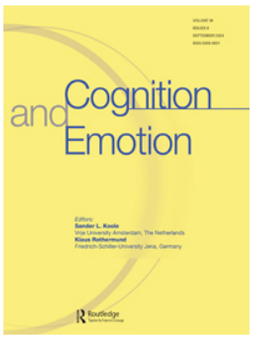

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Memory control immediately improves unpleasant emotions associated with autobiographical memories of past immoral actions

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ABSTRACT

The ability to stop unwanted memories from coming to mind is theorised to be essential for maintaining good mental health. People can employ intentional strategies to prevent conscious intrusions of negative memories, and repeated attempts to stop retrieval both reduces the frequency of intrusions and improves subsequent emotions elicited by those memories. However, it is still unknown whether memory control can improve negative emotions immediately, at the time control is attempted. It is also not clear which strategy is most beneficial for emotion regulation; clearing the mind of any thoughts of negative memories via direct suppression, or substituting memory recall with alternative thoughts. Here, we provide novel evidence that memory control immediately regulates negative emotions associated with autobiographical memories of morally wrong actions. Repeated control significantly improved negative emotions over time, regardless of the strategy used to implement control. Thought substitution involving either positive diversionary thinking or counterfactual thinking both induced positive feelings, whereas direct suppression neutralised emotions, regardless of whether memories were positive or negative. These empirical findings have implications for clinical practice as they indicate that memory control strategies could be effective emotion regulation methods for real-world intrusive memories.

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A large body of evidence supports the view that people can intentionally prevent unwanted memory retrieval (Anderson & Hulbert, 2021), and researchers have developed an increasingly specific model of the neurocognitive processes involved in such memory control (Anderson et al., 2016). In everyday life, retrieving an unwanted memory is often characterised by unpleasant emotions. Memory control may therefore be fundamental for emotion regulation and maintaining good mental health (Engen & Anderson, 2018). Consistent with this view, people with clinical or sub-clinical symptoms of mental illness have poorer memory control than mentally healthy people (Stramaccia et al., 2020). In addition, survivors of the 2015 Paris terrorist attacks who went on to develop PTSD had poorer functioning memory control brain networks than survivors who did not develop PTSD (Mary et al., 2020), leading them to perform worse in memory control tasks. It is therefore important to not only assess the cognitive processes related to memory control and forgetting, but also how memory

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control directly regulates unpleasant emotions elicited by memories.

Memory control is traditionally investigated using the Think/No-Think paradigm (Anderson & Green, 2001). Participants first learn associations between two stimuli (e.g. ordeal-roach) and one stimulus acts a reminder/cue (ordeal) that brings the associate to mind (roach). In the Think/No-Think task, cues are showed in either green (Think), where participants are instructed to voluntarily retrieve the associate from memory, or red (No-Think), where participants are instructed to stop any retrieval of the associated memory. Subjective measures of incidental retrieval during suppression attempts (during No-Think trials) are collected to measure intrusions as an index of failed suppression (Benoit et al., 2015; Gagnepain et al., 2017; Hellerstedt et al., 2016; Levy & Anderson, 2012; Mary et al., 2020; van Schie & Anderson, 2017). A consistent finding is that intrusions reduce over repeated attempts at memory control. Suppression also often has after-effects by rendering memories inaccessible in a surprise memory test, a phenomenon known as suppression-induced forgetting (Anderson & Green, 2001; Stramaccia et al., 2020; for reviews see Anderson & Hulbert, 2021; Marsh & Anderson, 2022). Here, we modified this task in several ways to investigate how autobiographical memory control changes emotions both during, and as a consequence of, memory control. The aim was to address several outstanding issues in the emerging research area to better understand the role of memory control in emotion regulation and mental health.

Most extant research investigates control over simple memories (emotional words/images) that are encoded in the lab (Depue et al., 2007; Gagnepain et al., 2017; Harrington et al., 2021; Joormann et al., 2009; Legrand et al., 2020; Nishiyama & Saito, 2022). Such research may not fully reflect the usefulness of memory control in regulating emotions associated with more complex memories. Previous research on autobiographical memory control has made strides towards explaining memory control in more real-world scenarios, but this research has mostly focused on the effects of control attempts on memory retrieval and forgetting rather than its consequences on emotion (Noreen & Ridout, 2016; Satish et al., 2022). Some findings indicate that suppressing thoughts about personal future fears (such as the person's fear that their family members will die from the COVID) reduced later negative affect for these fears (Benoit et al., 2016; Mamat & Anderson, 2023). A previous study also found that both repeated retrieval and suppression reduced subsequent negative emotions associated with morally wrong autobiographical memories (Satish et al., 2022). Therefore, our first aim was to understand the role of memory control in regulating emotions elicited by reminders of real-world autobiographical memories.

We specifically chose to study autobiographical memories of morally relevant actions. Memories of past immoral acts are often ridden with guilt and shame and threaten people's perception of a morally good self (Stanley & De Brigard, 2019). They are argued to be strong motivators to engage memory control processes in order to resolve the cognitive dissonance and negative emotions elicited by remembering such events (Anderson & Hanslmayr, 2014; Stanley & De Brigard, 2019). Indeed, a recent study found that morally wrong memories were more intrusive than morally right memories (Satish et al., 2022), suggesting that research with simpler stimuli may overlook factors that modulate memory control success. Furthermore, intrusions of past immoral actions reduced over repeated attempts at suppression, indicating that memory control can regulate unwanted thoughts associated with emotionally charged autobiographical memories. Here, we aimed to directly test if memory control can improve negative emotions associated with autobiographical memories of past immoral actions.

Extant literature on the role of memory control in emotion regulation has focused on the change in self-reported or physiological emotional responses to reminders of unwanted memories from before to after a memory control task (Benoit et al., 2016; Gagnepain et al., 2017; Legrand et al., 2020; Mamat & Anderson, 2023). These studies therefore investigated the *after-effects* ("offline") of control on emotion. Other findings indirectly suggest that memory control attempts also reduce emotional processing of negative memory contents at the time that control is attempted, since such control reduces skin-conductance responses for negative memories (Harrington et al., 2021) and activity in crucial brain structures involved in emotional memory (e.g. Depue et al., 2007), especially when controlling negative memories (Gagnepain et al., 2017). Here, we implemented a novel phenomenological measure of emotional responses to reminders to directly measure the immediate ("online") effects of memory control on subjective emotion on a trial-by-trial basis. With this measure, we aimed to assess how emotions were experienced by participants

immediately after retrieving/controlling their memories, and to track how subjective emotion changed over repeated attempts at memory control.

