between aspects of AM and thought suppression techniques as well as recovered memories was unexpected. This seems to further bolster the hope that we may gain even more insight into memory if motivated forgetting specifically is studied as

a separate phenomenon and forgetting generally studied in its own right. Focusing solely on remembering can limit our understanding of human memory.

Table 39.*A. Summary: Pearson's Correlations of CSFI with Autobiographical Memory Subscales*

	Events	Time Periods	Tasks	Thought Substitution	Direct Suppression	Avoid Reminders	Recovered Memories
MiniSAM_Episodic	-0.26***	-0.13**	-0.12**	0.04	0.02	-0.05	0.02
MiniSAM_Semantic	-0.13**	6.78×10^{-5}	-0.09*	0.04	0.06	0.02	0.03
MiniSAM_Spatial	0.07	0.04	0.03	0.11*	0.09	0.02	0.10*
MiniSAM_Future	-0.06	0.01	0.08	0.09	0.07	0.01	9.60×10^{-3}
MiniSAM_Total	-0.15**	-0.03	-0.06	0.12**	0.10*	-0.01	0.06

Note. Scores for the questionnaires are the POMP scores of the total raw scores. The CSFI subscores are average scores with a range of 0 to 4. Statistical significance is indicated as: * $p < .05$, ** $p < .01$, *** $p < .001$

B. Additional Statistics: Correlations of CSFI with Autobiographical Memory Subscales

		Events	Time Periods	Tasks	Thought Subst.	Direct Supp.	Avoid Reminders	Recovered Memories
MiniSAM Episodic	<i>Pearson's r</i>	-0.26	-0.13	-0.12	0.04	0.02	-0.05	0.02
	<i>p-value</i>	< .001	4.05×10^{-3}	9.21×10^{-3}	0.38	0.67	0.32	0.65
	<i>Upper 95% CI</i>	-0.17	-0.04	-0.03	0.13	0.11	0.05	0.11
	<i>Lower 95% CI</i>	-0.35	-0.22	-0.21	-0.05	-0.07	-0.14	-0.07
	<i>Effect size</i>	-0.27	-0.14	-0.12	0.04	0.02	-0.05	0.02
	<i>SE Effect size</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05
MiniSAM Semantic	<i>Pearson's r</i>	-0.13	6.78×10^{-5}	-0.09	0.04	0.06	0.02	0.03
	<i>p-value</i>	4.58×10^{-3}	1.00	0.04	0.39	0.21	0.74	0.53
	<i>Upper 95% CI</i>	-0.04	0.09	-2.75×10^{-5}	0.13	0.15	0.11	0.12
	<i>Lower 95% CI</i>	-0.22	-0.09	-0.19	-0.05	-0.03	-0.08	-0.06
	<i>Effect size</i>	-0.13	6.78×10^{-5}	-0.10	0.04	0.06	0.02	0.03
	<i>SE Effect size</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05
MiniSAM Spatial	<i>Pearson's r</i>	0.07	0.04	0.03	0.11	0.09	0.02	0.10
	<i>p-value</i>	0.15	0.39	0.52	0.02	0.05	0.62	0.03
	<i>Upper 95% CI</i>	0.16	0.13	0.12	0.20	0.18	0.12	0.19
	<i>Lower 95% CI</i>	-0.02	-0.05	-0.06	0.02	-1.41×10^{-3}	-0.07	8.88×10^{-3}
	<i>Effect size</i>	0.07	0.04	0.03	0.11	0.09	0.02	0.10
	<i>SE Effect size</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05
MiniSAM Future	<i>Pearson's r</i>	-0.06	0.01	0.08	0.09	0.07	0.01	9.60×10^{-3}
	<i>p-value</i>	0.17	0.83	0.10	0.05	0.17	0.79	0.84
	<i>Upper 95% CI</i>	0.03	0.10	0.17	0.18	0.16	0.10	0.10
	<i>Lower 95% CI</i>	-0.16	-0.08	-0.01	-4.58×10^{-4}	-0.03	-0.08	-0.08
	<i>Effect size</i>	-0.06	0.01	0.08	0.09	0.07	0.01	9.60×10^{-3}
	<i>SE Effect size</i>							

