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ORIGINAL ARTICLE

Imagine How Good That Feels: The Impact of Anticipated Positive Emotions on Motivation for Reward Activities

Max Heise[1] · Jessica Werthmann[1] · Fionnuala Murphy[2] · Brunna Tuschen-Caffier[1] · Fritz Renner[1]

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Abstract

Background Disease burden and unsatisfactory treatment outcomes call for innovation in treatments of depression. Prospective mental imagery, i.e. future-directed voluntary imagery-based thought, about potentially-rewarding activities may offer a mechanistically-informed intervention that targets deficits in reward processing, a core clinical feature of depression. We propose that the previously described impact of prospective mental imagery on motivation for everyday activities is facilitated by *affective forecasting*, i.e. predictions about an individual's emotional response to the imagined activities.

Methods Participants ($N=120$) self-nominated six activities to engage in over the following week and were randomized to either: (1) an *affective forecasting imagery* condition ($n=40$); (2) a *neutral process imagery* condition ($n=40$); or (3) a *no-imagery* control condition ($n=40$).

Results As predicted, increases in motivation ratings from pre to post experimental manipulation were significantly higher following affective forecasting imagery compared to both neutral process imagery ($d=0.62$) and no-imagery ($d=0.91$). Contrary to predictions, the number of activities participants engaged in did not differ between conditions.

Conclusions Results provide initial evidence for a potentially important role of affective forecasting in prospective mental imagery. We discuss how these findings can inform future research aiming to harness prospective mental imagery's potential for clinical applications.

Keyword Guided imagery; Behavioral activation; Major depression; Motivation; Prospective mental imagery; Episodic simulation

With an estimated global prevalence of over 279 million, depressive disorders are a leading cause of health loss (ranked 1st among mental disorders, 7th among non-communicable diseases, and 13th among all diseases; GBD, 2019; Vos et al., 2020). Given this high prevalence and burden of disease, improving and expanding currently existing treatments for depression is of paramount importance for mental health professionals. While existing psychological, pharmacological, and combination treatments for depression are effective (Bauer et al., 2015; Cuijpers, 2017; Cuijpers et al., 2021), they are clearly not always sufficient: It is estimated that about half of patients experience a relapse/recurrence within the twelve months following treatment (Ali et al., 2017). In longitudinal studies, patients with depression report being ill 46% of the time across a period of 12.8 years (Forte et al., 2015). These numbers highlight the continued need for treatment innovation to tackle the debilitating effects of depression.

One way forward in mental health treatment innovation is to focus research efforts on core clinical features and their underlying mechanisms instead of broad and heterogeneous diagnostic categories (Holmes et al., 2018; Insel et al., 2010). In the context of depression, aberrant reward processing, and specifically its impact on adaptive, reward-motivated behaviours, is one clinical feature/mechanism that has been gaining increasing attention (Admon & Pizzagalli, 2015; Khazanov et al., 2021; Renner et al., 2021; Treadway & Zald, 2011). Deficits in reward processing—such as reduced reward anticipation, one of the subconstructs in the Research Domain Criteria (RDoC) in the revised positive

✉ Max Heise
max.heise@psychologie.uni-freiburg.de

[1] Clinical Psychology and Psychotherapy Unit, Institute of Psychology, University of Freiburg, Engelbergerstr. 41, 79106 Freiburg, Germany

[2] MRC Cognition and Brain Sciences Unit, University of Cambridge, Cambridge, UK

valence domain (NIMH, 2018), or blunted experience of reward—typically manifest as anhedonic symptoms in the clinical picture (Kaya & McCabe, 2019). Anhedonia has been identified as a negative predictor for time to remission and number of depression-free days during pharmacological treatment (McMakin et al., 2012). Moreover, several studies found empirical support for the association of anhedonia and reduced reward-seeking behaviour in depression (Pizzagalli et al., 2008; Treadway et al., 2012). These studies suggest that anhedonia in depression is a clinically relevant treatment target for the development of novel treatment approaches.

Current evidence-based treatments for depression, such as Cognitive Behaviour Therapy (CBT) and its purely behavioural variant, Behaviour Activation (BA; Martell et al., 2001), share the common goal of overcoming motivational barriers to adaptive behaviours in order to promote individuals' re-engagement with rewarding activities. In the literature, there is a growing consensus to conceptualize reward processing as comprising several related but distinct components (Berridge et al., 2009; Craske et al., 2019; Forbes, 2020). One such framework proposes a distinction between *reward anticipation*, that is, an expectation about how rewarding a given activity will be; *reward motivation*, that is, the effort an individual is prepared to expend for reward attainment; and *reward experience*, that is, the pleasant/rewarding feelings experienced by an individual while engaging in the activity (Renner et al., 2021). Given the motivational deficits common in depression and reflected in the motivational focus of existing treatments such as CBT and BA, it seems expedient to investigate mechanistically-informed treatment options focussing on reward anticipation and its presumed down-stream effect on reward motivation. Accordingly, we have proposed the use of mental imagery to simulate engagement in potentially rewarding activities as a means to increase reward anticipation, which, in turn, should translate into increased motivation and positive changes in actual behaviour (Renner et al., 2019).