Memory control operates via at least two mechanisms: a) *Direct retrieval suppression*, involving purging contents of the memory from conscious awareness in an attempt to completely inhibit retrieval (Anderson et al., 2004; Benoit & Anderson, 2012; Bergström et al., 2009); and b) *thought substitution*, involving actively diverting attention to another thought, such as retrieving an alternate memory in response to the reminder, consequently removing the original memory from conscious awareness (Benoit & Anderson, 2012; Bergström et al., 2009; Hertel & Calcaterra, 2005). Research on memory control for emotion regulation is largely based on direct suppression (Stramaccia et al., 2020), whereas the effectiveness of thought substitution in regulating unwanted emotions is studied less (but see Joormann et al., 2009; Noreen & Ridout, 2016). Some have argued that thought substitution is more effective for inducing forgetting of unwanted memories than direct suppression, especially when direct suppression may fail (Hertel & Calcaterra, 2005; but see Bergström et al., 2009; Stramaccia et al., 2020 for conflicting findings). Recent evidence however indicates that thought substitution may also fail for people who are unable to successfully engage direct suppression (Noreen & Ridout, 2016). Therefore, we directly compared the effectiveness of these two strategies in regulating negative emotions in this study.

Previous studies in the Think/No-Think literature have asked participants to substitute thoughts both without and with specific instruction on the content of substitutes (Bergström et al., 2009; Joormann et al., 2009; Noreen & Ridout, 2016). Providing specific substitutes could improve memory control performance (Joormann et al., 2009), so we instructed participants to imagine alternate scenarios. We implemented thought substitution in two ways. One group was instructed to divert attention from the unwanted memory to a different imagined scenario, with no reference to the original memory while still perceiving the reminder of the original memory. This diversionary thinking strategy was inspired by guided imagery, which is sometimes used in clinical practice (Jain et al., 2012). Guided imagery involves vividly imagining a safe space, such as lying on a sunny beach and imagining the waves crashing into the beach with the sound of seagulls. Hence, our diversionary thinking group imagined a safe space that had no remnants of the original unwanted memory.

The second group was asked to change specific details of the original memory to create a counterfactual scenario, and imagine this scenario instead of the original memory, while continuously perceiving the reminder of the original memory. This episodic counterfactual thinking strategy (De Brigard et al., 2019) therefore also involved substituting the original memory with alternate thoughts, even though only specific details are changed. Episodic counterfactual thinking is argued to be cognitively distinct from episodic memory retrieval, future thinking, and semantic counterfactual thinking (De Brigard & Parikh, 2019) and is yet to be considered in the memory control field. There is however evidence that some types of counterfactual thinking can improve negative affect associated with unpleasant memories (De Brigard et al., 2019; Stanley et al., 2017). In our implementation, participants used an active form of counterfactual thinking similar to "imagery rescripting" in therapeutic contexts, which is argued to induce more positive emotions and help people process their intrusive memories in a healthier way (Arntz, 2012). This strategy involves choosing particularly intrusive memories and changing the details to be more positive, and then actively imagining this positive alternative scenario. We hypothesised that such active attempts to reimagine past events may recruit memory control processes to alter emotions associated with the unwanted memory. Hence, we aimed to compare the effectiveness of this strategy for memory control and emotion regulation against direct suppression and diversionary thinking.

We developed a modified version of the Think/No-Think paradigm (Anderson et al., 2004; Anderson & Green, 2001) used to study autobiographical memory control (Lu et al., 2022; Noreen & Macleod, 2013; Satish et al., 2022). Participants first reported autobiographical memories of their past morally right or wrong acts, rated these on various emotional and other descriptive characteristics, and created brief unique reminders for each memory. For example, memories of when they caused a car accident (morally wrong), or helped a homeless person find shelter for the night (morally right) might be cued with reminders "car accident" and "night shelter" respectively. Participants then tried to repeatedly retrieve or stop retrieval of their memories in response to these reminders in a Think/No-Think task. Critically, participants gave a brief and intuitive rating of how they felt after each attempt of retrieval or control to measure emotions in real-time on a trial-by-trial basis. A surprise memory test was conducted after

the Think/No-Think task,[1] where participants recalled and described each memory and self-reported emotional ratings for each memory.

Three different participant groups completed the task under different instructions on how to prevent retrieval for No-Think cues. The *direct suppression* group purged memories from awareness without distracting themselves with other thoughts by directing attention to the reminder, in line with instructions developed by Bergström et al. (2009). The *diversionary thinking* group substituted thoughts of the memory with vivid visual imagery of being in a positive place (Benoit & Anderson, 2012; Bergström et al., 2009; Hertel & Calcaterra, 2005). The *counterfactual thinking* group was instructed to imagine better alternative outcomes to the event (De Brigard et al., 2019). All groups received identical instructions for the Think cues; to simply retrieve the associated memories instead of using any particular memory control strategy. Think cues therefore functioned as a within-subjects control condition, allowing us to contrast memory control strategies with the typical process of bringing thoughts of the memory to mind in response to a memory cue.

Previous findings indicate that people can prevent intrusions of unwanted memories into awareness (Benoit et al., 2015; Harrington et al., 2021; Hellerstedt et al., 2016; Levy & Anderson, 2012; Satish et al., 2022). We therefore expected all strategies to be effective to some extent at online emotion regulation, which would be evident by a decrease in negative emotions for morally wrong memories when participants were avoiding retrieval compared to thinking of such memories. We expected the reverse pattern for morally right memories, since positive emotions associated with thinking of these memories should be lower when stopping retrieval. In short, successful memory control was expected to induce relatively more neutral emotional responses compared to retrieval. If the degree of emotion regulation effectiveness differed across strategies, this predicted pattern was expected to be more pronounced for strategies that were more successful. Furthermore, since unwanted memory intrusions consistently decrease over repeated control attempts (Levy & Anderson, 2012), we predicted that negative emotions associated with morally wrong memories would improve over repeated attempts at memory control, whereas positive emotions associated with morally right memories would reduce over repeated attempts at memory control.

Method

Participants

One hundred and thirty-five students at the University of Kent completed the study in exchange for course credits. Participants suffering from psychological (or neurological) illness and generally having a low mood were asked to not sign up to our study and we verbally ensured that they did not participate. All participants were required to be between 18–35 years old and native English speakers. The final sample included 53 participants in the direct suppression group ($M_{age} = 19.81$ years, $SD_{age} = 3.70$, 41 females), 35 participants in the diversionary thinking group ($M_{age} = 19.34$ years, $SD_{age} = 2.07$, 32 females), and 47 participants in the counterfactual thinking group ($M_{age} = 19.19$ years, $SD_{age} = 1.28$, 39 females). We aimed to collect around 35–50 participants per group to increase sample sizes compared to previous research (e.g. 24 in each direct suppression vs. thought substitution group in Bergström et al., 2009). This enabled us to achieve > .90 power to detect a large effect size ($d = 0.80$) for a pairwise group difference at $\alpha = .05$ (with > .60 power to detect a medium effect size, $d = 0.50$). This sample size also allowed us to detect a 3 (between) x 2 (within) x 2 (within) small interaction effect at $\alpha = .05$. With 135 participants, we had .90 power to detect the interaction effect size of $\eta_p^2 = 0.129$ and .60 power to detect $\eta_p^2 = 0.094$. The exact group sizes were determined by a combination of random group assignment and participant availability. Data collection was also stopped due to the COVID-19 pandemic, leading to uneven participant numbers. Fourteen participants (from a total of 149; 2 in direct suppression, 5 in diversionary thinking, and 7 in counterfactual thinking groups) were excluded because of incomplete data or technical problems with the testing software. No exclusions were made based on the measures analysed for inferential tests.