	<i>SE Effect size</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05
MiniSAM	<i>Pearson's r</i>	-0.15	-0.03	-0.06	0.12	0.10	-0.01	0.06
Total	<i>p-value</i>	1.09×10^{-3}	0.58	0.23	8.61×10^{-3}	0.03	0.83	0.19
	<i>Upper 95% CI</i>	-0.06	0.07	0.04	0.21	0.19	0.08	0.15
	<i>Lower 95% CI</i>	-0.24	-0.12	-0.15	0.03	0.01	-0.10	-0.03
	<i>Effect size</i>	-0.15	-0.03	-0.06	0.12	0.11	-0.01	0.06
	<i>SE Effect size</i>	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Note. Scores for the questionnaires are the POMP scores of the total raw scores. The CSFI subscores are average scores with a range of 0 to 4.

In summary, we determined dimensionality of the CSFI through EFA, and then established convergent and divergent validity through comparison of the relatedness of the various in the CSFI to theoretically relevant constructs. Indeed, comparison of measures across methods (e.g., self-report, behavioural observations, brain imaging, etc.) can yield stronger evidence for validity (Revelle & Garner, 2022). Although we did not explicitly undertake a study for the purposes of examining multi-method validity of the CSFI, we still have some preliminary data as a result of having administered the current version of the CSFI to the same participants that we were recruiting for the aINI-T mentioned in the previous chapter. However, given that previous administration of the CSFI used the version prior to the version determined in the current study (i.e., not the version with 32 items under 7 subscales), we will mention just a few notable observations in hopes of inspiring further investigations rather than endeavouring to give robust evidence for our observations.

During the undertaking of the aINI-T study described in the previous chapter, we also administered the CSFI (43 items, as presented in Appendix C) as the last survey to complete during the post-experimental questionnaire portion of the wrap-up Zoom meeting. As a result of the findings described in this chapter, we have since then removed the items from this dataset and transformed the data to the current version of the CSFI with 32 items and 7 factors. However, since this was not the exact form (length, order of items) in which it was administered, results would require further replication. From this sample of 34 participants (2 participants didn't show up to the wrap up session so their data is also missing from the CSFI data) who took part in the training, we see comparable averages of the various subscales (Table 40). However, an important difference can be observed in their differences such that the a-INI-T cohort scored on average lower than the larger CSFI-administered

population in every subscale except for direct suppression in which they reported higher tendency to use direct suppression strategy to control intrusive thoughts. On top of all of the foregoing evidence, this further shows that participants are truly learning a skill during this training, and specifically a targeted training on direct suppression as opposed to any of the other strategies. Having received the training, the participants have integrated this into their ability to do so effectively. Future studies can investigate just how much people's perception of their suppression ability shifts by administering the CSFI both before and after suppression training.

Table 40.

Descriptive Statistics of CSFI Subscales from the aINI-T Cohort (N = 34)

	Mean	Std. Deviation	Variance	Range
1. Events	0.57	0.41	0.16	1.38
2. Time Periods	0.74	0.78	0.60	2.25
3. Tasks	0.68	0.71	0.50	3.00
4. Thought Substitution	1.04	0.58	0.34	2.75
5. Direct Suppression	1.26	0.63	0.39	2.40
6. Avoidance of Reminders	1.14	0.66	0.44	2.60
7. Recovered Memories	0.64	0.82	0.68	2.33

Note. The CSFI subscores are average scores with a range of 0 to 4.