Mental imagery is defined as sensory experience in the absence of sensory input (Kosslyn et al., 2001). Occurring either involuntarily or voluntarily, mental imagery can be past-directed, that is, to relive past experiences, or future-directed, that is, to simulate future events (Holmes et al., 2016). For instance, you may find yourself day-dreaming about last night's dinner with a good friend (past-directed, involuntary) or you can actively imagine going for a run later today (future-directed, voluntary). Mental imagery techniques have long been integrated in various CBT treatments (Blackwell, 2021; Renner & Holmes, 2018; Saulsman et al., 2019) and recent years have seen a resurgence of interest in their possible applications and underlying mechanisms (for a review in the context of depression see Holmes et al., 2016). With regard to reward processing and depression, initial studies have shown that imagery based interventions can increase motivation and reward anticipation for enjoyable everyday activities (Hallford et al., 2020; Renner et al., 2019). In two studies using an episodic thinking task involving mental imagery of past and planned/unplanned future events, Hallford et al. (2020) found increases in ratings of anticipated and anticipatory pleasure that correlated with increased behavioural intention. Similarly, Renner et al. (2019) demonstrated that mental imagery increases anticipated pleasure/reward for and motivation to engage in planned everyday activities. In a conceptual replication and extension of the former study, Ji et al. (2021a) confirmed these findings and found evidence for a unique impact of mental imagery on anticipatory pleasure (state mood).

While these studies support the notion that mental imagery can increase reward anticipation and reward motivation, the underlying mechanism remains unclear. We argue that one possible explanation for these effects is *affective forecasting*, that is, mental imagery's ability to emulate the emotional impact of the imagined activity. Affective forecasting has previously been defined as the process of making "predictions about […] emotional reactions to future events" (Wilson & Gilbert, 2005, p. 131). In the case of planned everyday activities, mental imagery would thus enable the individual to experience their emotional response to the imagined future activity.

We propose that affective forecasting draws on two features of mental imagery that have been studied extensively: (1) its potential to boost the emotional salience of experiences and (2) its ability to recruit neural circuitry involved in actual perception. Mental imagery's close link to the affective dimension of experiences has been demonstrated in a number of studies both in healthy and depressed samples (Görgen et al., 2015a, 2015b; Holmes et al., 2008; Ji et al., 2021a; Ji et al., 2021b, for reviews see Ji et al., 2016; Holmes & Mathews, 2010). In two experiments with non-clinical participants, Holmes et al. (2008) showed that mental imagery processing produced stronger affective responses than verbal processing. In a related study, Görgen et al. (2015b) reported that for depressed individuals, the instruction to generate mental imagery of acoustically described objects produced stronger emotional effects than looking at pictures of the same objects (assessed using an implicit measure of affect). In a laboratory task employed to index spontaneous future thinking, Ji et al. (2021b) found that a tendency to experience positive, future-directed (vs. past-directed) mental images (vs. verbal representations) was associated with higher levels of optimism and lower levels of low mood. In sum, these findings show that mental imagery can be employed to tap into the emotional dimension of experiences, putting the spotlight, as it were, on the feelings experienced by an individual in a given situation.

The idea that mental imagery can generate 'as-real' (emotional) experiences receives further support in a growing cognitive neuroscience literature that shows substantial overlap in the brain structures involved in mental imagery and actual perception (Dijkstra et al., 2019, 2021; Pearson et al., 2015). Extending this line of research, recent experiments on visual perception suggest that, at the neural representation level, internally generated mental images may sometimes be mistaken for externally perceived stimuli (Dijkstra et al., 2021). Drawing on these findings we propose that in the case of potentially rewarding, enjoyable activities, the use of prospective mental imagery evokes the complex sensory experiences associated with specific everyday activities, resulting in neural activations closely resembling actual experiences. For depressed individuals suffering from reduced activity levels and, hence, fewer possibilities to experience reward, prospective mental imagery may offer these individuals a potential 'shortcut' to escaping the infamous *vicious circle of depression* by offering a 'taste' of what it feels like to re-engage in enjoyable activities. Ultimately, this approach may compensate for the blunted experience of reward and translate into increased motivation for and engagement in the targeted adaptive behaviours. An experimental investigation of this potential mechanism is crucial as it may advance our understanding of mental imagery and thereby inform the development of novel imagery-based therapeutic interventions.

The Present Study

The present study aims to test to what extent the motivational effects of simulating engagement in everyday activities using guided prospective mental imagery are facilitated by 'affective forecasting'. Affective forecasting here refers to the capacity of mental imagery to provide rich multisensory experiences of individual emotional responses to imagined future events. We compared the effect of two experimental mental imagery interventions: After planning in six target activities, participants followed either an imagery script focussing on their emotional responses to the target activity (*affective forecasting imagery)* or an imagery script focussing on perceptual details (*neutral process imagery)* with no reference to emotional aspects of the target activity. In addition, we included a no-imagery control condition to assess whether any effects between imagery conditions could be dissociated from a presumed general effect of mental imagery.

