Sleep On It:

Exploring the Role of Sleep in Imagery Rescripting Interventions Amongst Socially Anxious Young Adults

by

Jennifer Fudge

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Background. Previous research provides strong support for the efficacy of imagery rescripting (IR) interventions in treating social anxiety disorder (SAD). During IR interventions, individuals recall socially aversive memories and reimagine more adaptive outcomes to the event. IR has been proposed to violate maladaptive schemas encapsulated within the negative memory, thereby leading to positive outcomes. Drawing upon the sleep and memory literature, which suggests that sleep quality enhances the consolidation of new learning, we explored whether sleep quality enhanced the effects of an IR intervention amongst socially anxious individuals.

Methods. In this preregistered study, undergraduate students completed a three-part study. On day one, participants completed an IR intervention or perceptual control task, before being randomly assigned to a sleep enhancement or sleep-as-usual condition (T1). The following day, participants completed a sleep diary (T2) and answered questions about the memories, mental images and task details they focused on the previous day (T3). Data collection for this project is ongoing, with data analyses for the present thesis based on 31 study completers.

Results. Multilevel models revealed that IR enhanced the positivity of participants' mental images, and offered protective effects for positive affect and positive self-schemas. Moderation analyses suggested that better sleep moderates the effectiveness of IR across mental image appraisal accuracy ratings, negative self-schemas, and mental image valence.

Discussion. These findings further support our understanding of the benefits of IR interventions, and offer insight into the potential role for sleep to modify these effects. Future work could expand upon these findings by implementing longitudinal designs and employing both subjective and objective measures of sleep measurement.

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Introduction

The Nature and Prevalence of Social Anxiety

Nearly everyone worries about making the wrong impression or embarrassing themselves from one time to another. In fact, many commonplace situations elicit these concerns, such as when giving a presentation, attending a job interview, or going on a first date. While these experiences are undoubtedly uncomfortable, for most people, the anxiety is short-lived and the range of situations which induce these fears are few and far between. In essence, these types of occasional incidents represent the normative experience along a spectrum of social anxiety, which is normally distributed in the population (Ruscio, 2010). For individuals at the extreme high end of the spectrum, however, such as those with social anxiety disorder (SAD), fears of negative evaluation, humiliation, and rejection are pervasive and intense, leading to significant disruptions in day-to-day life (APA, 2013). The impact of SAD can be detrimental and widespread, often impacting individuals' sense of social connectedness (Aderka et al., 2012; Schneier et al., 1994; Wittchen et al., 2000), interpersonal functioning (Dabas et al., 2022; Heery & Kring, 2007), romantic relationships (Schneier et al., 1994; Wittchen et al., 2000), and education or work opportunities (Schneier et al., 1994; Stein & Kean, 2000; Stein et al., 2000). Indeed, the lifetime prevalence of social anxiety is estimated to be between 6.8% - 12.1% (Kessler et al., 2005; Stein & Kean, 2000; Stein et al., 2017), although significantly higher estimates have also been reported (Jeffries & Ungar, 2020), especially among youth (Salari et al., 2024).

In their classic cognitive model of SAD, Clark and Wells (1995) highlighted the importance of negative beliefs and negative mental imagery in maintaining the symptoms of social anxiety. According to Clark and Wells (1995), individuals with SAD hold negative beliefs

about the self (e.g., “I am worthless”) and others (e.g., “Most people are very critical”). When activated, the content of these beliefs increases the accessibility of autobiographical memories of adverse social events in which these beliefs were reinforced, directing attentional resources inwards toward the self and prompting hypervigilance of somatic symptoms of anxiety. Together, these cognitive processes give rise to a negatively biased mental image of how the individual appears to others in the social situation. This mental image typically depicts the individual in an unflattering light, in a manner that reaffirms their feared outcomes. For instance, an individual who fears being judged for showing signs of anxiety, such as blushing, may have an image of themselves in which they appear beet red. The negative mental image prompts the individual to further monitor their behaviour and direct attentional resources towards the self, thereby increasing self-focused attention and reducing the likelihood that the individual meaningfully engages with the social situation, thus preventing the encoding of potentially disconfirming social evidence and instead reinforcing their beliefs of social ineptitude.

Perpetuating this cycle of anxiety are safety behaviours: actions which facilitate social avoidance (e.g., not making eye contact), or are intended to mask the individual’s perceived undesirable traits (e.g., drinking alcohol to seem less shy). While providing temporary relief, safety behaviours ultimately maintain the negative beliefs underlying social anxiety by reinforcing the idea that social interactions are only bearable or successful when the individual is successfully able to hide their personal deficits. Furthermore, once a social situation has concluded, individuals with social anxiety often engage in rumination about the interaction, a process referred to as post-event processing. During post-event processing, the person fixates on details that confirm their negative self-perceptions, ultimately strengthening maladaptive schemas, and encoding negative interpretations of the event into memory. Altogether, the

distress brought about by these mechanisms of social anxiety can lead an individual to avoid and/or escape social situations entirely, which further prevents them from engaging in learning opportunities that might disconfirm the very negative beliefs fuelling their anxiety.

Similar processes were highlighted in Rapee and Heimberg's (1997) cognitive model of SAD, in which social anxiety is conceptualized as an interaction between negative beliefs, an internal locus of focus, and biased mental imagery, which trigger subsequent safety behaviours and avoidance. Akin to Clark and Wells (1995), this model suggests that socially anxious individuals inflate the presence of social threat and the likelihood of severe negative social consequences. Part of this overestimation of threat is due to the individual's belief that others expect a specific display of social behaviour (e.g., showing no physical signs of anxiety, having no pauses in conversation), which they are required to enact. Thus, the role of the mental image of self as seen by others is emphasized as a means of self-monitoring one's social performance, enabling one to compare the mental image of one's social performance to the perceived social criteria being used to judge them. Similarly, negative beliefs, interoceptive symptoms of anxiety, and ambiguous social cues (e.g., yawning) bias the image, yielding larger discrepancies between the individual's perceived social performance and construal of others' behavioural expectations, thereby inducing anxiety.

Building upon these classic models, Hofmann (2007) suggested that social anxiety is driven in part by errant beliefs that others have exceptionally high expectations for social behaviour. This assumption, paired with significant self-doubt regarding one's social skills and emotion regulation capabilities, and heightened estimates of the likelihood and severity of social consequences, leave the individual incapable of setting attainable social goals, which perpetuates their perceptions of social incompetence. Moscovitch (2009) further emphasized the role of

negative beliefs by reframing the core fear in SAD to be a fear of exposing perceived self-flaws to others. In contrast to earlier models which identified the core fear in SAD to be the experience of rejection or the social situation generally, Moscovitch (2009) proposed that individuals with SAD believe their true self to be inherently flawed, typically in the domains of undesirable social skills and behaviour, an inability to successfully hide anxiety symptoms, inadequate physical appearance, and/or personality faults. Later work by Moscovitch and colleagues, further clarified the underlying factor structure of these domains, which revealed three factors corresponding with feared flaws of the self: (a) inability to hide anxiety symptoms; (b) undesirable physical appearance; and (c) concerns about social competence, with items related to both personality faults and undesirable social skills/behaviour loading onto this third factor (Moscovitch & Huyder, 2011; Moscovitch et al., 2015). According to Moscovitch (2009), these perceived deficits in social self-portrayal drive the individual to engage in self-concealment, leading to fear of discovery and sensitivity to potential signs of scrutiny, which they believe would result in negative social consequences such as: negative evaluation, rejection, ostracism, and ultimate catastrophic consequences (e.g., being alone; Zlotnick & Huppert, 2025).

To this end, Moscovitch (2009) emphasized the importance of understanding not only the situational trigger for individuals with SAD, but also the nature of the self-attributes they attempt to hide for fear that exposing them to others would lead to negative self-portrayal and the resulting catastrophic consequences. Thus, according to Moscovitch (2009), while the same situation (e.g., going to a party) may elicit anxiety for multiple socially anxious people, the underlying reason may significantly differ, depending on which perceived flaws of the self the individual is attempting to conceal (e.g., fear of being socially unskilled and committing a social blunder versus fear of showing signs of anxiety and appearing trembly and red). Similarly,

commonly used safety behaviours may fulfil diverse purposes based on what they are being used to conceal. For instance, drinking alcohol can be used as a means to increase talkativeness and avoid the feared outcome of appearing boring. Alternatively, an individual who is concerned about having noticeably flushed cheeks (e.g., because of the belief that others will judge them as anxious and therefore socially inept), may drink alcohol in order to have an alternative explanation for their flushed appearance. As such, both feared situations and safety behaviours should be contextualized within the socially anxious individual's negative self-perceptions in order to plan behavioural experiments that best target the underlying fears maintaining the social anxiety.

In summary, while there is no singular conceptualization of SAD, existing models tend to agree on several key features, such as a heightened sensitivity to social threat, significant attention directed toward the self rather than the social environment, and engagement in behaviours which attempt to mitigate or forgo the anxiety. Notably, all models discussed here place a significant emphasis on negative beliefs about the self in social contexts, which fuel and maintain the cognitive, physical and behavioural mechanisms of SAD. This emphasis suggests the potential for such beliefs to be a key target in SAD treatment. However, first it is essential to explore the nature of such beliefs and why they exert such a powerful role in social anxiety.

The Role of Schemas and Autobiographical Memory

Negative beliefs (schemas) have long been implicated as a contributor to psychopathology (Beck, 1967; 1976). Schemas are mental representations of self, others and the world which are constructed over time and allow us to make sense of novel information and experiences (Markus, 1977; Ghosh & Gilboa, 2014). While maladaptive schemas (e.g., "I am unlovable") fuel emotional distress and increase the risk of developing psychopathology (Tariq

et al., 2021; Thimm & Chang, 2022; Welburn et al., 2002; Young, 1990), adaptive schemas (e.g., "I am worthy of love") boost self-esteem and improve mental well-being (Chi et al., 2022; Louis et al., 2018; O'Byrne et al., 2020). One fundamental feature of schemas is their strong link to the autobiographical memory system (Bartlett, 1932), which enables schemas to form and evolve around our experiences. In turn, this intricate enmeshment of schemas and memories allow us to hold a consistent and coherent sense of self (Conway & Pleydell-Pearce, 2000; Conway, 2005).

The relationship between self-schemas and autobiographical memory is bi-directional, such that autobiographical memories contribute to the formation and strengthening of existing schemas, while simultaneously, schemas influence what we remember (Moscovitch et al., 2023). Importantly, autobiographical memory is not an objective record of the past, but rather a reconstructive process which uses factual autobiographical details and schematic knowledge to recreate the previous events in our life (Barclay & Wellman, 1986). Despite individuals expressing a high degree of confidence in the recollection of their autobiographical memories, typically only the gist of an event is captured, leaving schemas to 'fill in the gaps', which can lead to false details intruding into the encoded memory (Barclay & Wellman, 1986; Fenerci et al., 2024; Hertel et al., 2008; Schacter 2012a; Wardell & Palombo, 2024). This can also occur when individuals recall events that were previously imagined rather than actually experienced (Fenerci et al., 2024). One explanation for this phenomenon could be that intentional recollection simultaneously activates associated knowledge and schemas, which may then inadvertently become substituted into the memory (Wardell & Palombo, 2024).

Similarly, schemas impact what we orient our attention towards and how we interpret experiences in the present, which in turn influences what we will remember about these events (Barclay & Subramanium, 1987; Wardell & Palombo, 2024). Schemas exist to help us encode

new information quickly (Ghosh & Gilboa, 2014; Tse et al., 2007). In the absence of schemas, we could not rely on our existing knowledge to contextualize incoming information, which would make novel situations far more cognitively taxing, considering we would need to 'understand from scratch' every time. Fortunately, schemas encapsulate the accumulated knowledge from a multitude of past experiences, allowing us to use pre-assembled sets of expectations and interpretations to incorporate new information rapidly (Ghosh & Gilboa, 2014; Gilboa & Marlatte, 2017; Tse et al., 2007).

Thus, on one hand, schemas streamline the manner in which new information can be consolidated into the memory system. However, on the other, this process can be deleterious when new information is stripped of necessary detail. When this occurs, the gist of the experience is extracted and schema-congruent details can be unintentionally imputed, such that the encoded memory falls in line with existing beliefs (Hertel et al., 2008; Schacter 2012a; van Kesteren & Metter, 2020). While this may be beneficial for understanding low-stakes situations which don't require details for adequate interpretation (e.g., the process of walking to the mailbox to grab the mail) this can be quite detrimental to the accurate encoding of other events. For example, with respect to social anxiety, if an individual has experienced previous instances of social exclusion and believes that they are unlikeable, they may preferentially notice and encode details which support this existing view (e.g., everyone else laughing at a joke they don't understand, being interrupted, having little to contribute for long stretches of the conversation) when approaching novel social situations. Moreover, they may simultaneously ignore information that is contradictory to their belief (e.g., someone explaining the joke afterwards to include them, receiving an apology for the interruption, being asked questions to help them engage in the conversation). They may also unintentionally encode details from previous

experiences (e.g., people glaring at them, others using a sarcastic tone of voice when speaking to them; Hertel et al., 2008; van Kesteren & Metter, 2020; Wardell & Palombo, 2024) because they expect them to happen again, even if they do not actually occur.

Beyond conceptualizing the past and the present, schemas also help us predict the future. Neuroscience research suggests that the same brain regions involved during memory recollection are activated when envisioning future events, implying the vital role of the past in future forecasting (Schacter et al., 2007; Rubin, 2014). Indeed, schemas may help us think about the future by drawing upon our prior experiences (Schacter, 2012a), which can lead to unintended negative consequences for vulnerable individuals, such as those with SAD, who are prone to negative memory biases. Indeed, predictions about the future tend to be overgeneralized and biased (Schacter, 2012b). The uncertain nature of future events means there is inherently less known information (relative to a situation that is unfolding in the present) about the event to draw upon, leading to less specific predictions and a heavier reliance on previous experience. As such, when trying to anticipate an imagined future, an individual with negative schemas is likely to draw upon negative past experiences and, because the event they are predicting has not yet occurred, will not have any additional contextual cues from the situation which might allow for the development of more adaptive expectations (Schacter, 2012b). In turn, this maladaptive prediction primes the individual when entering the social situation to be especially sensitive to details that are consistent with their negative expectations (Hertel et al., 2008; Schacter 2012a; van Kesteren & Metter, 2020).

In brief, schemas significantly impact attention, perception and memory systems, exerting powerful effects on the way we remember, understand and predict the events in our lives. As discussed previously, conceptual models of SAD collectively emphasize the role of

negative beliefs and negative imagery in perpetuating social anxiety symptoms. Although negative mental imagery has traditionally received somewhat less attention than verbally-based beliefs in the literature, it is considered a central cognitive mechanism in SAD that contributes to the maintenance of social anxiety symptoms (Clark & Wells, 1995; Moscovitch, 2009; Rapee & Heimberg, 1997), and one which often serves a powerful and emotionally evocative role (Holmes et al., 2008), thus making it an equally important consideration in the study and treatment of social anxiety.

Negative Mental Imagery in SAD

Previous work has shown that individuals with SAD experience frequent, intrusive negative mental imagery related to the self, particularly when engaged in, recalling, or anticipating feared social situations (Hackmann et al., 1998; Chiupka et al., 2012). These mental images tend to be visually vivid, distressing and experienced from an observer's perspective (Coles et al., 2001; Coles et al., 2002; Hackmann et al., 1998; Hackmann et al., 2000; Wells et el., 1998). Studies have shown that intrusive mental imagery is often derived from self-defining, painful social experiences from the person's past (Chiupka et al., 2012; Hackmann et al., 2000; Hirsch et al., 2004; Moscovitch et al., 2011; Moscovitch et al., 2018), and tends to depict the individual in a manner that exposes the very aspects of the self they are motivated to hide, amplifying their distress with elevated negative emotions including anxiety, embarrassment, and shame. (Chiupka et al., 2012; Hackmann et al., 1998; Moscovitch et al., 2011; Stopa, 2009; Swee et al., 2021).

It has been proposed that negative mental imagery interacts with the other cognitive mechanisms that maintain SAD (Hirsch et al., 2006a; Wild, 2011). For example, self-focused attention prevents the individual from noticing corrective information that could challenge the

image and encapsulated schema (Wild, 2011). Additional evidence suggests that the presence of negative mental imagery can negatively bias individuals' interpretation of their social performance (Hirsch et al., 2006a; 2006b; Stopa & Jenkins, 2007; Vassilopoulos, 2005) and sensitize them to evaluate ambiguous stimuli as threatening (Hirsch et al., 2003b). Research has shown that when negative mental images are held in mind during conversations or when making a speech, individuals with SAD and high social anxiety tend to perform worse, exhibit more physiological signs of anxiety, self-report increased anxiety symptoms, and use more safety behaviours (Hirsch et al., 2003a; 2004). Importantly, although such behavioural changes are apparent to objective observers, the degree to which participants estimate the noticeability of their anxiety and the level of impairment in their social performance is exaggerated (Hirsch et al., 2003a; 2004). Interestingly, evidence also suggests that the induction of negative inferential biases can lead to more subsequent negative mental imagery (Murphy et al., 2007), highlighting the interaction between these two processes.

Beyond the presence of negative mental imagery, the interpretation of the mental image may be especially important (Hirsch et al., 2006b; Moscovitch et al., 2013; Stopa, 2009). As discussed earlier, negative schemas likely facilitate biased interpretations of social situations by focusing on details which align with the maladaptive schema content (Clark & Wells, 1995; Rapee & Heimberg, 1997). Indeed, negative interpretation biases have been observed in SAD (Stopa & Clark, 2000) and could explain why negative mental imagery has been shown to elicit significantly higher affective and cognitive distress for highly socially anxious individuals compared to individuals with low social anxiety (Moscovitch et al., 2011). As noted by Moscovitch et al. (2011) it is not the presence of mental imagery or upsetting social memories that differentiates between low versus high social anxious individuals, but rather the way they

are appraised, which determines the differential impact of these events and images on these two groups. Akin to this line of thinking, when individuals with low social anxiety were primed to think of negative mental imagery, they reported decreases in subjective ratings of their performance and increased anxiety (Hirsch et al., 2003b; Hirsch et al., 2006b). Thus, negative mental imagery is unlikely to be exclusively experienced by those with higher social anxiety, and can have similar effects when experimentally induced in those with low social anxiety. Rather, in individuals with SAD and heightened social anxiety, it may be the combination of more prominent and accessible negative mental imagery, a negative interpretation of what these images mean about the self, and an overreliance on the imagery as accurate evidence about how the self appears to others (Hirsch et al., 2006b; Moscovitch et al., 2013; Wild, 2011) that differentiates those with problematic social anxiety from those without such symptoms.

CBT as a Treatment for SAD

Considering the prevalence and significant impact of social anxiety, a large body of research and clinical work has focused on the development of effective treatment for SAD. Currently, first-line treatment is cognitive behavioural therapy (CBT), which focuses on teaching clients the skills to challenge the maladaptive cognitive processes and modify the dysfunctional behaviours maintaining SAD (Mayo-Wilson et al., 2014). While various treatment packages exist and the exact composition of the intervention may vary by practitioner and setting, research has shown that CBT-based interventions for SAD tend to include the following basic components: psychoeducation, behavioural experiments, cognitive restructuring, social skills training, exposure, and relapse prevention (Gilboa-Schechtman & Azoulay, 2022; Morina et al., 2023).

Studies examining the efficacy of CBT for SAD have demonstrated some promising results. Indeed, multiple meta-analyses have shown that CBT leads to significant improvement in SAD symptoms (Hall et al., 2025; Kindred et al., 2022; Mayo-Wilson et al., 2014; Morina et al., 2023). In fact, it has been reported that up to 71% of individuals demonstrate reliable positive changes in SAD symptoms (Morina et al., 2023), with some analyses showing the added benefit of improved comorbid depression and generalized anxiety, and better overall psychological functioning (Kindred et al., 2022, Morina et al., 2023). Importantly, many of the benefits of CBT have been maintained at least up to 12 months after treatment concludes (Kindred et al., 2022; Mayo-Wilson et al., 2014), suggesting more sustainable effects of CBT than psychopharmacological interventions, which have a high rate of relapse following discontinuation (Mayo-Wilson et al., 2014).

Unfortunately, the picture of CBT treatment for SAD is more complicated than the aforementioned results make it seem. Other meta-analyses suggest that as many as 50% of individuals with SAD do not experience significant symptom improvement in response to CBT (Loerinc, 2015; Springer et al., 2018). Even more concerning, in one study on adolescents with SAD, only about 35% showed significant improvement following a general course of CBT (Evans et al., 2021). Thus, despite being the gold standard of SAD treatment, CBT has room for significant improvement. This raises the question of how CBT can be modified to be more effective for individuals with social anxiety.

Gilboa-Schechtman and Azoulay (2022) cited the shortcomings of CBT protocols for SAD that tend to focus on symptom reduction rather than positivity enhancement, as well as problems inherent in the application of one-size-fits-all treatments, rather than tailoring interventions to specific clients. A study by Rapee et al. (2009) showed that enhancing CBT for

SAD with treatment components that targeted an array of cognitive mechanisms in SAD (e.g., incorporating attention retraining to address attentional biases) led to significant reductions in clinical severity, anticipated costs of negative evaluation, negative views of one's social skills and physical appearance, and decreased anxiety whilst performing a speech task, compared to traditional CBT techniques. More recently, Leigh and Clark (2023) implemented an internet-delivered, SAD-specific CBT protocol that was based on the Clark and Wells (1995) model in adolescents with SAD. The authors found that compared to waitlist controls, adolescents who took part in the modified CBT intervention saw major treatment gains, with 77% of their sample no longer meeting diagnostic criteria for SAD at post-treatment, which increased to 91% at 6-month follow up. This work also represents a significant advancement to the field, as the development of effective evidence-based internet-delivered treatment significantly enhances the accessibility of treatment for individuals with SAD, who may otherwise find attending in-person sessions a barrier to psychological support. Furthermore, internet-based treatment may aid adolescent clients in overcoming additional challenges, such as scheduling conflicts due to school or extracurricular activities or a lack of reliable transportation.

Another disadvantage of traditional CBT, particularly for the treatment of SAD, is the failure to directly address the mental imagery which so powerfully drives SAD symptoms (Hackmann et al., 1998). For this reason, the study by Leigh and Clark (2023) specifically targeted negative mental imagery as part of their CBT intervention by incorporating video feedback. Rapee et al. (2009) also addressed this limitation in their directions for future research by highlighting the potential role for IR procedures in CBT protocols for SAD – a topic we return to below.

With respect to imagery in CBT for SAD, a series of studies by McEvoy et al. (2022a; 2022b) specifically explored whether the incorporation of imagery interventions into treatment improves outcomes for individuals with SAD, compared to more traditional, verbally-based techniques. In their randomized controlled trials, participants with diagnoses of SAD were assigned to either verbally-based or imagery-based group CBT treatments. While both treatments targeted the same maintenance mechanisms of SAD, including negative self-schemas, negative mental imagery, and negative automatic thoughts, the imagery-enhanced treatment incorporated more imagery-based techniques throughout the course of treatment (e.g., IR, mental visualization). Conversely, the verbally-based treatment followed a more traditional CBT intervention package, in which cognitions and thoughts were emphasized, and imagery was only directly introduced during a single video-feedback session. McEvoy et al.'s (2022b) analyses of primary and secondary clinical outcomes, such as changes in clinical severity, self-reported social interaction anxiety, diagnostic status, fear of negative and positive evaluation, performance anxiety, and generalized anxiety and depression symptoms showed large within-group effects across the course of treatment and at 1- and 6-month follow-up for both the imagery-enhanced and verbally-based interventions.