When inspecting the potential association between mental health indices measured at the same time point during which participants completed the CSFI, we see that the results largely resemble the foregoing pattern of associations within the general population, albeit much weaker here (Table 41A). We still see a strong positive correlation between most of the negative mental health indices with forgetting of time periods, forgetting of unpleasant tasks, and avoidance of reminders; indeed, accompanying this is also the negative correlation between the same CSFI subscales and positive mental health indices. And again, there doesn't seem to be a strong association between selective forgetting of negative memories and mental health state, and similarly no effects were found for recovered memories. Indeed, when the combined average of STAI-Trait, PCL-C, and BDI-II measured prior to training is probed for associations with CSFI, we see significant correlations in all subscale measures except for forgetting of events. This suggests that the measure of symptom severity prior to training is higher for those who tend to forget time periods ($r = 0.48$, $p = 3.85 \times 10^{-3}$), forget tasks ($r = 0.45$, $p = 7.97 \times 10^{-3}$), use less thought substitution ($r = -0.54$, $p < 0.001$), use less direct suppression ($r = -0.48$, $p = 4.07 \times 10^{-3}$),

avoid reminders ($r = 0.62, p < 0.001$), and have recovered memories ($r = 0.35, p = 0.05$). In other words, people who have more symptoms are characterised by heightened degrees of forgetting as well as less presence of active recruitment of strategies to control intrusive thoughts. It is important to note that cognitive control abilities also correlate with positive life outcomes (Diamond, 2011; Kryza-Lacombe et al., 2021; Martin & Ochsner, 2016); therefore, there could be mediating factors underlying the facilitatory relationship between employment of suppression and better mental health outcome; however, the precise underlying factors still require further investigation, perhaps through use of the CSFI.

But, the correlation can also go in the reverse direction: people became more vulnerable as a result not recruiting effective coping mechanisms to control thoughts. Notably, this INI-T study shows that even if people didn't recruit suppression previously, they still improved upon learning to do so effectively at the end of the training. So, in a way, the study may act to reverse the vulnerability factor. For the latter explanation, again, the element of empowerment through learning shines through, such that the potential of benefiting from suppression training awaits those who are keen to learn, even if they are from such vulnerable groups. Moreover, effective emotional regulation is reflected in suppression use, such that people who tend to use more thought suppression ($r = 0.57, p = 1.05 \times 10^{-3}$), avoid reminders less ($r = -0.36, p = 0.05$), and not have experienced recovered memories ($r = -0.39, p = 0.03$) also tend to be people who thought suppression training improved their mood during the time of training.

We then inspected the relationship between changes in mental health as a result of training and the CSFI subscales. Not many relationships are significant with a few notable exceptions (Table 41B). Firstly, people who tend to avoid reminders of negative thoughts also had the most improvement in state anxiety ($r = -0.37, p = 0.03$). People who improved more in negative affect also seem to use less thought substitution ($r = 0.36, p = 0.04$). On the other hand, people who improved more in depression tend to use less direct suppression ($r = 0.43, p = 0.01$). This may hint at how different mental health difficulties can shape preference as well as challenges to recruiting different strategies of thought control.

Table 41.*A. Correlations of CSFI from the aINI-T study's cohort (N=34) with Mental Health Indices at Post-Training*

	Events	Time Periods	Tasks	Thought Substitution	Direct Suppression	Avoid Reminders	Recovered Memories
STAI-State	-0.11	0.28	0.14	-0.46**	-0.25	0.27	0.09
PSWQ-PD	-0.04	0.18	0.33	-0.43*	-0.11	0.45**	0.17
PANAS-NA	3.74×10^{-3}	0.28	0.35*	-0.29	-0.17	0.31	0.15
BDI-II	0.26	0.45**	0.40*	-0.44**	-0.23	0.51**	0.33
STAI-Trait	0.10	0.50**	0.38*	-0.44**	-0.39*	0.58***	0.30
PCL-C	0.13	0.43*	0.44**	-0.35*	-0.40*	0.68***	0.42*
PANAS-PA	-0.25	-0.43*	-0.40*	0.55***	0.35*	-0.40*	-0.18
WEMWBS	-0.14	-0.45**	-0.49**	0.48**	0.36*	-0.49**	-0.26

Note. The full names for the mental health related questionnaires are listed in the *Abbreviations* at the beginning of this thesis (page 9). Scores for the questionnaires are the POMP scores of the total raw scores taken after the three days of suppression training on the Attention Training app. The CSFI subscores are average scores with a range of 0 to 4. Statistical significance is indicated as: * $p < .05$, ** $p < .01$, *** $p < .001$.

