Positivity bias in past and future episodic thinking: relationship with anxiety, depression and retrieval induced forgetting.

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Positivity biases in autobiographical memory and in episodic future thinking are considered important in mental wellbeing, and are reduced in anxiety and depression. The inhibitory processes underlying retrieval induced forgetting (RIF) have been proposed to contribute to these biases. This investigation found reduced positivity in past and future thinking to be associated with reduced memory specificity alongside greater levels of anxiety, depression and rumination. Most notably however, RIF was found to significantly predict memory valence. This indicates that the RIF may be important in maintaining such biases, facilitating the forgetting of negative memories when a positive item is actively retrieved.

Keywords: anxiety; autobiographical memory; depression; episodic memory; future episodic thinking; positivity bias; retrieval induced forgetting.

Introduction:

Mental time travel is a unique human ability that provides us with the capacity to mentally reconstruct past events (episodic memory) and simulate potential future ones (Suddendorf & Corballis, 1997) Despite the independence of episodic and prospective memory systems the underlying cognitive processes are intrinsically interrelated, relying on the same neural mechanisms and resources, often referred to as the 'core network' (Addis et al,. 2007, Schacter et al., 2008). Remembering involves the extraction and recombination of different aspects of an experience, in order to reconstruct a full episode or event (Addis et al., 2007, Suddendorf & Corballis 2007). Areas in the medial temporal cortex, the hippocampus in particular, are considered responsible for retrieving and binding stored information in a flexible manner, allowing construction of potential future events in addition to the reconstruction of past events (Slotnick, 2010). Indeed it is thought that the primary function of episodic memory is to retain information likely to be important for the future, with fragments of information from past experiences providing 'building blocks' that can be flexibly recombined to simulate hypothetical future events. (Suddendorf & Corballis, 2007, Addis et al., 2007, Spreng and Grady, 2010). This flexible construction of novel events allows us to mentally 'try out' different versions of such events and different behavioral responses (Buckner & Carroll, 2007; Gilbert & Wilson, 2007; Ingvar, 1979; Schacter & Addis, 2007; Suddendorf & Corballis, 2007), meaning we can anticipate and plan for the future (Davies & Stone, 1995, Pharm & Taylor et al., 1999).

Whilst this ability offers enormous adaptive benefits, it also allows for distortion and error in both memory and future simulations (Loftus, 2003; Roediger & McDermott, 1995; Schacter, 1999, 2001). The recombination of selectively encoded, stored and retrieved memory traces is governed by the working self, and is therefore influenced by current beliefs, active goals and self-images (Conway, 2005). Priority tends to be given to information that is consistent with these self-images and beliefs, allowing us to create a sense of personal identity and coherent, albeit slightly biased view of the self (Schacter, 1996).

Given a tendency to seek out positive experiences and avoid negative ones, it is perhaps not surprising that humans demonstrate a positivity bias in both episodic memory and future simulation (Sharot, 2011; Sharot et

al., 2007; Walker et al., 2003). Numerous studies have found that, whether cued voluntarily or involuntarily, more positive autobiographical events are generally recalled than negative ones (Berntsen, 1996; Clark et al., 2013; Ditta & Storm, 2016; Thompson et al., 1996; Suedfeld & Eich, 1995; Waldfogel 1948; Walker et al., 2003). This is also reflected in future episodic thinking; people spontaneously imagine more positive than negative events when asked to think about their future (Newby-Clark & Ross, 2003) and judge positive events as being more likely to happen (Weinstein, 1980). Such biases have also been observed in naturally occurring future episodic thoughts of young adults (Barsics et al. 2016).

Though such biases result in inaccuracies in the way events are remembered and predicted, these biases are proposed to offer their own adaptive benefits that outweigh their costs (Ainslie, 2007). Both remembering and imagining the future play important roles in psychological wellbeing (Schacter et al., 2008). Evidence indicates that positive memories can be retrieved in order to repair negative mood (McFarland & Buehler, 1998), whilst simulating positive future events are also thought to serve emotional regulation functions and decrease worry (Brown et al., 2002; D'argembeau & Van Der Linden 2007; Schacter et al. 2008; Taylor & Schneider, 1989; Taylor et al., 1998). Such positivity biases are associated with increased mental and physical wellbeing (Conversano et al., 2010), enhanced productivity, social bonding and ability to cope with stress (Taylor, 1989). Furthermore they are considered vital in maintaining positive views of one's self and one's personal future (Taylor & Brown, 1988).

In contrast, moderately depressed individuals tend to demonstrate a relatively unbiased and more realistic view of the self (Coyne and Gotlib, 1983) and the future (Strunk and Adler, 2009), whilst severely depressed individuals are less able to envisage positive future episodes (MacLeod et al., 1993) and show negative biases in future thinking (Miloyan et al. 2014, Roiser et al., 2012, Strunk et al., 2006), which can predict fatal outcomes (Oquendo et al., 2004). Depression is also associated with greater recall of negative memories relative to positive ones (Blaney, 1986; Clark & Teasdale, 1982; Eich et al., 1994, Anderson & Evans, 2015). Indeed the overly generalised past and future thinking common in depression (Williams et al., 1996, Dickson & Bates 2005, MacLeod et al., 1993), is widely considered a protective mechanism to prevent the retrieval of destabilising unhappy memories (Williams et al., 1996). In contrast anxious individuals favour recollection of

threat-related memories and negative self-referential information (Mitte & Harris, 2008; Myers & Derakshan, 2004), while social anxiety is associated with biases towards recalling more negative social autobiographical memories (Krans et al., 2014). It is not clear whether these negativity biases are anxiety or threat-specific, or whether they reflect a more general negativity bias in memory. However one might expect biases towards negative, threatening information to translate into an overall reduction in the positivity of memory. Increased simulation and anticipation of negative future events is also characteristic of anxiety disorders, alongside a greater tendency to believe future events will yield negative outcomes (MacLeod & Byrne, 1996; MacLeod et al., 1997; Miloyan et al. 2014; Ruane et al., 2005; Wu et al., 2015).

