



The effect of increasing state anxiety on autobiographical memory specificity and future thinking



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ABSTRACT

Background and objectives: Impairments in the specificity of autobiographical memory (AM) and future thinking are associated with a range of affective and psychopathological states, however, whether these deficits also occur in the context of state anxiety is not well known. We examined the effects of increasing state anxiety on the specificity of AM and future thoughts, as well as whether changes in rumination and executive functioning mediate any observed effects.

Methods: Sixty-four participants (M age = 29.1, SD = 11.5) were randomized to either an anxiety or neutral mood induction and completed pre and post-measures of the constructs of interest.

Results: There were significant decreases observed in AM specificity in the anxiety induction group, relative to the neutral group. No changes were observed for future thinking specificity. Rumination was increased as a result of the anxiety induction, but only a non-significant trend was observed with respect to its association with changes in AM and future thinking specificity. Verbal fluency and working memory were not affected by the induction.

Limitations: Physiological measures of anxiety were not used. State anxiety, although increased, was not high in severity. Future research might use a clinical sample to assess generalizability of these findings.

Conclusions: Although preliminary, these findings provide first evidence of the causal impact of an anxiety induction on the ability to retrieve specific AM.

1. Introduction

The recall of specific autobiographical memories, that is, memories of personal experiences that occurred within the space of a day, is an adaptive cognitive process, and associated with other adaptive cognitive processes such as problem-solving ability, planning, and decision-making (Dagleish & Werner-Seidler, 2014). Deficits in the voluntary retrieval of autobiographical memories (AM) that are specific (commonly termed overgeneral memory) are apparent in the context of dysphoric mood (Zinbarg, Rekart, & Mineka, 2006) and a range of psychopathologies such as clinical depression and posttraumatic stress disorder (PTSD; Williams et al., 2007), schizophrenia-spectrum disorders (Berna et al., 2015), and anorexia nervosa (Bomba et al., 2014; Huber et al., 2015). Reduced AM specificity therefore appears to have transdiagnostic relevance.

Although deficits in AM specificity have been identified as being associated with a range of psychological states, anxiety has been the focus of few previous studies. Findings to date on the association

between anxiety and AM specificity have been mixed. One reason for this may be the type of anxiety presentation under consideration. For example, social anxiety disorder (Heidenreich, Junghanns-Royack, & Stangier, 2007; Wenzel & Cochran, 2006; Wenzel, Werner, Cochran, & Holt, 2004) and some specific phobias (Wenzel, Jackson, Brendle, & Pinna, 2003) do not appear to be related to reduced AM specificity. Mixed evidence exists for the association of obsessive-compulsive symptoms and AM specificity (Boelen, Rafaele, Huntjens, & van den Hout, 2014; Wilhelm, McNally, Baer, & Florin, 1997). Other recent findings suggest that there is an association between higher general anxiety symptoms, such as excessive worrying and physiological arousal, and reduced AM specificity (Boelen, Huntjens, & van den Hout, 2014; Hallford & Mellor, 2017). This is noteworthy, as general anxiety symptoms are not necessarily predicated on particular external stimuli, in contrast to social anxiety and specific phobias which involve an anxious state that is triggered by that particular feared stimuli. Therefore, higher general anxiety symptoms may represent a more pervasive predilection to experience an anxious affective state, which might more

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consistently impair specificity in episodic thinking.

Conway and Pleydell-Pearce's (2000) self-memory system provides a framework for understanding how AM functioning may become overgeneral. It posits that AM is structured in a hierarchical manner, with conceptual themes at a higher abstracted level (e.g., the park is a fun place) and event-specific knowledge at a more detailed level (e.g., a specific day that was spent in the park with associated details such as how sunny it was and who was there). Unlike involuntary retrieval, which may be triggered by external stimuli in the environment or internal stimuli such as other thoughts, the voluntary retrieval of AM involves a generative search which begins at the conceptual level and progresses to event-specific details. Within this general framework, Williams and colleagues' (2006, 2007) have proposed three inter-related processes that may inhibit the retrieval of specific memories: capture and rumination, functional avoidance, and impaired executive functioning (CaR-FA-X). The capture process refers to when the generative search process becomes halted at the intermediate, schematic level where more highly elaborated personal concerns and/or self-representations may attract attention and arouse emotion, disrupting the retrieval of specific AM (Crane, Barnhofer, & Williams, 2007; Noboru & Satoshi, 2017). Ruminative thinking (repetitive thinking focused on past negative content) may then lead to further elaboration of personal concerns or self-representations, increasing the likelihood of attention capture, and activation of other intermediate representations rather than specific AM (Debeer, Hermans, & Raes, 2009). Functional avoidance refers to the avoidance of specific memories as a means of affect regulation. This is considered a learned process, whereby avoiding thinking about specific experiences that evoke negative affect can lead to a more generalized tendency to recall abstracted AM (Hallford, Austin, Raes, & Takano, 2018). Lastly, deficits in executive functions, referring to processes necessary for cognitive control such as monitoring of thoughts, inhibition of interfering cognitive information and holding multiple bits of information in working memory, may also be a factor in overgeneral memory (Dalgleish et al., 2007). These deficits impede the generative search for specific AM, for example, by inhibiting irrelevant internal or external information that might disrupt the search process, and reducing capacity to hold information in working memory while searching for event-specific levels of detail. A growing body of research has provided evidence for the role of these CaR-FA-X processes in explaining overgeneral AM (Sumner, 2012).

