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ORIGINAL ARTICLE

Emotional mental imagery generation during spontaneous future thinking: relationship with optimism and negative mood

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Abstract

Optimism is known to buffer against negative mood. Thus, understanding the factors that contribute to individual variation in optimism may inform interventions for mood disorders. Preliminary evidence suggests that the generation of mental imagery-based representations of positive relative to negative future scenarios is related to optimism. This study investigated the hypothesis that an elevated tendency to generate positive relative to negative mental imagery during spontaneous future thinking would be associated with reduced negative mood via its relationship to higher optimism. Participants ($N=44$) with varied levels of naturally occurring negative mood reported current levels of optimism and the real-time occurrence and characteristics of spontaneous thoughts during a sustained attention computer task. Consistent with hypotheses, higher optimism statistically mediated the relationship between a higher proportional frequency of positive relative to negative mental imagery during spontaneous future thinking and lower negative mood. Further, the relationship between emotional mental imagery and optimism was found for future, but not past, thinking, nor for verbal future or past thinking. Thus, a greater tendency to generate positive rather than negative imagery-based mental representations when spontaneously thinking about the future may influence how optimistic one feels, which in turn may influence one's experience of negative mood.

Introduction

Negative mood states such as feeling sad, anxious and unhappy are common in daily life, with some individuals experiencing higher levels of negative mood than others at any one time. Researchers have thus sought to understand the cognitive factors that not only drive heightened negative mood but also mitigate against it, as this may inform intervention development for prevalent mood dysregulation conditions such as depression and anxiety.

One factor known to influence the degree of negative mood is optimism, the generalised feeling that one's own future will turn out well (Carver et al., 2010). It is well established that those who are optimistic tend to experience reduced negative emotional and physiological impacts under stress (Brydon et al., 2009; Carver & Gaines, 1987; Scheier & Carver, 1985; Segerstrom et al., 1998). On the other hand, theory and evidence suggest that a negative view of one's future is one factor driving heightened levels of depression and anxiety (Abramson et al., 1989; Beck et al., 1979; Miloyan et al., 2016; Miranda & Mennin, 2007; Muris & Van Der Heiden, 2006; Pyszczynski et al., 1987; Roepke & Seligman, 2016; Strunk et al., 2006). Given that optimism buffers against negative mood, understanding factors that influence variation in how optimistic we feel may illuminate new pathways to reducing mood disturbance.

Emotional future mental imagery and optimism

While optimism is typically conceptualised as a dispositional trait that is relatively stable over time, there is evidence that optimism can also be viewed as a state construct that can vary from one time to another and across the lifespan. For example, fluctuations in optimism have been observed in relation to different life events as well as to changes in mood state and stress (Chopik et al., 2020; Segerstrom et al., 1998). As the future does not exist, it is likely that our mental representations of the future inform how optimistic we feel. Researchers have postulated that the human

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capacity to generate mental imagery-based representations of possible future scenarios is an important form of future thinking as it allows individuals to simulate and predict a variety of future outcomes (Bulley et al., 2019; Schacter et al., 2017). Mental imagery refers to internally generated sensori-perceptual experiences that can function as a weak form of veridical perception (Pearson et al., 2015). Thus, mental imagery-based representations of future scenarios can allow individuals to pre-experience what might happen in an as-if-real manner (Ji et al., 2016; Lang, 1979; Moulton & Kosslyn, 2009).

Due to its capacity to enable pre-experiencing of hypothetical emotional situations, mental imagery-based representations of emotional situations have a greater emotional impact than verbal-linguistic elaboration of the same situations (Holmes & Mathews, 2005; see Ji et al., 2016 for a review). Mental imagery-based representations of future experiences are postulated to play an important role in facilitating self-regulation (Bulley et al., 2019; Taylor & Schneider, 1989; Taylor et al., 1998) and emotion regulation (Brown et al., 2002; D'Argembeau & Van der Linden, 2007; Jing et al., 2017), particularly those involving visual mental imagery (D'Argembeau & Van der Linden, 2007; Holmes & Mathews, 2005). Thus, individual differences in the tendency to experience imagery-based representations of positive versus negative aspects of the future may disproportionately influence the tendency to experience negative emotional states.