Design, materials and procedure

The design was adapted from a previous study of autobiographical memory control (Satish et al., 2022). We conducted the study in two sessions, 24 hours apart. We collected autobiographical memory descriptions and ratings during session 1, and ran the Think/No-Think task in session 2. See Figure 1 for an illustration of the key procedural phases in the experiment.

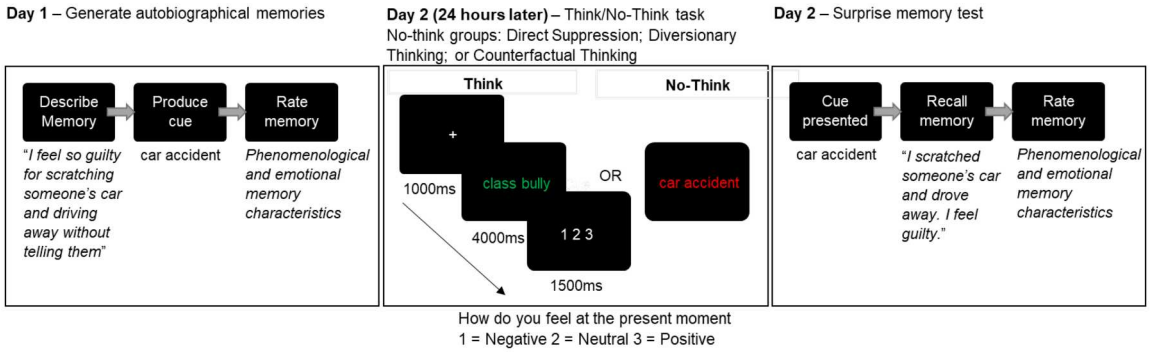

Figure 1. Illustration of the procedure and trial structure of key phases in the experiment. Participants attempted to control memories associated to red (No-Think) cues, and consciously recollect associated memories to green (Think) cues. Different groups of participants used different memory control strategies (direct suppression, diversionary thinking, or counterfactual thinking). Participants indicated how they felt in each trial using the "1 2 3" emotion rating scale.

Session 1. An experimenter conducted this session in a lab using the online Qualtrics survey software. We instructed participants to think of 22 different autobiographical memories, one at a time (10 morally wrong, 10 morally right, one birthday, and one holiday), and type a description in a text box provided to them on a computer screen using a keyboard. To aid recollection of morally wrong actions, we instructed them to think of memories where they lied, cheated, physically or emotionally harmed someone, or any other act they considered was morally wrong. Similar examples were also provided for remembering past morally right actions, such as memories where they were truthful, helped someone physically or emotionally, or other morally right actions. Participants had three minutes to think of and write about a specific memory in two to three sentences by describing their actions, the persons involved, the location, and how they felt. We instructed them to avoid writing about events that easily blend with other memories. Specifically, we instructed them that they should report distinct, non-overlapping memories that they could remember and report on the next day. We instructed them to describe each event in as much detail as possible.

After describing each memory, participants were instructed to think of a unique and specific personal title (2 words maximum) that would act as a memory cue in the subsequent Think/No-Think task. They were also instructed to avoid cues that could evoke multiple memories. The cues were split into three sets: a set for morally wrong memories, one set of cues for morally right memories, and one set of filler cues.

After participants generated the cue, they rated the memory for age (in years), vividness (How well do you remember the event? *1 = not well at all, 5 = extremely well)*, intentionality (How intentional were your actions? *1 = not intentional at all, 5 = extremely intentional*) and morality (How morally right or morally wrong were the actions you performed during the event? *1 = very morally wrong, 7 = very morally right)*. These phenomenological ratings have been used previously in moral autobiographical memory research (Stanley et al., 2017). The participants were then instructed to rate each memory for emotional affect and valence using two scales: a modified version of the I-PANAS-SF, which included 5 items each for positive and negative emotions: "Indicate the extent to which you feel this way at the present moment of the event" (e.g. Guilty, *1 = very slightly or not at all, 5 = extremely*); and SAM, a pictorial scale that measures emotional pleasure and arousal (Bradley & Lang, 1994).

Session 2. The second session began with control and practice tasks to ensure the validity of the methods.

Cue-test phase

The cues generated in session one were created to be used as reminders of the autobiographical memories in session two. Therefore, we first conducted an initial cue-test phase to ensure that participants could remember the autobiographical memory associated to each cue, by asking participants to rate how well they remembered the memory when presented with the cue. Participants were first shown a fixation cross for 1000 ms, followed by the cue for 5000 ms. Then, a scale (1 = *not well at all* 2 =

somewhat well 3 = *extremely well*) was shown, and participants indicated how well they remembered the associated memory[2].

We were able to measure the strength between the cue and the memory using this task, which we call "accessibility". We tested whether the accessibility of memories differed across moral memory type on the second day. Participants indicated that they remembered 94.16% of memories on average, and importantly this did not differ ($BF_{10} = 0.17$) between morally right ($M = 94.41\%$, $SD = 6.93$) and wrong ($M = 93.93\%$, $SD = 6.50$) memories, nor was this effect different across strategy groups ($BF_{10} = 0.04$). Furthermore, there was no difference in how quickly ($BF_{10} = 0.05$, Group $BF_{10} = 0.02$) nor how vividly ($BF_{10} = 0.51$, Group $BF_{10} = 0.16$) they could recall the morally right ($M_{rt} = 1.40$s, $SD_{rt} = 1.49$; $M_{vividness} = 2.52$, $SD_{vividness} = 0.36$) and wrong memories ($M_{rt} = 1.32$s, $SD_{rt} = 1.46$; $M_{vividness} = 2.46$, $SD_{vividness} = 0.33$). Indeed, the Bayesian analyses provide evidence for no significant difference in these measures between morally right and wrong memories. Therefore, although there was high variance in the types of cues that participants generated, both morally right and wrong memories were similarly accessible to participants from all groups (similar to Satish et al., 2022).

Strategy-practice phase

Next, each group practiced their assigned strategy to prevent retrieval of No-Think memories. In one trial, a cue appeared for 10s, preceded by a fixation cross for 1s. Only cues assigned to the No-Think condition were presented. Each group was given different instructions to control their memories.

We instructed participants in the direct suppression group to prevent any thoughts of the associated memory from coming to mind by following two requirements: (1) if the memory happened to intrude, participants were instructed to push it out of awareness, while paying full attention to the cue the whole time it was on the screen and (2) participants were instructed to refrain from generating substitute memories, images, or words to distract themselves (Bergström et al., 2009).