While the within-group effects for the imagery-enhanced CBT group are in line with previous benchmarking and pilot studies (McEvoy et al., 2015; McEvoy et al., 2018), contrary to the authors' hypotheses, there were no statistically significant between-group effects when primary outcome variables were examined based on self-report symptom measures. Thus, while both verbally-based and imagery-enhanced CBT group treatment were effective, the potential additional benefit of imagery-enhanced treatment over verbally-based intervention was not supported. However, McEvoy et al. (2022a) further examined secondary psychophysiological

indices across the two treatment groups and found that individuals assigned to the imagery-enhanced group, versus those assigned to the verbally-based CBT, showed slower heart rates and better vagal control while preparing, performing and recovering from a public speaking task. These results remained at 1-month and 6-month follow up, leading the authors to conclude that imagery enhanced condition may have led to better engagement with emotion regulation strategies, thereby allowing better regulation of physiological arousal.

In conclusion, while the preliminary evidence may not support an advantage for imagery-enhanced interventions, above and beyond verbally-based group CBT, there remains a strong theoretical basis and evidence supporting the efficacy of incorporating imagery-based techniques in treatments for SAD. Such interventions are also recommended by Moscovitch and Huppert (2026) in their recent chapter on SAD treatment. In their view, the major overarching goal of CBT for SAD is to weaken maladaptive schemas and strengthen positive schemas, which can be best facilitated through schema updating processes, and specifically the use of imagery-rich memory-based interventions, a topic we discuss in more detail in the following section.

Schema Updating

In the context of SAD, negative memories reinforce maladaptive perceptions of the self, others and the world, and concurrently, existing maladaptive schemas increase the likelihood of encoding negative memories (Romano et al., 2020a). This cycle continues to strengthen maladaptive schemas, which in turn perpetuates the heightened sensitivity to social threat, internal self-focus, and use of social safety behaviours and avoidance that maintain SAD (Clark & Wells, 1995; Moscovitch, 2009; Rapee & Heimberg, 1997). Consequently, research supports a significant negative memory bias amongst individuals with SAD, suggesting that people with

SAD have highly accessible negative schemas about the social self (Hertel et al., 2008; Krans et al., 2014; Moscovitch et al., 2018; Romano et al., 2020b).

Prior work suggests that memory retrieval simultaneously activates associated self-beliefs (Çili & Stopa, 2015; Wardell & Palombo, 2024) and self-evaluations (Çili & Stopa, 2015), which gives rise to a malleable sense of self that is susceptible to influence from the very events being recalled. In Çili and Stopa's (2015) series of experiments, recall of negative memories lead to worse affect and a poorer self-esteem. Interestingly, the opposite pattern of results were found when participants recalled positive memories (Çili & Stopa, 2015). Similar findings have also been reported amongst socially anxious populations (Kudryk et al., 2024; Martin et al., 2024; Moscovitch, 2024), in which positive memory recollection demonstrated protective effects against social anxiety symptoms. Together, these findings highlight how maladaptive schemas and memories impact well-being in SAD, while also suggesting the potential of enhancing adaptive memories and beliefs in SAD intervention.

This raises the question of how maladaptive schemas can be updated to be more adaptive, thus reducing the negative effects and bolstering the positive effects of schemas and memory on overall well-being? Although negatively-valenced schemas tend to be prioritized and harder to change (Vannucci et al., 2025), previous studies have successfully induced schema change (e.g., Matsumoto, 2025; Richter et al., 2019), including amongst individuals with SAD (e.g., Reimer & Moscovitch, 2015; Romano et al., 2021; Sheldon et al., 2025). It is proposed that schema change occurs in response to information that is inconsistent with the existing schema, thereby triggering a prediction error in the brain (Rescorla & Wagner, 1972), and prompting neural and cognitive processes to bypass the use of schemas as an encoding short-cut (Fenerci et al., 2024; Greve et al., 2019; Hensen & Gagnepain, 2010; Matsumoto, 2025; van Kesteren et al., 2012).

By far, the most cohesive conceptualization of the mechanisms and clinical application of schema updating is the schema-congruent and -incongruent learning (SCIL) model proposed by Moscovitch et al. (2023). According to the SCIL model, schemas can be either strengthened (reinforced) or weakened (updated) by leveraging the underlying cognitive and neural processes of the autobiographical memory system. In effect, schema-congruent learning occurs when an individual repeatedly reviews autobiographical information that is *consistent* with an activated underlying schema, thereby strengthening that schema, while schema-incongruent learning occurs when the individual rehearses autobiographical information that is *inconsistent* with the activated schema, thereby weakening that schema.

As outlined in detail in Moscovitch et al. (2023), when cued to recall autobiographical memories, brain regions associated with autobiographical memory construction and rehearsal (hippocampus), emotional arousal (amygdala), appraisal (orbitofrontal cortex), and schema representation and instantiation (ventromedial prefrontal cortex; vmPFC) are recruited, as the encapsulated beliefs and affective components of the memory are reactivated. During schema-congruent learning, the hippocampus, with input from the posterior neocortex, generates a gist-like simulation of schema-congruent details of the event and other easily accessible memories. This prioritization of details that are consistent with the activated schema then work to reinforce these beliefs. Conversely, during schema-incongruent learning the posterior neocortex supports the hippocampus in simulating episodic details that are inconsistent with the activated schema; this mismatch between the expectancies of the encapsulated belief and the simulation triggers a prediction error, essentially communicating to the lateral prefrontal cortex and hippocampus to halt the process of gist extraction and detail imputation from prior memories. Instead, a more detailed representation of the novel (inconsistent) information will be encoded. While it is not

known whether this process must be repeated multiple times, or whether one strong experience with schema-incongruent learning would suffice but presumably the encoding of schema-incongruent information will trigger the existing schema to update, in order to accommodate the new learning about self, others, and/or the world.

To this end, Moscovitch et al. (2023) outline a three-phase process for facilitating schema updating during treatment. The first phase, *preparation*, involves working with the client to identify the maladaptive schemas driving their psychological difficulties and key memories which encapsulate these beliefs, as well as working together to identify more adaptive or positive schemas that may be weaker and more fragile but represent how the client would "like things to be." (also see Padesky, 1994).

The second phase, *new learning*, facilitates mental simulation and autobiographical memory reconstruction to help the individual encode more adaptive autobiographical details which directly oppose, and therefore weaken, the activated maladaptive self-schemas, while reinforcing the activated positive ones. This stage can act upon either the schema-congruent or schema-incongruent learning pathways by incorporating a variety of memory-based strategies. For example, clinical interventions could include activities which aim to dismantle maladaptive memories, thereby operating on the schema-incongruent pathway by highlighting schema-incongruent information from past painful events. For instance, a client could be directed to recall a painful memory which reinforces their maladaptive schema. Once the memory is evoked and the encapsulated schema activated, the individual can be guided to question their interpretation of the situation, weigh the validity of their beliefs, and attend to schema-incongruent details of the event that may have previously been ignored. Similarly, the individual could reimagine a more satisfying ending to their memory, in which they were able to address

unmet needs at the time the memory occurred. In both variations, the client is able introduce new meaning to the activated and malleable memory, which can then be encoded as a more adaptive memory. This new interpretation should be less aligned with the activated maladaptive schema, thus triggering schema updating processes. Alternatively, clinicians could choose to operate on the schema-congruent learning pathway. Although schema-congruent learning is typically associated with the encoding of negative information and subsequent reinforcement of maladaptive schemas within the context of SAD, this pathway can also be co-opted and used to strengthen fragile adaptive schemas. One such example involves guiding clients to recall positive memories and deeply reflect upon the meaning of these events, thereby simultaneously activating and strengthening existing positive schemas (Moscovitch et al., 2024).

Once learning has taken place, the final stage, *rehearsal*, necessitates repeated exposure to the new learning, spaced out across time. Intentional rehearsal allows for the consolidation of the positive memory details needed to weaken maladaptive and strengthen adaptive schemas, respectively.

Given the importance of negative social memories to the development of maladaptive mental imagery (Hackmann et al., 2000) and maladaptive schemas, incorporating memory-based interventions in a manner that facilitates schema updating, in line with Moscovitch et al.'s (2023) recommendations, may yield significant benefits for SAD individuals. To this end, IR is a therapeutic technique that has shown promising findings amongst individuals with SAD, and may complement traditional CBT-based intervention strategies by levying the processes of negative mental imagery and underlying maladaptive schemas.

Imagery Rescripting (IR)

IR is a therapeutic technique in which individuals are guided to recall, reimagine and reinterpret painful memories. The technique was initially used by Layden et al., (1993) to help clients cope with highly visual traumatic memories, and challenge the maladaptive schemas associated with such events. Drawing upon this earlier work and from the authors' own clinical experiences using IR, Arntz and Weertman (1999) published their seminal paper on IR, in which they outlined a manualized 3-phase process for clinicians implementing this procedure, described below.

In phase 1, the client is instructed to recall and describe a painful memory as if the event were unfolding in the present moment, noting the sensory details of the memory and the emotions, thoughts, and behaviours of themselves and others at the time of the event. Here, the negative schema at the heart of the memory is activated by reliving the painful experience in a manner that elicits emotional distress and confronting its embedded negative imagery and meaning.

Once the client has a detail-rich mental image in mind, they are guided in phase 2 to reflect upon the memory from the perspective of their current self, with particular focus directed towards their younger self's needs. The client is then instructed to imagine and describe how they would intervene within the memory, with permission to engage in any corrective action they wish to try. Often, the client will be guided to enact compassionate strategies by soothing their younger self, or to enact assertive strategies by helping their younger self stand up to their perpetrator in the memory scene (e.g., a bully or abuser) (Romano et al., 2021). This phase concludes when the client reports that they have fully satisfied their younger self's emotional needs within the memory scene, often after trying multiple strategies.

In phase 3, the client is asked once again to recall the memory from the perspective of their younger self, but to reimagine the situation with the interventions implemented by their older self. From the younger self's perspective, the client is asked to reflect on their reactions to the intervention, and express any unmet needs. If the younger self still requires support, they are encouraged to request additional intervention from their older self, which will then be implemented. This process continues until the younger self has no remaining unmet needs.

To illustrate the execution of these three phases, consider the imaginary case of Joseph, who during treatment for SAD, rescripts a frightening childhood encounter with a schoolyard bully. While recalling the distressing memory, Joseph pictures his younger self cowering in fear on the grass, the bully looming powerfully above him, and a crowd of distant, unmoving spectators. In this scenario, the mental image reflects not only the actual events he experienced (e.g., being picked on and physically intimidated during recess) but also the internalized meaning Joseph attributes to the event (e.g., being powerless, with nobody willing to help him). During the second phase, Joseph assesses the mental scene and recognizes his younger self's desire to be defended. He then imagines his adult self walking up to the bully and verbally reprimanding him. In the third phase, Joseph's younger self witnesses adult Joseph scolding the bully, but expresses concern that he (young Joseph) will get in trouble. In response, adult Joseph speaks to the teacher supervising the yard. Finally younger Joseph expresses the need for physical comfort, which culminates in a hug from adult Joseph.

Reviews of IR suggest it is an effective intervention when used to treat SAD, OCD and PTSD, often eliciting significant both acute and enduring improvements in beliefs and negative mental imagery in as little as one session (Arntz, 2012; Arntz, 2025; Morina et al., 2017; Strachan et al., 2020). Recent meta-analyses confirm these conclusions, suggesting that when

used to treat SAD, PTSD and MDD, IR demonstrates strong effect sizes for reductions in memory vividness, memory distress, aversive mental imagery, maladaptive beliefs and clinical symptoms, with added benefits such as improvements in comorbid depression, lower dropout rates, and reports from clients that it is experientially less distressing to them than other treatments such as imaginal exposure (Lloyd & Marczak, 2022; Kip et al., 2023, Kroener et al., 2023). Further, IR demonstrated effect sizes similar to other established treatments (Kip et al., 2023) and could be a beneficial treatment option for individuals who do not respond to other first line treatments (Arntz, 2012).

IR as an Intervention for SAD

With respect to SAD specifically, researchers have explored the effects of IR when used as a standalone treatment, in combination with other established treatments, and in comparison to other evidence-based techniques. When used as an independent intervention, IR has shown promising results. Individuals who received weekly IR sessions experienced significant improvements in fear of negative evaluation and social anxiety symptoms (Frets et al., 2014). Another study, by Winter et al., (2025) found that 8 weekly sessions of IR significantly reduced social anxiety symptom number and severity, with 74% of individuals no longer meeting diagnostic criteria at the end of treatment.

Single sessions of IR have also demonstrated significant positive effects, including: reductions in fear of negative evaluation, lowered social interaction anxiety, increased positive meanings and emotions associated with the rescripted event, enhanced positive mental imagery, and strengthened adaptive schemas (Al-Uqaili et al., submitted; Nilsson et al., 2012; Reimer & Moscovitch, 2015; Romano et al., 2020b; Romano et al., 2021; Seinshe et al., 2024; Sheldon et al., 2025; Sorka et al., 2025). Physiological measures also showed that engaging in IR increased

heart rate variability, suggesting that individuals who underwent IR implemented emotion regulation strategies and attenuated their physiological arousal (Seinshe et al., 2024). Several studies including follow-up periods showed that the benefits of both single-session and multi-session IR were maintained even several months later (Frets et al., 2014; Nilsson et al., 2012; Romano et al., 2021; Winter et al., 2025). Impressively, Winter et al. (2025) found that 88% of their sample no longer met the diagnostic criteria of SAD at 3-month follow-up, with effect sizes rivalling in-person and virtual CBT treatments.

As discussed previously, CBT for SAD has often failed to directly target the mental imagery component of SAD (Gilboa-Schechtman & Azoulay, 2022), despite evidence that imagery-based techniques are effective when included in SAD treatment (Leigh & Clark, 2023; McEvoy et al., 2022a; McEvoy et al., 2022b). In response to calls to better address negative mental imagery in SAD interventions (e.g. Rapee et al., 2009), IR has been studied in combination with other CBT strategies, such as cognitive restructuring, and as an adjunct to traditional group or individual CBT treatment packages. In one study, compared to supportive counselling, individuals who received one session of IR and cognitive restructuring showed significant reductions in social anxiety symptoms, fear of negative evaluation, and memory and imagery vividness (Lee & Kwon, 2013). In another study, treatment-seeking SAD clients who attended one cognitive restructuring and IR session showed increased adaptive meanings attributed to the memory, reduced distress associated with the recalled event, decreased mental imagery distress and vividness, improvements in SAD symptom severity, and reduced anxiety when imaging feared social situations (Wild et al., 2007; Wild et al., 2008). The effects of IR also appear to lead to lasting changes, with many treatment gains persisting after one week (Wild et al., 2007; Wild et al., 2008) and 3-months later (Lee & Kwon, 2013).

Likewise, when one IR session was incorporated into a 12-week course of group CBT, affect increased and the strength and valence of beliefs about the mental image became more adaptive, which in turn was associated with less negative beliefs about the rescripted memory (McCarthy et al., 2022). In a study investigating the effects of up to two IR sessions as part of a 16-session CBT protocol, individuals showed significant improvements in fear of negative evaluation scores, reduced vividness and distress associated with the memory and mental imagery, and fewer negative beliefs (Takanashi et al., 2020). Importantly, individuals who received the treatment also rated IR favourably, with 82% of the sample agreeing that the technique was impressive, 59% saying it was effective, and 55% indicating that they recognized changes in their belief changed following rescripting (Takanashi et al., 2020).

To further understand the effects of IR in relation to established CBT techniques, several studies have also directly compared IR to imaginal exposure and cognitive restructuring. In one study, individuals assigned to IR demonstrated similar increases in the number of positive and neutral memory details as participants assigned to imaginal exposure (Romano et al., 2020b). Interestingly, those assigned to IR did not show simultaneous increases in negative memory details, whereas those assigned to imaginal exposure did. The authors postulated this difference was due to the underlying mechanisms of each intervention: IR aims to reduce the negative appraisal of memories, whereas imaginal exposure specifically targets the most distressing components of the event (Romano et al., 2020b). Thus, IR may have the added advantage of increasing the adaptive interpretations of prior memories, without the concomitant enhancement of the negative. Similarly, both the IR and imaginal exposure groups showed within-group trends towards decreased memory intrusiveness, vividness and negativity, and adaptive changes to core beliefs about the self and others across the duration of the study. These within-group effects were

larger within the IR than the imaginal exposure group, though not significantly so (Romano et al., 2020b). Moreover, Knutsson and colleagues (2020) found that both IR and imaginal exposure led to significant decreases in fear of negative evaluation and social anxiety symptoms post-intervention and at two and four week follow-up, with the IR group demonstrating additional improvements in image frequency, memory distress, and negative self-beliefs at post-intervention and follow-up.

Two studies have also evaluated IR versus cognitive restructuring. Strohm and colleagues (2021) compared individuals assigned to cognitive restructuring, IR, or a no-intervention control on measures of social anxiety, cognition, affect, and public speaking anxiety. When comparing baseline to 1-week follow-up scores, cognitive restructuring was found to be more effective than IR at reducing social anxiety symptoms, although both active interventions were superior to control. Additionally, while IR was superior to the no intervention control, it was less effective than cognitive restructuring at decreasing ratings of negative self-belief endorsement from pre-treatment to post-treatment and follow-up. Notably, IR was superior to both cognitive restructuring and the control group at improving positive affect from pre- to post-intervention.

In an earlier investigation by Norton and Abbott (2016) the findings were again mixed, with both IR and cognitive restructuring showing unique treatment advantages. For example, while both interventions significantly reduced social interaction anxiety from baseline to 1-week follow-up, cognitive restructuring led to larger baseline to follow-up reductions in fear of negative evaluation, comorbid depressive symptoms, and negative self-beliefs. On the other hand, IR was superior at reducing daily ratings of vividness and intrusiveness of negative mental imagery when comparing ratings from the pre- to post-intervention weeks. The authors maintained that both interventions were effective and should be used in tandem to treat SAD,

suggesting that cognitive restructuring and IR may act on different cognitive mechanisms, and may require differing number of sessions to reap the full benefits.

Some studies have also explored whether adding IR to traditional CBT enhances the clinical outcomes. The earliest study, by Ahn and Kwon (2018) compared SAD clients who received traditional group CBT to those who received enhanced group CBT (ECBT), which also included IR, video feedback, and exposure in order to address negative self-imagery. Although both groups showed impressive rates in terms of the number of individuals who achieved clinically significant change a 3-month follow-up, the proportion of clients was higher in the ECBT group. Moreover, individuals in the ECBT group saw treatment gains faster, specifically regarding SAD symptoms, fear of negative evaluation, maladaptive self-beliefs and judgement biases. Compared to the CBT group, the treatment effects of the ECBT group were also much larger and were longer lasting, as many treatment gains were maintained at 3-month follow-up.

Comparatively, Norton et al. (2021) tracked clients across an 8-week group CBT intervention, and then followed-up after the clients received two weekly sessions of IR, administered during weeks 9 and 10. As expected, individuals experienced significant reductions in social anxiety and comorbid depression and anxiety symptoms from pre- to post-CBT intervention. Importantly, subsequent IR sessions were associated with significant improvements in mood, reductions in negative emotions related to mental imagery, decreased negative emotions associated with the memory, and weakened negative core beliefs. Novel findings by Landkroon and colleagues (2022a) further suggest that IR can also be used to modify mental imagery of future outcomes. The authors found that IR can attenuate the anticipatory anxiety associated with behavioural experiments by reducing feelings of helplessness and decreasing ratings of the probability and severity of anticipated negative outcomes. These researchers also

compared IR to progressive muscle relaxation and found that IR led to more positive and fewer negative appraisals of the future event, and increased positive appraisals of the memory (2022b) when comparing pre- to post-intervention ratings.

From the literature reviewed above, it is clear that IR is a technique with strong potential and clinical utility for achieving strong outcomes with minimal therapist time, suggesting that it can be a quick and effective intervention for SAD. Recently, a fully self-guided IR protocol has shown strong effects (Sorka et al., submitted), suggesting the potential for reaching even greater numbers of clients who may not be able to access in person services. Although the exact mechanisms of IR are not fully understood, it is proposed that this technique targets the maladaptive schemas associated with the rescripted event (Arntz & Weertman, 1999; Arntz, 2012; 2025). Since the client works to address the previously unmet needs of their younger self (e.g., desire for nurturance, autonomy and authentic self-expression), and engages with the memory from a more mature and emotionally healthy perspective, the original meaning of the event is updated (Romano et al., 2021; Sorka et al., 2025, 2026). Furthermore, the exercise of reviewing the negative memory while being guided to view it from the perspective of the current/wise self and to situate it within the larger context of one's life has been shown to offer profound insight into one's self, and allow for the engagement of self-compassion and assertive intervention strategies during rescripting, which may be a novel experience for those with SAD (Romano et al., 2021).

According to the SCIL model (Moscovitch et al., 2023), IR likely facilitates schema updating through the engagement of the autobiographical memory system and direction of attention towards schema-incongruent information (e.g., during phases 2 and 3). The resulting mismatch between the maladaptive schema and novel interpretation of the event triggers a

prediction error and subsequent encoding of a detailed (vs. gist) memory trace of the updated memory meaning, simultaneously weakening the existing maladaptive schema. In this manner, IR fits into the new learning phase of the SCIL model; however, enacting lasting meaningful schema change likely necessitates subsequent rehearsal to continuously violate and weaken the maladaptive schema and consolidate this new learning into long term memory.

Moscovitch et al. (2023) suggested encouraging clients to repeat this new learning by purposefully engaging in sessions of rehearsal in which autobiographical recall and mental simulations are performed. The authors also proposed that sleep may play an important role during the rehearsal/consolidation phase of schema updating, with potential to moderate the effectiveness of IR interventions.

The Role of Sleep in the Consolidation of New Learning

The notion that sleep benefits memory has been popular for well over a century, with decades of research demonstrating the positive effects of sleep on various types of memory (for a review, see Rash & Born, 2013). Despite being regarded as a period of physical rest and rejuvenation, sleep is actually a time during which the brain remains highly active, alternating through different stages of neuronal activity. These stages, known as sleep stages, can be broadly classified into rapid eye movement (REM) sleep and non-rapid eye movement (NREM) sleep. REM sleep is commonly associated with dreaming and consists of low amplitude, high frequency waves which mimic the brain waves produced during wakefulness. Comparatively, NREM encompasses three distinct non-REM sleep stages, ranging from lighter (stage 1 and stage 2) to deeper sleep (stage 3). Similar to REM, each stage is characterized by a distinct pattern of neuronal activity. One illustrative example is stage 3 sleep, which is defined by large-amplitude, low frequency waves, hence earning the designation of slow-wave sleep (SWS).

Within the sleep and memory literature, REM and SWS have been repeatedly implicated in the consolidation of new memories. Consolidation refers to the processes by which newly-formed memories, which are fragile and susceptible to forgetting, are encoded into long-term memory (Müller & Pilzecker, 1900). In humans, sleep is theorized to facilitate this deeper encoding via the neurophysiological and biochemical processes which drive REM and SWS. According to the active systems consolidation hypothesis, newly formed memory traces undergo repeated reactivation at both the sub-cortical (hippocampus and thalamus) and neocortical levels during SWS, which allows for strengthening of neuronal connections and assimilation into pre-existing knowledge networks, followed by synaptic stabilization during REM (Alvarez & Squire, 1995; Diekelmann & Born, 2010; Rasch & Born, 2013; Stickgold, 2005; Walker & Stickgold, 2004).