Although the CaR-FA-X model was initially developed primarily in the context of depression and the effects of trauma (Williams, 2006), the processes described above may also conceivably account for reduced AM specificity in the context of anxiety. For example, rumination, which is known to be elevated in the context of anxiety disorders and symptoms of anxiety, independently of depressive symptoms (Olatunji, Naragon-Gainey & Wolitzky-Taylor, 2013), may mediate associations between general anxiety symptoms and reduced AM specificity (Hallford & Mellor, 2017). Further, anxiety is known to be related to impairments in executive functioning (Eysenck & Derakshan, 2011). For example, Garcia-Pacios, Del Rio, and Maestu (2014) found that in healthy participants hypervigilance to threat produced by increased state anxiety, relative to a control group, disrupted working memory performance. Notably, a lack of differences between the groups in depressive symptoms suggest this was not likely a cause. Choi, Padmala, and Pessoa (2012) also showed that in a sample of healthy individuals screened for psychological disorders state anxiety impacted the ability to monitor thoughts, and gave rise to additional threat-related thoughts that interfered with performance on cognitive tasks. This combination reduced executive functioning and increased rumination represents a plausible mechanism through which increasing state anxiety might contribute to a reduced capacity to voluntarily retrieve specific AMs.

Another cognitive function closely related to AM is that of future thinking, which encompasses thought processes that contribute to the mental construction, imagination or simulation of possible futures (Szpunar, 2010). Schacter, Addis, and Buckner (2008) suggest that

future thinking and AM are linked due to a shared dependence on the episodic memory system. Their *constructive episodic simulation hypothesis* states that the simulation of possible future events requires a flexible recombination of details from past events into novel scenarios. In support of this, research indicates that AM and future thinking share common neurological pathways (both are associated with activation in the hippocampus and medial temporal lobes), and individuals who experience difficulties in remembering their personal past events also experience difficulties in thinking about future events (for a review, see Szpunar, 2010). Further, specificity in past and future thinking are generally highly correlated (e.g., Williams et al., 1996).

Researchers such as Schacter et al. (2008) and Szpunar, 2010 argue that construction of progressively more detailed thinking observed in AM is also applicable to future thinking. Indeed, future thoughts can vary from general to specific. For example, a general future thought may be 'I will vacation overseas', whereas a specific future thought may be 'next Tuesday morning I will leave for the airport in a taxi from my house to go on vacation in Europe'. It has been suggested that the specificity of future thinking may then also be affected by the CaR-FA-X processes, which may inhibit specific future thoughts from being simulated (e.g. Fortunato & Furey, 2011; Kleim, Graham, Fihosy, Stott, & Ehlers, 2014). For example, individuals may functionally avoid thinking about unpleasant or negative future events, and develop the generalized tendency to have more abstract future thoughts. Indeed, individuals with Generalized Anxiety Disorder, which is characterized by repetitive negative thinking about possible future events, do demonstrate less vivid future thoughts relative to healthy controls (Wu, Szpunar, Godovich, Schacter, & Hofmann, 2015). Furthermore, limits in executive functioning caused by increased anxiety may also lead to less specific future thoughts (Sumner, Griffith, & Mineka, 2011; Williams et al., 2007). Such deficits are of concern, given that future thinking that is less specific, and more general or abstracted in nature, has been found to negatively affect adaptive psychological functions such as emotional regulation, coherence of one's identity, planning, problem solving and decision making (Schacter et al., 2008; Szpunar, 2010) and is related to poorer mental health (Hallford et al., 2018; Kleim et al., 2014; Williams et al., 1996).

In the current study we sought to examine the effect of increasing state anxiety on the specificity of AM and future thinking, as well as cognitive processes that may explain any effects. Given that previous studies have shown mixed findings in anxiety disorders, possibly due to the absence of the feared stimuli and therefore related state anxiety, an experimental approach was thought to be important to effectively examine whether fluctuations in state anxiety might also cause fluctuations in the specificity of episodic thought. We focused on two particular CaR-FA-X processes through which anxiety might be associated with reduced specificity in thinking: rumination and executive functioning. Some evidence suggests that rumination may mediate associations between general anxiety symptoms and reduced AM specificity (Hallford & Mellor, 2017), however, this has not been tested experimentally. Further, to the authors' knowledge, no research has examined executive functioning in this context. It was hypothesized that, relative to a neutral mood induction, participants who experienced increases in their state anxiety would demonstrate reduced specificity in AM and future thinking, and that these reductions in specificity would be associated with increases in rumination and decreases in executive functioning, as previously found to be associated with increased state anxiety.

2. Methods

2.1. Design

The study used a 2 × 2 between (condition: anxiety or neutral mood induction) – within (time-point: pre and post induction) subjects design to assess the effects of the mood induction on the dependent variables

of AM and future thinking specificity, rumination, and executive functioning.