The diversionary thinking strategy we used was inspired by guided imagery (Jain et al., 2012), which often involves imagining a safe space in vivid detail, and is conducted as a comprehensive session lasting more than a few minutes at the least. We provided three different examples of "safe spaces", including being at a beach, under a starry sky, and in a forest. Participants chose one out of these three safe spaces and were instructed to imagine experiencing that same safe space each time a No-think cue appeared on the screen at all points of the experiment. Importantly, they were instructed that instead of thinking about the memory associated to the cue, they should just keep imaging the safe place and keep their thoughts completely focused on the safe place while the cue was on the screen. We also provided instructions to ensure deep imagination of the safe space. For instance, if the safe space was being at the beach, we instructed participants to imagine hearing and seeing the waves crashing, seagulls flying and feeling the warmth of the sun.

We instructed the counterfactual group to imagine a more positive alternative outcome to the events associated with the No-Think cues. For instance, if the original memory referred to when the participant bullied their friend and that action led to a big fight, then they were instructed to imagine that they reconciled instead of fighting. Importantly, participants were instructed to imagine that same counterfactual scenario each time that cue appeared throughout the experiment.

Next, the participants extensively practiced the Think/No-Think task over three phases to ensure they fully understood the instructions. First, participants practiced retrieving/controlling their memories without the emotion ratings. Next, they were familiarised with pressing buttons for the rating scale, and then practiced using the scale in the Think/No-Think phase. The final practice phase was identical to the main task described below.

Think/No-Think phase

Ten morally wrong and ten morally right cues were pseudo-randomly assigned to the Think and No-Think conditions in equal proportions by the software, resulting in five cues in each condition (Think morally wrong, No-Think morally wrong, Think morally right, and No-Think morally right). Each cue was presented 12 times (resulting in 240 trials in total). The order of cue presentation was pseudo-randomised, ensuring that there were no more than three cues in a row from the Think vs. No-Think conditions. Participants were given a short break after each set of 40 trials.

In each trial, a white fixation cross was first presented on a black background for 1000 ms, followed by a cue presented in either green or red for 5000 ms.We instructed participants to retrieve the associated

memory if the cue was shown in green (Think), but if it was shown in red (No-Think), they had to either directly suppress, imagine a safe space (thought substitution), or think of the counterfactual event for that particular memory depending on their group.

After each cue, a black screen was shown for 200 ms, followed by an emotion rating scale for 1500 ms, which showed "1 2 3", wherein participants responded using keyboard button press (*1 = Negative, 2 = Neutral, 3 = Positive*). This scale was similar to the intrusions scale that is used in traditional Think/No-Think tasks (Benoit et al., 2015; Hellerstedt et al., 2016; Levy & Anderson, 2012; Satish et al., 2022), but was adapted to measure the emotions that participants felt immediately after each retrieval/control attempt. Participants were instructed to respond while the rating scale was displayed by pressing buttons on the keyboard to quickly and without deliberation indicate how they felt at that moment. This rating should be relative and they were instructed to use the positive button if they felt even slightly more positive than negative, and vice versa, and they should select neutral only if they were unable to tell how they felt at that time.

Surprise memory test phase

After the critical Think/No-Think task, participants completed a surprise recall test. Cues were presented on the screen and participants typed out a description of the associated autobiographical memory and then completed the same questionnaires as in the first session. These cues were now presented in white colour and participants were asked to ignore any previous Think/No-Think instruction, and to instead treat this as a new task. Final recall and self-reports were analysed but the results were inconclusive. Hence, we report the results in detail in a supplementary file.

We also administered a compliance questionnaire to ensure participants completed the task as instructed (Liu et al., 2021). Although some participants reported non-compliance with instructions ($N_{Direct\ Suppression} = 3$, $N_{Diversionary\ Thinking} = 4$, $N_{Counterfactual\ Thinking} = 12$), statistical analysis of the data yielded similar results regardless of whether non-compliant participants were included or excluded (please find data and analysis files for both results on OSF). Therefore, we report results from the analysis including all participants here, regardless of their compliance scores, in order to increase statistical power to detect effects.

Results

Phenomenological and emotional characteristics of autobiographical memories

We first inspected the characteristics of memories that participants provided on day 1, using the same measures considered in Satish et al. (2022): Memory age (measured in years), vividness (range, 1 = *low* to 5 = *high*), intentionality (range, 1 = *low* to 5 = *high*), morality (1 = *morally wrong*, to 7 = *morally right*), guilt (range, 1 = *low* to 5 = *high*), shame (range, 1 = *low* to 5 = *high*), pleasure (range, 1 = *low* to 5 = *high*), and arousal (range, 1 = *low* to 5 = *high*).

The results (Table 1) replicated previous findings that morally wrong memories are rated to have occurred in the more distant past (Escobedo & Adolphs, 2010), are less vivid, and their actions as less intentional (Satish et al., 2022) than morally right memories. These effects were identical across all three memory control strategy groups, as only main effects of memory type were found in a 3 (Strategy Group: Direct suppression, diversionary thinking, counterfactual thinking) x 2 (Think/No-Think Condition: Think, No-Think) x 2 (Memory Type: Morally Wrong, Morally Right) mixed ANOVA (see Table 1 for results). These analyses thus confirmed the success of the memory type manipulation and showed that any subsequent differences between strategy groups were not caused by confounds in the types of memories they had generated.

Memory control immediately regulates emotions

We extracted the trial-by-trial emotion ratings provided by participants during the Think/No-Think task, split across Think/No-Think and morally right/wrong conditions. Responses were averaged to produce a mean emotion rating for each of these conditions and converted to a scale ranging from -1 (Negative), 0 (Neutral), + 1 (Positive). Then, we tested if 1) emotions changed over time in the Think/No-Think task differently due to the experimental manipulations and 2) if the experimental manipulations affected the emotions in the Think/No-Think task overall, regardless of the repetition over time.

Immediate negative emotions improve over repeated memory control attempts

A primary aim of the study was to determine whether emotions change over repeated memory control

Table 1. Pre-TNT Ratings: Differences between morally right and wrong memory characteristics measured during the generation phase collapsed across all three memory control strategy groups. Pre vs. Post-TNT Ratings: Changes in phenomenological and emotional characteristics from before to after the Think/No-Think task for morally wrong versus right memory types. The table shows the mean pre vs. post-TNT task difference scores and the main effect of memory type on those scores (collapsed across memory control strategy and Think/No-Think instruction).