Predictably, research suggests that sleep is important to the consolidation of autobiographical memories (Matorina & Barense, 2024). In line with broader memory research, studies that implement sleep versus no sleep control designs continually find that sleep benefits autobiographical memory performance (Lokhandwala & Spencer, 2020; Scullin et al., 2017; Zhang et al., 2022). Additional studies have demonstrated that better sleep benefits several characteristics of autobiographical memories, such as the specificity of the memory (Barry et al., 2019; Khormizi et al., 2018), temporal order of events (Diamond et al., 2025; Drosopoulos, 2007; Griessenberger et al., 2012) and contextual features of the memory being recalled (Van der Helm et al., 2011). These effects have been replicated across both human and animal studies (Inostroza et al., 2013; Oyanedel et al., 2019). Zhang and colleagues (2022) further suggest that sleep may act to “rescue” autobiographical memories that may otherwise be forgotten by selectively enhancing degraded memory traces for salient autobiographical memories.

The quality of sleep is also an important factor in the consolidation of new autobiographical memories, such that individuals with poorer sleep quality and those who have medical conditions (e.g., obstructive sleep apnea) that lead to significant fragmentation of sleep tend to show deficits during later recall (Delhikar et al., 2019; Murre et al., 2014). Similarly, psychological (e.g., depression or anxiety) disorders and sleep disturbances have been implicated as having bidirectional deleterious effects (see Freeman et al., 2020 for a review).

Findings that sleep, and high quality sleep in particular, is important for memory consolidation is supported by neurological research, which suggests that sleep is essential for hippocampal functioning. Studies have shown that lack of sleep can disrupt the typical connectivity between the hippocampus and cortical structures, thereby impairing the consolidation of autobiographical memories into long-term memory (Chai et al., 2020; Yoo et al., 2007).

Investigations of sleep stages have implicated aforementioned SWS and REM as essential to autobiographical memory consolidation (Diekelmann et al., 2009). Increased SWS was related to better recall of the temporal order, visuospatial and contextual features of autobiographical memories (Casey et al., 2016; Diamond et al., 2025; Hockett et al., 2021; Rauchs et al., 2004; Scullin et al., 2013), with some effects being detectable up to one year later (Diamond et al., 2025). Similarly, SWS has been associated with improved memory in children (Diekelmann et al., 2009; Lokhandwala & Spencer, 2020), and even amongst elderly adults with mild Alzheimer's disease (Rauchs et al., 2013). Selective deprivation of SWS has also been associated with impairment of hippocampal functioning and subsequent memory consolidation, supporting the importance of SWS for the autobiographical memory system (Van der Werf et al., 2009).

REM sleep has also been shown to benefit temporal and spatial elements of memories (Griessenberger et al., 2012; Rauchs et al., 2004). Given that REM is the sleep stage most strongly associated with dreaming, some research has further suggested that dream content is reflective of the underlying consolidation and reorganization of new, emotional memories into existing knowledge structures (Malinowski & Horton, 2015). Beyond specific sleep stages, additional sleep factors, such as increased time to fall asleep, more nocturnal awakenings, and specific brain wave activity during stage 2 sleep (i.e., sleep spindles), have also been implicated in poorer autobiographical memory performance (Diamond et al., 2025; Rauchs et al., 2004; Singh et al., 2025; Van der Helm et al., 2011; Yeh et al., 2021).

Reconsolidation or 'updating' of existing memories is also improved by sleep. In a series of studies by Bryant et al. (2019), individuals learned two lists of items one day apart. Prior to learning the second list on day two of the experiment, the researchers reactivated the participants' memories for the first list of items to explore whether the items from list two would become erroneously encoded into the memory of list one items. Results demonstrated that individuals were more likely to update their memories of the first list of word learning with details from the second list if the participant engaged in a period of sleep after the second learning session (Bryant et al., 2019). Indeed, individuals assigned to the sleep condition were more likely to mistake content from the second word list as having been presented on the first word list, whilst individuals in the wake condition did not. Amongst the sleepers, sleeping longer after the first session and experiencing higher rates of specific brain wave patterns during stage 2 sleep (i.e. sleep spindle activity) after the second learning session were associated with stronger evidence of memory updating.

Sleep and Schema Updating

Considering the possible applications of sleep's role in the consolidation of memory and learning, it is surprising that few studies have directly examined the effect of sleep on schema updating. To our knowledge, only three studies have specifically explored this question, although other work has noted that schema updating is enhanced by a period of consolidation and suggested the integral role of sleep in facilitating this consolidation process (Richter et al., 2019).

In a study by Groch and colleagues (2017), participants with SAD and healthy controls first learned picture-word associations featuring ambiguous scenes and positive or negative words. During the subsequent nocturnal sleep, whilst in non-REM sleep, participants were played audio of some of the words they learned. The morning after the nocturnal cueing, participants completed a cued recall task in which they were presented with images from the image-word pairs and asked to provide the associated word. Participants were also asked to provide ratings of how affectively pleasant and arousing they found each image. Both the SAD and healthy control groups remembered words that were cued during sleep better than non-cued words, supporting the idea that reactivation of memory traces during sleep enhances the consolidation of novel learning. One week later, participants again completed the cued recall task and affective ratings of the images. While the memory advantage for cued vs. non-cued words was lost across both experimental groups, interestingly, SAD participants showed significantly lower pleasantness ratings for images that were paired with negative words, despite this difference not being present previously. The authors suggested that amongst SAD individuals, the reactivation of negative image-word pairs also activated existing negative schemas during sleep. This would have allowed easier consolidation of the negatively valenced word-image pairs into existing knowledge, but may have simultaneously resulted in the preferential extraction of

the emotional gist for the negative stimuli. This enhanced consolidation of negative affect towards the negative image-word pairs may have then be further encoded during subsequent nights of sleep, hence why the effects did not appear until one week later. These findings suggest that the reactivation of subsets of novel information can be prioritized during learning, and that sleep can facilitate the strengthening of this information. In the case of SAD, Groch et al. (2017) demonstrates the potential role for sleep to enhance the negative affective tone of novel memory traces, thereby strengthening existing negative schemas. This is in line with Moscovitch et al.'s (2023) proposal that sleep can enhance schema updating, in this case, via the schema-congruent learning pathway.

Azza et al. (2022) examined whether sleep benefitted the effects of IR on heart rate variability. In their study, undergraduate students with no history of psychiatric disorders underwent a detailed memory assessment, in which one neutral and one aversive memory were selected and described. Based on the participants' recollections, the experimenter prepared a written script and short audio narration of each memory, which were used during the subsequent two experimental sessions to help participants vividly recall the memories. During session one, participants completed a memory recollection task followed by measures of negative affect and maladaptive cognitions (T1). Next, participants completed an IR session with a trained psychologist focused on the aversive memory they had earlier described during the assessment phase, followed by a 90-minute interval of wakefulness or napping. Afterwards, participants completed a second round of the memory recollection task and measures of affect and cognition (T2). One week later, participants returned for a second session, during which they once again completed the memory recollection task and measures (T3). As the main outcome measure, heart rate was continuously monitored for all participants during both sessions.

When recalling the negative and neutral memories at T2, participants in the napping condition showed similar heart rates for both memories, whereas individuals in the wake condition had significantly higher heart rates when recalling the negative memory compared to the neutral memory. These findings indicate that for the nap group, the aversive memory no longer produced emotional arousal, above and beyond a neutral event, whereas emotional reactivity remained for those in the wake group. Moreover, only individuals in the nap group experienced T1 to T2 reductions in the distress associated with their appraisal of the memory and intensity of their emotional reaction to it. Notably, at one week follow-up, both groups showed similar heart rates when recalling the negative and neutral memories and showed similar T1 to T3 reductions in their ratings of distress associated with maladaptive cognitions and emotional intensity. The authors suggested that while the sleep intervention initially supported the benefits of IR by consolidating the new learning immediately, this advantage disappeared as both groups benefited from subsequent consolidation across the successive nights of nocturnal sleep between T2 and T3.

More recently, Recher et al. (2024) conducted a study combining elements of both IR and sleep-specific cuing. In this novel design, healthy young adults completed an IR task, followed by two nights of targeted memory activation. During the targeted memory reactivation, participants in the active experimental group were played audio recordings of words from their rescripted memory, while participants in the control groups were cued with neutral words or did not receive any audio cues. Participants assigned to the active condition were further divided into two groups to explore the potential role of additional targeted memory reactivation. One sub-group received three additional nights of the targeted memory reactivation, while the second sub-group did not receive any cuing. Trend analyses revealed that while all conditions experienced

significant within-group reductions in negative affect, emotional distress, and memory arousal and vividness from pre- to post-IR, the groups who received nocturnal cueing of words from their rescripted memories showed significantly larger effects when comparing pre-intervention scores to the scores taken after the two experimental nights (T3 and T4) and at one-week (T5) and one-month follow-up (T6). Those who received the three additional nights of targeted memory reactivation after the second experimental night also reported additional reductions in memory vividness at both one-week and one-month follow-up compared to those in the active condition who did not receive the extra nights of targeted memory reactivation. These findings suggest that not only does IR offer significant cognitive and emotional benefits, but that sleep can bolster these effects, as a function of reactivation of the memory traces of the rescripted memory.

Taken together, the results of these interventions suggest that the use of sleep interventions can yield significant benefits for schema updating amongst individuals with SAD and can enhance the effects of IR interventions amongst healthy controls. The latter appears to be in part facilitated by the reactivation of the new learning that takes place during rescripting, as suggested by the findings that targeted memory reactivation enhances consolidation. Moreover, targeted memory retrieval during sleep appears to offer promising avenues for the controlled consolidation of new learning, in line with additional work from related research areas (van der Heijen et al., 2022; Xia & Hu, 2025; Yuksel et al., 2025). However, it is important to note that amongst these early studies there has yet to be a single investigation which includes all three of the following elements: a) inclusion of an IR intervention, b) recruitment of a socially anxious sample, and c) measurement of schemas directly, versus solely focusing on memory characteristics and affective outcomes. While Groch et al., (2017) recruited a clinical SAD

sample, they did not implement an IR intervention, nor did they use memory stimuli that would allow for measurement of schemas. Conversely, the investigation by Azza et al. (2022) included an IR intervention but this was implemented in a sample of healthy participants and only included measurements of physiological indicators of emotion regulation. Similarly, Recher et al. (2024) incorporated IR, but did not include a clinical sample, nor did they include measures of schema content or valence in their work. Overall, these preliminary studies have given novel insight into the ways sleep can bolster the efficacy of memory-based interventions. Yet, several questions remain, and the benefits of sleep for schema-updating, especially in socially anxious participants, remains understudied and warrants further consideration.

Summary and Conclusions

In summary, previous research has shown that schemas are a key contributor to the maintenance of SAD, thereby fuelling emotional distress and functional impairment in a significant percentage of the population. As such, schema change is a pivotal treatment target for SAD. Schema incongruent learning is proposed to be a process by which maladaptive schemas can be challenged and updated to become more adaptive, and one which operates on the cognitive and neurobiological connections between schemas and the autobiographical memory system. To this end, IR is a promising intervention, which is theorized to facilitate updating of the maladaptive schemas encapsulated within negative autobiographical memories and mental imagery. However, continued research is needed to further explore the schema updating benefits of IR interventions in socially anxious individuals. Additionally, limited research has examined how the effects of imagery-rescripting interventions can be enhanced amongst individuals with social anxiety. Drawing upon the sleep and memory literature, which supports the role of sleep in the consolidation of autobiographical memory and new learning, we suggest that sleep can be

complimentary to IR in bolstering the consolidation of schema updating. To date, very few studies have explored the impact of sleep on schema updating or IR. Of the studies that have been conducted, only one has specifically examined the role of sleep in schema updating in individuals with SAD (Groch et al., 2017). Two others have explored how sleep impacts IR, but in non-psychiatric populations. To address these gaps and improve our understanding of the potential benefit of sleep for schema updating amongst socially anxious individuals, we aim to explore whether a self-guided sleep quality intervention enhances the consolidation of the new learning that is induced by an IR procedure.

Present Study

Undergraduate students at the University of Waterloo completed a three-part study. During the first experimental session, participants recalled an aversive social memory and associated mental image, then were randomized to rescript the memory through an online guided IR or engage in a non-IR control task in which they focused and reflected on the perceptual details of their memory. At the end of the first session, participants were then further subdivided into one of two conditions in which they were either provided with a set of research-backed sleep tips which have been shown to improve overall sleep quality, or with instructions to maintain their typical sleep schedule. Within an hour of waking the following morning, participants completed the second part of the study, in which they were asked to complete an online sleep diary based on their sleep the night before. Later that same day, participants completed the third and final study component, which required them to once again recall their aversive social memory and describe their mental image of the event.

Preregistered hypotheses (https://osf.io/b5j29/) were outlined, as follows:

1) Participants assigned to IR will demonstrate increased positive schemas, decreased negative schemas, heightened positive affect, diminished negative affect, reduced negative self-perceptions, and more adaptive meaning making of their mental images and memories relative to individuals assigned to the non-IR control condition, irrespective of sleep instructions;

2) There will be an imagery condition by sleep intervention interaction effect such that participants who receive both the IR intervention and the sleep quality enhancement instructions will demonstrate larger improvements in schema valence and content, affect, self-perceptions,

and mental imagery and memory meaning, compared to those assigned to IR and sleep-as-usual instructions; and

3) Participants who receive both the IR condition + sleep quality instructions will also report significantly greater benefits than those who receive the non-IR condition + sleep quality instructions as well as those who receive neither IR nor sleep quality instructions, with participants in this last group showing the smallest effects across these outcomes relative to the IR + sleep quality participants.

Method

Participants

University of Waterloo undergraduate students were recruited via the Psychology department's research participant pool. To be eligible for this online study, all participants were required to speak and write fluently in English, have no known diagnosis of a sleep disorder, and to have obtained a score of 19 or higher on the Social Phobia Inventory (SPIN; Connor et al., 2000), which corresponds to moderate levels of social anxiety. Eligibility was screened using participant responses to the departmental pre-screening survey, which was administered at the beginning of each academic term (September 2025, January 2026, May 2026).

In total, 93 participants were recruited and consented to partake in the study between November 2025 and June 2026. Participants were excluded from analyses if they did not provide an appropriate study ID number (n = 2), could not recall an appropriate memory (n = 3), or did not complete all three parts of the study (n = 57). Although data collection for the project is still ongoing, a hard cut-off date was pre-established in June 2026 for extracting the final set of collected data for the sake of this thesis, given the required thesis completion deadline of August 2026. Thus, the final sample for the sake of the thesis included 31 participants, consisting of mostly white (32.26%), East Asian (25.61%), and Southeast Asian (22.58%) females (87.10%) with a mean age of 20.39 (SD = 1.33). The average SPIN score for the sample was 38.48 (SD = 10.73). Additional demographic information is presented in Table 1.

Prior to commencement of data collection, all participants provided informed consent. In exchange for their participation, participants received an opportunity to enter a draw for one of 10 gift cards and up to 1.5 research participation credits, which could be converted into extra

credit in one of their psychology courses. All data were collected between November 2025 – June 2026.

Table 1

Demographic Variables of the Sample

Demographic Variable	Total	%
N	31	-
Gender		
Woman	27	87.10
Man	2	6.45
Non-Binary*	2	6.45
Race		
Black/African	1	3.23
East Asian	8	25.61
Hispanic/Latine	1	3.23
Mixed	2	6.45
South Asian	7	22.58
Southeast Asian	2	6.45
White/European	10	32.26
	Mean	**SD**
Age	20.39	1.33

Note. *The non-binary category also included individuals who identified as gender queer and gender non-confirming, but the category title was shortened for formatting purposes.

Materials

Pre-screening

Social Anxiety. To ensure our sample had elevated trait social anxiety and therefore would be more likely to have negative self-schemas and negative autobiographical social memories, participants completed the Social Phobia Inventory (SPIN; Connor et al., 2000). In order to be eligible for the study, participants were required to meet the cut off SPIN score of 19 or higher, as this corresponds to moderate levels of trait social anxiety. The SPIN is a 17-item self-report measure which assesses three domains of responses to social situations: fear, avoidance and physiological discomfort. All items (e.g., "Parties and social situations scare me", "I am bothered by blushing in front of people") are rated on a 5-point Likert scale ranging from 0 (not at all) to 4 (extremely), with the last two weeks serving as the reference point for participants' ratings. Higher scores indicate more symptoms of social anxiety and reflect higher levels of trait social anxiety.

Primary Outcome Measures

Schemas. Changes in schema content and valence were measured using the positive self-belief and negative self-belief subscales on the Brief Core Schema Scale (BCSS; Fowler et al., 2006). Each subscale includes 6 self-report items which evaluate the strength of core beliefs, such as "I am talented" (positive self-beliefs subscale), or "I am weak" (negative self-belief subscale). Respondents use a 5-point Likert scale (1- not at all, 5- extremely) to rate their current level of agreement with each statement, with higher scores on each individual subscale indicating a larger presence of schemas of the respective valence and content.

Affect. Fluctuations in affect across time were evaluated using the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988). The PANAS is a 20-item self-report questionnaire designed to assess positive (e.g., "I feel interested") and negative (e.g., "I feel ashamed") dimensions of emotions. All items are rated using a 5-point Likert scale from 1 (very slightly or not at all) to 5 (extremely). Given research supporting the orthogonal nature of positive and negative affect (Brown et al., 1998), the positive and negative emotion subscales were treated as distinct and co-occurring mood states.

Memory Recall Task

To ensure participants were recalling appropriate negative autobiographical memories, they were asked to bring to mind a past negative experience that took place within a social context (i.e., with one or more people present) and that occurred at a specific place and time (i.e., a true autobiographical memory). Moreover, participants were explicitly asked not to recall memories which contained themes of physical or sexual abuse or neglect. Following the memory instructions, examples of an appropriate specific autobiographical memory and a non-specific memory were presented to demonstrate the types of memories participants were instructed to recall. Afterwards, participants were asked whether they had such a memory in mind, using a "Yes" or "No" forced choice question.

Participants who reported initially being unable to recall an appropriate memory were provided with up to three additional prompts (e.g., "Think of a moment when you felt out of place, awkward, or uncomfortable with people you wanted to make a good impression on. Are you able to recall such an experience?"). After the third prompt, participants who were still unable to recall an appropriate memory were discontinued from the study.

Memory Description. Once participants indicated that they were able to recall an appropriate memory, they were presented with an open text-box and instructed to describe the memory in a few short sentences.

Memory Characteristics

Memory Recollection. To evaluate the quality of memory recollection throughout the study, participants indicated how well they were able to recall their chosen memory on 5-point Likert scale, with responses ranging from 1 (I don't remember it very well; I can recall very little about the event) to 5 (I remember it very well; I can recall everything about the event).

Age of Memory. Participants provided the approximate age of their memory, by selecting one of five multiple choice options, ranging from "0-1 year" to "5+ years". This question was only presented to participants once, during part one of the study.

Memory Distress. Participants selected how distressing their chosen memory was to them currently using a 1 (not at all distressing) to 7 (very distressing) sliding scale.

Recurrence. Participants were asked to reflect on how they would feel if the events of their chosen memory were to recur in the future. To measure participants' emotional reactivity to the possibility of memory recurrence, participants were administered the valence subscale of the *Self-Assessment Manikin* (SAM; Bradley & Lang, 1994). The SAM is a pictorial scale which features nine figures depicting a range of affective elements. The valence subscale specifically features 9 figures displaying faces ranging from sad to happy.

Mental Imagery Questions

Mental Image Description. Participants were provided with an open text box and instructed to describe their mental images of themselves within their memory in one or two sentences.

Mental Image Meaning 1. Participants were asked to briefly explain what their mental image meant about themselves as a person using an open text box response.

Mental Image Meaning 2. Participants were also asked to describe what their mental image meant about who they are and how other people treat them using an open text box.

Mental Image Valence. Participants used a 5-point Likert scale (1- Extremely positive, 5- Extremely negative) to rate how negative or positive they felt about their mental image.

Mental Image Accuracy. Participants indicated the degree to which they believed their mental image to be an accurate reflection of themselves as a person using a 5-point Likert scale (1- Strongly disbelieve, 5- Strongly believe).

Sleep Instructions

Participants assigned to the sleep quality enhancement group were provided with the following set of research-backed recommendations to increase the quality of their subsequent night's sleep:

1. Avoid caffeine, alcohol and/or nicotine at least 8 hours before bed (Drake et al., 2013; Garcia & Salloum, 2015; Spadola et al., 2019)

2. Avoid vigorous or high intensity exercise (e.g., running, sports) at least 2 hours before bed (Alnawwar et al., 2023; Oda & Shirakawa, 2013).

3. Try to engage in a calming activity before bed to help you relax and wind down. Examples of relaxing activities include: meditation, reading, taking a hot bath or gentle stretching (Tucker et al., 2008; Turmel et al., 2022).

4. While you don't want to go to bed hungry or thirsty, avoid heavy meals and large amounts of liquids before bed (Crispim et al., 2011; Iao et al., 2021; Kinsey & Ormsbee, 2015).

Sleep Diary

To measure subjective and objective measures of sleep quality, participants were provided with an online sleep diary adapted from Carney et al. (2012). Sleep diaries are commonly used in sleep research, as they are highly accessible, inexpensive and easy to use (Buyssse et al., 2006; Carney et al., 2012). Importantly, they also allow for the collection of key sleep data which can be used to calculate several sleep variables that are related to overall sleep quality. In line with sleep research guidelines, oft-reported sleep variables include: total sleep time, sleep onset latency, sleep efficiency, wake after sleep onset and nocturnal awakenings (Ohayan et al., 2017), although additional items related to subjective sleep quality ratings and sleepiness, and the timing of wake-promoting activities or substance consumption are also common (Carney et al., 2012; Morin, 1993). For the purpose of this thesis, only sleep efficiency, total sleep time and subjective sleep quality were analyzed.

The diary provided to participants included eight of the original items from Carney et al. (2012) which assess variables such as: a) the total amount of time participants spent in bed (e.g., "What time did you get into bed? Write the time that you got into bed. This may not necessarily be the time you began trying to fall asleep."); b) the total amount of time participants spent sleeping (e.g., "What time did you try to fall asleep? Write the time that you began 'trying' to

fall asleep."); c) the amount of time the participant spent awake after first falling asleep, referred to as wake after sleep onset ("In total, how long did these awakenings last? The total time you were awake between the time you first fell asleep and your final awakening. For example, if you woke 3 times for 20 minutes, 35 minutes, and 15 minutes, add them all up [20+35+15= 70 min or 1 hr and 10 min]"); and d) the participants' subjective sleep quality rating, which was evaluated on a 5-point Likert scale ranging from 1 (very poor) to 5 (very good).

Two of the original items were modified by providing multiple-choice responses instead of free-entry. The first item measured the amount of time it took for participants to fall asleep, also referred to as sleep onset latency, which was assessed using a 5-point multiple choice scale ranging from "0-15 minutes" to "60+ minutes". The second question assessed the number of awakenings the participant experienced after falling asleep using a 7-point multiple choice scale ranging from "0 times" to "5+ times". A third item was rewritten for clarity and brevity, which asked participants to indicate how long after their final awakening they spent trying to sleep, a variable which is used to calculate total time in bed.