B. Correlations of CSFI from the aINI-T study's cohort (N=34) with Changes in Mental Health Indices from Training

	Events	Time Periods	Tasks	Thought Substitution	Direct Suppression	Avoid Reminders	Recovered Memories
STAI-State	-0.19	-0.27	-0.28	0.21	-0.06	-0.37*	-0.23
PSWQ-PD	0.10	-0.08	-0.02	0.14	0.28	-0.02	0.08
PANAS-NA	-0.03	-0.09	0.01	0.36*	0.19	-0.19	-0.01
BDI-II	0.16	0.08	-1.27×10^{-3}	0.05	0.43*	-0.16	-8.49×10^{-3}
STAI-Trait	-0.09	-0.04	-0.08	0.31	0.02	0.15	-0.04
PCL-C	0.19	-0.07	-0.07	0.33	0.24	-3.75×10^{-3}	0.12*
PANAS-PA	-0.02	-0.17	-0.19	-0.06	-0.03	0.06	-0.21
WEMWBS	-0.02	-0.15	-0.25	-0.06	-0.04	-0.02	-0.23

Note. The full names for the mental health related questionnaires are listed in the *Abbreviations* at the beginning of this thesis (page 9). Scores for the questionnaires are the difference in POMP scores of the total raw scores taken as between post- and pre-training (post-pre) on the Attention Training app. The CSFI subscores are average scores with a range of 0 to 4. Statistical significance is indicated as: * $p < .05$, ** $p < .01$, *** $p < .001$.

Milking the Data for CSFI

Other than the aINI-T study's data, we also had some data from the vINI-T study but the data are of an older version of the CSFI which used Likert scale instead of the Expanded format. We still wanted to harness whatever we could and found that the items for the two strategy uses of direct suppression and thought suppression survived the many editions of the CSFI and were largely the same as the items in the current subscales. Therefore, we probed a little into the correlational relationship of DS and TS with a few of the auxiliary scales we included in the original study but did not use later for

the main analyses presented in Chapter 3. For instance, we found that both DS and TS are positively correlated with cognitive flexibility (DS & CFI-Alternatives: 0.32*, CFI-Control: 0.65***; TS with CFI-Alternatives: 0.37*, CFI-Control: 0.46**) and a sense of having meaning in one's life (DS & MIL-Presence: 0.58**; TS & MIL-Presence: 0.52***) which are both wholesome tendencies to possess, pointing to the adaptive nature of both of these strategies. Importantly, preliminary analysis seems to point to DS as showing a distinct pattern to TS, namely being more pertinent to the concepts of anxiety and control. This is gleaned from 3 correlational observations that is uniquely attributed to DS and not present in TS: 1) negative correlation with Intolerance of Uncertainty Scale's Inhibitory Anxiety subscale ($r = -0.65^{***}$), 2) negative correlation with Health Anxiety Inventory's Negative Consequences subscale ($r = -0.41^*$), and 3) differentially correlation with the Negative Urgency subscale ($r = -0.53^{***}$) and the Sensation Seeking subscale ($r = 0.42^{**}$) of the UPPS-P impulsive behaviour scale.

Regarding the first observation, IUS is the tendency for someone to consider the possibility of a negative event as unacceptable which is highly implicated for anxiety-related pathology. The Inhibitory Anxiety subscale of the IUS, as opposed to the Prospective Anxiety subscale is more relevant to suppression because people with adaptive suppression ability should have low inhibitory anxiety as they would then be able to stop worries from disrupting everyday functioning. Importantly, our results show that this is significant only for DS because those items involve an intentional stopping of the intrusive thought whereas TS is weaker in impact even though it may be relatively easier and more intuitive. Furthermore, the IUS was administered to the participants in the vINI-T study during the post-experimental questionnaire phase on the last day; therefore, they may well be responding to this after having acquired the skill of DS and benefited from it which would further lend support to why DS is centrally involved.