	Pre-TNT Ratings					Pre vs. Post-TNT Ratings				
	Morally Right mean (*SD*) ratings	Morally Wrong mean (*SD*) ratings	*F (main effect)*	*p*	*partial* η^2	Morally Right mean (*SD*) ratings	Morally Wrong mean (*SD*) ratings	*F (main effect)*	*p*	*partial* η^2
Memory Age (years)	4.95 (1.35)	6.70 (2.14)	**121.29**	**< .001**	**0.48**	-2.54 (0.79)	−0.08 (0.74)	**6.17**	**0.014**	**0.045**
Vividness	3.84 (0.64)	3.45 (0.66)	**58.77**	**< .001**	**0.31**	0.08 (0.54)	−0.04 (0.54)	**4.92**	**0.028**	**0.036**
Intentionality	4.27 (0.56)	3.31 (0.64)	**233.35**	**< .001**	**0.64**	0.08 (0.41)	0.02 (0.45)	1.93	0.17	0.01
Morality	6.14 (0.58)	2.29 (0.52)	**2439.42**	**< .001**	**0.95**	0.11 (.52)	0.06 (0.33)	2.2	0.14	0.02
Ashamed	1.15 (0.24)	2.79 (0.87)	**443.66**	**< .001**	**0.77**	0.02 (0.79)	0.26 (0.79)	**25.3**	**< .001**	**0.16**
Guilty	1.18 (0.27)	3.04 (0.92)	**558.88**	**< .001**	**0.81**	0.02 (0.79)	0.28 (0.54)	**23.14**	**< .001**	**0.149**
Pleasure	3.83 (0.55)	2.31 (0.54)	**403.48**	**< .001**	**0.75**	0.06 (0.33)	0.03 (0.36)	1.26	0.26	0.01
Arousal	2.44 (0.75)	2.55 (0.77)	2.7	0.1	0.02	0.08 (0.49)	0.05 (0.49)	0.1	0.74	0

Note. All measures rated on a 5-point scale (1 = low to 5 = high), except Morality (1 = Morally Wrong, 7 = Morally Right). *SD* is denoted in brackets. *df* = 132. Significant effects are marked in bold.

attempts. To capture the change in average emotion scores, we calculated the slope (β) of the line of best fit for emotion ratings over the 12 repetitions of memories in each condition, and submitted it to a 3 (Strategy Group: Direct suppression, diversionary thinking, counterfactual thinking) x 2 (Think/No-Think Condition: Think, No-Think) x 2 (Memory Type: Morally Wrong, Morally Right) mixed-design ANOVA. See Figure 2 for an illustration of the descriptive statistics illustrating the average emotion score for each repetition in the Think/No-Think task across our experimental conditions, collapsed across the different strategy groups. Participants generally felt better over repetitions when not thinking of morally wrong memories compared to when thinking of those memories, but the change in emotions over time is not apparent for morally right memories regardless of Think/No-Think instruction.

There were no statistically significant main effects nor interaction effects involving memory control strategy ($Fs < 1.82$, $ps > .16$). However, regardless of memory control strategy, we found a significant main effect of Think/No-Think condition on the slope of emotion ratings across repetitions ($F(1, 132) = 9.96$, $p = .002$, partial $\eta^2 = .07$) but the main effect of Memory Type on slope was not significant

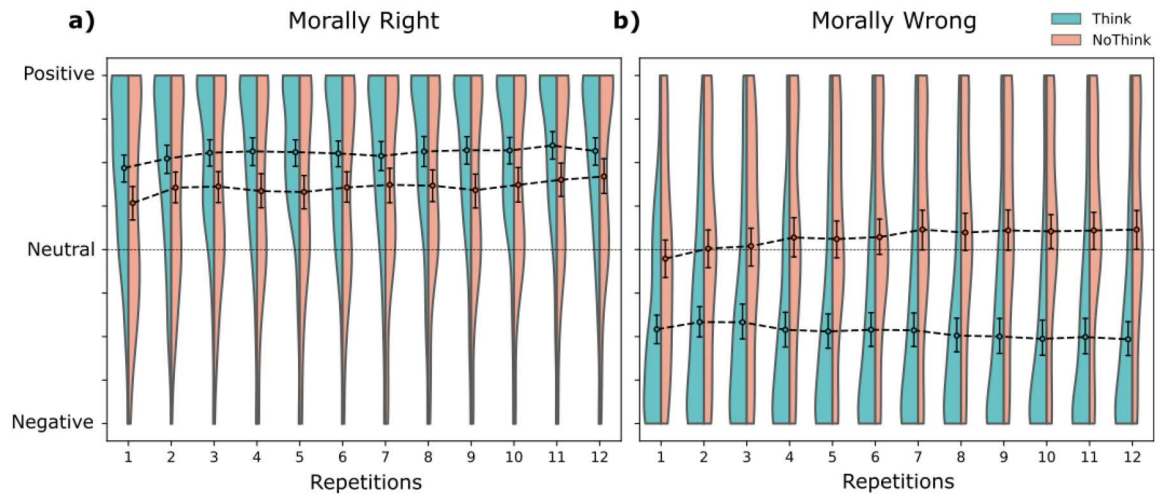

Figure 2. Average emotion ratings during the Think/No-Think task trials, compared across Think and No-Think conditions and 12 presentations of cues for a) morally right and b) morally wrong memories. The data is collapsed across strategy group. The split-violin plots illustrate the distribution of online emotion ratings for each condition. The error-bars depict bootstrapped 95% confidence interval. $N = 135$.

($F(1,132) = 1.23$, $p = .27$, partial $\eta^2 = .009$). Importantly, a significant Think/No-Think x Memory Type interaction effect was found ($F(1, 132) = 8.67$, $p = .004$, partial $\eta^2 = .043$). Therefore, the change in emotions experienced over time in the Think/No-Think task was affected by the intention to retrieve or avoid retrieval, regardless of the No-Think strategy, and this effect differed for morally right and wrong memories.

Follow up paired t-tests comparing the effect of Think/No-Think conditions on the slope of emotion ratings were conducted for morally right and morally wrong memories separately. There was no reliable difference between the slopes of Think ($\beta = .0051$) and No-Think ($\beta = .0054$) conditions for morally right memories ($t(134) = .07$, $p = .94$, $d = .006$; Figure 1(A)). We tested if the slopes were reliably greater than 0 to indicate an increase in positive feelings over the TNT task. One sampled t-tests indicated small effects sizes for both Think ($t(134) = 2.06$, $p = .041$, $d = .17$) and No-Think ($t(134) = 1.74$, $p = .084$, $d = .15$) conditions.

However, for morally wrong memories (Figure 1 (B)), the change in emotions over time was greater for the No-Think ($\beta = .0104$) than the Think condition ($\beta = -.0054$), $t(134) = 3.84$, $p < .001$, $d = .33$. One-sample t-tests indicated that the change in emotion score over time was significantly greater than 0 when participants were not-thinking about morally wrong memories $t(134) = 3.19$, $p = .002$, $d = .27$, whereas the slope was below 0 when participants were thinking of their morally wrong memories, and this was a small effect size $t(134) = -1.88$, $p = .062$, $d = .16$.

Therefore, repeated attempts of memory control were successful in improving the negative emotional response elicited by cues to memories of morally wrong actions, compared to retrieving these memories, regardless of the memory control strategy.