Nine additional items were also added to the sleep diary. For instance, two items were included which asked participants whether they woke up earlier than expected and by how much earlier. Participants also indicated when their final consumption of caffeine, nicotine, alcohol, and other recreational substances was relative to their sleep, using a 7-point multiple choice scale with answers ranging from 1 (1-2 hours before bed) to 7 (I did not consume [substance] yesterday). To assess the typicality of their sleep during the study to their habitual sleep, participants rated their habitual sleep quality, using a 5-point scale developed by Fudge et al., (2024) with responses ranging from 1 ("I suffer from chronic sleep loss and feel that my daytime functioning is impaired due to the poor quality of my sleep") to 5 ("I have no trouble sleeping

and usually feel that I get enough sleep and am well-rested"), and the typicality of their sleep, with a response scale ranging from 1 (very unlike my typical sleep pattern) to 4 (very similar to my typical sleep pattern). If participants indicated that their sleep differed from their habitual sleep pattern, they were asked to identify in what ways their sleep varied by selecting from a list of possible deviations (e.g., "Slept more than I typically do", "I slept less than I typically do").

Procedure

Students with SPIN scores of 19+, no diagnosed sleep disorder, and the ability to speak, read and write in English fluently were eligible to sign up for all three parts of the study on the study webpage, which was hosted on the University of Waterloo SONA system. Once signed up, participants were able to access links that would redirect them to each part of the study on Qualtrics. Each part of the study was only accessible during a specific period of time within the study schedule, as described in detail below (see also Figure 1). Subsequent parts of the study could only be accessed upon completion of all prior study components.

Part 1. During part 1, participants completed baseline measures (T1) of schemas and affect. They were then instructed to recall a painful social autobiographical memory, in which they felt rejected, excluded or underappreciated. Participants who could recall a memory were asked to describe the event in a short writing task, before answering several questions about the memory characteristics (e.g., vividness, age) as well as participants' emotional reactions to the event currently and when considering the possibility of recurrence. Next, participants were instructed to form a mental image of themselves within their chosen memory and to describe the image in a few short sentences. Afterwards, the participant rated the valence, meaning and accuracy of the image.

Participants were then randomly assigned to either the IR or perceptual detail rescripting (control) conditions. The rescripting and perceptual control tasks were based on methods we have developed and implemented in prior work (e.g., Al-Uqaili et al., submitted; Romano et al., 2021; Sheldon et al., 2025). Individuals assigned to the IR condition completed a series of writing tasks during which they were guided to reimagine and describe a more satisfying outcome to their distressing memory, such that they were able to better meet the needs of their younger self at the time of the event (See Appendix A for full instructions). Conversely, participants in the perceptual control condition were asked to reflect upon and describe the perceptual details of their memory (e.g., who was there, what was said) in several brief writing tasks. Upon completion of their respective writing tasks (T2), all participants described their chosen memory once more, this time incorporating the details they focused on during rescripting. Next, participants visualized an updated image of themselves in the rescripted memory and described the image in a few sentences, before completing the mental image questions and same measures of schemas and affect from T1.

Next, participants were randomly assigned to the sleep quality enhancement or sleep-as-usual conditions. Participants in the sleep quality enhancement condition were provided with a set of research-backed sleep enhancement recommendations to follow the subsequent night. Individuals assigned to the sleep-as-usual condition were not provided with any specific sleep instructions beyond maintaining their habitual sleep schedule.

Part one of the study lasted approximately 45 minutes and took place on experimental day 1, between the hours of 9am and 3pm, to ensure participants had adequate time to follow the provided sleep quality enhancement tips before going to bed.

Part two. The day after completing part one of the study, participants were asked to complete a sleep diary within one hour of waking, to ensure the most accurate recollection of sleep details. The sleep diary contained questions related to sleep quality, length, and timing, in addition to prompting the participant to reflect upon the typicality of their previous nights' sleep to their habitual sleep experience. Moreover, participants were asked to indicate whether they had consumed caffeine, alcohol, nicotine and/or recreational substances the day before, and when, relative to sleep, the timing of their consumption(s) occurred. In total, the second part of the study took approximately 20 minutes to complete.

Part three. The third part of the study (T3) took place on experimental day two, between the hours of 7am-11:59pm, and took approximately 45 minutes to complete. Participants were allowed to complete part three at any time during this timeframe, as long as they had already completed the second part of the study. During this part of the study, participants were instructed to bring to mind and recount in a few short sentences the original (non-rescripted) negative autobiographical memory they used in part one of the study. After briefly writing about the original event, participants answered the same set of questions about the memory's characteristics and their emotional responses to potential event recurrence. Next, participants were prompted to reflect upon the writing tasks they completed the previous day and summarize the elements of the memory they focused upon during these tasks. The purpose of this step was to prime participants' recollection of the IR or perceptual control task they completed during part one of the study and enhance their memory of their final, updated mental image of the event. Afterwards, participants imagined and briefly described the updated mental image of themselves in the memory. Once participants finished writing about the updated image, they were asked to describe what the mental image of themselves in the memory looked like presently and answered

questions about the valence and meaning of the current mental image. Participants then completed the same battery of cognitive and affective measures from T1 and T2, before being debriefed and given the opportunity to provide feedback.

Data Analysis Strategy

All statistical analyses were performed using R (R Core Team, 2026). To examine how IR (vs. control) impacted outcome measures over time, a series of multilevel models were conducted. All models were two-level random intercepts models in which repeated measures (Level 1) were nested within participants (Level 2), and the variables of Time, IR condition and their interactions were entered as fixed effects. See Deviations from Pre-Registration below for description of how sleep variables were incorporated into these models. All multilevel models were performed using the *lmerTest* package (Kuznetsova et al., 2017) and contrasts were computed using *emmeans* (Lenth & Piaskowski, 2025). A-priori planned contrasts were performed for variables with three time-points using estimated marginal means to explore differences in rates of change between the IR conditions and pre-intervention (T1), post-intervention (T2) and follow-up (T3). To account for multiple testing, the Benjamini-Hochberg correction was used. Effect sizes for planned contrasts were calculated using standardized mean differences.

It is important to note, that for ease of readability, only models with statistically significant effects are reported here. Moreover, within the models that are reported, only statistically significant effects are reported.

Prior to analyses, all outliers (n = 6) underwent 99% winsorization, in which data points exceeding +/- 2.33 standard deviations were replaced by the value which corresponded with the

1st and 99th percentiles. The data were also assessed for data missingness and models were screened for normality, linearity, homoscedascity and multicollinearity. Across all models, these analyses did not reveal significant violations of assumptions and missing data was minimal (<5%). For these reasons, in addition to the robustness of MLM to violations of assumptions and ability to handle missing data, all data were retained and no transformations or imputations performed. Descriptive statistics for each variable are provided in Table 1 and variable correlations are listed in Table 2.

Deviations from Pre-Registration

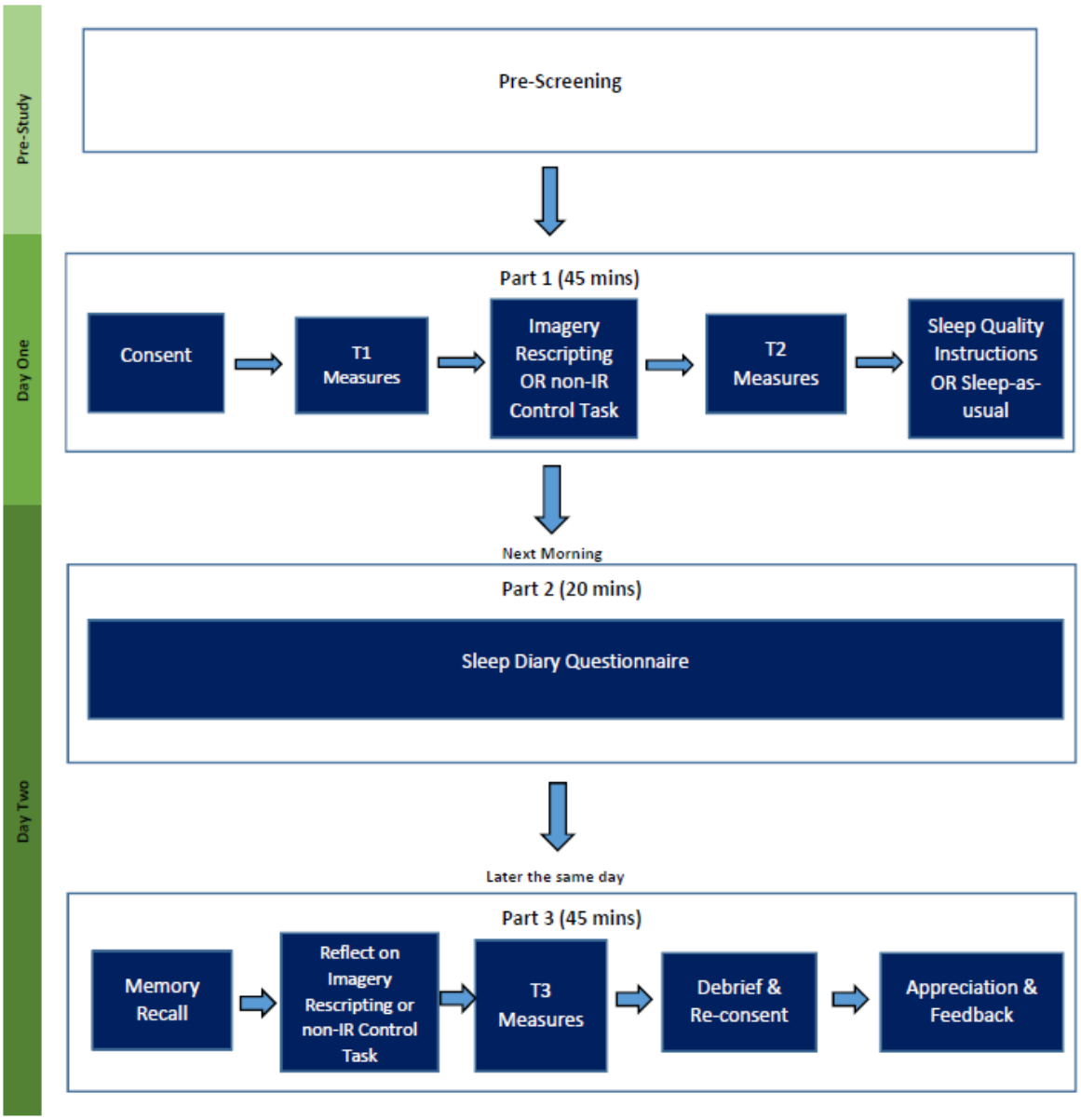
As noted above, data collection is ongoing for this project and will cease once the full desired sample size is achieved. For the sake of this MA thesis with a hard deadline of August 2026, analyses were conducted on data that had been collected by our predetermined thesis data cut-off date of June 5, 2026. Notably, this cut-off date is a deviation from the one original provided in our pre-registration (March 31, 2026). In early March 2026, we were still showing low levels of recruitment, and in response to concerns about the small sample size and limited power for subsequent statistical analyses, we opted to delay data analyses until June 2026, in an effort to recruit to extend recruitment efforts. Ultimately, we conducted analyses on N = 31 participants (14 in the Active IR condition and 17 in the Perceptual Control condition).

In our pre-registered analysis plan (https://osf.io/b5j29/), the primary and secondary analyses involved performing multilevel models with both the IR and sleep intervention conditions as fixed effects. Of the 14 participants assigned to the IR condition, 7 were further assigned to the sleep enhancement instructions, and 7 to the sleep-as-usual instructions. Of the 17 participants assigned to the Perceptual Control condition, 7 were further assigned to the sleep enhancement instructions, and 10 to the sleep-as-usual instructions. However, given our small

current sample size, our ability to draw reliable conclusions from any analyses between the four experimental groups would have been limited. Thus, thesis analyses were based on models which included only the IR condition as a fixed effect, with specific sleep variables added as continuous moderator variables to explore how sleep quality interacted with the IR conditions. These analyses were followed up by contrasts to explore significant interactions. To account for multiple testing, the Benjamini-Hochberg correction was applied, and only contrasts with significant corrected p-values will be reported here. Data analyses conforming with our preregistered plan will be conducted in the future once a sufficiently large sample has been recruited.

Figure 1.

Experimental Procedure



Results

IR Models

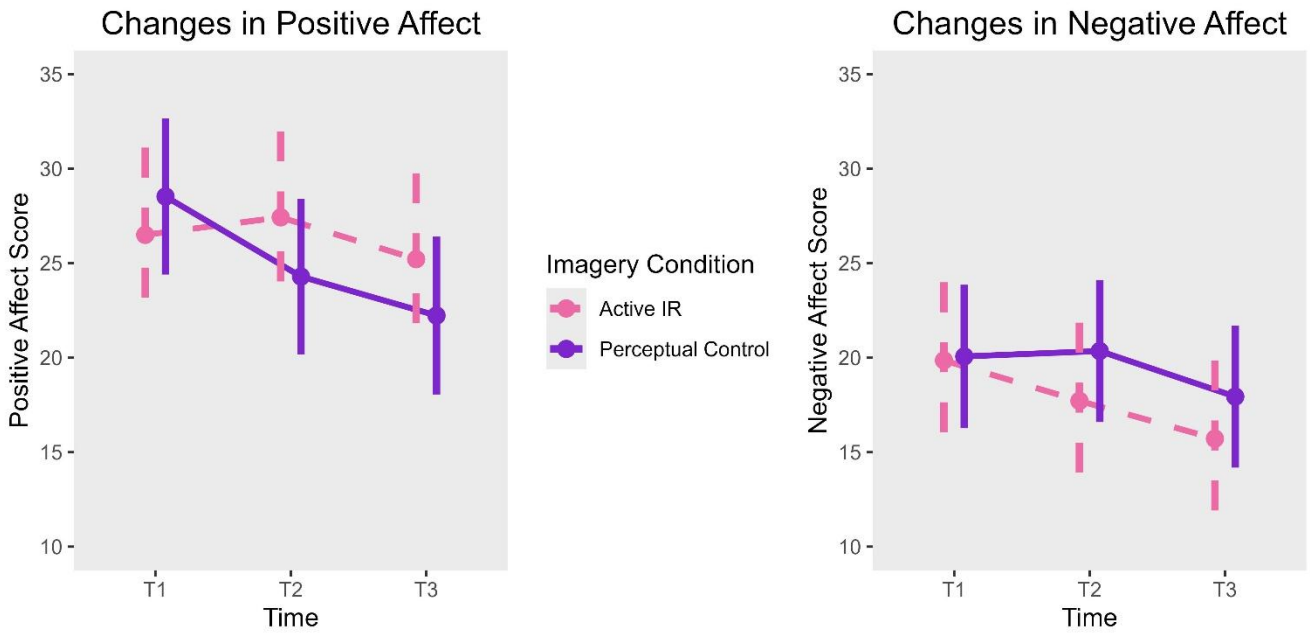
Affect

The positive affect model produced a significant Time x IR condition interaction. Planned contrasts revealed, as shown in Figure 2, that relative to the perceptual control condition, individuals in the active IR condition showed smaller reductions in positive affect from T1 to T2 (b = -5.16, SE = 2.33, t = -2.21, p = .031, d = 0.60), and T1 to T3 (b = -5.01, SE = 2.34, t = -2.13, p = .038, d = 0.58). Using Cohen's (1988) conventional benchmarks for standardized mean differences, these effects correspond to medium-sized effects. However these effects did not remain statistically significant following the Benjamini-Hochberg correction (both ps = .057). In the positive affect model, the fixed effects accounted for approximately 5.9% of the variance in positive affect (marginal R^2 = .059).

The negative affect model revealed a significant main effect of time, such that all participants experienced a significant reduction in negative affect from T1 to T3, regardless of IR condition (b = -4.14, SE = 1.38, t = -3.00, p = .004, d = .041; see Figure 2). Using Cohen's (1988) effect sizes guidelines, this effect corresponds to a small-sized effect. Follow-up contrasts did not reveal significant differences between the IR conditions across time. Within the model, the fixed effects explained 4.2% of the variance in negative affect (marginal R^2 = .042).

Figure 2

Changes in Positive and Negative Affect Across Time and Conditions



Note. Differences in positive and negative PANAS subscale scores between the IR conditions at pre-intervention (T1), post-intervention (T2), and 1-day follow-up (T3).

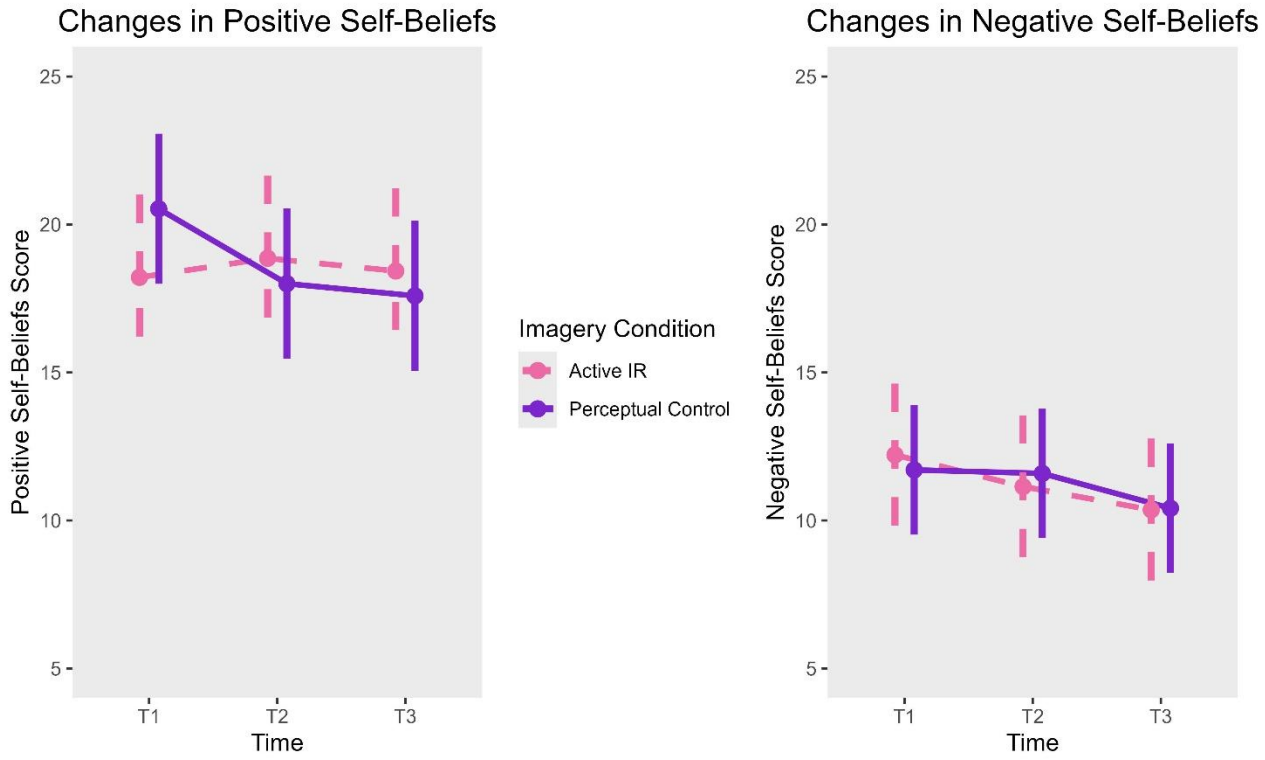
Schemas

The positive self-schema model revealed a significant Time x IR condition interaction. Follow up contrasts showed that compared to the decreases in positive schema strength observed across time in those assigned to the perceptual control condition, individuals in the active IR condition showed slight increases from T1 to T2 (b = 3.17, SE = 1.38, t = 2.30, p = .025, d = 0.61) and stable positive self-schemas from T1 to T3 (b = 3.15, SE = 1.38, t = 2.28, p = .026, d = 0.61). These effects are considered medium-sized (Cohen, 1988), and remained statistically significant after the Benjamini-Hochberg correction (both ps = .039). In the model, the fixed effects accounted for 3.4% of the variance in positive self-schemas (marginal R^2 = .034).

The negative self-schema model revealed a significant main effect of Time, such that all participants experienced significant decreases in their negative self-schema scores from T1 to T3 (b = -1.86, SE = 0.76, t = -2.44, p = .018, d = 0.35). This effect is classified as a small-sized effect (Cohen, 1988). Planned contrasts did not reveal significant changes in scores across time between the two conditions. In the model, the fixed effects accounted for 2.2% of the variance in negative self-schemas (marginal R^2 = .022).

Figure 3

Changes in Valence and Content of Schemas Across Time and Conditions



Note. Differences in positive and negative self-schema subscale scores from the BCSS at pre-intervention (T1), post-intervention (T2), and 1-day follow-up (T3).

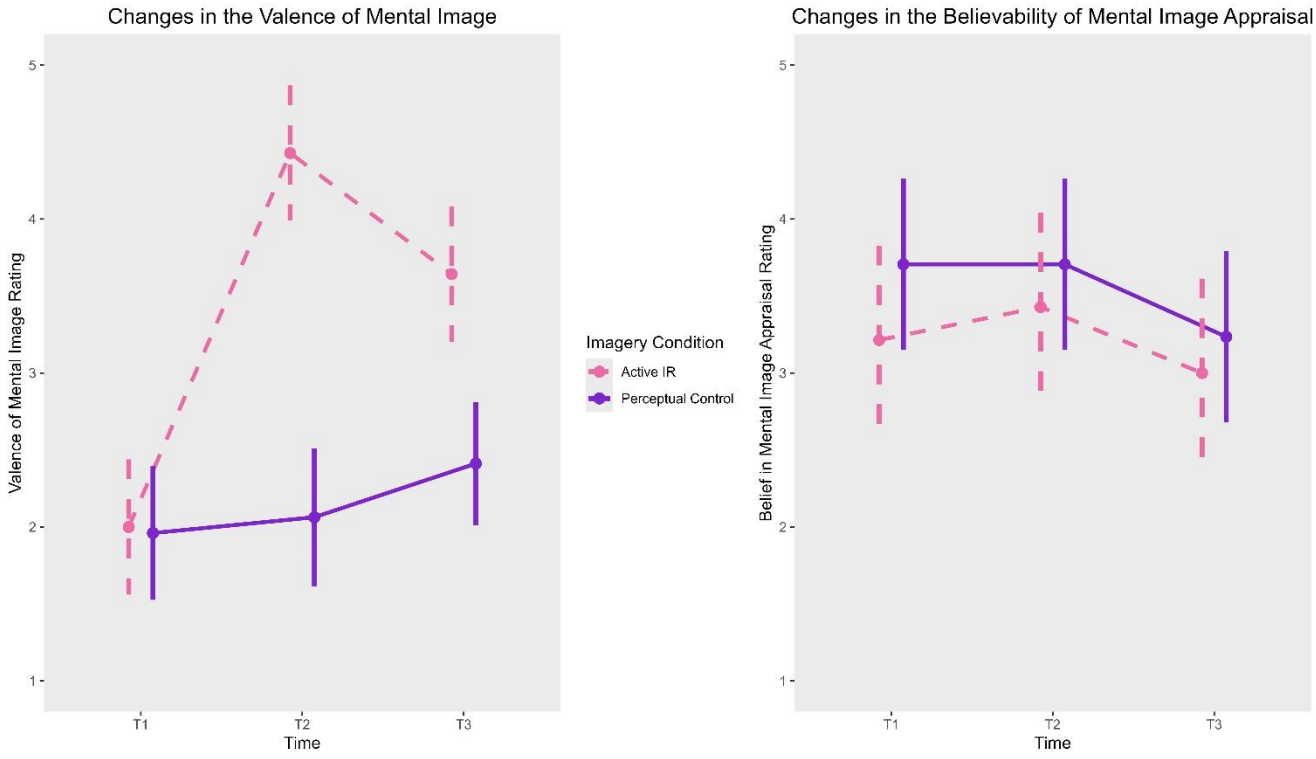
Mental Image

Changes in the valence of the participants' mental image of themselves within the memory and the strength of the participants' belief in the accuracy of the image appraisal were also assessed by entering each rating in separate models. The mental image valence model revealed a significant main effect of Time, such that all participants showed significant increases in the positivity of their ratings from T1 to T2, (b = 2.43, SE = 0.25, t = 9.81, p < .001 , d = 1.01), T2 to T3, (b = -0.79, SE = 0.25, t = -3.17, p = .003, d = 0.18), and T1 to T3, (b = 1.64, SE = 0.25, t = 6.64, p < .001 , d = 0.84). These effects are considered very large (T1 to T2), very small (T2 to T3), and large (T1 to T3) effect sizes. Significant Time by IR condition interactions also emerged. Planned contrasts showed that compared to the perceptual control group, the active IR group had significantly larger increases in valence scores from T1 to T2, (b = 2.33, SE = 0.35, t = 6.56, p < .001 , d = 1.86), T2 to T3, (b = -1.13, SE = 0.35, t = -3.24, p = .002, d = 0.95), and from T1 to T3, (b = 1.19, SE 0.35, t = 3.45, p < .001 , d =0.91). Based on Cohen (1988) benchmarks for effect sizes, these effects are considered very large (T1 to T2) and large-sized effects (T2 to T3, and T1 to T3). These effects remained significant after the Benjamini-Hochberg correction ($p_{T1\text{-}T2}$ < .001, $p_{T2\text{-}T3}$ = .002, $p_{T1\text{-}T3}$ = .002). Within the image valence model, fixed effects explained 56.5% (marginal R^2 = .565) of the variance in image valence ratings.