Both depression and anxiety are associated with a tendency towards rumination, repetitive intrusive thoughts and self-reflections, often negative in focus, dwelling on the same distressing memories for long periods of time (Kuo et al., 2012, Nolen-Hoeksema, 1991, 2000; Watkins & Moulds, 2005; Watkins, 2008, Wilkinson et al., 2013). It has been suggested that predisposition to rumination may be due to difficulty inhibiting unwanted memories (Nolen-Hoeksema, 2000). Indeed high trait rumination is associated with enhanced recollection of negative words compared to neutral and positive words (Kuo et al., 2012), and increased recall of and focus on negative memories (Lyubomirsky et al., 1998), whilst a single session of repeated negative memory retrieval has been found to negatively affect mood and establish biased recall a week later (Vrijsen et al. 2016).

Norby (2015) argues that the act of forgetting plays a vital role in maintaining mental wellbeing by limiting access to negative memories, promoting a positive outlook. Indeed it appears positivity biases in memory are driven by top-down, goal-directed processes, with little evidence to suggest that the strength of such positivity biases are effected at memory encoding stages (Hess et al., 2013). Retrieval Induced Forgetting (RIF), a phenomenon in which the selective retrieval of a particular memory trace causes the forgetting of another rival memory trace (Anderson, Bjork, & Bjork, 1994), has been put forward as a potential mechanism by which the positivity bias in memory occurs (Storm & Jobe, 2012). RIF is demonstrated by exposing participants to a list of category-exemplar pairs (e.g. Fruit - banana, Metal - silver). Retrieval practice of a subset of exemplars (e.g Fruit - ba_____?) inhibits subsequent retrieval of unpracticed exemplars belonging to the same category (eg.

orange), but not the retrieval of exemplars from a different unpracticed category (e.g. silver). As one would expect, there is typically enhanced recall, or 'facilitation', of practiced items. However, RIF of unpracticed exemplars from practiced categories is also a robust and consistently observed phenomenon (Anderson & Spellman, 1995; Bäuml & Hartinger, 2002; Edginton and Rusted, 2003; Groome & Sterkaj 2010; Potts et al., 2011).

This RIF effect is believed to be due to inhibition; when a retrieval cue activates non-target items in addition to the target memory, inhibition of non-target items resolves the competition, rendering non-target items less accessible, both in the moment and after a delay (Anderson, 2003; Anderson & Spellman, 1995; Edginton and Rusted, 2003; Murayama et al., 2014; Storm & Levy, 2012).

It should be noted that other theoretical accounts have been put forward, which suggest that the phenomenon can be explained by non-inhibitory, competition based mechanisms (eg Jonker et al. 2013; MacLeod et al. 2003; Verde, 2012). For example, it has been argued that retrieval of a subset of items strengthens those items and causing interference with other non-strengthened items, preventing non-strengthened items from being successfully retrieved. However it has been shown that RIF is cue-independent (Anderson & Spellman, 1995), competition dependent (Anderson, Bjork & Bjork, 2000; Jonker & Macleod, 2012) retrieval specific (Anderson & Bell, 2001) and independent of the level to which practiced items are strengthened (Storm & Levy, 2012). These findings, while consistent with the inhibitory account of RIF, cannot be explained by alternative theories of RIF. In addition, evidence from the psychopharmacological literature demonstrates an enhancing effect of nicotine on RIF, consistent with cholinergic accounts of inhibition that require effortful processing (Edginton and Rusted, 2003). While not excluding the potential for other factors to play a role in RIF, a recent meta-analysis provided strong support for the role of inhibition in RIF (Murayama et al. 2014), which is the most widely accepted view.

It has been proposed that these inhibitory mechanisms may act to reduce accessibility of negative items in autobiographical memory when a positive memory is actively retrieved (Storm & Jobe, 2012). Indeed associations have been made between RIF and reduced ability to recall negative memories (Storm & Jobe,

2012), whilst a paradigm adapted to examine RIF of autobiographical memories found RIF of negative but not positive memories (Wessel & Hauer 2006). RIF has also been associated with decreased imagination of negative future events (Giebl et al., 2015), proposed to be a result of the similar underlying mechanisms at play in episodic memory and future simulation. Specifically it is suggested that positive memory biases increase accessibility to positive information with which to construct future mental representations.

In addition, both anxiety and depression are associated with reduced RIF (Law et al., 2012; Groome & Sterkaj, 2010; Sterkaj et al, under review), consistent with widely held views of anxiety, depression and ruminative thinking relating to inhibitory deficits (Eysenck et al., 2007; Eugene et al., 2010, Whitmer & Banich, 2010). RIF appears to be involved in the suppression of unwanted, intrusive memories, with decreased RIF in individuals suffering from such memories (Groome & Pipilis, 2008). Storm & Jobe (2012) postulate that impairments in RIF, reducing ability to inhibit negative thoughts and memories, may increase vulnerability to depression.

This study was designed to further explore the established relationship between RIF and biases in both autobiographical memories and future simulations. Previous studies by Storm & Jobe (2012) and Giebl et al. (2015) found relationships between positivity biases and RIF based on the number of positively valenced past or future episodes relative to the number of negative episodes that participants could generate. Participants were thereby constrained in their retrieval search by the valence category (positive or negative). This study investigated whether such a pattern was still evident when participants reminisced and imagined future events freely as in response to neutral cue words, and self-rated the valence of these episodes, rather than being asked to generate episodes in predetermined valence categories. Such free recall and future episodic simulation is a greater reflection of natural everyday memory retrieval and future simulation, giving an indication of whether these findings are relevant outside of the laboratory. Specifically the study examined whether positive valence in memory and future episodic thinking related to higher levels of RIF. In addition, RIF, valence of memory and future imagining, ability to retrieve specific autobiographical memories and future simulations, were examined in relation to individual differences in levels of anxiety, depression and rumination.

Storm & Jobe (2012) suggest that RIF may be an even stronger predictor of positivity bias in memory of older adults, given their particularly strong avoidance of negative information both in the present and in memory (Carstensen et al., 1999; Mather & Carstensen, 2005), and increases in markers of emotional wellbeing with age (Blanchflower & Oswald, 2008; Stone et al., 2010). Age was therefore accounted for in the present study. Depression and anxiety are also associated with increased rates of smoking (Covey et al. 1998; Johnson et al. 2000; Patton et al. 1998). Given that nicotine has been found to increase inhibitory control via mediation of the cholinergic system (Edginton & Rusted, 2003; Rusted & Alverez, 2008), it was considered important to take into account whether participants had recently smoked, in case this mediated the relationship between mood and RIF.