Table 2. Results of an omnibus ANOVA testing for differences in the online emotion measure (collected during the Think/No-Think task) due to experimental manipulations, collapsed across repetitions.

Comparison	*F*	*p*	η_p^2
TNT (Think vs. No-Think)	**20.42**	**<.001**	**0.134**
TNT x Strategy Group	**29.16**	**<.001**	**0.306**
MT (Morally Right vs. Wrong)	**258.75**	**<.001**	**0.662**
MT x Strategy Group	0.85	0.431	0.013
TNT x MT	**115.89**	**<.001**	**0.467**
TNT x MT x Strategy Group	2.38	0.097	0.035

Note. MT = Memory. η_p^2 = partial eta sq. $df = 132$.

Both diversionary thinking and counterfactual thinking induced immediate positive emotions whereas direct suppression neutralised immediate emotions

Next, we conducted a 3 (Strategy Group: Direct suppression, diversionary thinking, counterfactual thinking) x 2 (Think/No-Think Condition: Think, No-Think) x 2 (Memory Type: Morally Wrong, Morally right) mixed-design ANOVA on the average emotion score, collapsed across all repetitions in the Think/No-Think task. See Table 2 for the results and Figure 3 for an illustration of the results.

We found a significant interaction between Think/No-Think condition and Memory Type. Follow-up paired-samples t-tests revealed that participants felt better after not thinking than thinking about their morally wrong memories ($t(134) = 8.04$, $p < .001$, $d = .69$) but felt worse after not thinking than thinking about their morally right memories ($t(134) = 3.41$, $p < .001$, $d = .29$).

The effect of the Think/No-Think manipulation on emotional experiences also differed depending on memory control strategy, as shown by a Strategy Group x Think/No-Think condition interaction (Table 2). Follow up paired-samples t-tests revealed that participants felt better when not thinking than thinking of their memories (overall, for both morally right and wrong memories) in both counterfactual thinking ($M_{No\text{-}Think} = .48$, $SD_{NoThink} = .45$, $M_{Think} = -.04$, $SD_{Think} = .27$), $t(46) = 6.51$, $p < .001$, $d = .55$, and diversionary thinking groups ($M_{No\text{-}Think} = .39$, $SD_{No\text{-}Think} = .42$, $M_{Think} = .06$, $SDThink = .25$), $t(34) = 3.83$, $p < .001$, $d = .50$. Direct suppression however affected participants' feelings differently from diversionary thinking and counterfactual thinking, because emotion ratings were lower for No-Think ($M_{No\text{-}Think} = -.15$, $SD_{No\text{-}Think} = .34$) trials compared to Think trials ($M_{Think} = .09$, $SD_{Think} = .35$), $t(52) = 3.55$, $p < .001$, $d = .20$, in the direct suppression group when collapsed across memory type. This result may be interpreted as direct suppression making participants feel worse than thinking about their memories, but the mean emotion scores were close to "neutral" for both morally right and wrong memories that were directly suppressed (see Figure 3), whereas for diversionary thinking and counterfactual thinking, the means were closer to the "positive" end of the scale. Therefore, direct suppression made participants feel more neutral whereas diversionary thinking and counterfactual thinking induced more positive feelings, regardless of the moral nature of their memories.

In sum, comparing online emotion ratings across repetitions in the Think/No-Think task showed that

Figure 3. Average emotion ratings in the Think/No-Think task, compared across moral Memory Type and Think/No-Think condition, for each Strategy Group. Diversionary thinking and counterfactual thinking improved feelings for both memory types, but direct suppression improved negative feelings for morally wrong memories, but dampened positive feelings for morally right memories. The *y*-axis depicts the online rating scale which ranges from -1 (Negative), 0 (Neutral), to +1 (Positive). Scatter dots show the mean emotion rating for a condition of each individual participant. The thick lines show the condition means and the boxes depict the 95% confidence interval of the means. $N = 135$.

emotions became more neutral as participants repeatedly performed the Think/No-Think task. Participants felt worse after repeatedly thinking of their past morally wrong acts, but contrastingly felt more positive after repeated attempts at memory control of morally wrong memories. These effects were found regardless of memory control strategy. Participants reported feeling more positive while thinking compared to not thinking of morally right memories, whereas controlling memories of morally wrong acts led to more positive feelings than thinking of them. The memory control strategies also seemed to affect participants' feelings differently. Both diversionary thinking and counterfactual thinking groups reported feeling more positive while not thinking than thinking about their memories, but the direct suppression group felt more neutral while not thinking than thinking about their memories, regardless of whether the memories were of past morally right or wrong actions.

After-effects of memory control and retrieval on emotion

To test for the after-effects of memory control on emotions, a difference score was computed between self-reports collected in the first session before the Think/No-Think task, and the second session after the Think/No-Think task, and this was used as a dependent variable to test the effect of the Think/No-Think manipulations on phenomenological characteristics of memories. A 3 (Strategy Group: Direct suppression, diversionary thinking, counterfactual thinking) x 2 (Think/No-Think Condition: Think, No-Think) x 2 (Memory Type: Morally Wrong, Morally Right) mixed ANOVA was conducted with the difference scores. We only found significant main effects of Memory Type for some measures (see Table 1), whereas all other effects were non-significant.

We found that the change in participants' ratings of memory age, vividness, guilt, and shame from

before to after the Think/No-Think task was different for morally right and morally wrong memories, regardless of whether participants had retrieved or controlled the memories (see Table 1). Participants reported a larger perceived memory age of morally right memories after compared to before the Think/No-Think task, and this difference was greater than the change in perceived age found for morally wrong memories. Furthermore, irrespective of whether people had repeatedly retrieved or attempted to stop retrieval, morally wrong memories were rated as more vivid after the Think/No-Think task than before, and this change was in the opposite direction than for morally right memories, which were rated as less vivid after the Think/No-Think task. Participants also reported feeling less ashamed and guilty for morally wrong memories after vs. before the Think/No-Think task, and this post vs. pre- Think/No-Think change was greater for morally wrong memories than the change in shame and guilt found for morally right memories.

Therefore, participants perceived their morally right memories as more vivid and having occurred more distantly in the past compared to morally wrong memories as a result of both thinking and not thinking of their memories. Furthermore, negative emotions of guilt and shame were reduced as a result of both thinking and not thinking of morally wrong memories, but not morally right memories.

Discussion

We compared the effectiveness of different memory control strategies at regulating emotions elicited by autobiographical memories of morally-relevant acts. Specifically, participants used either direct suppression (Anderson & Hanslmayr, 2014; Benoit & Anderson, 2012; Bergström et al., 2009) or thought substitution (Benoit & Anderson, 2012; Bergström et al., 2009; Hertel & Calcaterra, 2005) via either diversionary thinking or episodic counterfactual thinking (De Brigard & Parikh, 2019) to prevent memories from coming to mind. Subjective ratings of emotions were collected both immediately after each memory control attempt and in a memory test after the control task. We found new evidence that memory control immediately reduces subjective negative feelings associated with unwanted autobiographical memories of previous immoral acts. Diversionary thinking and counterfactual thinking strategies were particularly advantageous for immediate emotion regulation as they induced a positive mood, whereas direct suppression neutralised emotions. Furthermore, both voluntary retrieval and retrieval control reduced negative emotions of guilt and shame associated with morally wrong memories on a final test, similarly across all strategy groups.