Our preregistered hypotheses (https://osf.io/c5svx) were fashioned to detect changes in participants' *appraisal of* and *engagement in* potentially rewarding everyday activities. Specifically, we predicted that participants randomized to either of the imagery conditions (*affective forecasting imagery*, *neutral process imagery*) would show a greater increase in self-reported activity ratings (i.e., motivation, anticipated pleasure, and anticipated reward) from pre to post experimental manipulation compared to participants randomized to the no-imagery control condition (hypotheses 1 a/b). Furthermore, we hypothesised that participants in the *affective forecasting imagery* condition would report a greater pre to post experimental manipulation increase in activity ratings compared to participants in the *neutral process imagery* condition (hypothesis 1 c). In terms of activity engagement, we hypothesised that participants in either of the imagery conditions would engage in more scheduled activities, assessed with an activity diary, than participants in the no-imagery control condition (hypotheses 2 a/b). Finally, we expected the number of activities participants engaged in to be higher in the *affective forecasting imagery* condition than in the *neutral process imagery* condition (hypothesis 2 c).

Method

Design

A mixed design was used with activity ratings measured pre and post experimental manipulation and the number of activities participants engaged in obtained from a written diary. While all participants chose and scheduled six everyday activities to engage in over the following week, the present study's experimental manipulation consisted of whether participants then completed one of two versions of a guided mental imagery script (*affective forecasting* or *neutral process* imagery conditions) or re-checked their activity schedule (*no-imagery* control condition).

Randomization. Participants were randomly assigned to one of three equally sized conditions and, in a second step, to one of two sequences of activity type, that is, participants either handled three enjoyable activities first followed by three routine activities or vice versa (counterbalanced within each condition).

Participants

Participants were recruited from a volunteer panel and from the general public using posters and leaflets. The sample size of $N = 120$ was determined prospectively and pre-registered (osf.io/c5svx) based on the following parameters: $\alpha = 0.05$, Power = 0.90 to detect medium sized effects ($\eta^2 = 0.04$—0.06) in a 2 (pre vs. post experimental manipulation) × 3 (affective forecasting imagery, neutral process imagery, no-imagery control) repeated measures ANOVA. Participants were reimbursed for their time (7.50 €/hour). The study was approved by the local ethics committee (No. 342/18).

Materials

Questionnaires and activity ratings were presented and recorded using the online platform EFS Survey (Version Spring; 2019).

Baseline Questionnaires

Spontaneous Use of Imagery Scale (SUIS; Reisberg et al., 2003; German: Görgen et al. 2015a)—The SUIS assesses use of imagery in everyday life based on respondent's agreement with 12 statements (e.g., "When I first hear a friend's voice, a visual image of him or her almost always springs to mind"). Answers are recorded on a five-point scale ranging from 1 "never appropriate" to 5 "always completely appropriate". For the German version, Görgen et al. (2015a) found internal consistency to be somewhat lower compared to values previously reported for the English version (α = 0.66 vs. α = 0.83 as reported by McCarthy-Jones et al., 2012). In the present study, reliability indices were as follows: ω = 0.68, 95% CI [0.58, 0.77]; α = 0.66, 95% CI [0.57, 0.74].

Plymouth Sensory Imagery Questionnaire (PSI-Q; Andrade et al., 2014)—The PSI-Q assesses mental imagery vividness across seven sensory modalities (vision, sound, smell, taste, touch, sensation, emotion) by asking respondents to form mental images and rate their vividness (example item: "Imagine the appearance of a cat climbing a tree"). Vividness ratings can range from 0 ("no image at all") to 10 ("image as clear and vivid as real life") and are obtained for a total of 35 items (five per domain). Andrade et al. (2014) report excellent internal consistency of α = 0.96 for the PSI-Q. In the present study, reliability indices were as follows: ω = 0.94, 95% CI [0.92, 0.96]; α = 0.94, 95% CI [0.92, 0.95].

Dimensional Anhedonia Rating Scale (DARS; Rizvi et al., 2015)—The DARS assesses symptoms of anhedonia in four different domains (hobbies, food/drink, social activities, sensory experience). Respondents self-nominate at least two activities per domain and rate statements describing desire, motivation, effort, and consummatory pleasure on a five-point scale ranging from "not at all" to "very much". For the DARS excellent internal consistency has been reported, with Cronbach's α ranging from 0.91 to 0.96 in three studies conducted by Rizvi et al. (2015). In the present study, reliability indices were as follows: ω = 0.79, 95% CI [0.71, 0.87]; α = 0.80, 95% CI [0.75, 0.85].