Depression is widely associated with reduced ability to recall specific memories (William & Broadbent, 1986; Dalgleish et al., 2007; Williams & Scott, 1988; Sumner et al., 2010) and imagine specific future events (Williams et al. 1996), even at sub-clinical levels (Ramponi et al. 2004). In cued recall tasks, depressed individuals tend to report significantly fewer specific memories than healthy controls, instead reporting classes of events (e.g. 'I've always failed exams') or referring to extended time periods (e.g.'my first semester at University') (Williams et al. 2007). This over-general memory is thought to be a result of premature termination of the hierarchical memory search process at a point where only general, descriptive information has been accessed (Conway & Pledydell-Pearce, 2000). This is proposed to be a defensive mechanism, an avoidance of specific memories that, where there is already depressed mood, are likely to be negative in nature (Williams et al., 1996; 2007). Given such depressive tendencies to fail to recall a specific memory on cued-recall tasks (Williams et al. 2007), the numbers of past and future episodes that could be generated were taken into account here as an indicator of memory specificity. It was anticipated that reduced ability to generate specific past and future episodes might relate to a reduced positivity in any episodes that could be provided.

An overall positivity bias was predicted in both remembering and future imagining, in which more positive than negative events would be generated. Individual differences in levels of anxiety, depression and rumination were hypothesised to negatively predict the degree of bias towards positive episodes. Whilst facilitation was not

anticipated to relate to such biases, RIF was expected to predict greater positivity bias in both remembered and imagined future episodes.

Methods:

Participants and design:

An a priori power analysis was conducted to determine the sample size. Assuming a medium (0.15) effect size with a significance level of $\alpha = .05$ and a statistical power of 0.80, a minimum sample of 103 participants was necessary (Faul et al. 2009). Assuming a drop-out rate of approximately 10-15% (Hoerger, 2010), we aimed to recruit at least 113 participants.

Participants were recruited via advertisement in email circulars, on social media pages of community organisations in London and by word of mouth. A total of 119 participants volunteered to take part, having read a detailed information sheet and provided their informed consent. They did so via the online survey platform Qualtrics.12 participants who did not correctly complete the full experiment were excluded. The final sample of 107 participants consisted of 87 women and 20 men between the ages of 18-65 (mean age = 32.04, SD = 12.91). All participants were English speaking and had no known memory disorders. A survey design was used in which all participants completed RIF, autobiographical future thinking and memory tasks and anxiety, depression and rumination measures for multiple regression analysis.

RIF and facilitation:

RIF was measured using the original paradigm established by Anderson et al., (1994). Participants first studied a series of category-exemplar pairs (e.g. Fruit – banana; Metal - silver). The 8 categories used were taken directly from Appendix C of Anderson et al., (1994), as were the 6 exemplars for each category. Specifically, the "strong exemplars" (exemplars with an average taxomic frequency rank order of 8) from Anderson et al., (1994 Experiment 1) were used. Strong exemplars (e.g Fruit - orange) were found to produce a more robust RIF effect than weak exemplars (e.g. Fruit - guava) (Anderson et al. 1994).

After studying each of these 48 category-exemplar pairs for approximately 5 seconds each, participants were asked to practice retrieving a subset of exemplars from a subset of categories. This retrieval practice phase involved completing a retrieval cue comprised of word stem of an exemplar presented alongside its category (e.g. Fruit - ba____?). Half of the exemplars from half of the categories were practiced 3 times each, resulting in a total of 36 retrieval practice trials. The specific subset of practiced category-exemplar pairs were counterbalanced, such that participants were randomly allocated 1 of 4 possible sets of pairs to practice. Following this, participants were required to take a 10 minute break. Though the original paradigm involves a 20 minute distractor task, a reliable RIF effect has since been found with breaks as short as 5 minutes (Storm & Jobe 2012; Rowland et al. 2014).

A final category-cued recall phase presented each of the 8 category names and required participants to give as many of the original 6 exemplars from each category as they could. The order of the category cues was randomised. Number of recalled practiced exemplars from practiced categories (RP+), unpracticed exemplars from practiced categories (RP-) and unpracticed exemplars from unpracticed categories (NRP) could then be compared. Replicating the methods used by Storm & Jobe (2012), a single RIF score was obtained by subtracting final recall performance for RP- exemplars from NRP exemplars, with higher scores indicating greater RIF. Facilitation scores were calculated by deducting NRP recall performance from RP+ recall performance, with higher scores indicating greater retrieval practice effects.

Autobiographical recall and future simulation:

10 neutral cue words (e.g. grass, bread)(appendix 1) served as retrieval cues to prompt recall of autobiographical memories. Participants were instructed to generate and provide a brief description of a specific remembered event associated with each cue word. Memories could be from any time ranging from childhood to recent memories but could not be memories from the past week. Participants were asked to provide specific contextual details, such as when and where the event took place and how old they were at the time, to ensure a specific event was retrieved. An example of an appropriate memory description was provided at the start of this section (appendix 1). If a memory was not retrieved within approximately 1 minute participants were instructed to move on to the next word. Following each cue word participants rated the valence of the retrieved memory on a 7-point numerical rating scale (negative-positive).

This procedure was replicated for future episodic thinking with a new set of 10 neutral words. This time participants were required to imagine a specific future event associated with the word, again rating the valence of this event. The order of completion of these memory and future imagining stages were counterbalanced, as were the sets of 10 cue words used for remembering and future imagining.

The written descriptions of both past and future events were individually checked for validity and specificity prior to analysis. Memories were counted as specific if they described a single event or episode that lasted less than one day, and the number of specific episodes provided (out of a possible 10) was used as an indicator of participants' ability to generate specific memories and future episodes, (as per Williams & Broadbent, 1986; see Williams et al 2007 for a review).

Average valence scores for autobiographical memory and imagined future events were calculated by later converting the valence scores into a scale of -1 (negative), 0 (neutral) and +1 (positive). The average valence score for memories and future imagined events were each calculated such that more positive scores reflected a greater number of positively valenced events, whilst more negative scores indicated more negatively valenced events. Valence scores were calculated in this manner to overcome the potential for strong negative and strong positive valence scores to cancel one another out.