2.2. Participants

The sample comprised 64 participants (M age = 29.1, SD = 11.5) of whom 78.1% identified as female. Thirty-four participants were randomized to the anxiety mood induction group and 30 to the neutral mood induction group. A convenience sample was used, recruited through social media platforms (e.g., Facebook), personal networks, and snowballing. Inclusion criteria were 18 years of age or over and able to speak fluent English. The sole exclusion criterion was a current diagnosis of an anxiety disorder as self-reported by participant. The majority of the sample reported currently studying (59.4%). The majority were also employed, working either full-time (23.4%), part-time (26.6%), or casually (28.1%). With respect to ethnicity, 71.9% identified as Caucasian, 10.9% as Asian, 9.1% as Arab or Middle Eastern, 3.1% as African, and 4.7% as "Other". An independent samples t -test showed the groups did not differ in terms of age, $t(61) = -0.08$, $p = .453$, nor did they significantly differ with respect to the categorical demographic variables of age, sex, ethnicity, studying and work status (all chi-square tests $p > .05$).

2.3. Materials

Autobiographical memory and future thinking specificity. The Autobiographical Memory Test was used with standard instructions to assess memory specificity (AMT; Williams & Broadbent, 1986), and incorporated cues for future thinking specificity (Williams et al., 1996). The test required individuals to alternately retrieve specific autobiographical memories or generate specific future thoughts in response to 20 cue words (10 past and future oriented). For AM and future thoughts there were four cue words referring to neutral objects or places (e.g., *clothes*, *telephone*, *the sea-side*), three referring to positive emotions (e.g., *happy*, *optimistic*) and three referring to negative emotions (e.g., *upset*, *discouraged*). Two different sets of cue words were used for pre and post testing, and their order was counterbalanced across participants. The cue words were taken from previous AM and future thinking studies (Williams & Broadbent, 1986; Williams et al., 1996). Explicit instructions regarding the task of retrieving specific AM and generating FT were verbally provided to participants before testing. The instructions included definitions of specific AM and future thoughts, and one example of a specific and non-specific response to a past ("*park*") and future ("*cloud*") cue word. The 20 cue words were then provided verbally, one at a time, and participants were given 60 s to respond to each of them. Participants were asked to verbalize their responses to the cue words, which were audio recorded. The recordings were listened to at a later date and coded as either specific (relating to a specific personal past event or a specific possible future event occurring within 24 h) or non-specific (all other responses). An initial subset of 80 responses to the modified AMT were coded by the first author and two co-authors, and another subset of 80 by the first author and another co-author. Inter-rater reliability was found to be high, with intraclass correlation coefficients of 0.80 and 0.91, respectively. The remaining responses were then coded by these three co-authors independently. Scores on AM and future thinking specificity are reported as percentages.

State anxiety. State anxiety was measured using a visual analogue scale (VAS), whereby participants were asked to put a vertical mark on a line to indicate how anxious they were feeling "*right now*" with 0 mm indicating "*not at all*" and 100 mm indicating "*very much*". The scores for this anxiety VAS were calculated by measuring where participants placed their vertical line on the 100 mm horizontal line (0–100).

Rumination. Rumination was measured using a visual analogue scale (VAS) whereby participants were prompted to "*Indicate how much you are mulling things over in your head right now that have happened to*

you in the past by putting a vertical mark on the line below" on a 100 mm horizontal line, where 0 mm indicated "*not at all*" and 100 mm indicated "*very much*". Participant scores for rumination were calculated by measuring where participants placed their vertical line on the 100 mm horizontal line (0–100). This measurement was not specific to rumination on sadness, but rather assessed how much participants were reviewing and considering personally-relevant experiences that it was predicted would increase in the threat-salient, anxiety mood condition.

Executive functioning. To assess these cognitive abilities, verbal fluency and backwards digit span subtests were taken from the Cognitive Telephone Screening Instrument (Kliegel, Martin, & Jager, 2007). The verbal fluency task required participants to name as many words as possible in 1 min that began with either the letter 'A' or 'E'. Participants were then required to name in 1 min as many professions or types of furniture as they could. The two different verbal fluency tasks were counterbalanced across pre and post-induction. The number of correct responses to the letter and word cues at each time-point were summed to create a total verbal fluency score. Working memory was assessed using a digit span task, which required participants to repeat twelve number sequences in reverse order. The length of the number sequence increased after every two number sequences. Again, there were two sets of numbers which were counterbalanced across time-points. Correct responses were scored as one and summed to create a total with a possible range from 0 to 12.

Anxiety and depressive symptoms. Baseline assessment of symptoms of generalized anxiety and clinical depression were conducted using the self-report symptom ratings scales of the seven-item Generalized Anxiety Disorder 7-item Scale (GAD-7; Spitzer, Kroenke, Williams, & Löwe, 2006) and the nine-item Patient Health Questionnaire (PHQ; Kroenke, Spitzer, & Williams, 2001). Both measures use items corresponding to the Diagnostic and Statistical Manual for Mental Disorders 4th edition criteria for Generalized Anxiety Disorder and a Major Depressive Episode, respectively (American Psychiatric Association, 2000). Respondents rate themselves on each criterion to indicate how often they have experienced the symptoms in the last two weeks using a 0 (*not at all*) to 3 (*nearly every day*) scale. Scores on each item are then summed. The GAD-7 (Spitzer et al., 2006) and the PHQ have good validity and reliability (Kroenke, Spitzer, Williams, & Löwe, 2010). In the current study, internal reliability was excellent for the GAD-7 (Cronbach's alpha = .92) and the PHQ (Cronbach's alpha = .87).