Experimental evidence suggests that generating mental imagery-based representations of hypothetical emotional scenarios can influence one's attitudes towards such scenarios (Benoit et al., 2019). Further, emotional scenarios that are imagined more frequently are judged as more realistic and likely to occur, but only when such scenarios are hypothetical future-oriented scenarios, not past-oriented counterfactual scenarios (De Brigard et al., 2013; Schacter et al., 2015; Szpunar & Schacter, 2013). Thus, when spontaneously thinking about the future, individuals who tend to generate mental imagery-based representations of positive rather than negative scenarios may also feel more optimistic about what the future holds, compared to those who are less likely to do so.

To our knowledge, no study has directly examined the relationship between biases in one's *tendency* to generate positive relative to negative mental imagery during spontaneous (uninstructed) future thinking and optimism. However, some researchers have examined the relationship between biases in one's *ability* to generate positive relative to negative future mental imagery and optimism. Such studies have found that, when instructed to *deliberately* generate mental imagery-based representations of future scenarios in response to emotional verbal cues, lower subjective imagery vividness for positive, but not negative, scenarios is associated with lower optimism (Blackwell et al., 2013; Ji et al., 2017; Sharot et al., 2007). In addition, clinical researchers have found that instructing participants to generate mental imagery representations of one's best possible self can increase optimism, and to a greater extent than generating mental imagery representations of daily activities (Meevissen et al., 2011; Peters et al., 2010). Thus, there is some suggestion that positive mental imagery focused on the future may be related to one's level of optimism. However, the evidence to date rests largely upon the findings of studies that assess biases in instructed future mental imagery generation and as a result do not directly bear upon biases in one's tendency to generate positive mental imagery spontaneously (i.e. in the absence of instructions or task requirements).

Preliminary evidence from a recent experience sampling study suggests that the emotional valence of mental imagery during spontaneous future thinking may relate to varying levels of optimism (Beaty et al., 2018). Beaty et al. (2018) sampled the temporal direction and valence of daily cognition across a seven day period, and found that higher optimism was associated with greater positivity of future-oriented thought content, on average (Beaty et al., 2018). Interestingly, optimism was not related to the overall frequency of future thinking, or to the emotional valence of past-oriented thought content. Thus, optimism may be specifically related to the positivity of mental imagery-based thoughts during future thinking. However, it is worth noting that Beaty et al. (2018) did not explicitly assess the representational format of cognition. Rather, the authors indirectly inferred the presence of mental imagery-based future thinking from the vividness ratings participants provided for all spontaneous thoughts. In addition, the valence of thought content was averaged across all future-oriented thoughts. Thus, whether optimism was associated with higher frequencies of positive *relative to* negative future thinking remains unclear.

The present study

While previous research provides encouraging support for a link between one's capacity to generate positive future mental imagery and optimism, the relationship between one's spontaneous tendency to generate positive relative to negative mental imagery during spontaneous future thinking and optimism remains to be directly tested. Most importantly, no study has assessed whether optimism mediates the relationship between individual differences in the tendency to generate positive relative to negative mental imagery during future thinking and negative mood.

The present study tested the hypothesis that an increased tendency to generate positive relative to negative mental imagery during spontaneous future thinking contributes to

higher optimism, which in turn results in a reduced negative mood. In line with this hypothesis, at any given time, individuals experiencing reduced negative mood will be more optimistic about the future (prediction 1), and those feeling more optimistic about the future will exhibit a higher tendency to generate positive relative to negative mental imagery during spontaneous future thinking (prediction 2). Further, higher levels of optimism will statistically mediate the relationship between participants' tendency to generate positive relative to negative mental imagery during spontaneous future thinking and lower negative mood (prediction 3).

To test the above relationships, the study required a task that could (a) evoke and record the real-time occurrence of future-oriented thoughts without instructions to generate such thoughts; and (b) distinguish between mental imagery-based future thoughts from those that do not involve imagery (verbal future thoughts); and (c) distinguish between emotionally positive and emotionally negative future thoughts. To achieve this, the study adapted a sustained attention to response task developed by Ji et al. (2018) to evoke spontaneous thinking by encouraging mind wandering. Without instructions to generate thoughts of any kind, participants self-reported the temporal direction (future, past, present, atemporal), representational format (imagery-based vs. verbal), and emotional valence (positive, negative, neutral) of spontaneous thoughts during the task. The task was further modified to include concurrent assessments of optimism and negative mood. The task's design enabled exploration of the extent to which any observed relationships between the tendency to generate positive relative to negative mental imagery during spontaneous thinking and optimism were unique in temporal direction (present for future, but not past, thoughts) and representational format (present for imagery-based, but not verbal, future thoughts).