The belief in the accuracy of the mental image appraisal model revealed no significant main effects of Time, nor any significant Time by IR condition interactions. Similarly, planned contrasts did not yield significant differences between the IR conditions in the rates of change in strength of image appraisal scores over time. Within the model, fixed effects (marginal R^2 = .049) explained 4.9% of the variance in the strength ratings.

Figure 4

Changes in Mental Image Valence and in Strength of Belief in Mental Image Appraisal Across Time and Conditions



Note. Differences in participants' mental image valence and strength of belief in the accuracy of the mental image appraisal from pre-intervention (T1), post-intervention (T2), and 1-day follow-up (T3). Higher scores on this scale indicate more positive ratings of the valence of the image.

Memory Distress

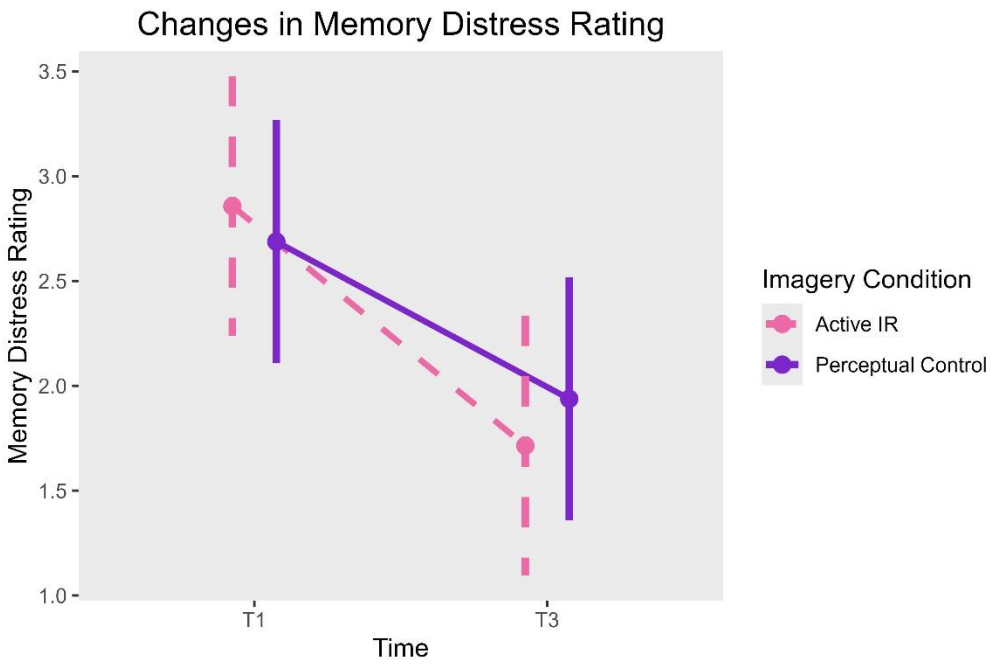
The memory distress model revealed a significant main effect of Time, indicating that all participants showed significant reductions in memory distress ratings from T1 to T3, (b = -1.14, SE = 0.28, t = -4.08, p < .001, d = 0.77), a medium to large effect (Cohen, 1988). Within the model, fixed effects accounted for 14.7% of the variance in memory distress ratings (marginal R^2 =.147).

Event Recurrence

The valence of participants' affective response to memory event recurrence model did not reveal any significant main effects or interactions (see Figure 6). Within the model, fixed effects accounted for 2.7% of the variance of valence of emotional reaction scores (marginal R^2 =.027).

Figure 5

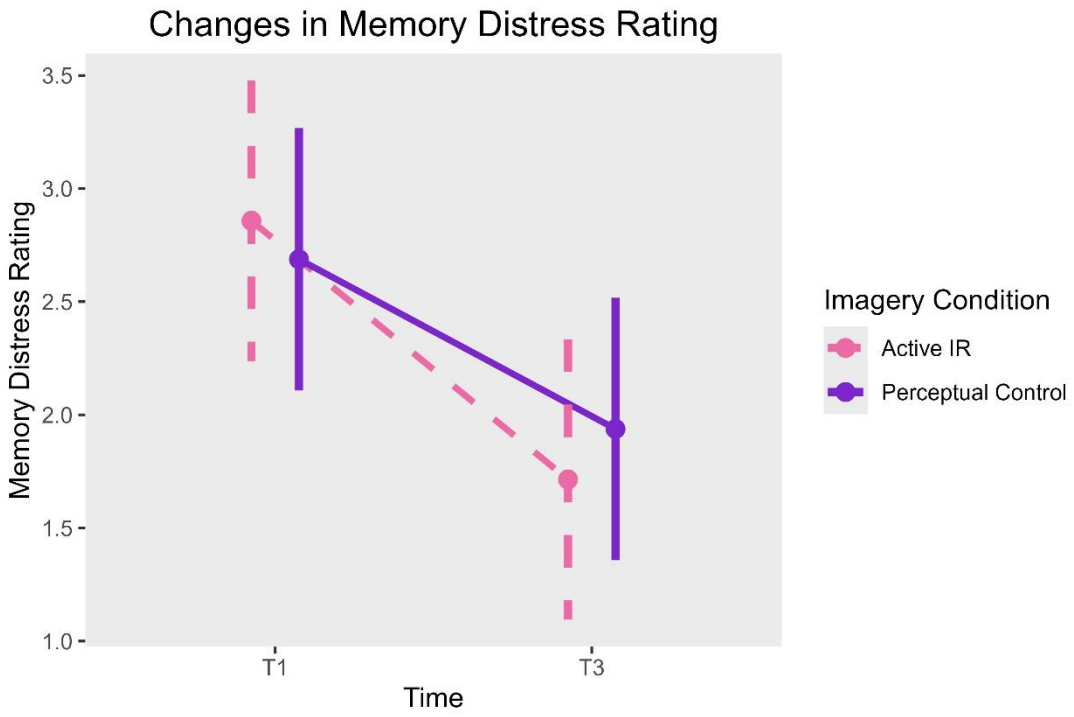
Changes in Ratings of Memory Distress Across Time and Conditions



Note. Differences in participants' ratings for memory distress from pre-intervention (T1) to 1-day follow-up (T3).

Figure 6

Changes in Valence of Emotional Response to Event Recurrence Across Time and Condition



Note. Differences in participants' ratings for the valence of emotional reactions when considering the possibility of the recalled event recurring in the future, from pre-intervention (T1) to 1-day follow-up (T3).

Moderation Analyses

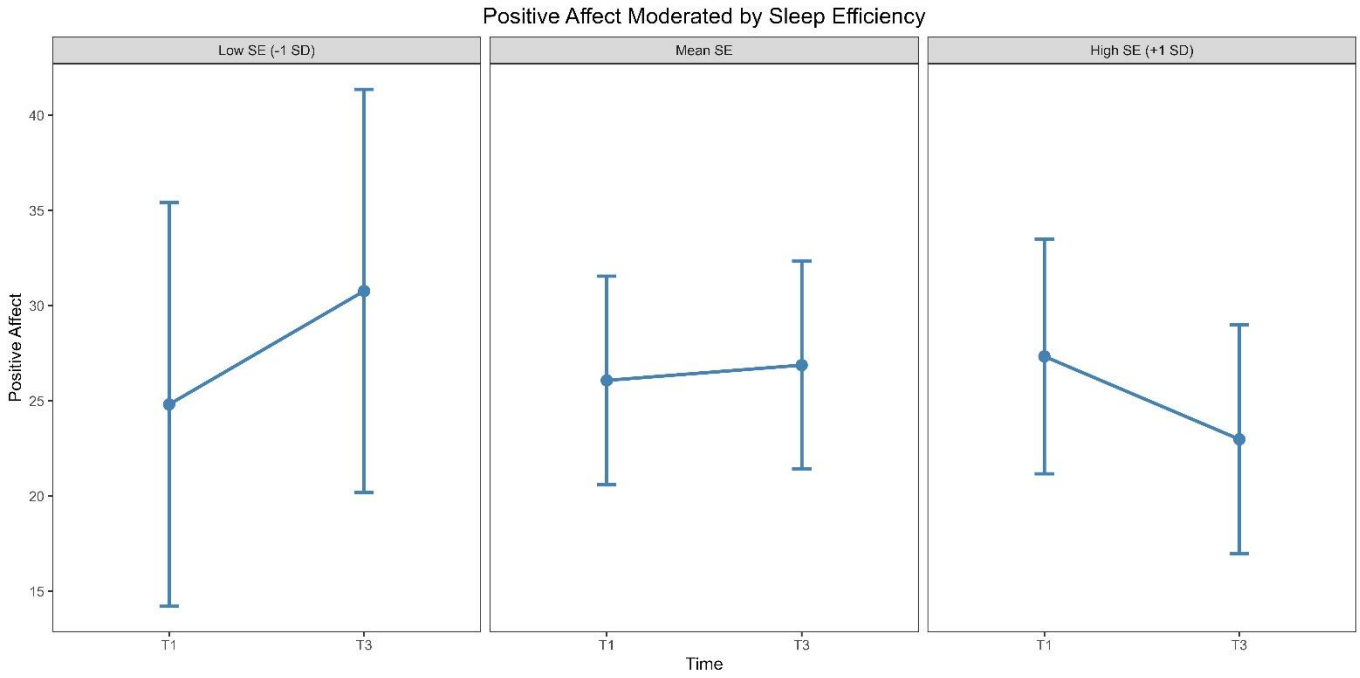
Sleep Efficiency

Moderating Effects of Sleep Efficiency on Positive Affect

The positive affect model revealed a significant Time by Sleep efficiency interaction from T1 to T3, (b = -128.89, SE = 59.81, t = -2.16, p = .005), indicating that the rate of change in positive affect from T1 to T3 significantly varied across levels of sleep efficiency. As illustrated in Figure 7, individuals reporting low SE showed increased positive affect from T1 to T3, while those with high sleep efficiency demonstrated decreased positive affect. A significant 3-way interaction between Time x IR condition x Sleep efficiency was also observed from T2 to T3, (b = 161, SE = 68.45, t = 2.36, p = .022), indicating that the rate of change between the IR conditions from T2 to T3 significantly differed across levels of sleep efficiency. Planned contrasts confirmed that at low sleep efficiency, individuals in the active IR condition unexpectedly experienced increased positive affect from T2 to T3 whereas individuals in the perceptual control condition reported decreases in positive affect from T2 to T3, (Low: b = 11.71, SE = 4.15, t = 2.83, p_{BH} = .030, d = 1.36; See Figure 8), a very large effect (Cohen, 1988). Positive affect change between the IR conditions from T2 to T3 amongst participants reporting high sleep efficiency was not statistically different.

Figure 7.

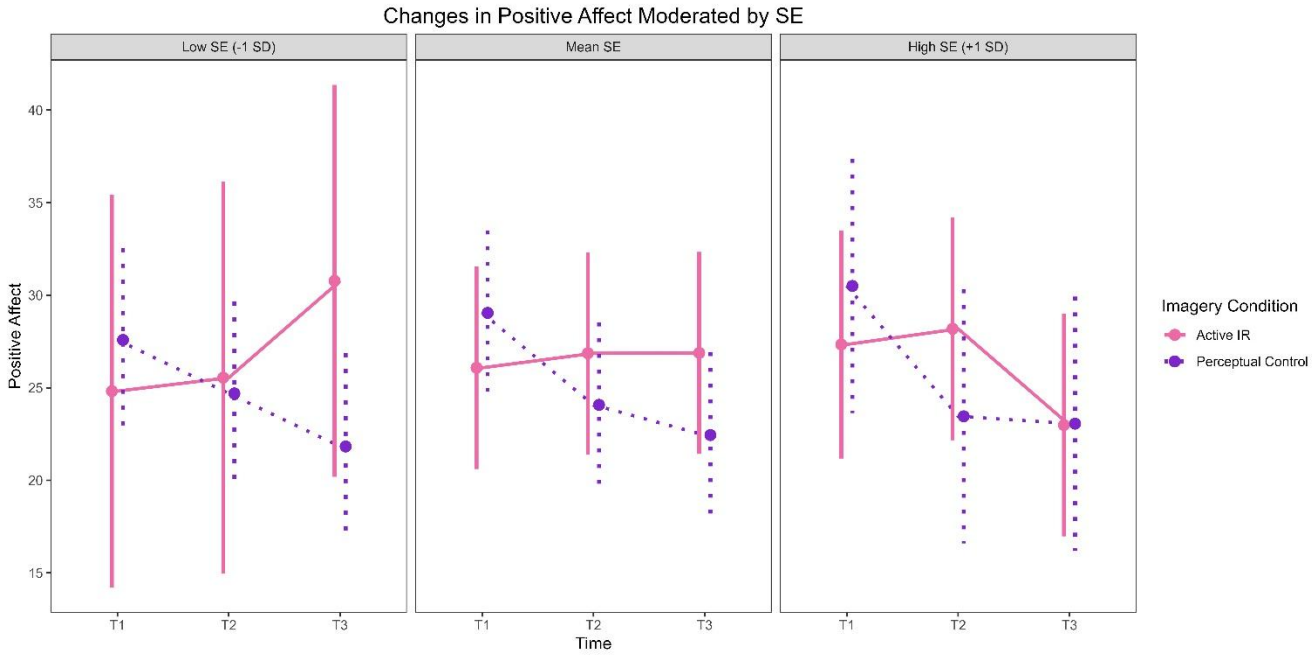
Time x Sleep Efficiency Interaction Effect on Positive Affect Scores Across Time Collapsed Across Conditions



Note. Changes in positive affect subscale scores on the PANAS by sleep efficiency level from pre-intervention (T1) to 1-day follow-up (T3) is shown collapsed across conditions.

Figure 8

Time x IR Condition x Sleep Efficiency Interaction Effect on Positive Affect



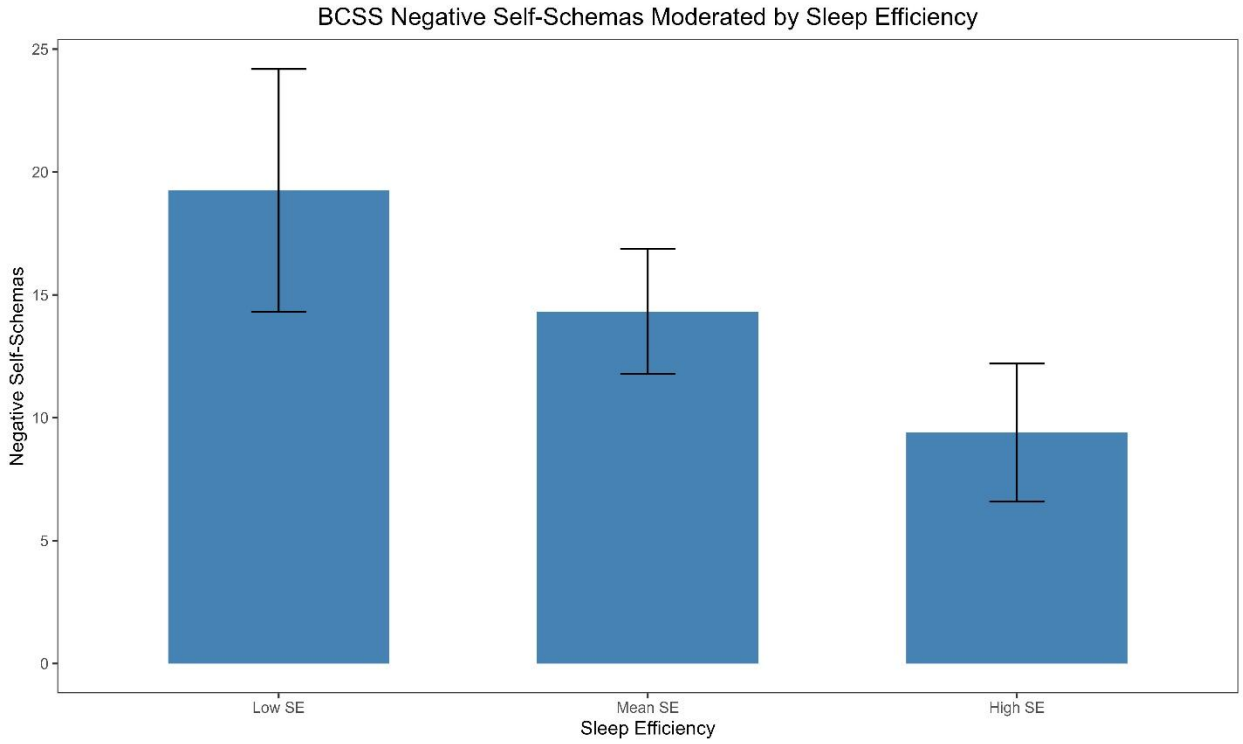
Note. Changes in positive affect subscale scores on the PANAS, between condition and across levels of sleep efficiency, at pre-intervention (T1), post-intervention (T2) and 1-day follow-up (T3).

Moderating Effects of Sleep Efficiency on Negative Self-Schemas

The negative self-schemas model revealed only a significant main effect of sleep efficiency, such that individuals with better sleep efficiency had significantly lower negative self-schema scores, (b = -123.14, SE = 39.03, t = -3.16, p = .003; see Figure 9).

Figure 9.

Main Effect of Sleep Efficiency on Negative Self-Schemas



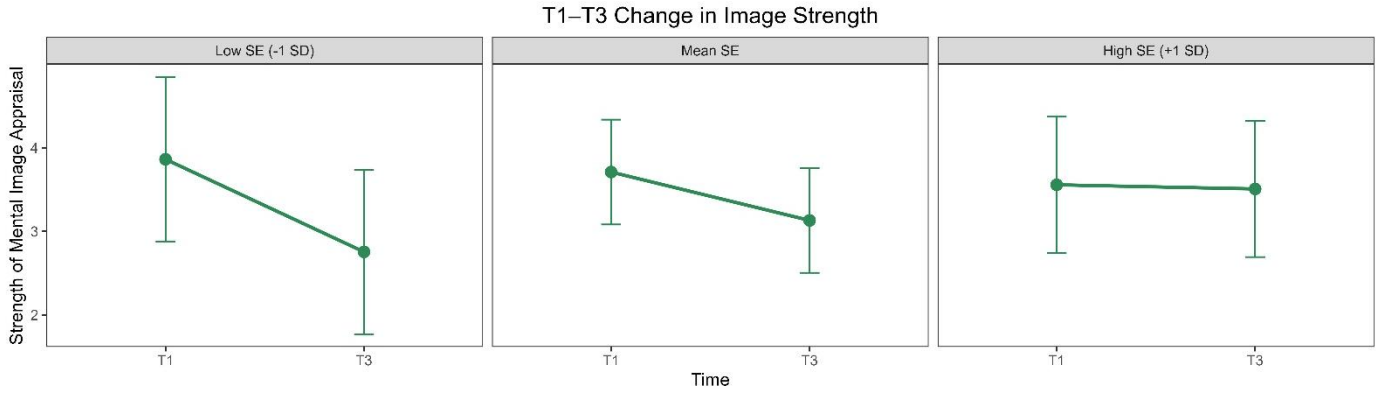
Note. Changes in negative self-schema subscale scores on the BCSS at different levels of sleep efficiency, collapsed across condition and time.

Moderating Effects of Sleep Efficiency on Mental Image Appraisal Strength

The strength of mental image appraisal model revealed significant Time x sleep efficiency interactions from T1 to T3, (b = 27.10, SE = 11.65, t = 2.33, p = .024), suggesting that the change in mental image strength scores from T1 to T3 changed significantly depending on sleep efficiency levels (see Figure 10). As sleep efficiency increased, the rate of change from T1 to T3 decreased, with individuals reporting high sleep efficiency reporting more stable image appraisal strength scores across time. Additionally, a significant condition by sleep efficiency interaction emerged, (b = 31.21, SE = 12.35, t = 2.53, p = .014; see Figure 11). Specifically, participants in the active IR condition reported stable scores, while those in the perceptual control condition reported stronger belief in the accuracy of their image appraisal scores, leading to larger differences between the two groups as sleep efficiency increased. Three-way Time x condition x sleep efficiency interactions were also significant, from T1 to T3, (b = -27.72, SE = 13.59, t = -2.04, p = .046), as depicted in Figure 12. However, once the Benjamini-Hochberg correction was applied, the contrast analyses did not yield any statistically significant findings.