Temporal Experience of Pleasure Scale (TEPS; Gard et al., 2006)—The TEPS assesses anticipatory and consummatory components of anhedonia by asking respondents to indicate their agreement with 18 statements (e.g., "I enjoy taking a deep breath of fresh air when I walk outside."). Ratings are recorded on a six-point scale ranging from 1 "very false for me" to 6 "very true for me". Gard et al. (2006) report acceptable internal consistencies ranging from $\alpha = 0.71$—0.79 for the total, anticipatory, and consummatory scales of the TEPS. In the present study, reliability indices were as follows: anticipatory pleasure ω = 0.50, 95% CI [0.37, 0.62]; α = 0.49, 95% CI [0.35, 0.63]; consummatory pleasure ω = 0.66, 95% CI [0.54, 0.77]; α = 0.65, 95% CI [0.55, 0.74].

Behavioral Activation for Depression Scale (BADS; Kanter et al., 2006; German: Teismann et al., 2016)—The BADS assesses the level of behavioral activation across four factors (activation, avoidance/rumination, work/school impairment, social impairment) for the past week. Respondents rate the appropriateness of 25 statements (e.g., "I did something that was hard to do but it was worth it.") on a seven-point scale ranging from 0 "not at all" to 6 "completely". Teismann et al. (2016) report good internal consistency ($\alpha = 0.85$) for the German version. In the present study, reliability indices were as follows: ω = 0.78, 95% CI [0.70, 0.85]; α = 0.78, 95% CI [0.72, 0.84].

Depression Anxiety and Stress Scales (DASS-21; Lovibond & Lovibond, 1995; Henry & Crawford, 2005; German: Nilges & Essau, 2015)—The DASS-21 assesses symptoms of depression, anxiety, and stress by asking respondents to indicate the applicability of 21 statements (e.g., "I found it difficult to relax") over the past week. Ratings are recorded on a four-point scale ranging from 0 "did not apply to me at all" to 3 "applied to me very much, or most of the time". For the German version, Nilges and Essau (2015) report acceptable to good internal consistencies ranging from $\alpha = 0.76$ for anxiety, to $\alpha = 0.86$ for stress, and $\alpha = 0.88$ for depression. In the present study, reliability indices were as follows: depression ω = 0.85, 95% CI [0.80, 0.91]; α = 0.85, 95% CI [0.81, 0.89]; anxiety ω = 0.67, 95% CI [0.54, 0.81]; α = 0.67, 95% CI [0.58, 0.76]; stress ω = 0.80, 95% CI [0.74, 0.87]; α = 0.80, 95% CI [0.75, 0.86].

Positive and Negative Affect Scale, state version (PANAS; Watson et al., 1988; German: Krohne et al., 1996)—The PANAS state version assesses current positive and negative affect using ratings of 10 adjectives (e.g., "excited") for each dimension. Ratings can range from 1 "not at all" to 5 "extremely". For the German version, Krohne et al. (1996) report good internal consistencies for the two components ($\alpha >= 0.84$). In the present study, reliability indices were as follows: positive affect ω = 0.83, 95% CI [0.79, 0.88]; α = 0.83, 95% CI [0.78, 0.87]; negative affect ω = 0.86, 95% CI [0.80, 0.92]; α = 0.86, 95% CI [0.83, 0.90].

Activity Scheduling

Participants received a list of enjoyable and routine everyday activities (German translation of list used by Renner et al., 2019; available at https://osf.io/qu2sg). While their choice was not restricted to activities on this list, experimenters ensured that all selected activities met the following three criteria: First, activities should not already be part of participants' daily or weekly routines. Second, activities needed to have a minimum duration of 10 min. Third, following a common BA practice (Addis & Martell, 2004), activities were categorised as routine/mastery activities (e.g., "cleaning the kitchen") or enjoyable activities (e.g., "taking a bath"). Participants were instructed to choose a date and time for engaging in each of the six target activities that would fit into their regular daily/weekly routines.

Activity Ratings

Participants provided ratings of *motivation* ("How motivated are you to engage in this activity next week?"), *anticipated pleasure* ("How enjoyable will it be to engage in this activity next week?"), and *anticipated reward* ("How rewarding do you think having completed this activity will be?"). Ratings were recorded for each of the six target activities pre and post experimental manipulation. Ratings were presented on a computer screen using visual analogue scales (VAS) with endpoints labelled 0 "not at all" and 100 "extremely". Participants in the imagery conditions also rated *imagery vividness* and *imagery pleasantness* of the guided imagery scripts using equivalent VAS scales.

Guided Imagery Scripts

Imagery instructions. Trained experimenters guided participants through the mental imagery task using standardized scripts (see study protocol available at https://osf.io/nwx3z for the original texts). Scripts were based on a previous study (Renner et al., 2019) and pilot-tested. Experimenters read the imagery instructions aloud, filling in relevant details of target activities (time, date, and context). Both imagery script variants (described in more detail below) guided participants to imagine *initiating*, *engaging in*, and *completing* each target activity. Participants were instructed to generate vivid imagery from a first-person perspective while making use of all sensory modalities.