The second observation of HAI is important to consider because the Negative Consequences subscale conveys a sense of defeat (e.g., *unable to enjoy life*) and destructive outlook if something upsetting were to happen in the form of a "serious illness". If a person can suppress upsetting thoughts effectively, this worry would not be as destructive, if existent at all. And the results seem to support this, such that high DS suppressors are less likely to have high anxiety about health. The third observation of

thought control being relevant to impulsive behaviour is not surprising; however, it is surprising that DS differentially mapped onto Negative Urgency and Sensation Seeking while TS did not associate with UPPS-P at all. In the case of Negative Urgency, good suppressors will be able to cope in a healthier way when upset rather than resonating with statements such as “*when I am upset, I often act without thinking*”. Similarly, while Sensation Seeking can also lead one into a slippery slope of alcohol and drug use for escape, it also can have a positive adaptive component of being open to new experiences which would make someone who has a good sense of self-control resonate with a statement such as “*I quite enjoy taking risks*”. In this way, good suppressors would not be avoidant on new experiences, an adaptive feature of suppression that seems to be reflected in the data.

Finally, the subscale of recovered memories was also briefly investigated from the vINI-T cohort data as the subscale carried over all of the 3 items in the new editions of the CSFI, making it potentially relevant for our discussion. Interestingly, it revealed a positive association with metacognitive questionnaire’s “lack of cognitive confidence” subscale ($r = 0.43^{**}$). This is actually a great point of reflection as it overturns any concerns relating to the recovered memory subscale as superficial due to the great controversy related to recovered memories we are all too familiar with. Here, it shows that the scale is not superficial as those who have recovered memories but still consider their memories as untrustworthy for whatever reason are those who hypothetically didn’t fully embrace their recovered memories and thus would be in the midst of their healing journey. This would then reflect in maladaptive tendencies being associated with prevalence of recovered memories such as people with recovered memories being more prone to inhibitory anxiety (IUS-Inhibition: $r = 0.34^*$), low cognitive flexibility (CFI-control: $r = -0.39^*$), or lack of the presence of meaning in their lives (MIL-Presence: $r = -0.38^*$). Indeed, more future research is needed to investigate the nuances of each of the subscales, in their contribution to the intriguing and to-be-investigated phenomenon of “superforgetters”: people who have superior ability to selectively forget emotionally distressing memories.

Future Directions

In the discussions above, we mentioned a couple of avenues for future explorations and applications of CSFI. Here, we hope to highlight how CSFI may prove useful to unblock a few of the avenues of research which seemed to have been previously blocked previously due to lack of a tool to answer some of these questions appropriately. For instance, just as the profound impact valence can have on retrieving autobiographical memories, there is obviously an emotional (valence and arousal) factor involved in one's selective retrieval and suppression of negative memories. Studies showcasing divergence of RIF effects in positive and negative memories (Stone, Luminet, et al., 2013) seem to point to the role of metamemory in individual differences in valence-related forgetting. Thus, a future area of research could be how metamemory interacts with selective forgetting, which may have implications for suppression ability and tendency, avoidance behaviour, as well as experiences of recovered memories, all of which are subscales in the CSFI. On the other hand, less negative affect during retrieval seems to be linked to higher purpose in life (Sutin et al., 2021). This points to emotional regulation as potentially an underlying factor which can be accessed and modulated through suppression strategies, a subscale that can be used as an avenue for future investigations. Similarly, there could be implications of retrieving much fewer negative events when one has higher purposes in life which would warrant future investigations as it could feature in selective forgetting tendencies in the general population.

Furthermore, a relationship between selective forgetting and autobiographical prospection can be gleaned from research showcasing how imagining events in the future (i.e., episodic future thinking) can cause related AMs to become less memorable and even forgotten (Ditta & Storm, 2016), as well as preceding chapters showcasing evidence for how suppression of future events can have protective mental health benefits. A tool to allow a formal inquiry in this topic shall pave the way for a fuller understanding of the development of memory. Moreover, just as how suppressing past upsetting events may lead to forgetting, the relevance of this ability and its subsequent forgetting effects to episodic future thinking has yet to be explored. In other words, these lend further support for the far-reaching potential of the usability of the CSFI in research beyond an investigation of the past, but also extend to the present and the future.