Measuring Depression, Anxiety and Rumination levels:

Anxiety and depression levels were assessed using the Hospital Anxiety and Depression Scales (HADS) (Zigmond & Snaith, 1983. This 14 item self-report measure provides an assessment of both anxiety and depression, with 7 items each (Watson et al., 1995). Participants are asked to rate statements such as 'I feel tense or wound up' (anxiety subscale) and 'I feel cheerful' (depression subscale, reverse scored), according to how they have been feeling over the past week. Despite its brevity the HADS has good internal consistency and concurrent validity (Bjelland et al., 2002). Reported Cronback's coefficients (α) for anxiety and depression subscales are .80 and .76 respectively (Mykletun et al., 2001). Though initially validated for use in non-psychiatric hospital outpatients, it has since been validated for use in general populations (Kjaergaard et

al., 2014). Each item is scored from 0-3, with total scores for anxiety and depression each ranging from 0-21. Higher scores are indicative of higher levels of depression and anxiety with scores categorised as follows: Normal 0-7, mild 8-10, moderate 11-14 and severe 15-21 (Snaith & Zigmond, 1994).

Rumination was assessed using the Ruminative Response Scale (RSS), part of the RSQ (Nolen-Hoeksema & Morrow, 1991). This 22 items measure asks participants how often they engage in ruminative thought patterns when they are feeling sad or down. Each item is rated on a 1 (almost never) -4 (almost always) likert scale. The RRS is a reliable and valid measure of rumination (see for an overview Luminet, 2004), with high internal consistency (reported Cronbach's coefficient of .91 (Moberly et al. 2008)). Scores range from 22-88 with higher scores indicative of higher levels of ruminative thinking.

Procedure:

Participants completed the RIF study phase and retrieval practice phase. During the break the participants were asked to provide some basic demographic information, smoking status (never - multiple times per day) and time since their last cigarette. Having then completed the final test phase of the RIF procedure, participants completed the episodic memory and future episodic thinking tasks in the order to which they had been randomly assigned. Finally the HADS and RSS were completed. All participants provided their informed consent before taking part, and the procedure was carried out in accordance with the British Psychological Society's code of human research ethics (2014). This study received ethical approval from the University of Westminster's ethics committee.

Results:

Descriptive statistics for all included variables are reported in Table 1, with additional demographic information in (Appendix 2).

Out of the total 107 participants who completed the study, 8% were moderately-severely depressed (HADs scores of 11-21); 13% were mildly depressed (scoring between 8-10) and 79% scored within normal ranges (0-

7). In terms of anxiety, 31% scored in the moderate-severe range (11-21), 27% in the mild anxiety range (8-10); and 42% within normal ranges (0-7). 9 participants held a current anxiety disorder diagnosis, whilst 11 were diagnosed with depression.

Positivity bias:

Memories and imagined future events were categorised into positive, negative and neutral events by their valence ratings such that valence ratings of -3 to -1, 0 and 1 to 3 were scored as negative (-1), neutral (0), or positive (1) respectively. A positivity bias was observed with positive mean valence scores for both memory (M=0.211, SD=0.374) and future episodic thinking (M=0.431, SD=0.417). On average, valence of future episodic thinking was significantly more positive than memory valence (t=-4.8, df = 106, $p < .001$, d=0.56, two-tailed).

Out of a possible total of 10 episodes, significantly more positive than negative episodes were reported in both the memory (positive M=5.383, SD=1.984, negative M=3.206, SD=1.985) (t=-6.271, df=106, p<.0001, d=1.10, two-tailed) and future thinking (positive M=6.570 SD=2.093, negative M=2.365, SD=1.949) (t=-11.260, df=106, p<.0001, d=2.08, two-tailed) tasks.

Retrieval induced forgetting:

The mean number of items recalled at the final test stage of the RIF procedure is reported in figure 1. More RP+ items were recalled than NRP or RP-. More importantly, significantly fewer RP- items (M=0.998, SD=0.672) were recalled than NRP items (M=1.284, SD=0.592) (t=-6.163, df=106, p<.0001, d=0.45, two-tailed), demonstrating a significant RIF effect.

Of the 107 participants, only eight smoked daily (Appendix 2), and smoking status was not found to correlate significantly with RIF score (r_S=.036, N=107, p=.710, two-tailed). Further, the positive correlation was found between time since last cigarette (12hrs, 24hrs, >24hrs) and RIF score was not significant (r_S=.135, N=107, p=.167, two-tailed).

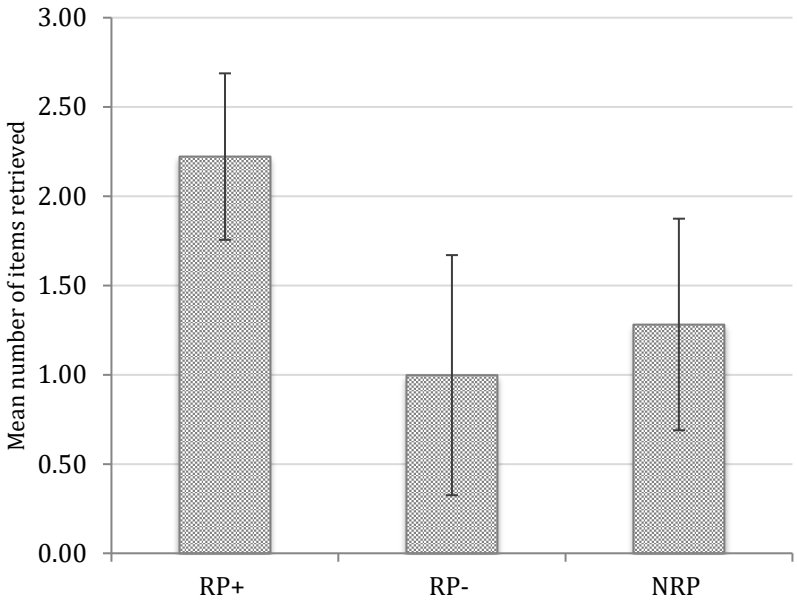

Figure 1
Average number of RP+, RP- and NRP items retrieved in the final test phase of the RIF procedure.