Figure 10

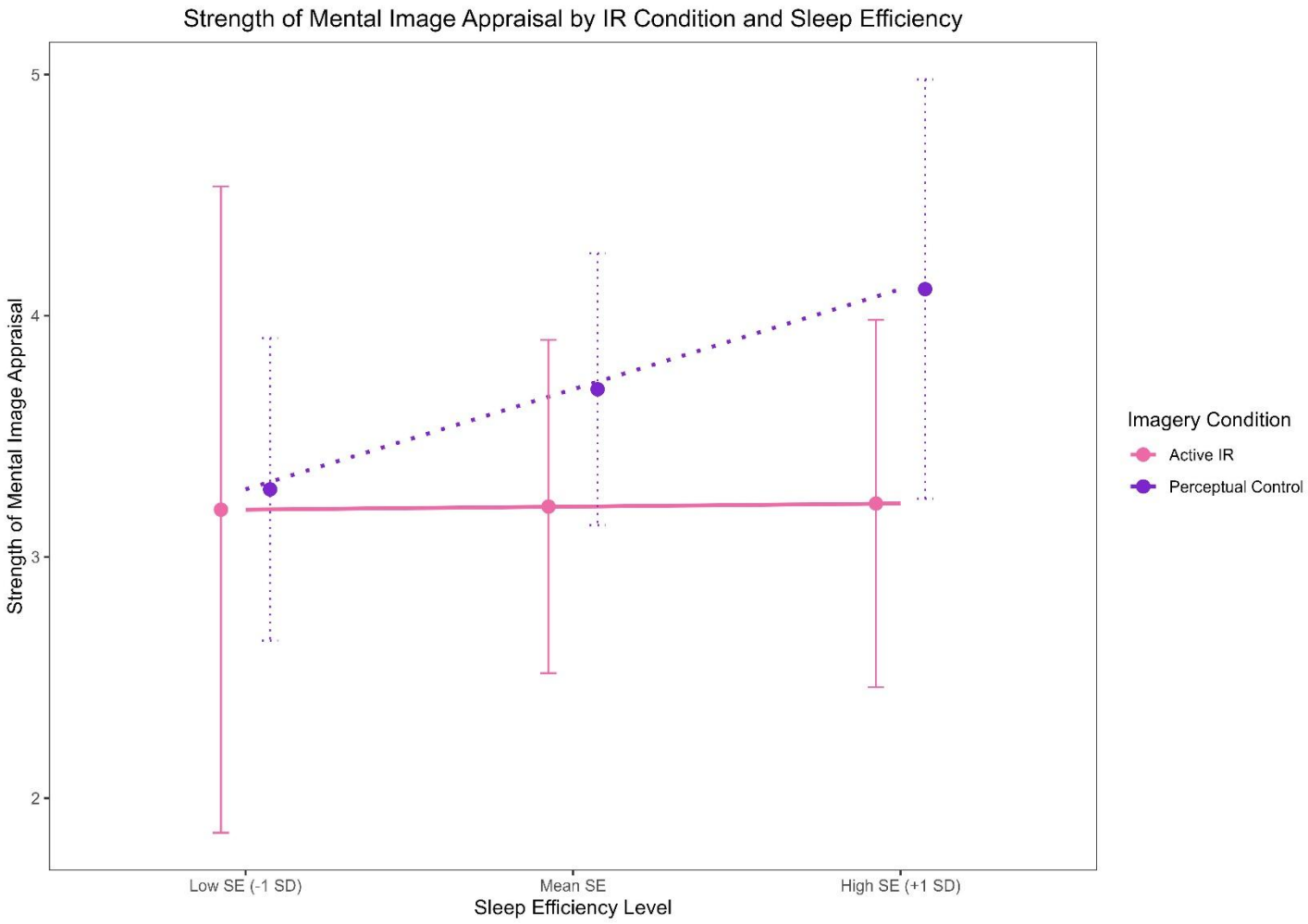
Time x Sleep Efficiency Interaction Effects on Strength of Mental Image Appraisal



Note. Changes in participants' ratings of the strength of the accuracy of their mental image appraisal across levels of sleep efficiency, from pre-intervention (T1) to 1-day follow-up (T3).

Figure 11

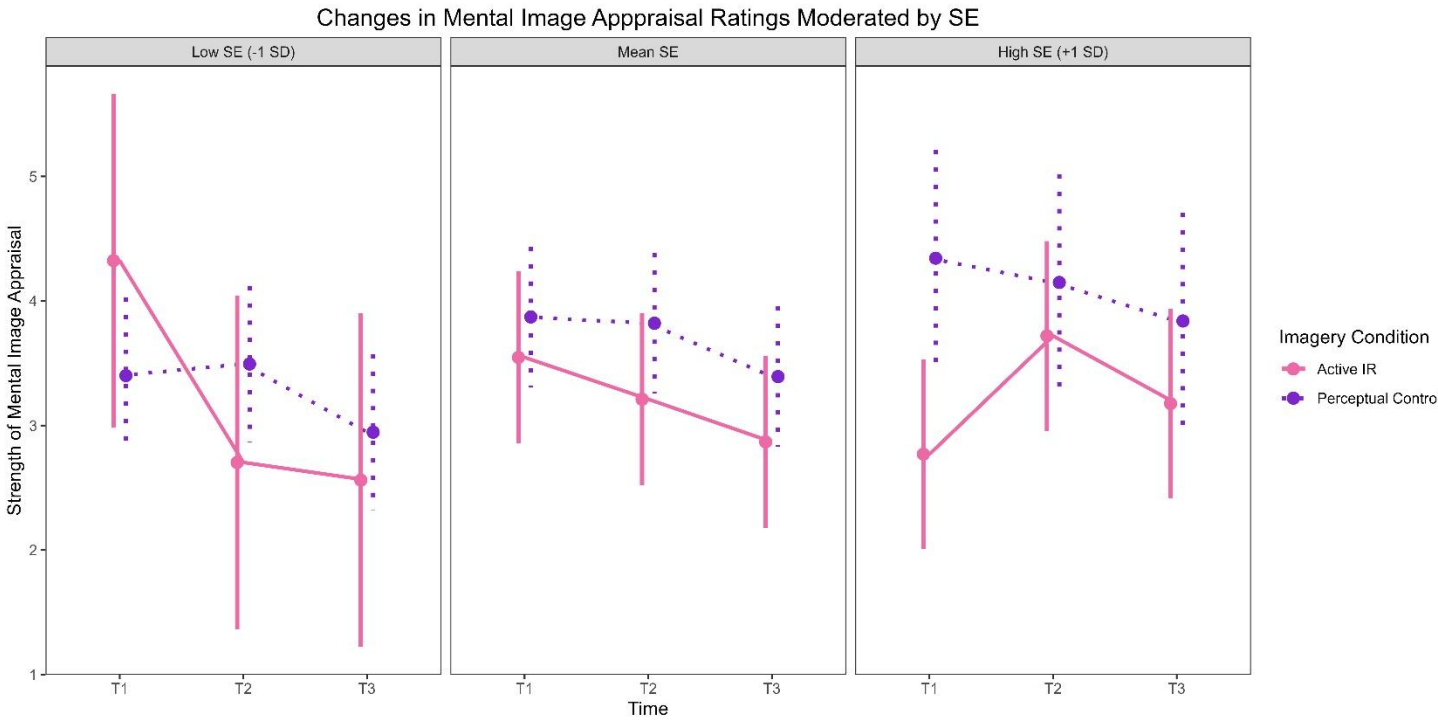
IR Condition x Sleep Efficiency Interaction Effect on Strength of Mental Image Appraisal



Note. Differences in participants ratings of the strength of the accuracy of their mental image appraisal between IR conditions and across levels of sleep efficiency.

Figure 12

Time x IR Condition x Sleep Efficiency Interaction Effects on Strength of Mental Image Appraisal



Note. Changes in participants' ratings of the strength of the accuracy of their mental image appraisal between IR condition and across levels of sleep efficiency, at pre-intervention (T1), post-intervention (T2), and 1-day follow-up (T3).

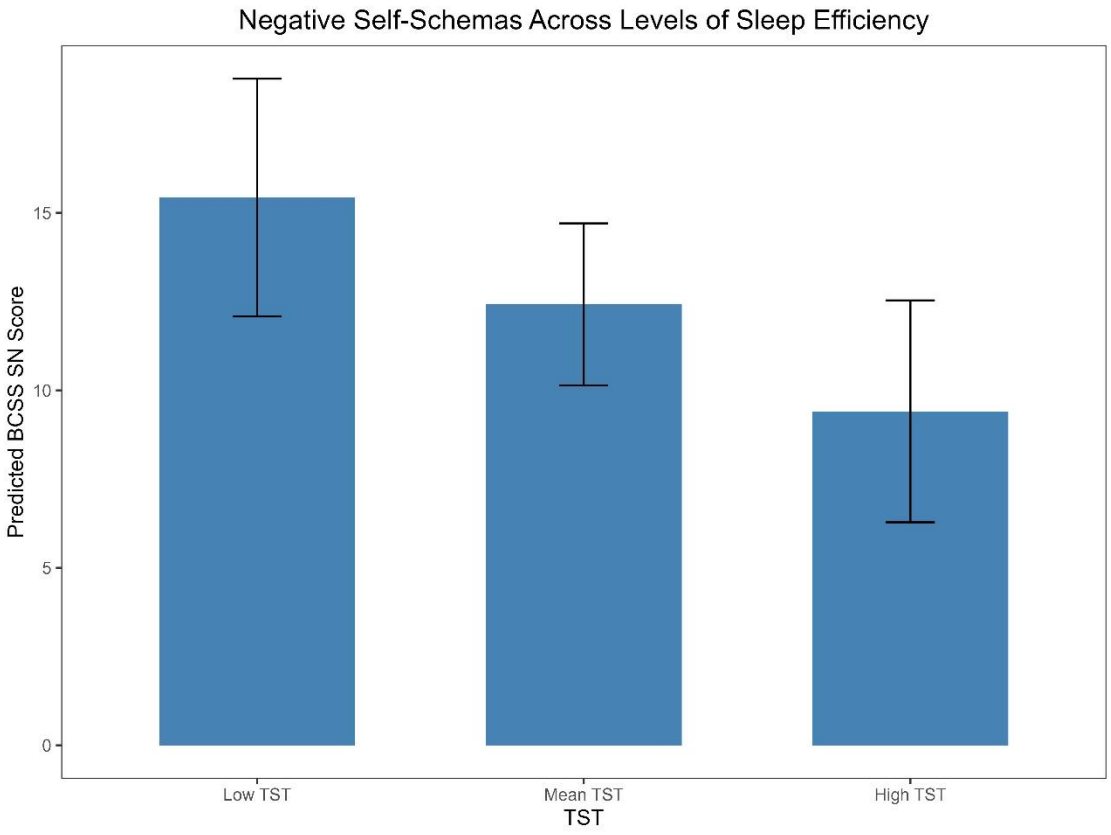
Total Sleep Time

Moderating Effects of Total Sleep Time on Negative Self-Schemas

The negative self-schema model yielded a significant main effect of total sleep time, suggesting a general trend toward increased total sleep time and decreased negative self-schemas, (b = -0.023 , SE = 0.009, t = -2.61, p = .013; See Figure 13). Furthermore, there was a significant condition x total sleep time interaction, (b = 0.030, SE = 0.012, t = 2.51, p = .014), demonstrating that there were significant changes in negative self-schema scores between the two conditions across levels of total sleep time. Specifically, participants in the active IR condition showed decreases in negative self-schemas as total sleep time increased, whereas those in the perceptual control group demonstrated slight increases in negative self-schemas over time (See Figure 14).

Figure 13

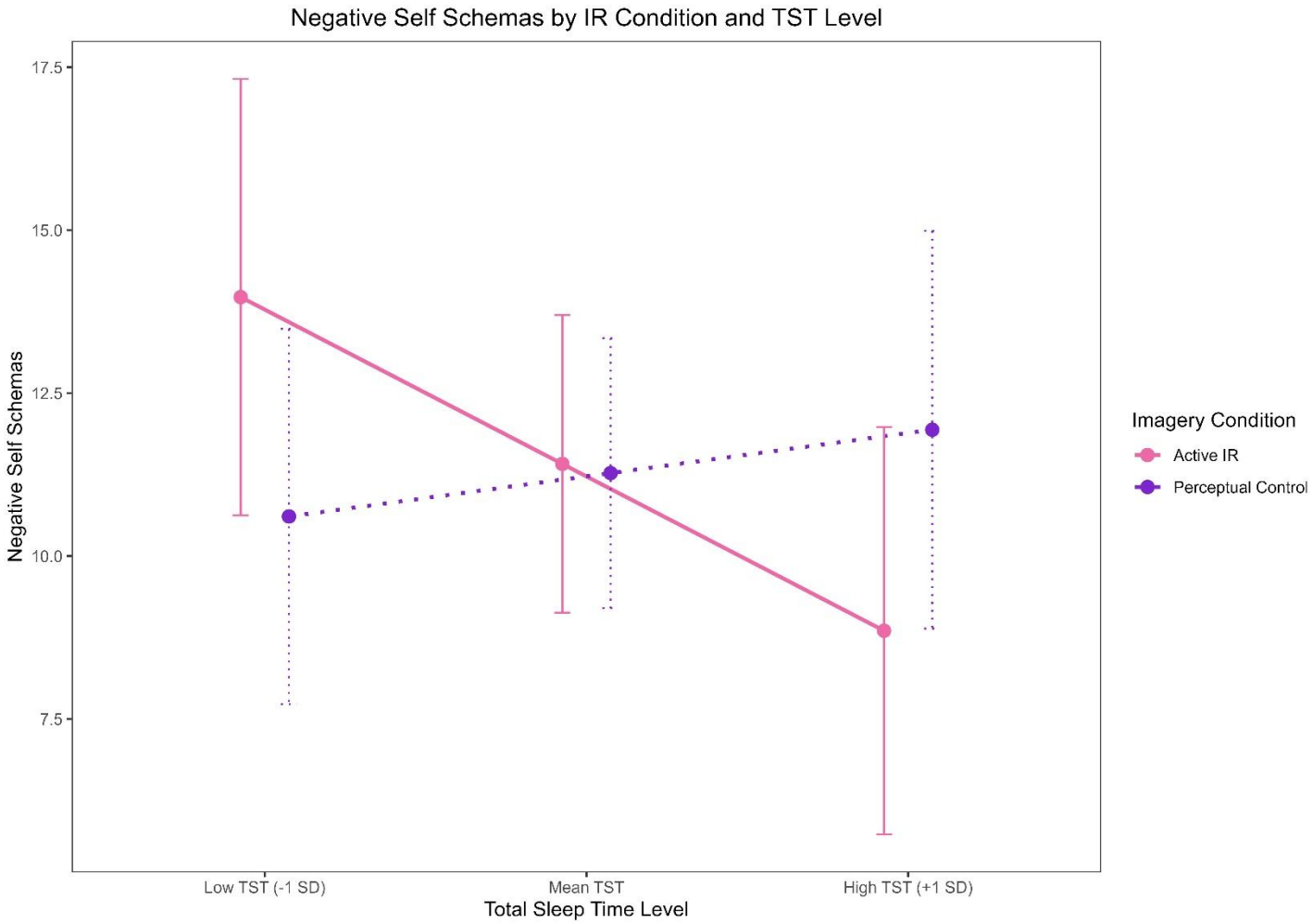
Main Effect of Total Sleep Time on Negative Self-Beliefs



Note. Changes in negative self-schema subscale scores on the BCSS at different levels of total sleep time (TST), collapsed across condition and time.

Figure 14

IR Condition x Total Sleep Time Interaction Effects on Negative Self-Schemas



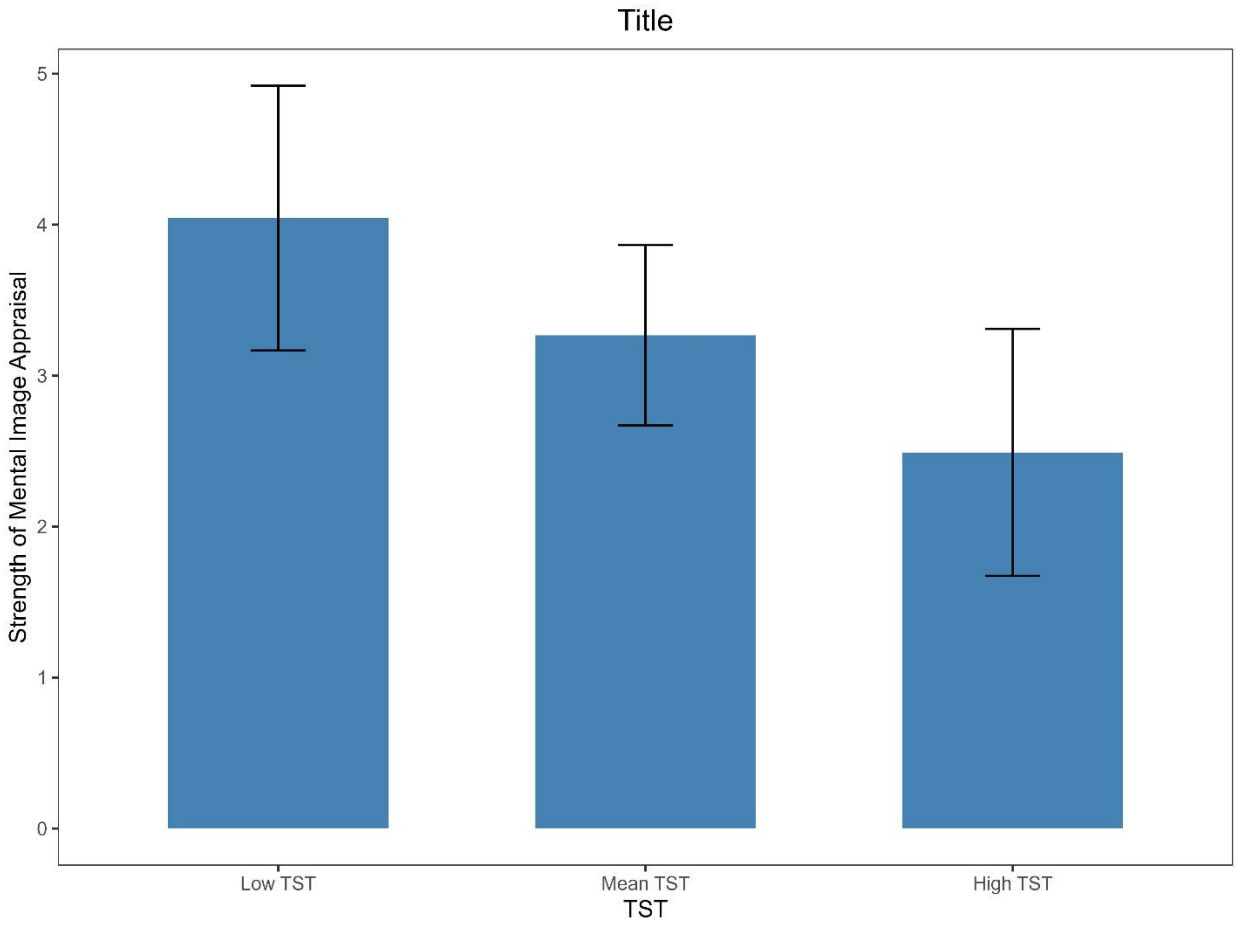
Note. Changes in negative self-schema subscale scores on the BCSS between IR conditions at different levels of total sleep time (TST).

Moderating Effects of Total Sleep Time on Mental Image Appraisal Strength

The strength of mental image appraisal model revealed a significant main effect of total sleep time, such that as total sleep time increased, ratings of the strength of the belief in the accuracy of the mental image appraisal significantly decreased, (b = -0.006, SE = 0.002, t = -2.57, p = .013; See Figure 15). Additionally, the interaction between condition x total sleep time was significant, (b = 0.009, SE = 0.003, t = 2.79, p = .007; See Figure 16), revealing that differences between the active IR and perceptual control groups increased as total sleep time increased, such that individuals in the perceptual control group rated their image appraisal as more accurate as total sleep time increased, whereas individuals in the IR condition reported more stable scores irrespective of total sleep time.

Figure 15

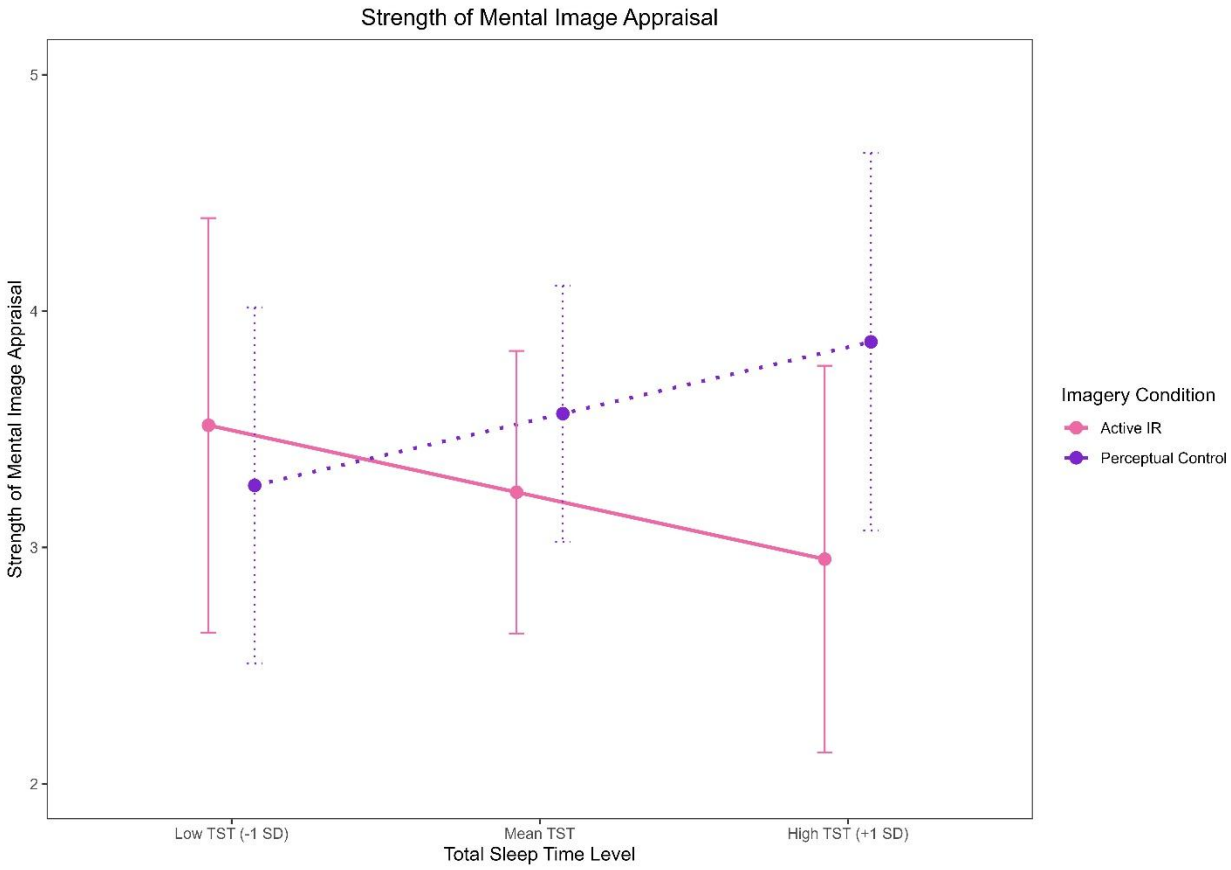
Main Effect of Total Sleep Time on Strength of Mental Image Appraisal



Note. Changes in participants' ratings of the strength of the accuracy of their mental image appraisal at different levels of total sleep time (TST), collapsed across condition and time.

Figure 16

Condition x Total Sleep Time Interaction Effect on Strength of Mental Image Appraisal



Note. Changes in participants' ratings of the strength of the accuracy of their mental image appraisal between condition and across levels of total sleep time, at pre-intervention (T1), post-intervention (T2), and 1-day follow-up (T3).