Imagery training. Prior to starting the actual imagery scripts, participants in the two imagery conditions completed a standard imagery training task illustrating the use of mental imagery (cf. Holmes & Mathews, 2005). In this training task, experimenters prompted imagery vividness and asked participants to provide descriptions of the generated images. If needed, experimenters provided additional standardized instructions to increase vividness or generate more detailed imagery (e.g., by asking participants to focus on the surface/texture of the imagined object).

Imagery duration. The imagery training task lasted about 2 min. Completion of each guided script—irrespective of imagery version—took 3 min, resulting in a total imagery intervention duration of approximately 20 min (six target activities at 3 min each + an additional 2 min of imagery training).

Affective forecasting imagery. The overall goal of this imagery script was for participants to anticipate the positive emotional outcomes associated with the target activities. Consequently, and depending on the type of activity, instructions placed a particular emphasis on either (1) emotions evoked by engaging in the activity (enjoyable activities) or (2) emotions evoked by completing the activity (routine/mastery activities).

Neutral process imagery. This imagery script aimed to induce emotionally neutral mental imagery of the target activity. Instructions in this script were identical to those of the affective forecasting imagery with the exception that all references to the emotional outcomes of engaging in the target activities were replaced by prompts to imagine engaging in the activity in as much perceptual detail as possible.

Activity Week

Activity diary. During the week following the lab session (activity week), participants kept a written activity diary, in which they indicated whether they engaged in each planned activity and how much time they spent on the activity (duration in minutes). In case of non-completion, participants could specify reasons for not engaging in the given activity; to encourage honest responses, the experimenter explained that the current study focussed on finding reasons why people do/do not complete activities. The present study used an adapted version of the diary employed by Renner et al. (2019).

Text messages. Participants received text messages prompting them to conduct a short imagery exercise (in either imagery condition) or to conduct their activity at the scheduled time (no-imagery control condition). For participants in the imagery conditions, the purpose of these messages was to encourage them to engage in imagery during their activity week.

Procedure

The study procedure was structured into two separate parts (cf. Figure 1): First, in a lab session, participants received verbal and written information about the study, provided written informed consent, and completed the baseline questionnaires described above. Participants proceeded to self-nominate six activities to complete in the following week and provided ratings of anticipated pleasure, anticipated reward, and motivation for each activity. Depending on the

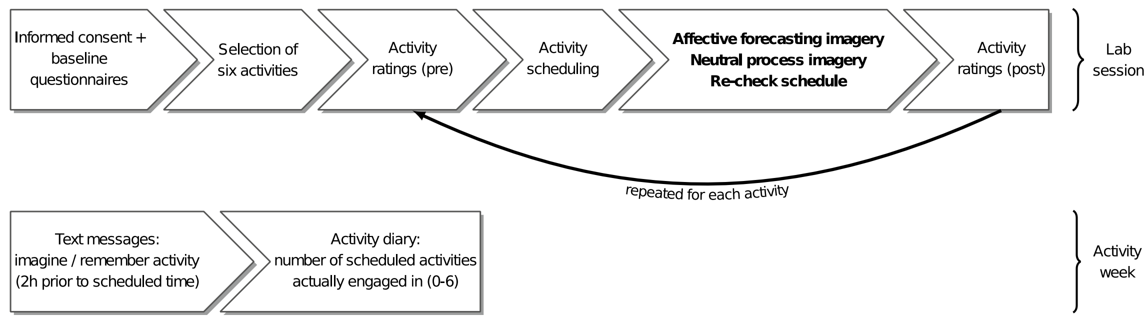

Fig. 1 Study procedure; Schematic illustration of the present study's procedure. Text in bold highlights the respective manipulations of the three experimental conditions (affective forecasting imagery, neutral process imagery, and no-imagery control)

experimental condition, activity scheduling was followed by having participants complete: (1) the affective forecasting imagery script, (2) the neutral process imagery script, or, in the no-imagery control condition, (3) a verification of time, date, place, and required preparations for their scheduled activities (in line with standard BA procedure; Addis & Martell, 2004). To assess influences on mood, participants in all conditions rated how happy, sad, anxious, and calm they felt on VAS scales with endpoints labelled 'not at all' and 'very much' before and after the intervention. At the end of the lab session, participants in all conditions received instructions on how to complete the written activity diary. Overall, the lab session took about 1:45–2 h to complete. In the second part of the experiment, outside the laboratory, participants recorded their actual engagement in the scheduled activities in a written diary during the week following the lab session. To promote imagery use, participants in imagery conditions received text messages via mobile phone two hours prior to an activity's scheduled date and time asking them to perform a brief imagery exercise. In the no-imagery control condition, these messages asked participants to simply remember their activity. All participants were asked to return their diary to the research team at the end of the activity week in a pre-paid envelope.