Method

Participants

Forty-four individuals (28 females; age $M = 24.61$, $SD = 5.36$) from the local community and universities in Cambridge, United Kingdom participated in the study. Sample size was guided by bootstrapped (bias corrected) mediation analysis recommendations for 0.80 power and medium and large paths for α and β respectively (Fritz & Mackinnon, 2010). To increase the likelihood of recruiting participants with varied levels of naturally negative mood, the study was advertised as seeking participants who are "feeling blue" *or* "not experiencing mood disturbance". Eligibility criteria included: (1) age between 18 and 65; (2) not receiving current psychopharmacological or psychological treatment for a mental health condition; (3) no history of neurological disorder(s); and (4) self-identified native-level English language proficiency. Participants were reimbursed for their time and travel. The study was approved by the Cambridge Psychology Research Ethics Committee (ethics code: PRE.2014.13).

Materials

Spontaneous thought generation task

The laboratory task used to evoke and record uninstructed spontaneous thoughts consisted of four components: (a) a trial-by-trial sustained attention component to induce boredom and encourage spontaneous thought generation; (b) a spontaneous thought reporting component initiated by the participant at any time during the task; (c) an optimism rating component, and (d) a mood rating component.

(A) Sustained attention component

Each trial required participants to respond to a visually-displayed digit (1000 ms duration) on the computer screen, which ranged from "1" to "9" with equal probability. Participants were required to press a pre-specified key on the keyboard for all numbers except the number "3", for which they were to withhold the keypress. To promote the occurrence of spontaneous thoughts using verbal cues (Vannucci et al., 2017), singular word cues were also presented aurally via headphones on each trial (max 1000 ms duration, spoken by a female native British English speaker). Word cues varied in emotional valence (negative, positive, or neutral), based on normative ratings from the Affective Norms for English Words corpus (ANEW; Bradley & Lang, 1999). Word cues of each valence category did not differ in ANEW Arousal ratings, $F(2, 357) = 0.52$, $p = 0.603$, or in imageability ratings (ease with which a word evokes an associated mental image, as rated provided by independent raters, $F(2, 357) = 2.33$, $p = 0.10$. There were 360 trials in total, with 120 word cues from each valence category in valence-congruent blocks. On each trial, the 1000 ms digit was preceded by a fixation cross (500 ms) and blank screen (1000 ms), thus stimulus onset asychrony (SOA) duration was 2500 ms.

(B) Spontaneous thought reporting component

Parallel to the sustained attention component of the task, participants were instructed to press a key every time they became aware that their mind had wandered away from the computer task to think about other things. The keypress paused the sustained attention component of the task so that the following features of thought content could be self-rated: (a) Representational Format (*mental imagery*, *verbal*, *both*); (b) Emotional Valence (on a 5-point scale, ranging from 1 (*Very negative*) to 5 (*Very positive*); and (c) Temporal Direction (on an 8-point scale: Past (1—*Years*; 2—*Months*;

3—*Days/Weeks*), Present (4), Future (5—*Days/Weeks*; 6—*Months*, 7—*Years*), or Atemporal (8).

(C) Optimism rating component

To assess the current level of optimism, participants received prompts to rate how optimistic they currently felt at four points throughout the task in response to the question "At the moment I am feeling "optimistic". Ratings were provided on a 10-point VAS scale ranging from "not at all" to "extremely". To explore whether the relationship between Biases in Future Imagery Tendency and Optimism was specific to optimism, we also asked the participant to rate how hopeless they felt using the same rating scale in response to the question "At the moment I am feeling "hopeless".

(D) Negative mood rating component

To assess the current level of negative mood, participants received prompts to rate how "sad", "anxious", and "happy" (reverse scored) they currently felt in the same manner as the optimism rating.