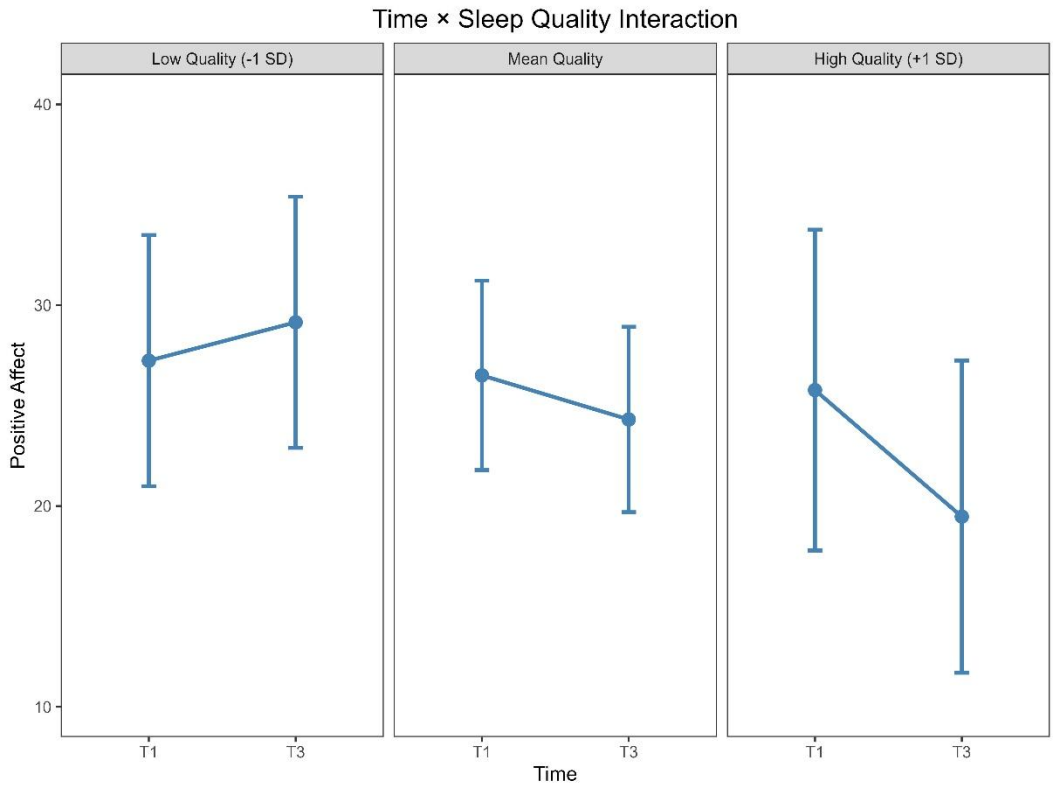
Subjective Sleep Quality

Moderating Effects of Subjective Sleep Quality on Positive Affect

The positive affect model revealed a marginally significant Time by subjective sleep quality interaction from T1 to T3, such that changes in positive affect scores differed across levels of sleep quality ratings, (b = -4.83, SE = 2.40, t = -2.01, p = .050; Figure 17). Unexpectedly, individuals with low sleep quality reported a slight increase in positive affect from T1 to T3, whereas those with high sleep quality ratings reported decreased positive affect overall.

Figure 17

Time x Sleep Quality Interaction Effects on Positive Affect



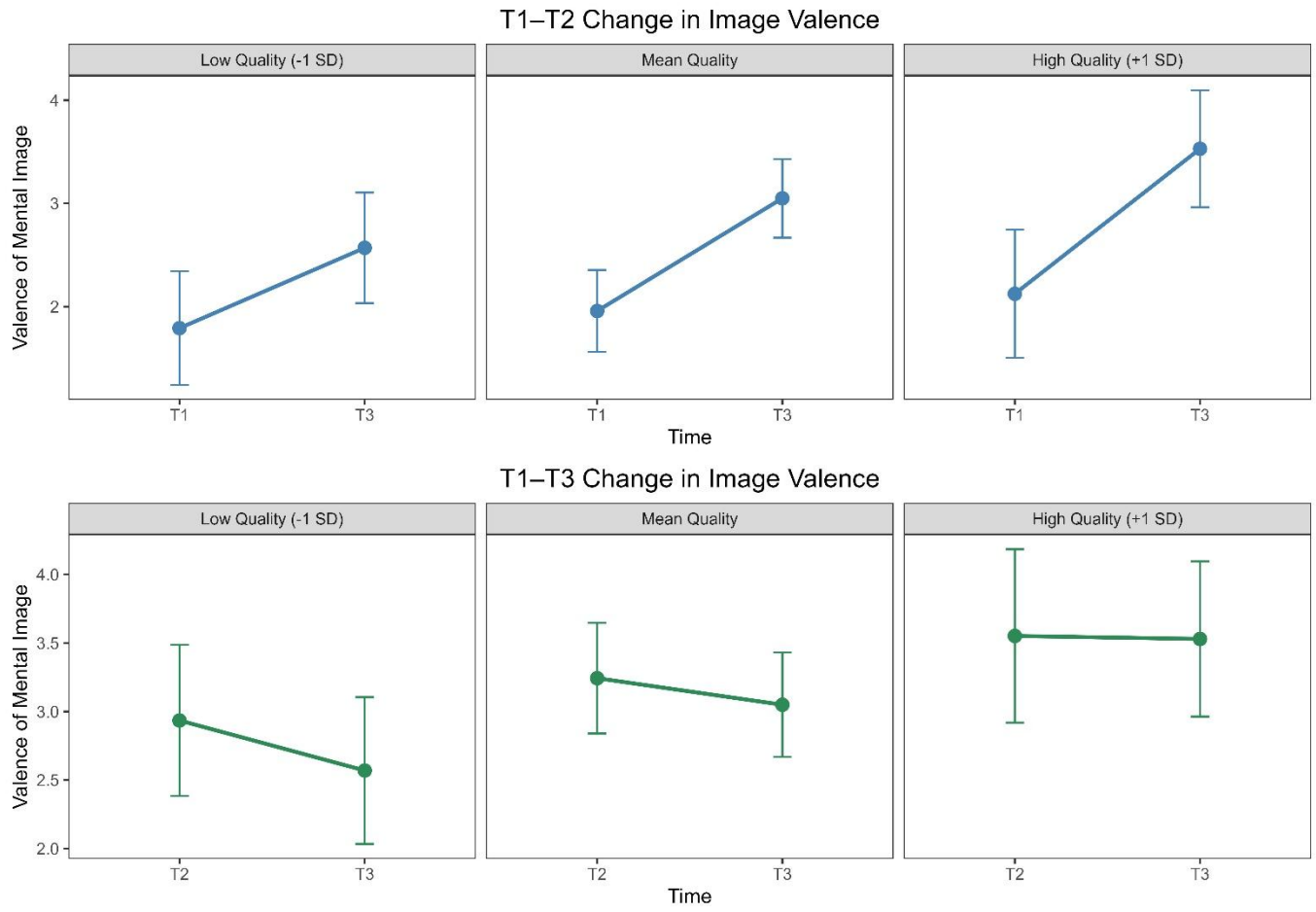
Note. Changes in positive affect subscale scores on the PANAS from pre-intervention (T1) to 1-day follow-up (T3), across levels of subjective sleep quality ratings.

Moderating Effects of Subjective Sleep Quality on Mental Image Valence

The mental image valence model revealed significant Time x Sleep quality interactions from T1 to T3, (b = 0.80, SE = 0.33, t = 2.41, p = .02), and T2 to T3, (b = 0.68, SE = 0.33, t = 2.05, p = .045; see Figure 18). As sleep quality increased, the increase in mental image valence score from T1 to T3 became larger, indicating a trend towards more positive ratings. The rate of change in image valence from T2 to T3 shifted from modest decreases, suggestive of more negative image valence, to relative stability as sleep quality increased. A marginally significant Time x IR condition x Sleep quality interaction was also observed from T1 to T3, (b = -0.87, SE = 0.43, t = -2.01, p = .050; see Figure 19), and from T2 to T3, (b = -0.96, SE = 0.43, t = -2.23, p = .030). Follow up contrasts revealed that individuals who reported high sleep quality and were assigned to the IR condition showed significantly larger increases in the positivity of their mental image ratings, from T1 to T3 compared to those reporting average sleep quality, (Average: b = 1.36, SE = 0.34, t = 4.03, $p_{BH} < .001$, d = 1.09; High: b = 2.09, SE = 0.52, t = 3.99, $p_{BH} < .001$, d = 1.68). Further, at average sleep quality, individuals in the active IR condition smaller decreases in valence ratings from T2 to T3, compared to those at low sleep quality (Low: b = -1.78, SE = 0.47, t = -3.80, $p_{BH} < .001$, d = 1.43; Average: b = 1.00, SE = 0.34, t = -2.83, $p_{BH} < .001$, d = 0.77). Using Cohen's (1988) conventional benchmarks for standardized mean differences, the effects of most of these contrasts correspond to very large-sized effects, while the last effect falls corresponds to a medium sized effect.

Figure 18

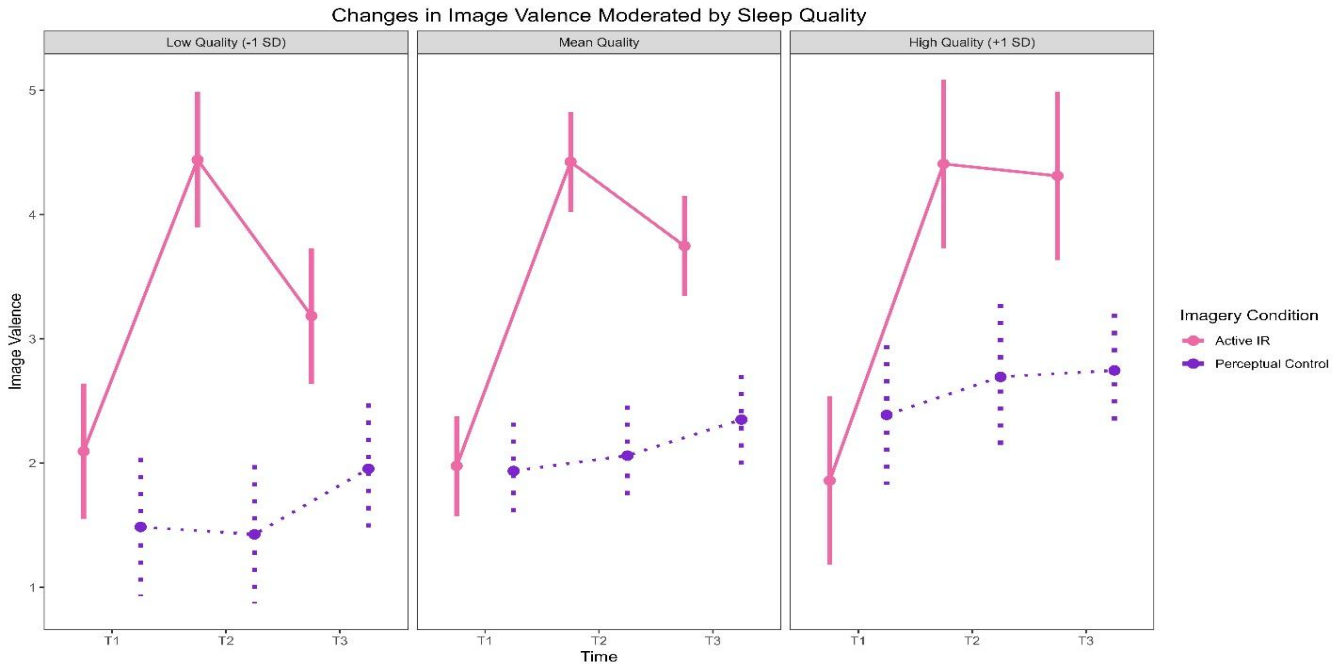
Time x Sleep Quality Interaction Effects on Image Valence



Note. Changes in valence ratings of participants' mental image across levels of subjective sleep quality from pre-intervention (T1) to post-intervention (T2; Top), and pre-intervention (T1) to 1-day follow-up (T3; Bottom).

Figure 19

Time x IR Condition x Sleep Quality Interaction Effects on Image Valence



Note. Changes in valence ratings of participants' mental image between IR condition and across levels of subjective sleep quality at pre-intervention (T1), post-intervention (T2), and 1-day follow-up (T3).

Table 2.

Descriptive Statistics of Study Variables

	Active IR Condition *M* (SD)			Perceptual Control *M* (SD)		
N	14			17		
SPIN Score	37.80 (9.77)			39.10 (11.70)		
Outcome Variable	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
Positive affect	26.23 (6.43)	27.43 (8.83)	25.21 (7.63)	28.53 (7.47)	24.29 (9.94)	21.94 (10.10
Negative affect	19.86 (7.75)	17.71 (6.41)	15.71 (5.50)	19.50 (8.94)	20.35 (8.92)	17.94 (7.87)
Positive self-schemas	18.21 (4.81)	18.86 (6.00)	18.43 (4.70)	20.53 (4.65)	18.00 (5.76)	17.59 (5.44)
Negative self-schemas	12.21 (5.34)	11.14 (3.84)	10.36 (3.54)	11.71 (5.43)	11.59 (4.62)	10.41 (3.95)
Mental image valence	2.00 (0.55)	4.43 (0.65)	3.64 (1.08)	1.91 (0.69)	2.00 (1.00)	2.41 (0.87)
Mental image strength*	3.21 (1.31)	3.43 (1.22)	3.00 (1.04)	3.71 (0.99)	3.71 (1.10)	3.24 91.25)
Event recurrence valence**	4.07 (1.00)	-	4.71 (1.07)	4.24 (2.22)	-	4.71 (1.90)
Memory Distress	2.86 (1.41)	-	1.71 (0.73)	2.69 (1.40)	-	1.94 (0.93)
Moderating Variable	**Mean (SD)**					
Sleep Efficiency	0.92 (0.04)					
Total Sleep Time (Mins)	459.55 (133.57)					
Subjective Sleep Quality	3.52 (0.85)					

Note: * Refers to participants' strength of belief in the accuracy of their mental image appraisal. ** Refers to the valence of participants' emotion reaction when considering the possibility of future event recurrence. T1 = pre-intervention; T2 = post-intervention ; T3 = 1-day follow-up.

Table 3

Correlations Between Study Variables Collapsed Across Conditions

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Pos. Affect	1.00	0.04	0.56***	0.16	0.28	0.24	-0.02	0.44*	0.03	-0.03	-0.10
2. Neg. Affect		1.00	-0.27	0.76***	-0.46***	0.12	0.66***	-0.40*	-0.45*	-0.14	-0.52**
3. Pos. Self-Schemas			1.00	-0.14	0.36*	0.16	-0.30	0.61***	0.08	-0.03	0.48**
4. Neg. Self-Schemas				1.00	-0.19	0.13*	0.61***	-0.31**	-0.43	-0.24*	-0.28
5. Mental Im. Valence					1.00	0.23	-0.33	0.39*	0.40*	0.22	0.29
6. Mental Im. Strength						1.00	-0.22	0.12	0.26	0.04	0.07
7. Memory Distress							1.00	-0.25	-0.37*	-0.04	-0.26
8. Recurrence Valence								1.00	0.21	0.12	0.52**
9. Sleep Efficiency									1.00	0.52**	0.19
10. Total Sleep Time										1.00	0.14
11. Sub. Sleep Quality											1.00

Note: Pos. = Positive; Neg. = Negative; Im. = Image; Sub. = Subjective. Mental Im. Strength refers to the strength of belief in the accuracy of the mental image appraisal. Recurrence Valence refers to the valence of the affective response when considering the possibility of the remembered event recurring again in the future. Correlations for all outcome variables used follow-up (T3) data based on N = 31 participants. * $p < 0.5$, ** $p < 0.01$, ***$p < 0.001$

Discussion

The purpose of this study was to explore the potential impacts of IR and sleep quality on schemas, affect and other psychological outcomes amongst undergraduate students with elevated social anxiety symptoms. Previous work has found that standalone IR interventions lead to adaptive changes in schemas, affect, memory characteristics, and psychological outcomes amongst individuals with SAD (Frets et al., 2014; Nilsson et al., 2012; Reimer and Moscovitch, 2015; Romano et al., 2021; Seinshe et al., 2024; Sheldon et al., 2025; Sorka et al., 2025; Winter et al., 2025). Models of schema-updating such as the SCIL model (Moscovitch et al., 2023) propose that IR works by activating schema-incongruent learning pathways, which violate existing maladaptive schemas encapsulated within negative autobiographical memories and initiate neurological processes to encode novel memory traces of more adaptive interpretations of the event and of the self.

Drawing upon sleep research, which has found strong support for the role of sleep in the consolidation of new learning (Alvarez & Squire, 1995; Diekelmann & Born, 2010; Rasch & Born, 2013; Stickgold, 2005; Walker & Stickgold, 2004), we examined whether enhanced sleep quality could strengthen the schema-incongruent learning that is facilitated by IR interventions (e.g., Romano et al., 2021). Further, we wanted to expand upon the few studies that have found evidence of an important role for sleep in schema-updating (Azza et al., 2022; Bryant et al., 2019; Groch et al., 2017; Recher et al., 2024), including sleep-enhanced reductions in memory valence and distress, and enhanced emotion regulation (Azza et al., 2022; Bryant et al., 2019; Recher et al., 2024).

Drawing upon these findings, we hypothesized that participants who received IR would experience greater benefits across outcome measures those who did not, and that IR and sleep

enhancement instructions would interact such that participants who received both IR and sleep enhancement instructions would benefit the most while those who received neither IR nor sleep enhancement instructions would benefit the least.

Due to our limited sample size, rather than comparing the combination of the four between-subject experimental conditions directly with one another, we ran a series of moderation analyses to explore the direct effects of sleep on the psychological, cognitive and affective measures of interest, and examine whether sleep moderated the effect of the IR interventions on these same outcomes. Specifically, we examined the moderating role of sleep efficiency, total sleep time and subjective ratings of sleep quality. While these analyses do not allow direct evaluation of specific pre-registered hypotheses 2 and 3, they do allow us to draw some conclusions about the moderating effect of sleep variables.

The Impact of IR on Outcome Measures

Regarding the first hypothesis, our findings were partially supported. From pre-intervention to post-intervention, individuals who were assigned to the active IR group had mental images that were significantly more positive than those in the perceptual control group. This finding is in line with previous work which found adaptive shifts in the mental image and associated memory details following IR interventions (Al-Uqaili et al., submitted; Lee and Kwon, 2013; McCarthy et al., 2022; Nilsson et al., 2012; Norton & Abott, 2016; Romano et al., 2020b; Wild et al., 2007). Moreover, IR appeared to have protective effects for positive affect and positive self-schemas, as those who were assigned to the active IR group showed significantly smaller decreases in positive affect and positive self-schemas following the intervention and at follow-up.

Previous research has suggested that IR enhances positive self-schemas (McCarthy et al., 2022; Nilsson et al., 2012; Sheldon et al., 2025; Sorka et al., 2025), a finding that was not replicated in our study. Notably, one of the proposed mechanisms underlying shifts in self-schemas during IR is the adoption of more adaptive appraisals of the negative event (Arntz & Weertman, 1999; Arntz, 2012; 2025). To this end, participants in our study did report increased positivity in their mental images; however, we did not see changes in the strength of the belief in the accuracy of the mental image appraisal between conditions, which may suggest that more participants held onto residual negative interpretations of the event. One explanation for this could be that our study delivered IR using a self-paced, online format, compared to clinician-led sessions employed in other work. Perhaps online formats of IR do not yield the same emotional engagement and cognitive processing as synchronous sessions being facilitated by a trained clinician, thus leading to smaller effects on schema updating. Nonetheless, our findings indicate that online IR is beneficial for the preservation of existing positive self-schemas, while additional strengthening of these schemas may require the more guidance, session time, and emotional and cognitive exploration that can only be accomplished via therapist-led interventions.

Similarly, prior IR studies have found that positive affect increases following the intervention (McCarthy et al., 2022; Reimer & Moscovitch, 2015; Seinshe et al., 2024; Sorka et al., 2025; Strohm et al., 2021), which was not replicated in our study. However, considering the moderate positive correlation between positive self-schemas and positive affect and the way in which both variables showed similar rates of change across the experiment amongst participants in the active IR condition, it is possible that changes in positive affect are directly tied to the valence and strength of self-beliefs. This idea is supported by findings that eliciting positive self-beliefs and self-evaluations via autobiographical memory recall can enhance positive affect (Cili

& Stopa, 2015; Kudryk et al., 2024; Martin et al., 2024; Moscovitch, 2024). Since positive self-schemas did not increase amongst the participants who completed the active IR intervention, this may partly explain why positive affect showed a similar pattern. However, such interpretations are speculative and entertained with caution, given the lack of clear cause-and-effect within our study.

Between the active and control interventions, there were no significant differences in negative affect, negative self-schemas or memory distress. However, all three models showed a significant main effect of time, such that each outcome significantly reduced from pre-treatment to follow-up. While most prior work has found that IR offers a significant advantage over various control tasks at reducing negative mood, negative self-beliefs and memory distress (Lee & Kwon, 2013; McCarthy et al., 2022; Nilsson et al., 2012; Norton et al., 2021; Recher et al., 2024; Reimer & Moscovitch, 2015; Romano et al., 2020b; Seinshe et al., 2024; Sheldon et al., 2025; Sorka et al., 2025; Wild et al., 2007, 2008), one study has not shown this difference (Knutsson et al., 2020). This one anomalous study specifically examined the efficacy of IR versus in-vivo exposure when treating individuals with SAD, and found that both treatments led to similar benefits. Since the tasks for both IR conditions in the present study involved repeated review and interaction with the details of the negative memory, it is possible that participants in the perceptual control condition derived unexpected benefit from such exposure. In line with Craske (2014)'s inhibitory learning model, repeated exposure to and elaboration upon the negative memory details in the perceptual control condition may have altered participant's conditioned affective and cognitive responses to the memory, which may have then competed for retrieval with the original maladaptive responses and produced acute effects that appeared similar to those of the active IR group. Moreover, the finding that both IR groups demonstrated

enhanced adaptive changes to schemas over time suggests that schema updating is a process which requires a longer period of time, compared to other adaptive cognitive changes (e.g., mental imagery), before its effects are detectable. Considering the essential role of consolidation to schema updating (Moscovitch et al., 2023), it is possible that schema change requires time to allow for multiple iterations of consolidation processes, such as sleep, to occur.

Impact of Sleep Efficiency on Outcomes

Sleep efficiency is the percentage of time an individual spends asleep during the period in which they attempt to sleep. In our study, we found that low sleep efficiency was associated with increased positive affect from pre-intervention to follow-up, while those with high sleep efficiency showed reduced positive affect scores. These findings are surprising, given that higher sleep efficiency is an indicator of better overall sleep quality, which in turn is associated with more positive mood states and stronger emotion regulation abilities (Palmer & Alfano, 2017; Tomaso et al., 2021; Yoo et al., 2007). One explanation is that our sample exhibited a ceiling effect for sleep efficiency ratings, and thus even when exploring across the levels of sleep efficiency, there was not a meaningful difference between those reporting low and high sleep efficiency. Clinical guidelines suggest that 85-90% sleep efficiency is associated with good quality rest, while those with scores above 90% are considered to fall in the excellent range (Ohayan et al., 2004; Ohayan et al., 2017). The mean sleep efficiency of our sample falls into this latter range, with even the low sleep efficiency level still within the recommended guidelines. In fact, only two individuals in our sample reported experiencing sleep efficiency below the recommended guidelines, which is considered suggestive of sleep challenges, like insomnia. Therefore, our findings may not reliably indicate that lower sleep efficiency is

beneficial for positive affect, but rather that parsing amongst those with high sleep efficiency can lead to spurious or non-meaningful effects.

Conversely, in-line with our hypothesis, negative self-schema ratings significantly decreased as sleep efficiency increased. One explanation could be that this finding is spurious, for the same reasons suggested above. However, this finding could also be evidence of new learning via the schema-incongruent learning pathway (Moscovitch et al., 2023), which has been strengthened through consolidation processes during sleep. Although this effect was not unique to a specific IR condition, and thus cannot be attributed to the active IR or perceptual control intervention, it is possible that any violations to the maladaptive schemas, whether due to the reappraisal of the negative event and self in the active IR condition or possible inhibitory learning in the control IR condition, were benefited by higher sleep efficiency.