Statistical Analyses

To test for differences in activity ratings (hypotheses 1 a-c), we conducted separate repeated measures ANOVAs with condition (affective forecasting imagery vs. neutral process imagery vs. no-imagery control) as a between-participants factor and time of measurement (pre vs. post experimental manipulation) as a within-participants factor. Given a significant condition × time interaction, we conducted a priori defined pairwise comparisons on the pre to post experimental manipulation change scores using t-tests with Bonferroni-corrected α-levels of 0.016 (accounting for three comparisons/rating). Where F-tests indicated unequal variances, the Welch approximation of degrees of freedom was used. To test for differences in the number of scheduled activities participants engaged in (hypotheses 2 a-c), we conducted an ANOVA with condition (affective forecasting imagery vs. neutral process imagery vs. no-imagery control) as a between-participants factor. The software R (R Core Team, 2021) with the following packages were used: stats (Version 4.0.4; R Core Team, 2021) for ANOVAs, MBESS (Version 4.9.0; Kelley, 2022) for McDonald's omega, psych (Version 2.1.9; Revelle, 2021) for Cronbach's alpha, and randomizeR (Version: 1.4.2; Uschner et al., 2018) for random number lists required for randomizations.

Results

A total of $N = 120$ participants (92 females, mean age: 25, $SD = 6.2$, range 18–63) completed the present study. Further sample characteristics and baseline questionnaire scores as a function of experimental condition are provided in Table 1.

Experimental Effects on Activity Ratings (Hypotheses 1 a-c)

Mean values and standard deviations of activity ratings pre and post experimental manipulation are reported in Table 2. To test the experimental effects on activity appraisal described in hypotheses 1 a-c, we assessed differences between conditions (affective forecasting imagery, neutral process imagery, and no imagery control) on change in activity ratings (motivation, anticipated pleasure, and anticipated reward) from pre to post experimental manipulation. Detailed results for each activity rating are reported in the following paragraphs. For a graphical summary of the comparisons involved, see Fig. 2.

Motivation. As predicted, the interaction of condition × time for motivation ratings could be confirmed, $F(2, 117) = 8.68$, $p < 0.001$, $\eta^2 = 0.13$, indicating that the change in self-reported motivation differed significantly between conditions. Pairwise comparisons on the change from pre

Table 1 Demographic sample characteristics and baseline questionnaire scores

	Affective forecasting imagery $n=40$ M (SD)/n (%)	Neutral process imagery $n=40$ M (SD)/n (%)	No-imagery control $n=40$ M (SD)/n(%)	ANOVA/χ^2
Demographic characteristics				
Age	25.7 (6.9)	24.2 (7)	25 (4.5)	$F(2, 117)=0.58, p=0.562$
Female gender	32 (80%)	32 (80%)	28 (70%)	χ^2 (2, $n=92$)$=0.35, p=0.840$
Occupation: student	34 (85%)	37 (92.5%)	34 (85%)	χ^2 (2, $n=105$)$=0.17, p=0.918$
Baseline questionnaires				
BADS	111.9 (22.6)	111.9 (17.6)	109.3 (17.6)	$F(2, 117)=0.24, p=0.785$
DARS	87.3 (8.7)	85.9 (9.9)	83.8 (10.2)	$F(2, 117)=1.37, p=0.259$
DASS-21 Depression	2.7 (3.1)	4.1 (4.2)	3.1 (2.8)	$F(2, 117)=1.67, p=0.193$
DASS-21 Anxiety	2.5 (2.4)	2.2 (2.3)	2.3 (2.4)	$F(2, 117)=0.11, p=0.896$
DASS-21 Stress	4.8 (4)	5.1 (3.1)	5.2 (3.4)	$F(2, 117)=0.17, p=0.848$
PSIQ	7.5 (1.3)	7.5 (1.2)	7.3 (1.1)	$F(2, 117)=0.22, p=0.802$
SUIS	41.6 (6.6)	39.1 (5.9)	36 (6.4)	$F(2, 117)=8.13, p<0.001, \eta^2=0.12$
TEPS AP	4.5 (0.6)	4.4 (0.6)	4.2 (0.4)	$F(2, 117)=3.84, p=0.024, \eta^2=0.06$
TEPS CP	4.9 (0.7)	5 (0.6)	4.6 (0.7)	$F(2, 117)=2.38, p=0.097$

BADS: Behavioral Activation for Depression Scale (Kanter et al., 2006). DARS: Dimensional Anhedonia Rating Scale (Rizvi et al., 2015). DASS-21: Depression, Anxiety, and Stress Scales (Henry & Crawford, 2005). PSI-Q: Plymouth Sensory Imagery Questionnaire (Andrade et al., 2014). SUIS: Spontaneous Use of Imagery Scale (Reisberg et al., 2003). TEPS: Temporal Experience of Pleasure Scale (Gard et al., 2006), AP Anticipatory Pleasure, CP Consummatory Pleasure