Procedure

Participants were tested individually. Upon arriving at the laboratory, participants gave written informed consent, completed a demographics questionnaire and received instructions for each of the three components of the task, including an explanation of the difference between mental imagery-based versus verbal thoughts. Participants then practiced all three components of the task before commencing the main task, following which participants were debriefed and reimbursed. Participants were then verbally given the following instructions:

> "You are taking part in a study examining concentration, which requires you to carry out a vigilance task on the computer. In the task, you are going to see the digits 1 to 9 on the screen, one at a time. Your job is to press the "GO" key [sticker over "3" on keyboard side number pad] as soon as you see a number other than 3, and not press anything when you see the number 3. Additionally, you will also hear a word on each trial, these simply form part of your task environment. Your task is to focus on the digit vigilance task.
>
> Now, because this task is quite repetitive and monotonous, people tend to find that occasionally their attention lapses, and their mind wanders off. When this happens, people tend to think about all sorts of things that are unrelated to this task without intending to; the mind just spontaneously wanders off to somewhere else. This is quite normal, and we are interested in the type of things that goes through your mind during this task, so there is no need to control your thoughts in any way, just let it go where it wants to.
>
> What goes through people's minds can either take the form of words and phrases, which are "verbal thoughts", or they can be like mental images. A verbal thought might be "I'm really hungry". A mental image might be if you felt hungry and started visualising a delicious burger in your mind, with sizzling bacon and cheese melted over the bun. Although mental images often take the form of pictures in your mind's eye, they can actually include any of the five senses, so you can imagine sounds too."

Data extraction

To assess the relationship between optimism and the tendency to generate positive relative to negative imagery during future thinking, the frequency of imagery-based spontaneous future thoughts rated by participants as being positive or negative in emotional valence were computed as proportional to the total frequency of future-oriented thoughts. A Future Imagery Positive Bias Index was computed by subtracting negative future imagery proportional frequency from positive future imagery proportional frequency, such that a positive score reflected a greater tendency to generate positive relative to negative imagery during future thinking. Bias Indices were computed for verbal future thoughts, as well as imagery and verbal past thoughts, using the same approach. Further, a Negative Mood Index score was computed by summing "Sad", "Anxious", and reverse-scored "Happy" ratings, where higher scores indicate higher levels of negative mood.

Results

Participant characteristics

Participants (63.60% females) were aged 18–42, $M = 24.60$, $SD = 5.36$, with 16.80 years of education on average ($SD = 2.78$ years). Negative Mood Index scores at test time ranged from 1.88 to 24.5, $M = 10.60$; $SD = 5.46$.

General Spontaneous Thought (ST) characteristics

A total of 906 Spontaneous Thoughts (STs) were reported, 143 (15.80%) of which were future-oriented. For Future STs, 110 (76.90%) involved mental imagery, with the most common type of Future ST being mental imagery-based and positive in valence (42.7%). The numbers and percentages of Future, as well as Past, Present and Atemporal STs by representational format and valence are shown in Table 1.

Table 1 The frequency (raw and %) of future, past, present and atemporal spontaneous thoughts (STs) by representational format and valence of STs

Temporal orientation	Representation format	Frequency	Valence			Total
			Negative	Neutral	Positive	
Future	Imagery	Raw	19	30	61	110
		%	13.3%	21.0%	42.7%	
	Verbal	Raw	8	15	10	33
		%	5.6%	10.5%	7.0%	
	Total	Raw	27	45	71	143
		%	18.9%	31.5%	49.7%	
Past	Imagery	Raw	71	65	137	273
		%	22.0%	20.2%	42.5%	
	Verbal	Raw	15	18	16	49
		%	4.7%	5.6%	5.0%	
	Total	Raw	86	83	153	322
		%	26.7%	25.8%	47.5%	
Present	Imagery	Raw	20	36	46	102
		%	7.2%	13.0%	16.6%	
	Verbal	Raw	55	99	21	175
		%	19.9%	35.7%	7.6%	
	Total	Raw	75	135	67	277
		%	27.1%	48.7%	24.2%	
Atemporal	Imagery	Raw	29	34	35	98
		%	17.7%	20.7%	21.3%	
	Verbal	Raw	15	37	14	66
		%	9.1%	22.6%	8.5%	
	Total	Raw	44	71	49	164
		%	26.8%	43.3%	29.9%	
Total	Imagery	Raw	139	165	279	583
		%	15.3%	18.2%	30.8%	
	Verbal	Raw	93	169	61	323
		%	10.3%	18.7%	6.7%	
	Total	Raw	232	334	340	906
		%	25.6%	36.9%	37.5%	

The relationship between positive relative to negative future imagery frequency, optimism, and negative mood

Zero-order correlations between Negative Mood Index Scores, Optimism ratings, and Future Imagery Bias scores, as shown in Table 2, showed a significant negative relationship between Negative Mood Index Scores and Optimism, $r = -0.73$, $p < 0.001$, consistent with Prediction 1. Consistent with Prediction 2, a significant positive relationship was found between Optimism and Future Imagery Bias score, $r = 0.40$, $p = 0.013$. Further decomposition of this relationship revealed a significant positive relationship between the percentage of positive imagery and optimism, $r = 0.36$, $p = 0.03$. The relationship between negative imagery and optimism fell below the statistical significance threshold, $r = -0.25$, $p = 0.14$. Therefore, higher optimism was associated with a greater positive bias in future imagery tendency, driven primarily by greater *positive* imagery generation tendency during future thinking.