2.4. Procedure

The project was approved by the Deakin University Human Research Ethics Committee. Those who agreed to participate were provided with a plain language statement and signed informed consent was obtained. All participants were entered into a draw to win movie tickets at the completion of the study. No other compensation was offered. Participants engaged in the testing session in a location that was convenient for them. Testing conditions required a quiet room that was devoid of distractions, containing a table and chairs. This was either their place of residence or on the university campus. Location was not counterbalanced between the groups. They completed the baseline measures in the following order: the modified AMT, measures of executive functioning, the PHQ and GAD-7, and the measure of state anxiety and rumination. They were then randomly allocated into the anxiety mood induction group or the neutral mood induction group using a manual coin toss method. For both conditions, the mood induction was based on a protocol validated by Nuevo, Montoria, Cabrera, Marquez, and Izal (2014) that incorporates multi-modal stimuli shown to alter mood (music and verbal stimuli; Westermann, Spies, Stahl, & Hesse, 1996), and has been shown to be effective in altering mood as assessed by self-report and behavioural measures. In an attempt to reduce demand characteristics, participants were advised to experience the induction and answer subsequent questions about

their affective state honestly, and not just to appease the experimenters. The participants then watched a power point slide show in which thirty anxiety-related or neutral statements (taken from a larger pool of items validated for their arousal and valence effects; Sinclair, Soldat, & Ryan, 1997) were sequentially displayed for 15 seconds each whilst listening to classical music. The anxiety mood induction group listened to a shortened version of Ligeti's Orchestral Piece Requeim and watched thirty anxiety-provoking statements (e.g. 'I'm an incredibly anxious person', 'My mind is troubled and full of worries') whilst the neutral group listened to a shortened version of Gabriel Faurve Ballade for Piano and Orchestra, and watched thirty neutral statements (e.g. 'I feel mentally alert and calm', 'Today is fine'). Following the induction, participants were asked to spend 2 minutes in an incubation period to focus on and build the respective mood state by dwelling on related anxious or neutral thoughts, as research indicates this can enhance the effect of mood inductions (Sinclair, Mark, Enzle, Borkovec, & Cumbleton, 1994, 1997). In total, the mood induction took 10 minutes. The participants then completed the post-induction measures in the following order: the measures of state anxiety and rumination, the modified AMT, and the measures of executive functioning. If participants underwent the anxiety mood induction, they completed their session by watching a short comedic video to help mitigate against residual elevated state anxiety. The whole testing session took around 70 min to complete in total.

2.5. Data analytic strategy

Power analyses conducted using G*Power 3.1 indicated that to detect a small-to-moderate sized interaction effect ($f^2 = 0.20$), with an alpha level set at 0.05 and statistical power of .80, a total sample size of 52 participants were required. We oversampled ($N = 64$), and therefore were powered to detect effects of this magnitude or smaller. SPSS 24.0 was used for all analyses. Descriptive statistics were generated for the study variables. A between-groups MANOVA and follow-up univariate ANOVAs were used to assess for differences on all variables at baseline and between the two different sets of AM and future thinking cue words. A series of 2×2 repeated measures ANOVAs were used to test the main hypothesis of an effect of the anxiety induction on AM and future thinking specificity, rumination, and executive. Where interaction effects were found, paired samples t -tests were used to assess for within-group change over time. Residualized changes scores were also generated for the study variables by regressing the post-induction scores onto the pre-induction scores. Pearson correlations were then conducted on these change scores to assess whether any changes in AM or future thinking specificity were related to any changes in rumination, and executive functioning.

3. Results

Means and standard deviations for the study variables are shown in Table 1. A MANOVA indicated that the two groups did not significantly differ on any variables prior to the induction, $F(9, 54) = 0.89, p = .537, \eta_p^2 = 0.06$, nor were any pre-induction differences between groups found at the univariate level (all p values $> .05$). Another MANOVA was conducted to assess for any differences between the two sets of cue words on AM and future thinking specificity at pre and post-induction. The results indicated that responses to the two subsets of cue words, did not significantly differ at the multivariate level, $F(4, 59) = 0.89, p = .312, \eta_p^2 = 0.07$, nor were any pre-induction or post-induction differences on AM or future thinking specificity found between the two cue sets observed at the univariate level (all p values $> .05$). A paired samples t -test indicated that the sample as a whole at pre-induction reported a significantly higher frequency of specific responses to past cues relative to future, $t(63) = 9.4, p < .001, d = 1.37$. The correlations between variables at pre-induction are shown in Table 2.

To assess the effect of the anxiety induction, a repeated measures

Table 1
Means and standard deviations of all study variables.

Variable	Pre-Induction	Post-Induction
PHQ-9		
Anxiety Group	7.3 (4.4)	–
Neutral Group	9.6 (6.1)	–
GAD-7		
Anxiety Group	6.1 (4.1)	–
Neutral Group	7.4 (5.7)	–
State Anxiety		
Anxiety Group	27.8 (25.4)	48.8 (29.3)
Neutral Group	31.4 (23.1)	15.4 (19.2)
AM Specificity		
Anxiety Group	67% (19%)	52% (23%)
Neutral Group	60% (21%)	59% (22%)
Future Thinking Specificity		
Anxiety Group	33% (24%)	30% (28%)
Neutral Group	33% (26%)	33% (24%)
Rumination		
Anxiety Group	33.9 (29.1)	51.2 (33.3)
Neutral Group	38.1 (27.3)	21.2 (24.7)
Verbal Fluency		
Anxiety Group	28.5 (7.8)	27.7 (7.8)
Neutral Group	26.2 (7.5)	28.3 (8.7)
Working Memory		
Anxiety Group	6.9 (1.6)	7.5 (1.7)
Neutral Group	6.1 (1.6)	7.0 (2.2)

PHQ-9 = Patient Health Questionnaire 9-item version (possible range 0–27), GAD-7 = Generalized Anxiety Disorder 7-item Scale (possible range 0–21), AM = Autobiographical Memory.