The Moderating Role of Sleep Efficiency

Despite no significant difference in the strength of participants' belief in the accuracy of their negative mental image appraisal between the IR and perceptual control conditions overall, we found that the combined effects of intervention condition and sleep efficiency significantly modulated these results. Amongst those assigned to the IR group, participants' ratings of the believability of their negative appraisals significantly decreased as sleep efficiency increased. It should be noted, however, that these findings no longer reached statistical significance after correcting for multiple tests. Regardless, these trends indicate that higher sleep efficiency may have amplified the new learning that occurs during active IR and led to enhanced consolidation of the schema-incongruent interpretations of the mental image.

Interestingly, participants who were assigned to the perceptual control condition demonstrated the opposite pattern, such that repeated exposure to the upsetting details of the event in the absence of rescripting led to enhanced conviction in the negative appraisals of the mental image for more efficient sleepers, such that better sleep resulted in stronger upholding of the beliefs, while poorer sleep did not allow for as effective consolidation to take place. Together, these findings offer support for both learning pathways proposed in the SCIL model (Moscovitch et al., 2023), such that the violation of encapsulated schemas in the active IR condition triggers the schema-incongruent pathway and weakens negative beliefs for highly efficient sleepers, while the reinforcement of maladaptive schemas for perceptual control participants activated the schema-congruent pathway and strengthens negative beliefs under conditions of more efficient sleepers. Notably, these findings are inconsistent with the results we found in the IR only model, where both the active and control IR groups demonstrated reduced belief in the mental image appraisal over time, which raised the possibility of the perceptual control condition benefiting from inhibitory learning. Here, our findings are suggestive that IR outperforms the perceptual control intervention. One possible reason for this discrepancy is that sleep quality is an important factor in amplifying the efficacy of IR, due to the fact that sleep is vital for the consolidation of new learning. If true, the nuanced effects across levels of sleep efficiency would have been lost in the models that did not include sleep variables, thus attenuating the effects of the intervention. Regardless, further research is needed to better understand this pattern of findings and definitely assess the effects of IR on the belief in the accuracy of mental image appraisals.

Impact of Total Sleep Time on Outcomes

Total sleep time is the total amount of time an individual spends asleep. When within a healthy range, greater sleep time is typically associated with better overall sleep quality, especially compared to sleep timing that is below a healthy range. When individuals get enough sleep, it means that they are able to cycle through and spend enough time in each sleep stage, allowing them to reap maximum benefits from the neurological processes underlying each sleep stage. This is especially important for memory consolidation, as suggested by the systems consolidation hypothesis, given that slow wave sleep and REM are implicated as important processes in the transfer of new learning to long-term memory. Slow wave sleep tends to be prioritized during sleep cycles in the first half of the night, while REM predominates later sleep (Rasch & Born, 2013). Accordingly, longer total sleep time would be expected to be associated with greater consolidation of new learning and more adaptive outcomes, as previous research has shown (Bryant et al., 2019). Indeed, we found that higher total sleep time was associated with lower negative self-schema scores and weaker belief in the accuracy of the negative mental image appraisal. Therefore, participants' new learning appears to be enhanced by sleep periods which are long enough to accommodate all sleep-related consolidation processes.

The Moderating Role of Total Sleep Time

Our findings also demonstrated that total sleep time moderated the effects of IR interventions on negative self-schemas and the strength of the belief in the accuracy of the negative mental image appraisal. Individuals assigned to the active IR condition experienced significant reductions in negative self-schema scores as total sleep time increased, which indicates that longer sleep time enhances the effects of IR interventions in challenging and reducing negative self beliefs. A similar pattern of results were observed when examining the

strength of the negative mental image appraisal: as total sleep time increased, individuals in the active IR group saw their belief in the accuracy of the appraisal decrease, indicative of adaptive schema-incongruent learning and consolidation, versus those in the perceptual control condition, whose conviction in their negative image appraisal remained stronger.

In light of these findings, it is possible to speculate that less sleep may have protected individuals in the perceptual control condition, where elaboration of the negative memory details without rescripting could potentially reinforce maladaptive appraisals through schema-congruent learning. In this condition, participants with better sleep may have experienced more efficient and effective consolidation of such appraisals. As such, shorter, poorer quality sleep may have disrupted the learning of maladaptive thinking patterns by preventing additional consolidation of such thinking.

Impact of Subjective Sleep Quality on Outcomes

Subjective sleep quality reflects an individual's self-reported rating of the quality of their sleep the previous night, allowing one to report on their subjective feelings of wakefulness, readiness for the day, and sleep experience. Here, unexpectedly, we found that higher subjective sleep quality was associated with lower positive affect ratings from pre-intervention to follow-up, while lower subjective sleep quality was associated with increased positive affect overall, across conditions. Previous work has found that higher subjective sleep quality is associated with improved mood and psychological well-being (Pilcher et al., 1997), hence, the finding that positive affect deteriorates as sleep quality increases was surprising. However, as suggested previously, it is possible that lower sleep quality prevented the consolidation of the negative affective experience associated with recalling painful memories, thus increasing (or preventing decreases in) positive affect. Concurrently, the opposite could be true for those with higher

subjective sleep quality, such that their higher sleep quality lowered positive affect because it allowed the negative aspects of their memories to be strengthened via sleep-enhanced consolidation.

The Moderating Role of Subjective Sleep Quality

Subjective sleep quality also moderated the effects of IR on mental image valence ratings from post-intervention to follow-up. Amongst individuals in the active IR group, mental image valence ratings were equally positive from post-intervention to follow-up when the individual reported high levels of sleep quality. In contrast, mental image valenced ratings decreased and become more negative amongst individuals with low sleep quality. This finding is not only in line with our hypothesis, but also consistent with results of a previous investigation into the moderating effect of sleep on the outcomes of an IR intervention outcomes by Recher et al. (2024), who found that IR led to more positive ratings of the recalled memory, in addition to other benefits, which were enhanced by sleep. Both our results and the findings of Recher et al. (2024), support to the idea that IR activates schema-incongruent learning through the violation of the maladaptive schemas driving the negative mental imagery, and that sleep-dependent consolidation can enhance these effects.

Limitations

This study is not without its limitations. Critically, our final sample size was much smaller than anticipated, leaving our study underpowered. As indicated in our preregistration, our initial recruitment goal was a minimum of 120 participants, which would have allowed 30 participants per experimental group and was expected to provide enough power for to detect small-to-moderate interaction effects (Harrall et al., 2023; Leon & Heo, 2009). While

recruitment for this project continues, the strict timeline for the submission of this thesis and unforeseen challenges in participant retention required us to shift our statistical approach to to account for our limited power. Although interesting effects and trends still emerged in our data, it is important to recognize the limitations of our analyses. Small sample sizes can lead to upwardly biased effects, yielding over-estimation of true effects and inflating the chances of reaching statistical significance. Simultaneously, the opposite can also be true, such that the real effect size can be underestimated and yield statistical non-significance (Button et al., 2013; Gelman & Carline, 2014). Moreover, our focus on findings that reached statistical significance places an overemphasis on p-values, which are susceptible to bias in small samples (Button et al., 2013). This means the findings we presented here may represent biased estimates of the true effects, and the results of this investigation may change when reanalyzed with a larger sample. Further, results that previously did not reach statistical significance and were omitted may reach statistical significance, thereby changing the conclusions drawn from this study. As such, all results presented here should be interpreted with caution.

Beyond the number of participants recruited, there are certain elements of our sample which limit the generalizability of our findings to other populations. First, we recruited a non-clinical socially anxious sample. While our sample may share diagnostic features with individuals who meet the clinical criteria for SAD, our participants may not experience the same degree of severity or impact of symptoms, and may have a different clinical presentations. This is important, as the underlying mechanisms proposed in SAD may not map on exactly to elevated social anxiety in a non-clinical undergraduate sample. For example, the negative self-schemas and mental imagery that are so prevalent in SAD may be less dominant or impairing in our sample and could be one factor underlying the discrepancies between our work and other

investigations of IR as an intervention for SAD. It is also possible that a clinical sample would have responded differently to the study paradigm. Previous work has established that compared to healthy controls, individuals with SAD have significantly poorer sleep quality (Horenstein et al., 2019; Stein et al., 1993). Thus, a clinical sample may have entered into the study with significantly poorer baseline sleep quality, which could lead to different sleep-related findings.

In addition to recruiting a non-clinical sample, our sample largely consisted of white, south Asian, and southeast Asian female undergraduate students. While prevalence statistics suggest that SAD is more common amongst teenagers and young adults (Lau et al., 2021; Stein & Kean, 2000), females (Asher et al., 2017; MacKenzie & Fowler, 2013), and those identifying as white (Hofmann et al., 2010), SAD does not exclusively impact these populations, and as such, the findings presented here may not extend to other age groups, gender identities, or racial backgrounds. Additional research is needed amongst those who have been underrepresented not only in our study, but in the literature at large. Namely, individuals with minority gender identities and those from diverse cultural groups (e.g., east Asian, Black, Indigenous, Latinx), as well as their intersections. The unique challenges facing these groups such as sexism, transphobia, and racism, and the role of diverse socio-cultural influences on views of the self, social norms and mental health, may contribute to varied conceptualizations and presentations of SAD, which could limit the applicability of the findings reported here to these groups. Overall, while our findings offer interesting insight into the potential for IR and sleep quality interventions in the treatment of SAD, but our preliminary results should be considered cautiously in light of the limitations presented here.

Future Directions

To expand upon the findings of this project, future work should consider implementing study designs that extend beyond a two-day period. One benefit of longer timeframes would be the ability to assess the effectiveness of IR at longer follow-up junctures, and explore whether schema change requires a longer period of time to take effect. Most prior IR studies have explored the effects of IR interventions up to a week later, with a few designs including follow-up at 3- and 6-months. Including longer follow-up time points would allow for further examination of the long-term benefits of IR and explicit exploration of whether the time required for schema updating exceeds that required to update the mental image. Longer designs would also enable researchers to collect baseline sleep data for participants, which could be contrasted with sleep data post-intervention for better evaluation of the efficacy of the sleep quality intervention. Additionally, allowing participants several habituation nights could enhance the effectiveness of the sleep interventions, since participants in the sleep quality enhancement condition would have a few days to adjust their nighttime routines and schedule the timing of their activities (e.g., meal timing, exercise routine) and consumption of substances (e.g., nicotine, alcohol, caffeine). This would give participants the best chance of optimizing their sleep, and could offer a better contrast to the sleep of participants assigned to the sleep-as-usual condition.

Subsequent investigations would also benefit from the use of both objective and subjective measures of sleep. While subjective sleep ratings and sleep diaries are commonly used in sleep research, objective sleep measures provide the added benefit of biological indicators as opposed to relying solely on participant recollections regarding critical sleep parameters such as sleep efficiency and total sleep time. Considering the breadth of literature supporting the important role of sleep in the consolidation of new learning, it is vital to investigations such as

the one described here that sleep variables are measured as accurately as possible. Indeed, previous work has found that subjective reports of sleep quality only moderately correlate to objective measures (Masaki et al., 2024).

While there is great value in exploring how subjective experiences of overnight sleep and restfulness impact schema updating and psychological outcomes, robust measurement of key sleep variables is paramount. To this end, polysomnography and actigraphy are two psychophysiological options for collecting sleep data. Polysomnography involves the use of electrodes to measure electrical activity on the scalp, face and eyes, which offers precise measurement of waking and sleeping states. In addition to accurately assessing sleep parameters, polysomnography permits researchers to record sleep stages and would provide opportunities to explore whether slow wave sleep and REM facilitate schema updating, as the systems consolidation hypothesis would suggest. Unfortunately, polysomnography necessitates an elaborate equipment and space set up and would require more expensive and time-consuming in-person studies where collecting data on many participants can be cumbersome. Actigraphy, on the other hand offers a more convenient option, as this methodology employs wearable devices (e.g., watches) which use movement and heart rate data to estimate sleep parameters, and which participants could wear at night in their natural environments. Future studies should consider incorporating these methodologies into their designs, while also weighing the feasibility and accessibility of each method.

Additional research is also needed to explore the affective, cognitive and psychological outcomes of IR interventions when delivered synchronously by trained clinicians compared to a self-directed online module. In our study, we did not find significant changes in schemas, negative affect, memory distress or strength of appraisals between the IR condition – findings

that are contrary to several prior studies. Notably, our investigation implemented a pre-recorded online IR task, in which participants were instructed to complete a series of written prompts and self-report measures. Conversely, most studies examining the impact of IR have recruited clinicians or trained research personnel to facilitate the intervention. It is possible one of the reasons we did not replicate some previously reported findings is because of differences in the efficacy of self-guided versus clinician-led IR paradigms. Indeed, our findings are similar to another study which implemented a self-guided online IR procedure. Al-Uqaili et al. (submitted) also found no significant change in schemas following a self-guided IR intervention, but – like us – observed significant shifts in the valence of mental images. Interestingly, Sorka et al. (submitted) found that self-guided IR interventions are very effective for treating anxiety. Therefore, while both clinician-led and self-guided IR protocols can offer significant benefits, the specific effects may vary depending on the intervention format. Additional research is needed to explore how each delivery method impacts IR outcomes and what mechanisms may be driving these differences.

Conclusions

In summary, our investigation advances our understanding of the beneficial effects of IR interventions amongst those with elevated social anxiety. Specifically, we showed that IR can effectively target the mental image of socially aversive memories, yielding significant shifts towards more positive images, and can serve a protective role against the degradation of positive self-schemas and positive affect whilst repeated reviewing the negative details of a painful memory. Additionally, we found evidence that the effects of IR on certain variables, such as negative self-schemas and the strength of belief in the accuracy of the mental image appraisal, are amplified when followed by enhanced sleep, specifically periods of sleep that are

characterized by higher sleep efficiency and longer total sleep time. These findings support existing frameworks, such as the SCIL model of schema updating and systems consolidation hypothesis of sleep-dependent consolidation of new learning. Future research should seek to address the limitations of our investigation by recruiting large clinical samples of individuals from diverse cultural backgrounds and gender identities. Moreover, this work could be extended through the implementation of longitudinal designs and addition of objective measures of sleep. Additional unanswered questions, such as whether the format of IR delivery affects the outcomes of the intervention, also remain to be explored, offering intriguing opportunities for future study.

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Appendix A: IR and Perceptual Control Task Instructions

Imagery Rescripting Condition (Random Assignment):

*Writing Task #1: (Memory Recollection)
Please bring to mind the negative experience you had and describe the memory as if it is unfolding in the present moment. E.g., "I am standing in the classroom, and I can see my classmates staring at me." Please include as much detail as possible.

[textbox]

*[This message will **not** be displayed to participants.] Mandatory: Since all data collected after this question is directly related to this response (in which they provide their specific memory), individuals who do not respond to this question will receive an error message and will be given an opportunity to return to answer this question. Those who choose not to answer the question a second time will be redirected to the debrief and their data will be excluded from the study. Those who do not answer this question will be granted 0.25 credit for their time.

Writing Task #2 (Image formation):
Imagine taking a photograph or a video of yourself during your negative social experience. What would this image look like? In 2-3 sentences, describe the details of your image.

[textbox]

2b. What do you think this image says or means about you as a person?

[textbox]

2c. What do you think this image says about who you are and how people treat you?

[textbox]

2d. How negatively would you rate this image?

Extremely negative
Somewhat negative
Neither negative nor positive
Somewhat positive
Extremely positive

2e. How strongly do you believe this image to be an accurate representation of you as a person?

Strongly disbelieve
Somewhat disbelieve

Neither disbelieve nor believe
Somewhat believe
Strongly believe

Instruction #1
Now that you've described and reflected on your negative memory and image in detail, we are going to ask you to interact with your memory in a number of ways. In this next section, you will be asked to visualize your memory in detail again, but this time to imagine it in a new way that feels more satisfying and uplifting.

We will guide you through this process step-by-step in the next few pages.

Instruction #2
To start, please take a moment to bring the memory to mind and visualize it fully..

Do you currently have the memory clearly in your mind?

☐Yes
☐ No

*If yes: Please continue to the next step.
*If no: Please take another moment to visualize the memory. Once you have it in mind, continue to the next step.

Instruction #3

With the memory now clear in your mind, please take a moment to imagine yourself experiencing an alternative, more satisfying outcome than the one you actually experienced.
Are you able to imagine a different, more positive outcome to the situation?
☐Yes
☐ No

*If yes: Please continue to the next step.
*If no: Please take another moment to envision a more positive outcome to the situation you experienced. Try to imagine what would have made the situation less upsetting or negative for you. When you have this alternative outcome in mind, please continue to the next step.

Instruction #4

Continue to envision an outcome that better meets your needs and makes you feel less badly about yourself in your memory.

Are you able to imagine an outcome to the situation that better meets your needs and makes you feel less badly about yourself?

☐Yes
☐ No

*If yes: Please continue to the next step.
*If no: Please take another moment to envision an alternative outcome to the situation. Focus on what could have happened that would have better met your needs or made you feel less badly about yourself at the time. When you have such an outcome in mind, continue to the next step.

Instruction #5

Now that you have this more positive outcome in mind, take a minute to visualize how the event could have gone differently so that this outcome could have been a reality.

Are you able to envision a way that this alternative outcome could have become a reality?

☐Yes
☐ No

*If yes: Please continue to the next step.
*If no: Please take another minute to envision how this alternative outcome could have been a reality. Think about what could have occurred differently at the time that would have allowed the more positive outcome to occur. When you can imagine how this positive outcome could have occurred, please continue to the next step.

Writing Task #3 (Changing Outcome)

Please mentally visualize and describe in detail what could have happened to make this outcome possible. You can change the actions or words of yourself or others, as long as it reaches a positive outcome that would be satisfying and believable for you.

[text entry box]

Instruction #6
Now, please take a moment to visualize your memory with these updated details.

Are you able to visualize your memory with these updated details?

☐Yes
☐ No

*If yes: Please continue to the next step.
*If no: Please take another minute to envision your memory. Think about the positive outcome you envisioned earlier, and the ways you imagined how this outcome could occur. When you can visualize your memory with these updated details, please continue to the next step.

Writing Task #4 (Updated Memory)

Now we would like you to take several minutes to describe this updated memory. Please describe how the memory unfolded, including any changes you were asked to envision in the previous steps. Include as many details as you can.

[textbox]

Writing Task # 5 (Updated Image)
Imagine taking a new photograph or a video of yourself in this updated memory. What would this updated image look like? In 2-3 sentences, please describe the details of your updated image.

[textbox]

5b. What do you think this image says or means about you as a person?

[textbox]

5c. What do you think this image says about who you are and how people treat you?

[textbox]

5d. How negatively would you rate the this image?

Extremely negative
Somewhat negative
Neither negative nor positive
Somewhat positive
Extremely positive

5e. How strongly do you believe this image to be an accurate representation of you as a person?

Strongly disbelieve
Somewhat disbelieve
Neither disbelieve nor believe
Somewhat believe
Strongly believe

Non-IR Perceptual Imagery Control Task Condition (Random Assignment):

*Writing Task #1: (Memory Recollection)
Please bring to mind the negative experience you had and describe the memory as if it is unfolding in the present moment. E.g., "I am standing in the classroom, and I can see my classmates staring at me." Please include as much detail as possible.

[textbox]

*[This message will **not** be displayed to participants.] Mandatory: Since all data collected after this question is directly related to this response (in which they provide their specific memory), individuals who do not respond to this question will receive an error message and will be given an opportunity to return to answer this question. Those who choose not to answer the question a second time will be redirected to the debrief and reconsent. Those who do not answer this question will be granted 0.25 credit for their time.

Writing Task #2 (Image formation):
Imagine taking a photograph or a video of yourself during your negative social experience. What would this image look like? In 2-3 sentences, describe the details of your image.

[textbox]

2b. What do you think this image says or means about you as a person?

[textbox]

2c. What do you think this image says about who you are and how people treat you?

[textbox]

2d. How negatively would you rate this image?

Extremely negative
Somewhat negative
Neither negative nor positive
Somewhat positive
Extremely positive

2e. How strongly do you believe this image to be an accurate representation of you as a person?

Strongly disbelieve
Somewhat disbelieve
Neither disbelieve nor believe
Somewhat believe

Strongly believe

Instruction #1
Now that you've described and reflected on your negative memory and image in detail, we are going to ask you to interact with your memory in a number of ways. In this next section, you will be asked to visualize your memory in detail again, but this time to focus on certain aspects of the memory.

We will guide you through this process step-by-step in the next few pages.

Instruction #2
To start, please take a moment to bring the memory to mind and visualize it fully..

Do you currently have the memory clearly in your mind?

☐Yes
☐ No

*If yes: Please continue to the next step.
*If no: Please take another moment to visualize the memory. Once you have it in mind, continue to the next step.

Instruction #3
Take a moment to recall the setting where the memory took place. You may choose to reflect on details such as the specific place the event occurred, the time of day or year, or whether you were indoors or outdoors.

Can you see the setting clearly in your mind?

☐Yes
☐ No

*If yes: Please continue to the next step.
*If no: Please take another moment to visualize the setting. Try to bring to mind when and where the event occurred. Once you have it in mind, continue to the next step.

Writing Task #3 (Background and setting):
Now that you have the setting clearly in mind, please take a moment to describe it as if you are seeing it in front of you now. E.g., “It is a Monday morning, and I am in my school gymnasium.” [textbox]

Instruction #4:
Next, take a moment to recall who was present during the experience and what they were doing at the time of the event.

Are you able to bring to mind who was present during the experience and what they were doing?

☐Yes
☐ No

*If yes: Please continue to the next step.
*If no: Please take another moment to visualize who was there during your memory. Focus on what they were doing while the event was occurring. Once you can bring to mind who was present and what they were doing, continue to the next step.

Writing Task #4 (Characters present):
Now that you have reflected on who was present during your memory, please describe what they were doing at the time of the event. Please write these details as though the event is unfolding in the present. E.g., "I see my mom watching from the crowd".

[textbox]

Instruction #5:

Now, take a moment to recall what words were spoken during the event. These can be words spoken by yourself or what others may have said to you when the memory occurred.

Are you able to clearly recall what words were spoken during the event?

☐Yes
☐ No

*If yes: Please continue to the next step.
*If no: Please take another moment to recall what words were spoken during the event. Focus on what you may have said to others as the situation unfolded and what others may have said to you. When you can bring to mind what words were said during your memory, continue to the next step.

Writing Task #5 (Words spoken):
Please take a moment to describe what was said as though you are hearing or saying it in the present. E.g., "I hear my dad say…" "I am not able to say anything; I am too afraid".

[textbox]

Writing Task #6 (Updated Image):

Imagine taking a new photograph or a video of yourself in your memory, including all of the details you described in the previous tasks. What would this new image look like? In 2-3 sentences, please describe the details of this new image.

[textbox]

6b. What do you think this image says or means about you as a person?

[textbox]

6c. What do you think this image says about who you are and how people treat you?

[textbox]

6d. How negatively would you rate this image?

Extremely negative
Somewhat negative
Neither negative nor positive
Somewhat positive
Extremely positive

6e. How strongly do you believe this image to be an accurate representation of you as a person?

Strongly disbelieve
Somewhat disbelieve
Neither disbelieve nor believe
Somewhat believe
Strongly believe