To test prediction 3, a mediation model was conducted with Future Imagery Bias score as a predictor, optimism rating as mediator, and Negative Mood Index score as the outcome variable. As depicted in Fig. 1, the regression coefficients between Future Imagery Bias and Optimism, and between Optimism and Negative Mood, were statistically significant. Consistent with Prediction 3, the indirect effect was (1.60) (− 2.10) = − 3.36. We tested the statistical significance of this indirect effect using 10,000 bootstrapped samples. The 95% confidence interval for the indirect effect, computed by determining the indirect effects at the 2.5th and 97.5th percentiles, ranged from − 6.38 to − 0.82, and the indirect effect was statistically significant $p = 0.015$. Thus, optimism statistically mediated a negative relationship

Table 2 Zero order correlations between sad mood, optmism, and future thinking frequency

	Sad Mood Index Score	Optimism Score	Future thinking total frequency	Future Imagery Bias Score	Future Verbal Thought Bias Score
Sad Mood Index Score					
Pearson's *r*	–				
p value	–				
Optimism Score					
Pearson's *r*	− 0.785	–			
p value	< 0.001***	–			
Future thinking total frequency					
Pearson's *r*	− 0.037	− 0.055	–		
p value	0.812	0.723	–		
Future Imagery Bias Score					
Pearson's *r*	− 0.178	0.398	0.012	–	
p value	0.285	0.013*	0.941	–	
Future Verbal Thought Bias Score					
Pearson's *r*	− 0.208	0.116	− 0.084	− 0.057	–
p value	0.211	0.486	0.617	0.734	–

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

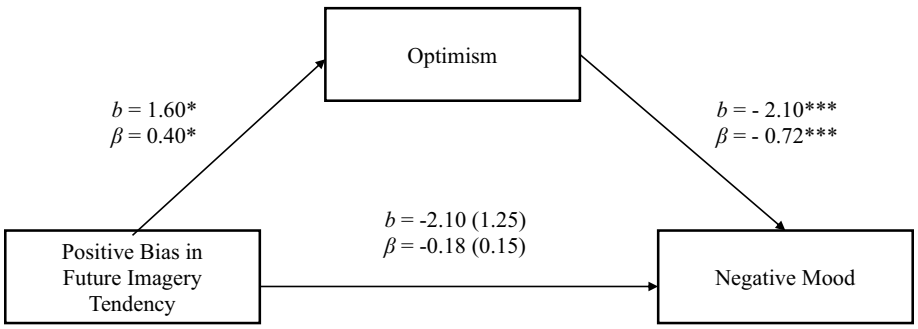

Fig. 1 Unstandardised (*b*) and standardised (β) regression coefficients for the relationship between Positive Bias in Future Imagery Tendency (higher score indicates greater tendency to generate positive relative to negative imagery during future thinking) and Negative Mood (higher score indicates higher negative mood), mediated by optimism (higher scores indicate greater optimism). The regression coefficients between Positive Bias in Future Imagery Tendency and Negative Mood, controlling for optimism, are presented in parentheses. *$p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

between positive bias in future imagery tendency and negative mood.

To explore the specificity of the relationship between participants' tendency to generate positive relative to negative imagery during spontaneous future thinking and optimism, zero-order correlations were conducted between optimism and verbal future thinking, as well as imagery-based and verbal past thinking. There was no evidence for significant relationships between Optimism ratings and Positive Bias scores for Future Verbal Thoughts, Past Imagery-based Thoughts or Past Verbal Thoughts, all $r \leq -0.28$, all $p \geq 0.09$, suggesting the relationship between optimism and positive bias in future imagery tendency is unique in representational format and temporal direction.

In addition, there was no evidence for a significant zero-order correlation between Positive Bias scores for Future Imagery and Hopelessness, $r = -0.17$, $p = 0.31$, suggesting the relationship between emotional future imagery tendency and optimism was specific.