Attempts to stop memory retrieval in response to reminders had strong effects on immediate negative emotions measured on a trial-by-trial basis in the Think/No-Think task. As predicted, participants indicated that thinking of morally wrong memories made them feel worse than not thinking of such memories. Crucially, participants also reported feeling better over repeated attempts at stopping retrieval of morally wrong memories. These results indicate that repeated memory control can successfully regulate immediate negative emotions associated with morally wrong autobiographical memories, especially in contrast to repeatedly retrieving such unpleasant memories, which exacerbates negative emotions.

The reduction in negative emotions for morally wrong memories across No-Think trials is likely a result of increasing success in preventing intrusions of the memories. A large body of research indicates that memory intrusions are highly frequent during initial attempts to stop retrieval, but intrusions occur less frequently over time, suggesting that repeated control attempts improve people's ability to stop unwanted conscious recollection (Benoit et al., 2015; Davidson et al., 2020; Harrington et al., 2021; Hellerstedt et al., 2016; Levy & Anderson, 2012; Mary et al., 2020; Satish et al., 2022; van Schie & Anderson, 2017). This real-time improvement in memory control is often found in studies investigating the mechanisms underlying direct suppression, and is thought to indicate a gradual inhibition of unwanted memory traces that prevents automatic retrieval of the traces in response to reminders (Benoit et al., 2015; Levy & Anderson, 2012). Our results suggest that repeatedly preventing unwanted retrieval also leads to parallel weakening of the emotional response associated with the memories in real time. Furthermore, diversionary thinking and counterfactual thinking appear to induce gradual improvements in preventing unwanted memory intrusions similar to direct suppression, since all control strategies reduced subjective negative emotional responses with repetition. We found a large variability in affective responses following memory control, with individual participant data points spanning the

entire range of the scale (see Figure 3). Previous research indicates that this variability could partly be due to stable individual differences in the efficacy of memory control mechanisms (Gagnepain et al., 2017), as such differences in ability to control memories would also affect people's emotional responses to those memories. In addition, due to the unconstrained nature of autobiographical memories, variability in memory characteristics likely also contributed to differences in emotional responses across participants in this study. Future research is needed to understand the different factors that determine the extent to which people can regulate their emotional responses using memory control strategies.

The results also indicate that the different memory control strategies affected immediate emotions in different ways, regardless of repeated attempts at control. Both diversionary thinking and counterfactual thinking induced more positive immediate feelings, whereas suppressing retrieval of both morally right and wrong memories made participants feel more neutral compared to retrieving memories (which made them feel positive or negative depending on the memory). Therefore, the results indicate that direct suppression can be helpful for making emotions more neutral, regardless of the emotional nature of the memory, but counterfactual thinking and diversionary thinking may provide an added benefit by inducing positive emotions, regardless of whether the to-be-controlled memory is negative or positive in nature, at least when measured immediately after attempts at control.

The differences in immediate emotional responses across strategies can be explained by considering how the strategies were implemented. Direct suppression instructions emphasise stopping any thoughts of the memory from entering conscious awareness (Anderson & Hulbert, 2021; Benoit & Anderson, 2012; Bergström et al., 2009; Engen & Anderson, 2018). Therefore, when intrusions of morally right or wrong memories reduce due to inhibitory control and the mind is cleared of thoughts about the memories, any positive (morally right) or negative (morally wrong) emotions associated to the memory would also diminish, causing the person to feel more neutral. In contrast, both diversionary thinking and counterfactual thinking, as implemented here, required participants to redirect attention from the unwanted memory to a more positively imagined scenario, where participants substituted thoughts of the memory by imaging a safe space such as lying on a beach (diversionary thinking) or imagining a better version of the to-be-controlled memory (episodic counterfactual thinking; De Brigard & Parikh, 2019). Diverting attention from the unwanted memory to the alternate imagined positive scenarios therefore had strong positive effects on immediate emotions. For morally right memories, participants indicated that thinking of these alternate scenarios made them feel more positive than thinking of their actual memories. These strategies also provided an added benefit for morally wrong memories, because controlling these memories induced positive feelings compared to thinking about their memories, which induced negative feelings.

The results from this study provide novel evidence that diversionary thinking and counterfactual thinking can be useful strategies for regulating immediate emotions elicited by unwanted memories. There is mixed evidence regarding whether thought substitution is more effective than direct suppression in inducing forgetting of unwanted memories by memory control (Bergström et al., 2009; Hertel & Calcaterra, 2005; Stramaccia et al., 2020). Here, we show that thought substitution using positive substitutes is more viable than direct suppression in inducing immediate positive emotions (see also Joormann et al., 2009) although both strategies are effective at reducing negative emotions. Likewise, our findings are in line with a recent study indicating that counterfactual thinking of a more positive scenario can improve negative emotions (De Brigard et al., 2019), even though a range of research indicates that such counterfactual thinking sometimes worsens negative feelings as participants may feel regretful that the positive outcome did not occur (Allen et al., 2014; Epstude & Roese, 2008; Rim & Summerville, 2014). In both strategies as implemented here, participants actively imagined a more positive alternate scenario, which is likely important for inducing positive emotions (De Brigard & Parikh, 2019; Joormann et al., 2009). Therefore, all three strategies potentially serve a purpose in regulating emotions associated with autobiographical memories, based on the goal of emotion regulation. If the person's goal is to feel positive immediately, then diversionary or counterfactual thinking, rather than direct suppression, could be used to induce these positive feelings. Whereas, if the goal is to reduce emotions and feel relatively neutral, then direct suppression could be particularly beneficial.

We also found that memory control subsequently reduced feelings of guilt and shame associated with

morally wrong memories. Previous studies have found that retrieval suppression subsequently improves negative emotions elicited by paired-associate stimuli (Gagnepain et al., 2017; Legrand et al., 2020; Nishiyama & Saito, 2022). Here, we extend these findings to show that memory control, either by direct suppression, diversionary thinking, or counterfactual thinking, improves negative emotions associated with morally wrong autobiographical memories. However despite our finding that memory control was beneficial for regulating negative emotions when compared to retrieving memories *online* at the time of control, memory control did not have an added benefit over retrieval in terms of emotional *after-effects* as measured in the final test, after the memory control task. That is, the reduction in guilt and shame on the final test was found across all morally wrong memories, not only for memories that were repeatedly controlled, but also for memories that were repeatedly retrieved in the Think/No-Think task.