ANOVA was conducted with the state anxiety measure. No main effect for time was found, $F(1, 62) = 0.78, p = .382, \eta_p^2 = 0.01$, but the interaction effect was significant, $F(1, 62) = 42.1, p < .001, \eta_p^2 = 0.40$. Paired sample t -tests indicated that participants in the anxiety induction reported increased anxiety after the induction, $t(33) = 4.9, p < .001, d = 0.77$ (95%CI = 0.27–1.25), whereas participants in the neutral mood induction reported decreased anxiety, $t(29) = 4.4, p < .001, d = 0.75$ (95%CI = 0.22–1.27). These findings indicated that the mood inductions were successful in increasing anxiety in the anxiety condition and reducing anxiety in the neutral mood condition.

To assess the effect of the inductions on AM specificity, a repeated measures ANOVA was conducted. The results showed a significant main effect for time on AM specificity, $F(1, 62) = 8.6, p = .004, \eta_p^2 = 0.13$, and a significant interaction effect, $F(1, 62) = 5.7, p = .020, \eta_p^2 = 0.09$. Paired sample t -tests indicated that participants in the anxiety induction group had significantly reduced AM specificity following the anxiety induction, $t(33) = 4.0, p < .001, d = 0.71$ (95%CI = 0.21–1.19), whereas no significant changes were observed in the specificity of AM in the neutral mood group, $t(29) = 0.40, p = .687, d = 0.04$ (95%CI = –0.46 – 0.55). Fig. 1 shows the AM specificity scores across groups and time.

A second repeated measures ANOVA was then conducted with future thinking as the DV. The results showed there was no effect for time, $F(1, 62) = 0.23, p = .634, \eta_p^2 = 0.00$, and no significant interaction effect, $F(1, 62) = 0.36, p = .551, \eta_p^2 = 0.01$, indicating that the inductions had no effect on future thinking specificity in either group. Fig. 2 shows the future thinking specificity scores across groups and time.

To assess the effect of the inductions on rumination, a repeated measures ANOVA was conducted. The results showed no significant main effect for time, $F(1, 62) = 0.00, p = .954, \eta_p^2 = 0.00$, but a significant interaction effect, $F(1, 62) = 24.9, p < .001, \eta_p^2 = 0.19$. Paired sample t -tests indicated that participants in the anxiety induction group reported significantly increased rumination following the anxiety induction, $t(33) = 3.5, p = .002, d = 0.55$ (95%CI = 0.06–1.03), and participants in the neutral mood induction group reported significantly decreased rumination following the neutral induction, $t(29) = 3.7,$

Table 2
Zero-order correlations between study variables at pre-induction.

	PHQ-9	GAD-7	State Anxiety	AM Specificity	FT Specificity	Rumination	Verbal Fluency	Working Memory
PHQ-9	–							
GAD-7	.56***	–						
State Anxiety	.19	.33**	–					
AM Specificity	.18	.01	-.02	–				
FT Specificity	-.09	-.21†	-.15	.33**	–			
Rumination	.12	.19	.46***	.05	.09	–		
Verbal Fluency	-.20	.08	-.18	.1	-.01	-.07	–	
Working Memory	-.12	-.04	-.10	.15	.11	-.09	.42**	–

† $p < .10$, * $p < .05$, *** $p < .001$. PHQ-9 = Patient Health Questionnaire 9-item version, GAD-7 = Generalized Anxiety Disorder Scale 7-item version, AM = Autobiographical Memory, FT = Future Thinking.

$p = .001$, $d = 0.65$ (95%CI = 0.12–1.16).

A repeated measures ANOVA was then conducted on the executive functioning scores. The results for verbal fluency indicated there was no effect for time, $F(1, 62) = 0.30$, $p = .588$, $\eta_p^2 = 0.01$, and no significant interaction effect, $F(1, 62) = 1.5$, $p = .219$, $\eta_p^2 = 0.02$, indicating that the inductions had no effect in either group. The results for working memory showed a significant main effect for time, $F(1, 62) = 14.0$, $p < .001$, $\eta_p^2 = 0.19$, but no interaction effect, $F(1, 62) = 0.38$, $p = .542$, $\eta_p^2 = 0.01$. A paired sample t -test using the whole sample indicated a small increase in working memory scores from pre to post-induction, $t(63) = 3.7$, $p < .001$, $d = 0.43$ (95%CI = 0.08–0.78).