We can also see numerous opportunities to apply the CSFI at a subscale level. For instance, in relevance to the subscale of forgetting unpleasant tasks, a recent model of procrastination has proposed procrastination as an easy to access method to avoid aversive and difficult task-related emotions (Sirois, 2023). From this, one can see the dots connecting amongst one's ability and tendency to selectively forget unpleasant tasks (measured in the tasks subscale of CSFI), avoid unpleasant memories (avoidance subscale), and procrastinate. All of which point to the potential applying the CSFI in future investigations of procrastination. Notably, CSFI's subscale of forgetting tasks can also be applied in the emerging investigations into the opposite phenomenon of procrastination: precrastination - people's tendency to complete tasks quickly just to get them done sooner (Wasserman, 2019). This is especially of interest given the potential relevance of inhibitory control in precrastination contributing to adaptive and maladaptive behaviour.

In terms of the subscales on the various strategies of attempting to forget negative information, in the case of avoidance, given that avoidance behaviour is shown to be maladaptive in extinction studies by not allowing new safety information to come through (Nitta et al., 2020), the CSFI can help inform research into the relationship of avoidance tendency and self-initiated use of suppression strategies. Moreover, if experiential avoidance is maladaptive in potentially promoting psychopathology (Scherf et al., 2019), then its presentation in people alongside other proven adaptive strategies (e.g., direct suppression) can be investigated using the CSFI. In addition, given evidence of greater avoidance behaviour as a predictor of increasing likelihood in OCD patients not responding to CBT treatment (Selles et al., 2020), the CSFI can give insight into further investigations of how manifestations of thought control ability and tendency may be specifically relevant to avoidance behaviour in shaping OCD symptomatology. Thus, the subscales of strategies can also be especially useful in application of research in clinical populations. Not only is there already the obvious connection of recovered memories and forgetting of time periods as relevant topics in trauma research, there is also robust literature showing the relevance of motivated forgetting in clinical populations, and these intersecting areas can now all be studied in an integrated manner through the use of the CSFI.

This thesis is just the first step for CSFI, it needs further development and validation which requires time, just as how the TCAQ is still being validated 14 years after its inception (Feliu-Soler et al., 2019; Luciano et al., 2005). Specifically, in order to robustly support both worlds of academic research and clinical practice, we welcome investigators to explore the CSFI with all of its subscales in further investigations of internal consistency, stability, convergent validity, structural validity, known-groups validity, measurement error, responsiveness, and so on.

5.3. *Materials & Methods*

Participants

Four hundred and fifty nine anonymous people were recruited through the online survey platform, Prolific (<https://www.prolific.co>, 2014). Of these, we excluded 6 participants due to incomplete data and failed attention checks. The final sample included the 453 participants (see Table 25 for further demographic characteristics and exclusion criteria). As part of one of the introductory questions on the survey, we asked participants who wish to take part in Part 2 of this study to respond to that question. This allowed us to collect their anonymous ID and feed that to the selection feature of Prolific's survey setup to be able to invite the same participants back after 2 weeks. To account for the possibility of large losses due to the gap in experiments, we set the cap to 200 participants. Out of the 200 people who signed up for Part 2, 182 of them returned and completed the second part of the study.

We determined the sample size according to the standards in the field which led us to decide on 300 participants as a good base number (L. A. Clark & Watson, 1995). Anticipating approximately 15% of unusable data which was the case for a previous pilot, and accounting for about a third of people dropping out, we sought to recruit 450 participants. The MRC CBU web committee as well as the Cambridge Psychology Research Ethics Committee both approved the study, with all participants providing informed consent digitally. Participants were compensated with the standard MRC CBU rate via Prolific's platform upon completion of the survey, as long as they didn't fail attention checks and did not have extremely unusual completion times.