The finding that repeatedly thinking about morally wrong memories immediately made people feel worse, but subsequently reduced negative feelings of guilt and shame may seem surprising, but is consistent with some prior findings (De Brigard et al., 2019). This account argues that people automatically direct attention to emotionally salient information, but this selective attention allows for subsequent reflection and reprocessing of the salient information that helps in regulating emotions (Todd et al., 2012). Our results fit the predictions of this theory of affect-biased attention as a form of emotion regulation. Participants may have selectively attended to negative details of their immoral memories during Think trials, when they were voluntarily asked to retrieve and hold their memories in mind, which induced immediate negative feelings that worsened over repeated thoughts. In the subsequent memory test, when participants had to describe these memories in some detail, they possibly had more time to reprocess these negative details and regulate negative emotions associated with them. They could have also avoided thinking of the most negative aspects of those events on the final test. It is also possible that online and offline ratings of emotions captured different aspects of people's feelings. These explanations are speculative and further research is needed to clearly determine how immediate emotional reactions during memory control attempts influences subsequent longer term emotions associated with those memories. These studies should include a final test baseline condition to separate the effects of memory retrieval and control from non-specific causes of emotional changes, such as habituation/fatigue. Future research could also consider whether varying levels of cognitive effort are required to implement these strategies, and whether their effectiveness in regulating emotions is affected by cognitive load (e.g. a recent study found that cognitive load impairs memory control; Noreen et al., 2020).

Our thought substitution manipulations were inspired by strategies used in clinical practice. For diversionary thinking, we provided instructions inspired by guided imagery (Jain et al., 2012), where people actively imagine a safe space that engages thought substitution mechanisms. For counterfactual thinking, the instructions were inspired by imaginative rescripting (Arntz, 2012; Stavropoulos et al., 2023), where people change specific details of intrusive memories and create a more positive narrative to the original memory. The diversionary thinking strategy therefore involved imagining a completely distinct event from the original unwanted memory, whereas the counterfactual thinking strategy involved changing details of the same event and repeatedly imagining this counterfactual event. Therefore, these strategies were different in terms of the memory content that was changed, but nevertheless induced similar effects on participants' subjective feelings. Both types of thought substitution induced immediate positive emotions in response to morally wrong autobiographical memories, providing empirical evidence of their effectiveness in regulating unwanted memories and emotions in real life. It is important to consider how these strategies are implemented in the clinic however. Although positive counterfactual thinking may provide immediate relief from negative feelings, this may create problems if the person continues to lie to themselves about the original episode, providing a strategy for the person to morally disengage from their past immoral acts in order to excuse future immoral decisions (e.g. Galeotti et al., 2020).

Direct suppression, which involves preventing any thoughts about the memory from coming to mind without substituting it with alternative thoughts, in contrast made participants feel immediately more neutral. Because this strategy involves confronting reminders while actively suppressing the unwanted memories, it may enable people to weaken those unwanted memories and make them less intrusive, regulating negative emotions that come with remembering disturbing memories in real life (Mamat & Anderson, 2023; Satish et al., 2022). Despite differences

in the immediate emotional response elicited by different strategies, there were no differences between strategies in their after-effects on emotional responses, as assessed in the final test. The improvements in immediate negative emotions across repeated attempts at memory control were also similar regardless of the strategy used to achieve control. Hence, our results suggest that direct suppression was as successful as the other strategies at regulating negative emotions in the longer term. Together with other evidence indicating that direct suppression regulates emotions (e.g. Mamat & Anderson, 2023), our findings therefore suggest that direct suppression may also be beneficial for clinical practice. Therefore, there is potential for training people to use all the tested memory control strategies to regulate both unwanted memories and emotions, in order to improve their mental health (*cf.* Mamat & Anderson, 2023). However, before practical implementation, it will be important to test the after-effects of these memory control strategies on emotions and mental health over various time-delays from months to years, to better understand how negative emotions from unwanted memories can be permanently counteracted.

One potential limitation of this study is that we used a 3-point Likert scale to measure online emotions. We used this scale to enable participants to report emotions in an intuitive way without dwelling on their responses. Crucially, the time-window to respond is usually short in Think/No-Think studies in order to stop participants from thinking of the memories they are supposed to avoid, since doing so would reduce the effectiveness of the memory control strategy (Ashton et al., 2024). The potential downside to this scale however is that very subtle differences in emotions may be undetectable. In the future, continuous rating scales could be used to provide fine-grained measures of emotional responses, which could reveal subtle effects of memory control strategies. Nevertheless, the present study provides clear evidence that there are changes in emotions due to memory control even when measured with a relatively coarse rating scale.

Our research aimed to investigate memory control effects on emotions in an ecologically valid design by studying control over autobiographical memories of morally relevant actions, the type of memories that we deal with in everyday life. Furthermore, we adapted instructions for memory control (especially in diversionary thinking and counterfactual thinking) from strategies used in clinical practice, and thus attempted to mimic such scenarios in the experiment. However, the study was conducted in a controlled laboratory environment, and administering instructions for direct suppression requires experimental training. So, whether such memory control can be implemented in day-to-day situations in a similar way is not entirely clear from this study. Future studies attempting to use this paradigm would benefit from following protocols outlined in Nardo and Anderson (2023). We collected data from mainly healthy undergraduate students at a university in the UK. Future research could explore whether these results generalise to people from varied cultures and ages, including those with relevant mental health conditions. Therefore, this study provides evidence that emotions associated to autobiographical memories can be immediately regulated using the three strategies mentioned above, in a controlled lab-environment that may mimic a clinical therapy session. However, future research is needed to replicate and demonstrate the generalisability of these findings.

Conclusion

Our findings suggest that memory control can reduce negative emotions associated with unpleasant memories of our past immoral acts. By stopping memories from coming to mind, people can improve their immediate subjective emotions, and their ability to stop unwanted retrieval and reduce negative feelings improves over repeated attempts at memory control. Thought substitution, implemented as either diversionary thinking or counterfactual thinking, and may provide an advantage over direct suppression in situations where we need to induce immediate positive feelings. However, all three strategies investigated here regulated unwanted memories and emotions, indicating that memory control benefits our mental wellbeing and functioning in everyday life.

Notes

1. We did not find changes in memory descriptions after the think/no-think task and those results are hence not reported in detail in the main manuscript. We also did not test for suppression-induced forgetting as typically done, due to a lack of a baseline condition in this study. Please see supplementary material for more details about this analysis.
2. A control study indicated that participants could accurately recall their memories 24hrs after first describing them, see Satish et al. (2022) for details.

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Ethics statement

Ethics approval was awarded by University of Kent's, School of Psychology ethics committee. Consent to participate & publish was obtained from all individual participants included in the study. They specifically consented for anonymised data to be available on online repositories and to be published in peer-reviewed journals.

Data availability statement

The data and analysis code that support the findings of this study are openly available in the Open Science Framework, an open science platform. Please use this link to access this material on OSF: https://osf.io/gyk38/. This link is set to view-only for the peer-review process and will be fully accessible after publication.

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