Table 2 Activity ratings: pre/post values and change scores

	Pre		Post		Pre-post change		
	M	*SD*	*M*	*SD*	*M*	*SD*	*d*
Motivation							
Affective forecasting imagery	64.3	14.8	76.9	12.8	12.6	10.7	0.91
Neutral process imagery	65.9	13.3	72.0	11.6	6.1	10.2	0.49
No-imagery control	63.0	16.7	66.3	17.4	3.3	9.9	0.19
Pleasure							
Affective forecasting imagery	60.2	14.0	71.6	13.8	11.4	11.5	0.82
Neutral process imagery	56.8	10.6	65.0	11.1	8.2	7.7	0.76
No-imagery control	57.0	10.0	59.2	10.4	2.1	7.5	0.21
Reward							
Affective forecasting imagery	83.9	8.8	88.0	9.8	4.1	6.7	0.44
Neutral process imagery	81.9	10.1	84.8	10.1	2.9	5.9	0.29
No-imagery control	82.0	10.8	81.2	14.0	−0.8	6.4	−0.06

Means and SDs for activity ratings (motivation, pleasure, reward) measured pre and post experimental manipulation and pre to post experimental manipulation change score with Cohen's d grouped by experimental condition (affective forecasting imagery, neutral process imagery, no-imagery control)

to post experimental manipulation revealed a significant difference between affective forecasting imagery and neutral process imagery, $t(78)=2.78$, $p=0.007$, $d=0.62$, amounting to a medium effect (Cohen, 1988) in support of hypothesis 1 c. The comparison between affective forecasting imagery and no-imagery control confirmed a significant difference, $t(78)=4.05$, $p<0.001$, $d=0.91$, amounting to a large effect in support of hypothesis 1 b. There was no evidence for a significant difference between neutral process imagery and no-imagery control (hypothesis 1 a), $t(78)=1.26$, $p=0.210$, $d=0.28$.

Anticipated pleasure. As predicted, there was a significant interaction of condition × time for ratings of anticipated pleasure, $F(2, 117)=10.75$, $p<0.001$, $\eta^2=0.16$, indicating that the change in ratings of anticipated pleasure differed significantly between conditions. A pairwise comparison on the change from pre to post experimental manipulation did not reveal a significant difference between the two imagery