Change scores on the variables of interest were then correlated to assess whether changes in anxiety were related to changes in the measures of rumination and executive functioning, and whether changes in these variables were related to changes in AM and future thinking specificity. The results (see Table 3) indicate that increases in anxiety were related to reduced AM specificity, but did not reach statistical significance with reduced future thinking specificity ($p < .10$). Increases in anxiety were related to increases in rumination. Increases in rumination were associated with decreased AM and future thinking specificity, but neither reached statistical significance at the $p < .05$ level. Increases in rumination were not related to lower future thinking specificity. Changes in the measures of executive functioning were not related to changes in other variables, with the exception of changes in verbal fluency being associated with AM and future thinking specificity.

To assess whether baseline depression and clinical anxiety

symptoms were associated with changes on the variables, Pearson correlations were conducted with the PHQ and GAD-7 and change scores on all variables of interest. The results showed that symptoms of clinical depression and anxiety were not associated with changes on any of the variables (all $p > .10$).

4. Discussion

The current study aimed to assess the effects of increases in state anxiety on the specificity of AM and future thinking. A further aim was to examine whether increasing state anxiety had effects on rumination and executive functioning, and whether these were related to any changes in AM and future thinking specificity. The findings showed that the anxiety induction increased self-reported levels of state anxiety and, relative to the neutral mood condition, participants in the anxiety condition demonstrated decreased specificity in the recall of AM. Congruent with our rationale, increases in state anxiety were related to reductions in AM specificity. This finding is consistent with previous research investigating the impact of other affective states (e.g., dysphoria; Zinbarg et al., 2006) on episodic thought, by showing that increases in state anxiety adversely impact voluntary generative retrieval of AM in a non-clinical sample. Further, it provides evidence for a direction of causality between anxiety and reduced AM specificity, extending on previous correlational research (Hallford & Mellor, 2017; Hallford, Noory, & Mellor, 2018). Although not hypothesized, the neutral mood condition was found to decrease anxiety and rumination, which is perhaps unsurprising given the stimuli were generally positive

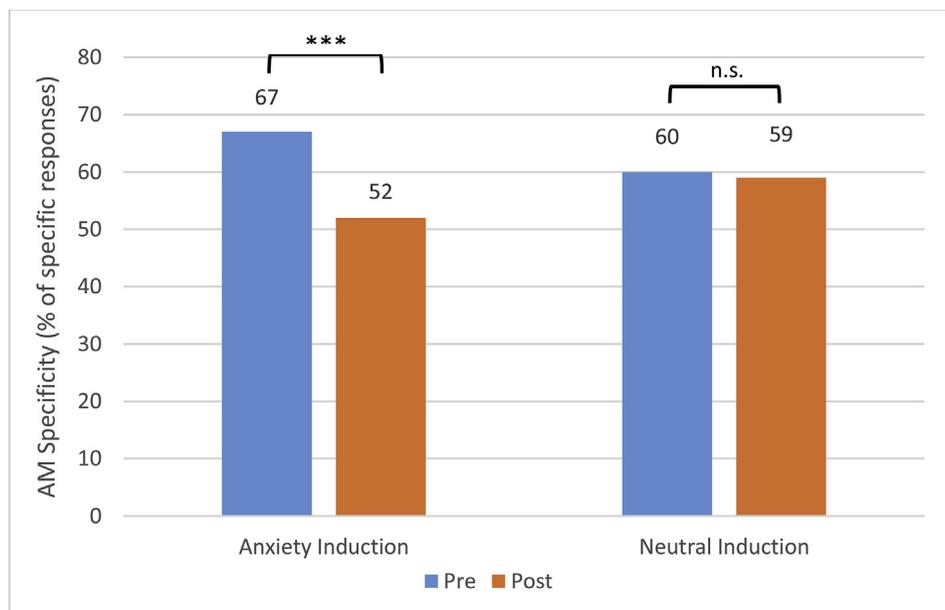


Fig. 1. Pre and post-induction mean scores on AM specificity for both. Conditions. n.s. = not statistically significant, *** $p < .0001$.

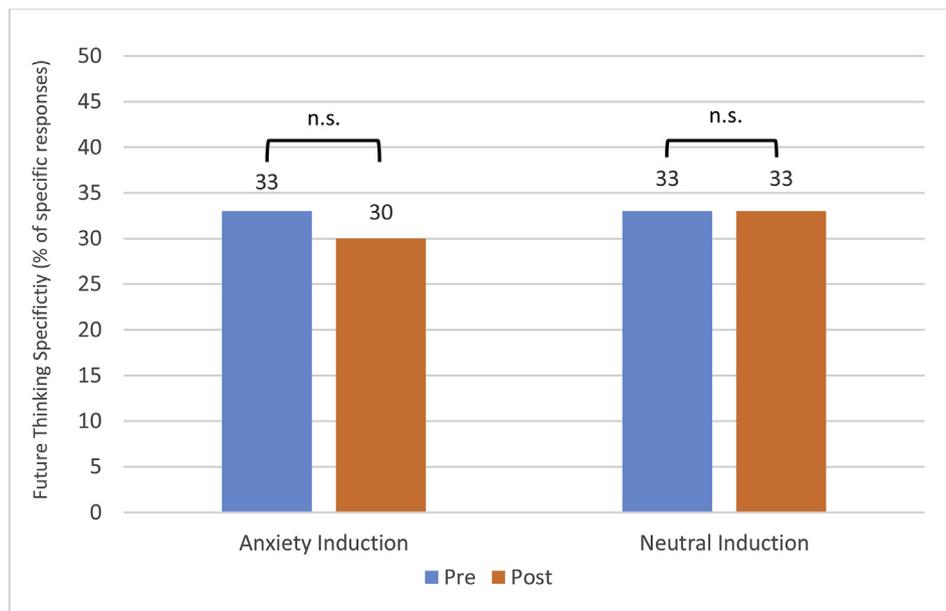


Fig. 2. Pre and post-induction mean scores on future thinking specificity. For both conditions. n.s. = not statistically significant, ****p* < .0001.

in nature. While this was not planned, it still had the effect of creating a discrepancy between the groups in terms of state anxiety and rumination, the context in which to test for associated changes in past and future specificity.