To determine whether the relationship between Positive Bias in Future Imagery Tendency and optimism should be interpreted within overall differences in Future Thinking as a function of optimism, the relationship between optimism and total Future ST frequency, and optimism and total Neutral Future Imagery and Neutral Future Verbal ST frequency, were examined. No significant correlations were found, all $r \leq |0.08|$, all $p \geq 0.63$, indicating that optimism was not

related to the overall tendency to think about the future, or think about neutral aspects of the future.

Discussion

The present study investigated the relationship between the tendency to generate positive relative to negative mental imagery during spontaneous future thinking, optimism, and negative mood. As predicted, optimism was found to statistically mediate the relationship between an elevated tendency to generate positive relative to negative mental imagery during spontaneous future thinking and reductions in self-reports of negative mood. Specifically, a higher tendency to generate positive imagery during spontaneous future thinking statistically predicted higher optimism, and higher optimism in turn statistically predicted reduced negative mood. Importantly, the relationship between positive bias in future imagery generation tendency and optimism was unique in representational format and temporal direction.

The present findings add to previous evidence showing that enhanced mental imagery-based representations of positive aspects of the future are related to greater optimism (Blackwell et al., 2013; Ji et al., 2017). While previous research focused on the subjective vividness of positive and negative imagery that participants were instructed to generate, this study provides the first evidence that a higher frequency of positive relative to negative imagery during *spontaneous* future thinking is uniquely associated with increased optimism. It is interesting to note that, consistent with Beaty et al. (2018), optimism was not related to the tendency to think about the future in general. Thus, although more optimistic individuals may not think about the future more often, they may be more likely to generate positive mental imagery-based representations when thinking about the future. Further, the present findings also add to growing evidence that deficits in positive cognition and information processing may be driving mood dysregulation in conditions such as depression (Dunn, 2012; LeMoult & Gotlib, 2019; Winer & Salem, 2016). While previous research has shown that depression is associated with reduced accessibility of positive mental imagery of the future when instructed to imagine the future (Gamble et al., 2019; MacLeod, 2016), the present results extend this research by showing that when thinking about the future, a reduced tendency to generate positive imagery may be related to elevated negative mood, in part due to the mutual relationship with lower optimism. In terms of clinical implications, the present results suggest that targeting accessibility of positive future mental imagery to increase its spontaneous occurrence in daily life, such as through cognitive bias modification tasks (Blackwell et al., 2020), may contribute to mood improvement via its promotion of greater optimism, representing an important future direction for clinical research, particularly in young people (Pile & Lau, 2018; Pile et al., 2020).

It is interesting to note that the relationship between the tendency to generate positive relative to negative imagery during future thinking and one's view of the future was specific to optimism, and did not extend to hopelessness. Although optimism/pessimism and hopelessness share conceptual similarities, hopelessness is more specific than optimism/pessimism. While optimism/pessimism reflect evaluations of how the future is likely to turn out in general, hopelessness is postulated to result from an anticipated absence of positive future events and goals, therefore the evaluation that one's circumstance cannot be improved in the future (Abramson et al., 1989; Baumeister, 1990; Beck et al., 2001; Roepke & Seligman, 2016). While there is evidence suggesting that impoverished ability to deliberately imagine positive future events is linked to hopelessness (see MacLeod, 2016 for a review), we are not aware of experimental investigations of impoverished tendency to imagine positive future events and hopelessness. We note that the majority of participants in the present study exhibited a net positive bias in future imagery tendency (bias score > 0), whilst hopelessness is associated with clinical depression and suicidality (Abramson et al., 1989; Beck et al., 1988). It is therefore possible that the relationship between future imagery and hopelessness will be stronger in clinical populations that exhibit overtly negative biases in future imagery tendency.

We note that, in terms of temporal orientation, the most frequently reported type of spontaneous thought were past-oriented ones (35.54%), which is consistent with Ji et al. (2018), as well as other studies using slightly different variants of attentional vigilance laboratory tasks (Guesdon et al., 2020; Plimpton et al., 2015), particularly those using verbal cues (Vannucci et al., 2017). Interestingly, this contrasts with experience sampling studies of spontaneous past and future thinking in daily life, where a higher frequency of future-oriented than past-oriented thoughts were observed (Beaty et al., 2018). Thus, laboratory tasks designed to induce mind wandering using verbal cues may preferentially evoke past-oriented spontaneous cognition, despite past-oriented spontaneous thoughts perhaps not occurring more frequently than future ones in daily life. In addition, the majority of spontaneous thoughts in the present study involved mental imagery (64.35%), which is almost identical to the 63.96% found in Ji et al. (2018), suggesting the majority of spontaneous mind wandering episodes involve mental imagery-based thinking, at least when assessed in the laboratory using a task that incorporates concurrent exposure to verbal cues.