Multivariable relationships:

Bivariate correlations between variables are reported in Table 1. As one would expect, there were significant positive correlations between rumination, anxiety and depression scores, and between overall valence of memories and future episodic events. Lower rumination, anxiety and depression scores also significantly correlated with more positive past and future episodic thinking. The number of memories and future events generated positively correlated with the respective valence scores, and negatively correlated with the various mood-related measures. Facilitation negatively correlated with memory valence, whilst significant positive correlations were observed between RIF and memory valence. The positive correlation between RIF and the valence of future episodic thinking did not reach significance, but it was not significantly different from the significant correlation between RIF and memory valence ($Z = .706$), $p = .48$).

Table 1:
Descriptive statistics and bivariate correlations between variables entered into the multiple regression. N=107

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Mean memory valence		.293**	.630***	.329***	.187*	-.258**	-.135	-.131	-.183*	-.041
(2) Mean future valence				.618***	.106	-.134	-.264**	-.231*	-.249**	.066
(3) Number of memories					.070	-.143	-.167*	-.080	-.122	-.036
(4) Number of future episodes					-.016	-.140	-.219*	-.197*	-.224*	-.069
(5) RIF						-.024	.002	.158	.136	.066
(6) Facilitation							-.058	.011	-.016	.151
(7) Rumination score								.513***	.539***	-.216*
(8) Anxiety score									.593***	-.237*
(9) Depression score										.074
(10) Age										
MEAN	0.211	0.432	8.953	8.822	1.159	0.942	44.243	8.523	4.373	32.037
SD	0.376	0.419	1.944	1.980	1.921	0.521	15.007	4.548	3.699	12.908

Note. Number of memories = number of cue words for which a memory could be generated, Number of future episodes = number of cue words for which a future episode could be generated, RIF = retrieval induced forgetting score (NRP - RP-).
* $p < .05$ ** $p < .005$ *** $p < .0005$

These were followed up by two separate multiple linear regressions, computed using the enter method of variable entry. First, RIF, facilitation, rumination, anxiety and depression scores and number of memories generated were entered as predictors of mean valance of episodic memory. The complete model was significant, $F(7,99)=12.361$, $p<.0001$), explaining 42.9% of variance (Adj. $R^2=.429$). As table 2 shows, RIF and number of specific memories generated were significant positive predictors of memory valence whilst facilitation was a negative predictor of memory valence.

Secondly, memory valence scores, number of future episodes generated, RIF, facilitation, rumination, anxiety and depression scores were entered as predictors of mean future episode valence. The complete model was significant, $F(8,98)=9.365$, $p<.0001$, explaining 38.7% of variance (Adj. $R^2 =.387$). As table 3 shows, the average number of specific future episodes that could be generated was the only significant predictor, positively relating to future episode valence. Multicollinearity was not a limiting issue in either regression.

Table 2: Regression coefficients for the regression predicting valence of autobiographical memories with RIF, rumination, anxiety, depression, age and number of memories generated.

	B	SE	*β*	*t*	*p*	Tolerance	VIF
Number of memories	.112	.015	.582	7.685	<.0005	.940	1.064
RIF	.033	.015	.169	2.233	.028	.946	1.057
Facilitation	-.122	.054	-.170	-2.247	.027	.946	1.057
Rumination score	.001	.002	.053	.557	.579	.600	1.668
Anxiety score	-.005	.008	-.057	-.564	.574	.531	1.884
Depression score	-.013	.010	-.133	-1.285	.202	.506	1.978
Age	.001	.002	.002	.024	.981	.800	1.251

Table 3: Regression coefficients for the regression predicting valence of future episodes with RIF, rumination, anxiety, depression, age, memory valence and number of future episodes generated.

	B	SE	*β*	*t*	*p*	Tolerance	VIF
Number of future episodes	.120	.018	.566	6.801	<.0005	.836	1.196
Memory valence	.052	.096	.046	.540	.590	.788	1.268
RIF	.025	.017	.116	1.450	.150	.904	1.106
Facilitation	-.048	.065	-.060	-.743	.459	.897	1.115
Rumination score	-.001	.003	-.053	-.539	.591	.600	1.666
Anxiety score	-.002	.010	-.026	-.250	.803	.528	1.894
Depression score	-.011	.012	-.093	-.866	.389	.498	2.007
Age	.003	.003	.098	1.148	.254	.794	1.259

Additional regression analyses were then run to check for any interactions between RIF and anxiety, depression or facilitation in predicting the valence of memories and future episodes. The variables were centred and the interaction terms anxiety*RIF, depression*RIF and facilitation*RIF entered into both regressions. The interaction term depression*RIF was significant in the model predicting memory valence (B=.011, SE_b=.005, β=.196, t=2.10, p=.038), remaining significant in a model including only the main effects and interaction (F(8,97)=10.339, p<.0005, Adj. R^2=.442). The interaction is illustrated in figure 2. Whilst there was a positive association between RIF and memory valence for the normal and mildly depressed groups, the opposite was the case for the moderately-severely depressed group, were a negative relationship was observed. None of the other interactions were significant in either regression.