Contrary to our hypothesis, increases in state anxiety did not affect future thinking specificity, nor were changes in state anxiety significantly correlated with changes in future thinking specificity. To the authors' knowledge, this is the first study to examine the effects of increasing state anxiety on future thinking specificity in a non-clinical sample. This was an unexpected result considering the observed effect on AM specificity and proposed associations between AM and future thinking (Miloyan, Pachana, & Suddendorf, 2014; Schacter et al., 2008; Szpunar, 2010). The lack of effect on future thinking specificity contrasts with previous studies showing significant deficits in future thinking specificity in clinical samples with elevated anxiety, such as individuals with PTSD (Brown et al., 2013; Kleim et al., 2014). Further, studies with clinically-depressed samples have shown they demonstrate related deficits in both AM and future specificity (e.g., Hallford et al., 2018; Williams et al., 1996).

It may be that the absolute level of state anxiety that was produced by the induction in our study was not strong enough to affect the generation of future thoughts. Indeed, the effect on AM specificity was only of moderate strength. Associations were found between changes in state anxiety and future thinking specificity, albeit weak, that were suggestive that a stronger induction may have produced statistically significant effects. A possible explanation is differences in the methodology that was used to facilitate the production of future thought. In our study, we used an explicit method of retrieval, and coded future thoughts as specific or non-specific. In our experience of coding the

responses, we noted that it was at times difficult to differentiate between specific future events (unique events occurring on one day), and those that might occur within one day but were categorical and occur repeatedly over time. Given this difficulty, we adopted an approach that erred on the side of coding a response as specific if participants provided some details that might be related to a specific occurrence (e.g., particular thoughts, sequences of events, people). This may have reduced the sensitivity of the measure. Notably though, post-hoc exploratory analyses to assess for effects on the number of categoric responses for AM and future thinking showed no significant time or interaction effect (both $F < 1$, $p > .610$). Future studies may consider using a recombination procedure involving individuals simulating future events based on combinations of various information provided about their past (Addis, Musicaro, Pan, & Schacter, 2010). This procedure impresses as being cognitively more intensive, and therefore may be more sensitive to changes in affective states. Yet other studies have shown that implicit methods of assessing the specificity of future thinking, such as sentence completion tasks, show effects of dysphoria on future thinking specificity (Anderson, Boland, & Garner, 2016; Dickson & Bates, 2006), indicating they too may be relatively more sensitive to changes in affective states. A floor effect was possible also, given that the average number of specific future thoughts was quite low, and therefore for some participants it might not have been possible to find a significant decrease in specificity (on average only 3 out of 10 future thoughts were specific in nature across the groups and time-points). Previous findings do indicate that individuals tend to report less specific future thoughts relative to past (e.g., Addis, Musicaro, Pan, & Schacter, 2010; Anderson & Dewhurst, 2009). Another possibility is that the cognitive process of future thinking may simply be less prone to

Table 3

Zero-order correlations between residualized change scores.

	State Anxiety	AM Specificity	Future Thinking Specificity	Rumination	Verbal Fluency	Working Memory
State Anxiety	–					
AM Specificity	-.32**	–				
Future Thinking Specificity	-.22†	.44***	–			
Rumination	.72***	-.22†	-.23†	–		
Verbal Fluency	-.04	.24*	.34**	.00	–	
Working Memory	.10	-.03	.09	.01	-.03	–

†*p* < .10, **p* < .05, ****p* < .001.

disruption by negative affective states in non-clinical samples, relative to clinical samples, some of which show large impairments (Hallford et al., 2018). The induction of state anxiety, although effective enough to disrupt the generative retrieval of AM, is not equivalent to pervasive deficits in future cognitions that likely develop over time and through processes such as functional avoidance in PTSD (Brown et al., 2013). Future research may utilize stronger anxiety inductions and other procedures to elicit future thinking to assess for any effects of state anxiety.

We were also interested in whether changes in rumination and executive functioning may, at least in part, account for any observed impairments in specificity. With respect to rumination, the anxiety induction did lead to increases in reported rumination relative to the neutral induction condition. A trend was observed regarding the association between rumination and decreased AM specificity and future thinking, however, this did not reach statistical significance. It is possible that this is attributable to a lack of opportunity for participants to engage thoroughly in rumination during such a brief induction. It may also be that the cognitive process of worry is more relevant in future thinking than rumination, given that it also pertains to future thoughts, is typically overgeneral in nature, and is highly correlated with anxiety (Watkins, 2008). Despite worry being a plausible mediator in the association between anxiety and future thinking, the lack of change in future thinking specificity negates the possibility of this mechanism of effect in the current study.