Finally, the present results demonstrate the importance of distinguishing the representational format of mental representations when investigating individual difference in future thinking. While early mind wandering research

distinguished, and emphasised the importance of, future-oriented thoughts that involve mental imagery versus those that did not (i.e. verbal future thinking) (Giambra, 1977; Singer & Antrobus, 1972), this distinction had been largely lost in subsequent research. Results from the present study demonstrate that assessing spontaneous future thinking frequency as a function of both the emotional valence as well as representational format of thought content can enhance the understanding of individual differences in future thinking.

Limitations and future directions

Given the cross-sectional nature of the study, the indirect relationship between a higher tendency to generate positive relative to negative imagery during future thinking and lower negative mood, via higher levels of optimism, is statistical in nature, and does not bear upon the causality and directionality of these relationships. Future research should seek to replicate and establish causal direction, such as by experimentally inducing increases or decrease in the frequency of positive relative to negative mental imagery generation during future thinking, and assessing whether it leads to corresponding increases or decreases in optimism and negative mood. Such research will help to assess the relevance of emotional future mental imagery as a potential novel intervention target for mood and anxiety disorders.

Second, the present study did not directly assess thought *content*. Previous research has shown that spontaneous future thoughts tend to be more abstract and less concrete for individuals with high relative to low dysphoria (Plimpton et al., 2015). Thus, it is possible that anomalies in emotional mental imagery during future thinking extend beyond the frequency of imagery generation to the degree to which future imagery, once generated, reflects concrete planning-related thoughts relating to future goals. Future research should investigate future imagery content in relation to optimism and negative mood.

In addition, while the present study did not aim to investigate similarities/differences in anxiety versus sadness in terms of their relationship to imagery-based spontaneous thought and optimism, previous research on deliberately-generated mental imagery suggests impoverished positive future mental imagery may have unique relationships to elevated depression symptoms rather than anxiety, in adults (Holmes et al., 2016) and adolescents (Pile & Lau, 2018). Future research should systematically investigate possible differences in the relationship between elevated sad mood versus anxiety, imagery-based spontaneous future thinking, and optimism, ideally via experimental inductions of sad versus anxious mood state.

Finally, spontaneous thoughts were self-caught in the present study, thus relying on participants' monitoring of their own conscious experience (Giambra, 1993). Previous research suggests self-, relative to probe-caught (via the delivery of pseudo-random thought probes) spontaneous cognition alters phenomenological experience during undemanding cognitive tasks to a lesser extent (Schooler, 2002; Smallwood et al., 2003). Nonetheless, the results must be interpreted as pertaining to spontaneous future thinking occurring within one's meta-awareness (Smallwood & Schooler, 2015). Future studies investigating individual differences in spontaneous future thinking frequency should employ both self- and probe-caught approaches.

Conclusion

Findings from this study suggest that a higher tendency to generate positive relative to negative mental imagery during spontaneous future thinking may indirectly lead to reduced negative mood via its unique relationship to increased optimism. In light of the growing consensus that psychopathology-linked individual differences in spontaneous future thinking is a clear research priority (Andrews-Hanna et al., 2013; Berntsen, 2019), the present study shows that assessing individual variation in biases in *mental imagery-based* future thinking may be a particularly important avenue for future research on mood dysregulation.

Author contributions JLJ: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Visualization; Writing—original draft; Writing—review and editing; FM: Conceptualization; Methodology; Supervision; Writing—review and editing; BG: Conceptualization; Methodology; Writing—review and editing; CM: Conceptualization; Methodology; Supervision; Writing—review and editing; EAH: Conceptualization; Funding acquisition; Methodology; Supervision; Writing—review and editing.

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Availability of data and material Data for this manuscript can be viewed via the Open Science Framework at: https://osf.io/x3h7t/?view_only=590ee853c8c64821ac4bc3215adcf784.

Declarations

Conflict of interest The authors declare no conflicts of interest.

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