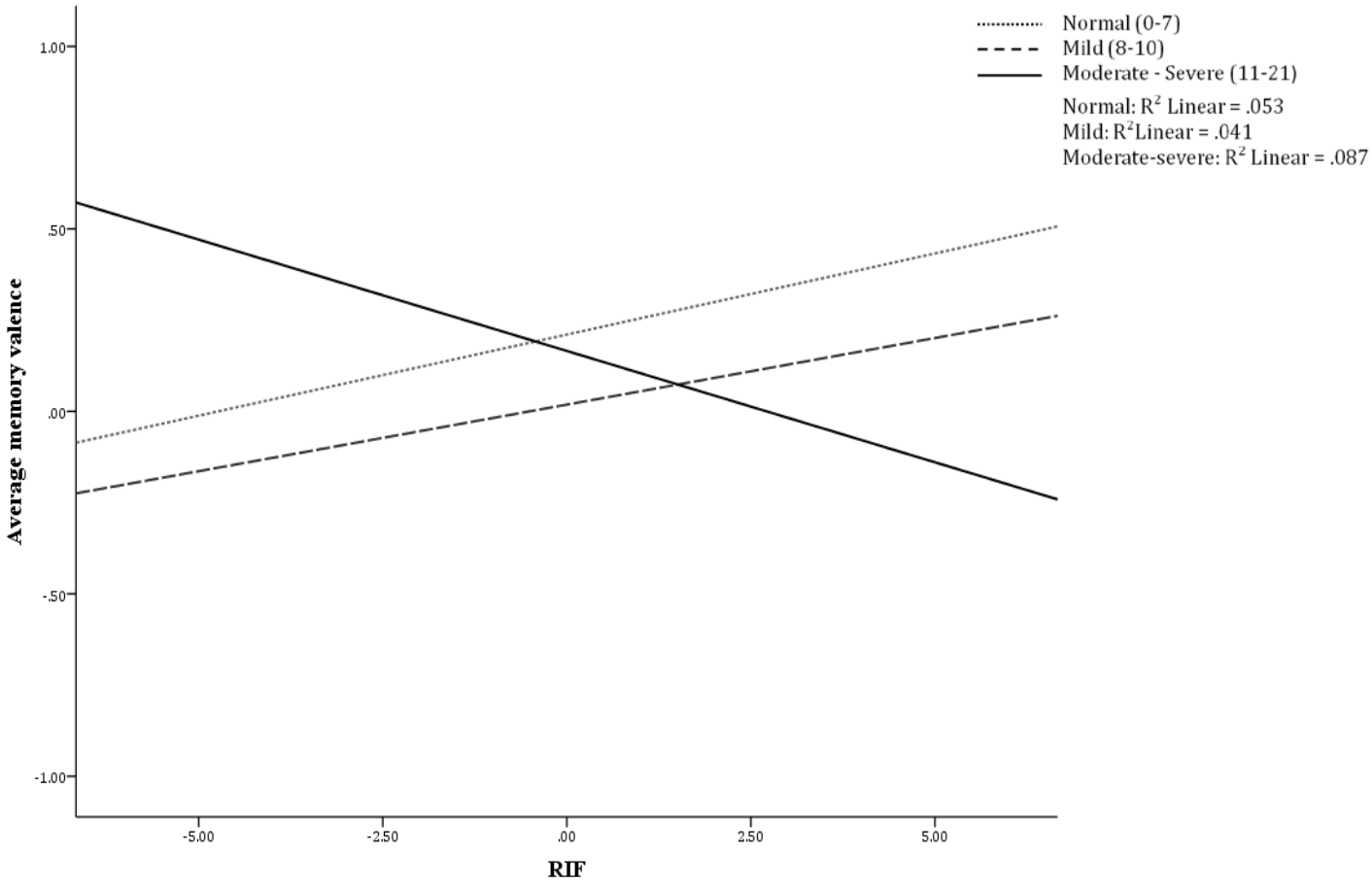

Figure 2: Interaction between depression, RIF and memory valence.
Depression level grouped by HADs score (normal – 0-7, mild – 8-10, moderate-severe – 11-21).

Discussion:

Positivity biases in both past and future thinking are commonly observed and are considered to play an important role in mental wellbeing. The present findings support this theory, observing an overall positivity bias in both temporal directions, the extent of which related to individual differences in levels of anxiety, depression and rumination within a subclinical population. Specifically, the mean valence of memories retrieved correlated negatively with depression, whilst greater positivity in future thinking related to lower levels of anxiety, depression and rumination. Further, whilst number of episodes retrieved significantly predicted the overall average valence of past and future episodes, higher levels of rumination correlated with the retrieval of fewer memories and fewer future episodes were generated with increasing depression,

anxiety and rumination. Importantly, individual RIF levels were found to significantly relate to the valence of memories, indicating that RIF may contribute to such positivity biases.

The observed positivity biases in memory reflect previous findings, with average proportions of positive (53.83%) and negative (32.5%) memories falling within previously found ranges (see Walker at al., 2003 for a review). The imagined future was even more positively biased, again replicating previous findings (Grysman et al. 2013, Sharot et al. 2007). Given that the future is less constrained than the past, and therefore more susceptible to influence of current personal goals, this is perhaps unsurprising (Sharot & Dolan, 2012; Shao, 2010). Nonetheless, past and future positivity was significantly correlated, adding to the growing body of evidence indicating shared mechanisms underlying remembering and imagining processes (Schacter et al. 2008).

Such biases are also proposed to enhance mental wellbeing by helping to create a positive and coherent self-identity within the framework of a continually improving self (Conway 2005; D'argembeau & Van der Linden, 2004; Schacter, 1996; Taylor & Brown, 1988) and can help regulate current emotions (Josephson et al.1996; McFarland & Buehler, 1998; D'Argembeau & Van Der Linden, 2007; Schacter, 2008).

Though in this sample, valence of remembered or imagined episodes were not significantly predicted by levels of anxiety, depression or rumination, the significant correlational relationships observed within a non-clinical sample with largely low-mild (0-10) HADS scores (Snaith & Zigmond, 1994), demonstrate their importance. Particularly interesting is the temporal direction (past and future) of these relationships. Whilst anxiety, depression and rumination all significantly negatively correlated with future positivity, only depression significantly correlated with memory valence scores. Indeed whilst anxiety is commonly associated with reduced positivity in future outlook (MacLeod & Byrne, 1996; MacLeod et al., 1997; Steinman et al. 2013), findings of biases in memory are less consistent (Burke & Mathews, 1992; Levy & Mineka, 1998, Rapee et al., 1994), and tend to be specific to threat related material (Becker et al., 1994; Saunders 2012; Myers & Derakshan, 2004; Mitte & Harris, 2008) rather than the general negativity that appears to characterise depressive memory (Macleod & Salaminiou, 2001; Macleod et al., 1997; Strunk et al. 2006). Indeed the present findings support Beck et al.'s 1987 proposal that whilst anxiety centres on

prospective threat and harm, depression centres on hopelessness, loss and self-deprecation that permeates thinking about both the past and future. It is the uncertainty specific to future events that is thought to be critical in producing high levels of anxiety (Eysenck et al. 2006). More recent studies support this theory, reporting that anxiety disorders relate to an anticipated future threat or harm, whilst depression is more often associated with experiencing the loss of something that was valued (Finlay-Jones & Brown, 1981, Surtees, 1995; Sandin et al., 2004). Not only does this split provide interesting insight into the subtle differences underlying the pathology of anxiety and depression, the common neural mechanisms underlying remembering and imagining, and the related relationship between characteristics of both past and future episodic thinking may contribute to the common co-morbidity between these two conditions.