With respect to executive functioning, neither verbal fluency nor working memory were significantly affected by the mood inductions in the expected directions, and only change scores on verbal fluency were associated with changes in AM specificity. There are several possibilities for these findings. As previously discussed, it may be that the anxiety induction did not induce strong enough effects to impair these cognitive processes. The induction used in this study produced only moderate effects on state anxiety and may not have been personally-relevant or threatening enough to affect cognitive functioning more broadly. Despite this, executive functioning has been shown to mediate the relationship between state anxiety and working memory due to hypervigilance of threat competing for executive resources (Garcia-Pacios et al., 2014) and shown to be related to the specificity of AM recall (Ros, Latorre, & Serrano, 2010). In the case of Garcia-Pacios et al.'s study (2014), their use of a threat monitoring task, in anticipation of an electric shock, may be a more proximal variable for assessing the effects of state anxiety on executive functioning. Indeed, this could be a more specific test of reduced attentional control that might predict the generative retrieval of specific AM (Eysenck & Derakshan, 2011), relative to the verbal fluency task that was used. It is also noteworthy that tests of executive functioning were administered last in the battery of assessments at post-induction and. Therefore, it is possible that the increases in state anxiety did cause impairments in executive functioning which accounted for reduced AM specificity, however, these effects may have been transient and attenuated by the time these cognitive functions were assessed again. Practice effects, particularly on digit span, could have possibly countered any such effects also.

Given that rumination and executive functioning did not account for the effects of state anxiety on AM specificity in our analyses, other mechanisms may be responsible. The capture process, whereby the search for specific AM becomes truncated at an intermediate schematic level of thought, was not assessed in the current study and may account for the effects. In a state of increased anxiety, individuals may be more prone to having intermediate-level AMs relating to personal threat-related thought or self-representations activate in their self-memory system, inhibiting the retrieval of specific memories. This process may be independent of increased rumination. One way in which future research may investigate this capture process is by examining the effect of the personal relevance of cues, as this appears to be a moderator of effects between dysphoria and AM specificity (Crane et al., 2007;

Noboru & Satoshi, 2017). In the context of anxiety, for example, cues related to personally-worrying problems, relative to those that are not, could be hypothesized to prompt a higher level of state anxiety which may capture generative retrieval at a more emotionally-charged self-relevant stage of AM retrieval, and lead to reduced AM specificity.

The findings of the current study may stimulate further research into the effect of increasing anxiety on AM specificity. In the clinical context, individuals with anxiety disorders such as GAD are known to experience higher levels of state anxiety, trait anxiety, and autonomic arousal (Thayer, Friedman, & Borkovec, 1996). Our findings, by extension, suggest that they may also experience related impairments in AM specificity. To the authors' knowledge, only one previous study has used a clinical sample to examine the effect of symptoms of GAD on the specificity of AM (Burke & Mathews, 1992). In this study, individuals with GAD were shown to have reduced AM specificity relative to healthy control participants, however, these differences were not found in a second experiment, which was potentially attributable to a lack of sensitivity in the measures to detect group differences (i.e., only five word cues were used). Further research is needed with clinical samples to assess the reliability of these differences with more robust methodology. Further, the trend association observed between our measures of GAD symptoms and future thinking specificity at baseline is suggestive that further examination of trait anxiety and its impact on future thinking may be warranted.

Several limitations to the current study should be noted. Despite efforts to reduce demand characteristics, the artificial nature of the anxiety induction limits the generalizability. A more naturalistic and ecologically valid paradigm may be used in future studies, such as something involving an anxiety-provoking task (e.g. a short speech) or at least reference to personally-relevant worries. Trait rumination was not assessed, which may have provided greater precision for our test of the effects of rumination on specificity. We note though that recent meta-analytic findings published following the completion of this study indicate that there is very limited support for the association between trait rumination and AM specificity (Chiu et al., 2018). Asking about other aspects of state rumination (e.g., considering the causes and consequences of negative experiences), might also provide a more robust assessment of this cognitive process. We replicated findings from Nuevo et al. (2014) that self-reported anxiety, as assessed on a VAS scale, changed in response to the anxiety induction. However, we did not use objective physiological measures of anxiety, such as heart rate or galvanic skin response, to assess changes as a result of the induction and whether they correlate with AM specificity. A related point regarding measurement is that the inductions may have caused increased arousal and stress, or negative affect. Although physiological arousal and negative affect may be thought of as components of anxiety, future research may seek more specificity in measurement to delineate the particular aspects of change related to AM specificity. Although participants in our study reported changes in state anxiety following the mood induction, the mean scores indicated that anxiety was not high, in an absolute sense, and we cannot be sure that this was indicative of being in a state of high or heightened state anxiety. A non-clinical sample was used, and therefore further studies are need to generalize to clinical populations. Given that GAD and OCD sufferers may be more pervasively exposed to anxiety-triggering stimuli, relative to more specific phobias, and that there is already some evidence of AM specificity impairment in these groups (see introduction), they may be of particular interest.

5. Conclusion

In conclusion, the current study found evidence for the effects of increasing state anxiety on AM specificity in a non-clinical sample, but not on future thinking, and only partial support for the proposed mechanisms underlying this effect. Such findings may stimulate further research into the effects of state anxiety on the retrieval of AM, in non-

clinical and clinical samples, as well as on mechanisms which may account for this.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jbtep.2019.101488>.

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