Procedure

This is a two-part online study, with the second part including only a portion of the opted-in participants for the purposes of measuring test-retest reliability. Part 1 consisted of the CSFI, as well as additional questionnaires with relevant convergent and divergent characteristics as our construct (detailed below). Part 2 included the CSFI and the TCAQ, and took place automatically via an

invitation that got activated 2 weeks after the participant's completion of Part 1. For both Part 1 and Part 2, the window for completion was open for about 2 days. The median time of completion was 31 minutes for Part 1 and 10 minutes for Part 2.

Materials

The questionnaires included are the following: TCAQ (25 items) (Luciano et al., 2005), TSI-R (21 items) (van Schie et al., 2016), WEMWBS (14 items) (Tennant et al., 2007), STAI - State & Trait (40 items) (Spielberger et al., 1983), BDI-II (20 items – excluding suicide ideation) (Beck et al., 1996), DASS (21 items) (Lovibond & Lovibond, 1995), BBTS (12 items) (L. R. Goldberg & Freyd, 2006), CD-RISC-10 (10 items) (Campbell-Sills & Stein, 2007; Connor & Davidson, 2003), and Mini-SAM - (10 items) (Palombo et al., 2013).

These questionnaires were ordered with CSFI always appearing first. The CSFI was randomised such that it will contain blocks of an equally distributed number of items from each subscale. After its pseudo-randomization to ensure all items have equal placement, the items within the CSFI were not randomised for each participant after that. The rest of the questionnaires were in the following order: mental health questionnaires, trauma, resilience, and memory surveys. The mental health surveys were randomised within that category. However, the items in all the questionnaires were not randomised and kept in their original published form.

Quality of the collected data was checked in 3 stages:

1. Before data collection begins (e.g. requiring testing is done on a laptop and not a mobile device).
2. During the study session (e.g. initial eligibility/device screening, requiring a minimum level of task performance to continue)
 - a. There were 3 attention check questions with explicit instruction to select a particular response in order to verify that participants are actually paying attention. Anyone who fails this would automatically be excluded and not be paid via Prolific.

-
3. After participants complete the study (e.g. checking data for markers of inattention/low effort, outliers)
 - a. There were 2 covert infrequency items or attention checks that were not used to exclude participants at the outset (because Prolific does not allow covert attention checks). No participant was excluded based on this alone.

Statistical Analyses

To put questionnaires on a uniform scale, most of the scores included in the Tables for this chapter were converted (unless otherwise stated as raw data) to percentage of maximum point (POMP) scores which is calculated as: $POMP = 100 * (raw - min) / (max - min)$. Analyses of the correlations shown in Tables were performed using JASP (JASP Team, 2021). Statistical analyses of polychoric correlation were carried out in R (Revelle & Garner, 2022).

Closing Remarks

It is my earnest hope that the works described in these pages are of benefit to the fields of psychology and neuroscience, and more broadly to humanity through its applications in mental health, which ultimately is the healing of hearts. Whether it is to train people to more successfully control their intrusive thoughts, or to make such a training more accessible and easier to implement via an app, or to develop a measurement instrument to better capture people's cognitive profile of forgetting tendencies, all of these efforts are directed towards applying what I have learned about thought suppression, forgetting, and mental health to help people's journey through the trials and toils of life. The past couple of years of running these studies have truly been a gift of learning and growth. Every difficulty seemed worthwhile as I saw people with whom I probably would have never crossed paths with benefit from such a small endeavour. Witnessing their joy and gratitude was heartwarming to say the least. Indeed, everything has its time and place. Motivated forgetting as an intervention for healing may be beneficial in some contexts for some people, and another tool may be more effective for others. The intention behind the writings in this thesis has not been one to unilaterally endorse motivated forgetting, but to simply signpost to its existence and attempt to remove some obstacles that may have been occluding the path to investigate it further. I sincerely hope that whoever reads these will take what is beneficial, challenge what seems amiss, and move the field forward as we ceaselessly uncover and receive the knowledge of the beautiful intricacies of perhaps one of the most essential qualities of our worldly existence - forgetting.

“Words of wisdom are the lost property of the believer.

So, wherever they find it, they are most deserving of it.”

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