The present study also finds anxiety, depression and rumination relate to the number of future episodes that could be generated, whilst negative rumination related to retrieval of fewer specific autobiographical memories. Ruminative thought is theorised to contribute to the reduced ability of depressed individuals to access specific memories, via its domination of working memory capacity (Barnard et al., 2006; Conway & Pleydell-Pearce, 2000; Williams et al., 2007). Indeed the present findings support previous evidence for such a relationship between negative rumination and overgeneralised memory (Sutherland et al., 2007; Watkins et al. 2001; Sumner et al. 2011). Such overgeneralised memory is considered a defence mechanism against the retrieval of negative or distressing memories (Hermans et al., 2005; Haque et al. 2014). It is thought that this strategy may arise when valence of specific memories become increasingly negative and intrusive in nature, as is typical in depression (Lyubomirsky et al. 1998, Meiser-Stedman et al., 2012), for example when novel memory cues are mapped on to negative ruminative thought dominating current working memory capacity (Haque et al. 2014; Williams et al. 1996). Indeed the present findings support such a hypothesis, with significant correlations between the number of both past and future episodes generated and their average valence, though a causal relationship cannot be concluded based on this correlational design. It seems likely that similar processes may occur in anxiety related worry and imagined future events (Mclaughlin et al., 2007).

This is particularly interesting in the context of the present findings relating RIF to the average valence of memories. Level of RIF was found to significantly predict average autobiographical memory valence such that increased RIF related to more positive autobiographical memory. These findings further those of Storm & Jobe (2012), finding a relationship between RIF and the average self-rated valence of memories freely retrieved in response to a set of neutral cue words, rather than valence determined by the total number of memories that could be retrieved in explicitly stated positive or negative retrieval categories. This free recall in response to neutral memory cues is a greater reflection of the way memory operates in everyday life, and therefore provides further support for the theorised role of RIF in promoting and maintaining such biases.

Storm, Bjork & Bjork (2005) describe RIF as a 'memory modifier', with retrieved items becoming more accessible whilst other information associated with the same retrieval cues become less recallable. Over time, such retrieval processes act to update, shape and sometimes distort memory. As suggested by Storm & Jobe (2012), a predisposition towards positivity may increase the likelihood of negative information being deemed inappropriate and therefore targeted by inhibition, rendering it inaccessible to consciousness, shaping memory in a positively valenced direction. Indeed RIF procedures adapted to study autobiographical memories have found that retrieval practice of certain memories can reduce accessibility of related memories (Barnier et al., 2004; Hauer & Wessel, 2006). Some studies have indicated a possible bias in RIF itself, with greater forgetting of negative relative to positive material (Hauer & Wessel 2006; Harris et al., 2010, Experiment 1); and reduced RIF of negative, but not neutral items in anxious individuals (Saunders, 2012). However, such findings have been inconsistent (Barnier et al., 2004; Stone, Barnier, et al., 2013; Stone, Luminet, et al., 2013). Whilst not discounting the role of differences in inhibitory control of negative relative to positive or neutral material, the current study finds a relationship between memory positivity and independently measured RIF of neutral word pairs, indicating that, to some extent, general ability to inhibit non-target items during active retrieval of a specific target item relates to positivity biases in memory. Such inhibitory abilities alone would not be sufficient to generate these biases; rather they may work in combination with natural tendencies towards positively valenced memories to increase biases. When general biases are demonstrated towards the active retrieval of positive memories, RIF may help to maintain and enhance such biases by facilitating the forgetting of associated negative material.

Not only do depressed individuals lack the bias towards positive information memory (Blaney 1986; Clark & Teasdale, 1982; Anderson & Evans 2015; current findings), but it appears RIF is also reduced both in severe clinical depression (Groome & Sterkaj, 2010), and anxiety (Eysenck et al., 2007; Law et al., 2012; Saunders 2012). Though the present study did not find significant relationship between RIF and either depression or anxiety scores, it should be noted that previous such findings have been found in cases of severe depression and anxiety levels, or high state anxiety (Potts et al. 2012; Saunders 2013; Groome & Sterkaj, 2010) therefore these findings should not be considered contradictory. Moulds & Kandris (2006) also found no association between RIF and dysphoria in a normal student sample. It may be that, in mild depression, RIF-facilitated forgetting of negative memories is compromised by reduced active retrieval of positive memories, leading to more negative overall memory valence without a reduction in RIF itself. However, in the context of the greater negativity biases observed in severe depression, RIF may become counterproductive, further increasing access to negative autobiographical memories.

The interaction that appeared between RIF and depression would support this conclusion. RIF was positively associated with memory valence in the groups obtaining HADS-D scores within normal and mild ranges. However, the moderate-severe depression group showed the opposite pattern; greater RIF was associated with reduced memory positivity. This may well be a reflection of the tendency towards pessimistic, mood congruent memory retrieval in severe depression, contrasting with the positivity bias of healthy individuals (Miloyan et al. 2014; Roiser et al. 2012, Rusting et al. 2010)). Whilst active retrieval of positive memories may facilitate forgetting of associated negative memories (via RIF), it may be that when there is a bias towards negative memory retrieval (in severe depression), competing positive memories are inhibited. As such, high RIF levels alongside negative memory retrieval tendencies would be disadvantageous, worsening existing negativity biases. The tendency for RIF to be reduced in severe depression may therefore reflect a protective mechanism; an attempt to reduce cycles of negative memory retrieval. Such reductions may also contribute to over-general memory tendencies in depression (Groome & Sterjak, 2010; Watkins & Moulds, 2005). When attempting to retrieve a specific item from memory, the ability to inhibit competing memory traces that are activated by the same cue is essential (Anderson, 2003).

Decreased RIF is associated with reduced ability to inhibit non-target memories (Storm & Bui, 2015; Aslan & Bauml, 2011). Reduced RIF may thereby contribute to over-general memory tendencies in depression, reducing access to specific memories that are likely to be negative in nature. The present findings of greater memory negativity in depressed individuals showing higher RIF levels would support this theory, though the small number of participants within the moderate-severely depressed group should be taken into account.

Though the small number of smokers in this study limited the influence of nicotinic modulation of RIF (Edginton & Rusted, 2003; Rusted & Alvers, 2008), the apparent relationship between RIF and positivity biases may well be implicated in the use of smoking as a form of self-medication. Smoking is indeed particularly common in depressed and anxious groups of people, thought to be due, in part, to its ability to regulate negative affect (Schleicher et al. 2009). Nicotinic augmentation of inhibitory processes including RIF may help reduce the intrusively of negative thoughts and memories, contributing to the regulation of negative emotion.

Whilst RIF positively related to memory valence, the degree to which retrieval practice increased later recall of practiced items (facilitation) was found to negatively predict memory valence. Though this relationship was not anticipated, it does follow that, while inhibitory abilities related to greater positivity bias, factors that increase recall of repeatedly retrieved items related to reduced positivity bias in memory. The repeated retrieval of a target memory during the retrieval practice phase of RIF is, it could be argued, similar to the processes involved during rumination about a specific event or memory (Vrijsen et al. 2016). Habitually ruminating on certain memories has been found to increase future recall of the same those memories (Hertel et al. 2017; Vrijsen et al. 2016). A greater level of facilitation may augment the extent to which rumination influences the nature of later memory retrieval. Given that this type of ruminative thinking tends to be negative in nature (Nolen-Hoeksema et al. 2008), individual differences in the degree to which memory practice increases the strength of a memory may therefore effect the degree to which an episode of negative rumination influences overall memory valence. Greater facilitation may lead to greater influence of negative retrieval practice on overall memory valence. Given that the repeated imagination of the same

specific future episode is less common than rumination over a past event, it follows that the correlation between facilitation and the valence of future episodic thinking did not reach significance.

The current study did not find RIF to significantly predict the valence of future episodic thinking, contrasting with Giebl et al.'s (2016) findings. Giebl et al (2016) measured positivity bias using a similar procedure to Storm & Jobe 2012, in which the number of positive future events that could be constructed in response to 20 neutral cue words were compared to the number of negative events that could be constructed in response to a second set of 20 cue words. Using this method a significant correlation was found only between RIF and negative future episodic thinking, whereas correlations between RIF and positive future thinking did not reach significance. The use of only one condition in the current study, allowing participants to freely generate positive, neutral or negative events, may therefore explain the lack of a significant relationship emerging between RIF and valence of future episodic thinking, particularly given the strong positivity bias observed. However, given the strong relationship between episodic memory and future episodic thinking, it stands to reason that factors influencing memory valence may, directly or indirectly, influence the valence of future thinking. Indeed when the correlation between RIF and memory was compared with the correlation between RIF and future thinking, there was not a significant difference, reflecting the highly related nature of these two types of mental 'time-travel'. As future thinking is less constrained than memory and more heavily influenced by additional factors (Sharot & Dolan, 2012), a greater level of power may have been required to detect a small relationship such as this.

Overall, these findings contribute to a growing body of research indicating a relationship between mental wellbeing and positivity bias in valence of memories and future episodic thinking, alongside evidence that inhibitory mechanisms involved in RIF may enhance such positivity bias in healthy people. In depressed individuals it appears the opposite effect may occur, with RIF exacerbating negativity biases in memory. This suggests that reduced RIF may be a protective mechanism in depressed individuals, perhaps also contributing to over-general memory tendencies. It is worth considering the practical implications of these findings, particularly in relation to improving symptoms of depression and anxiety. Active engagement with positive remembering and future imagining may assist in mood repair (Harris et al., 2010, Quoidback et al.

2009), whilst further exploration the potential to modify cognitive biases in past and future thinking via active engagement with valenced material may be particularly valuable in therapeutic contexts (Woud & Becker, 2014; Murphy et al. 2011).

Disclosure of interest:

The authors have no conflicts of interest to report.

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Appendix 1: Remembering and future thinking tasks:

Autobiographical memory task instructions:
You are now going to be presented with some words. For each word, please think of an event that happened to you which the word reminds you of. The event could have happened at any point in your life from when you were small to last week, please do not include memories from the past week. It might be an important or trivial event, but the memory should be a specific event - an event that lasted less then a day and occurred in a particular time and place.

For example, if presented with the word 'daffodil', it would not be okay to write 'I remember the daffodils in my garden' because that is not a specific event, but it would be okay to write 'I remember picking daffodils for my mother's fiftieth birthday last year' (because that is a specific event).

Please write the memory event in the text box below each cue word. You may write as much or as little as you like, but try to include the specific details of the event.You will then be asked to rate the emotion (positive-negative) associated with that memory, and to give a rough estimate of how old you were when this event happened.

It is important to try to think of a different memory for each cue word. If you cannot think of a specific memory after approximately 1 minute you should move on to the next cue word.

Future imagining task instructions
You are now going to be presented with some words. For each word, please think of a future event that could happen to you related to that word. This event could be going to happen at any point in your life, but please do not include events imagined over the next week. It might be an important or trivial event, but the imagined event should be a specific event - an event that will last less then a day and occur in a particular time and place.

For example, if presented with the word 'dog', it would not be okay to say 'walking my dog' as this is not a specific event. It would be okay to say 'walking my dog in the lake district with my daughter this summer holiday'.

Please write the imagined future event in the text box below each cue word. You may write as much or as little as you like, but try to include the specific details of the event. You will then be asked to rate the emotion (positive-negative) associated with that event, and give a rough estimate of how old you imagine yourself to be in the event you think of.

It is important to try to think of a different event for each cue word. If you cannot think of a specific event after approximately 1 minute you should move on to the next cue word.

Cue words

Block A
Grass
Gigantic
Wildlife
Bread
Search
Pottery
Ladder
Occasion
Nursery
Shallow

Block B
Rhythm
Rapid
Youngest
Bathe
Fashion
Refund
Pianist
Uncle
Onion
Library

Appendix 2: Demographic information

	Number of participants	
Mental health diagnosis	Currently	Ever
Anorexia nervosa	0	3
Anxiety not otherwise specified	7	11
Attention deficit hyperactivity disorder	0	1
Bipolar disorder	1	1
Body dismorphic disorder	1	1
Borderline personality disorder	2	2
Depression	11	21
Generalised anxiety disorder	2	2
Obsessive compulsive disorder	0	1
Psychosis	1	1
Total	**17**	**28**
Smoke		
Ever	20	
Occasionally	11	
Every day	3	
Multiple times per day	5	