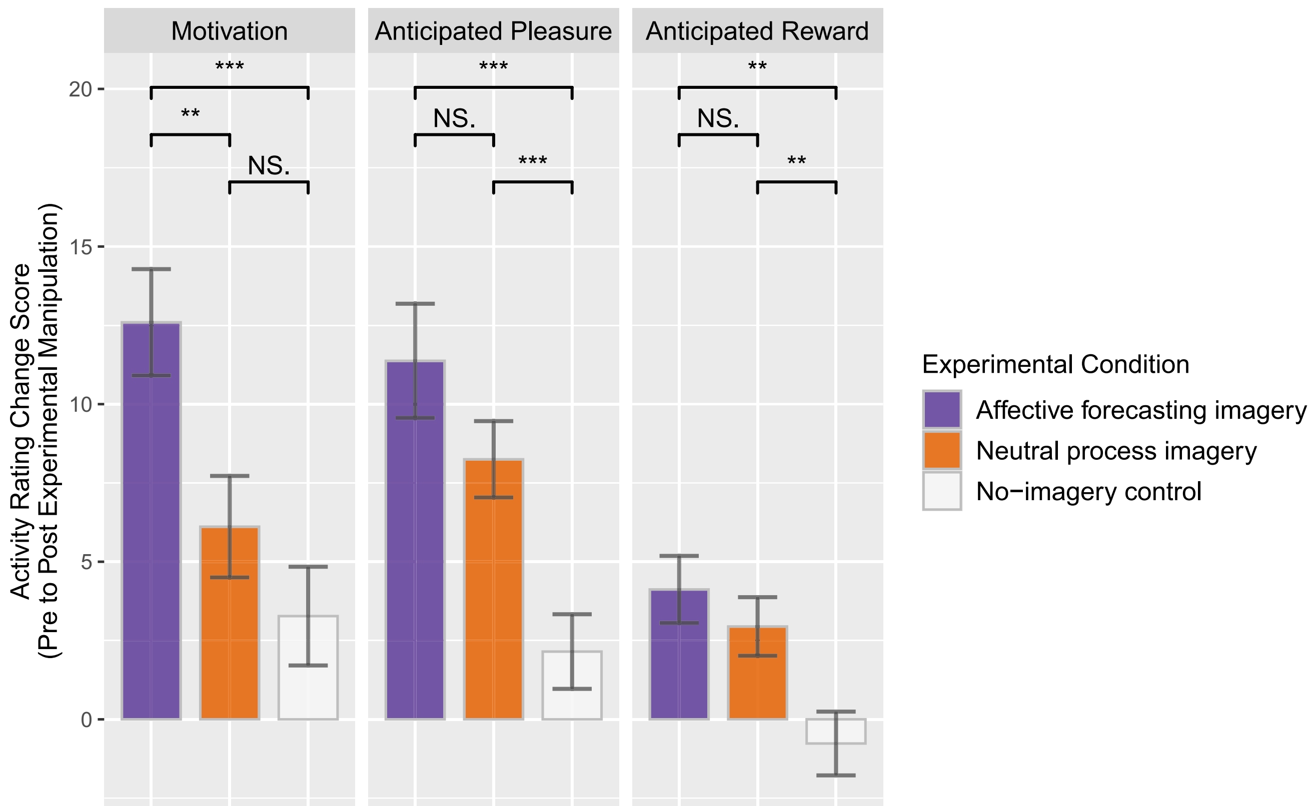

Fig. 2 Changes in activity ratings from pre to post experimental manipulation; Comparison of activity rating change scores (motivation, anticipated pleasure, and anticipated reward) between experimental conditions (affective forecasting imagery, neutral process imagery, no-imagery control). Higher values indicate larger increases in the respective activity rating from pre to post experimental manipulation. Pre and post ratings used VAS scales with range 0–100. Error bars represent standard errors of the mean. Significance: $** = p < 0.01$, $*** = p < 0.001$

conditions, $t(68.08) = 1.43$, $p = 0.156$, $d = 0.32$ (hypothesis 1 c). A significant difference could be confirmed between affective forecasting imagery and no-imagery control, $t(67.18) = 4.27$, $p < 0.001$, $d = 0.95$, amounting to a large effect in support of hypothesis 1 b. The comparison between neutral process imagery and no-imagery control revealed a significant difference, $t(78) = 3.60$, $p < 0.001$, $d = 0.81$, amounting to a large effect in support of hypothesis 1 a.

Anticipated Reward. As predicted, a significant interaction of condition × time for ratings of anticipated reward could be confirmed, $F(2, 117) = 6.47$, $p = 0.002$, $\eta^2 = 0.10$, indicating that the change in ratings of anticipated reward differed significantly between conditions. A pairwise comparison on the change from pre to post experimental manipulation did not reveal a significant difference between the two imagery conditions, $t(78) = 0.83$, $p = 0.408$, $d = 0.19$ (hypothesis 1 c). The comparison between affective forecasting imagery and no-imagery control confirmed a significant difference, $t(78) = 3.33$, $p = 0.001$, $d = 0.74$, amounting to a medium effect in support of hypothesis 1 b. The comparison between neutral process imagery and no-imagery control revealed a significant difference, $t(78) = 2.70$, $p = 0.008$, $d = 0.60$, amounting to a medium effect in support of hypothesis 1 a.

Experimental Effects on the Number of Activities Participants Engaged in (Hypotheses 2 a-c)

Participants returned a total of 97 activity diaries (81%). Return rates did not differ significantly between conditions ($\chi^2(2) = 0.27$, $p = 0.875$). Across conditions, participants engaged in an average of 4.6 out of six possible activities ($SD = 1.1$). In the affective forecasting imagery condition, participants engaged in 4.6 ($SD = 0.9$), in the neutral process imagery condition in 4.7 ($SD = 1.1$), and in the no-imagery control condition in 4.4 ($SD = 1.3$) activities. Contrary to our hypotheses, there was no evidence of a significant main effect of condition for the number of activities participants engaged in, $F(2, 111) = 0.84$, $p = 0.435$.

Exploratory Analyses

Baseline Questionnaires Associated with Imagery Effects

To identify measured variables that are associated with imagery effects, we examined zero order correlations between baseline questionnaires and activity rating change scores and number of activities engaged in. This revealed a negative correlation between baseline TEPS Consummatory Pleasure scores—a proxy of anhedonia—and the number of activities engaged in for participants in the neutral process imagery condition. To explore whether anhedonia, as indexed by TEPS Consummatory Pleasure scores, moderated imagery effects, we regressed the number of activities engaged in on imagery condition (dummy-coded) and baseline TEPS Consummatory Pleasure scores. This revealed a significant interaction of imagery condition and anhedonia score, $\beta = 0.825$, $t(71) = 2.266$, $p = 0.026$. To interpret this interaction, we plotted the number of activities engaged in as a function of low/high TEPS Consummatory Pleasure scores (median split calculated across all participants), which revealed the following descriptive pattern: For participants with low TEPS Consummatory Pleasure scores, that is, individuals experiencing more pronounced symptoms of anhedonia, those who underwent the neutral process imagery script condition engaged in more activities ($M = 5.1$, $SD = 0.8$) than those who underwent the affective forecasting imagery condition ($M = 4.5$, $SD = 0.9$). Conversely, for participants with high TEPS Consummatory Pleasure scores, that is, participants with low anhedonia, those who underwent the affective forecasting imagery script appeared to engage in more activities ($M = 4.8$, $SD = 0.8$) than those who underwent the neutral process imagery script ($M = 4.5$, $SD = 1.2$; cf. Figure 3). We note that this exploratory post-hoc analysis should be interpreted with caution until it is further replicated.

Regarding activity engagement, two additional statistically significant correlations were detected: In the no-imagery control condition only, the DASS-21 Stress and Depression scales were found to be negatively correlated with the number of activities engaged in, $r(37) = -0.35$, $p = 0.030$ and $r(37) = -0.34$, $p = 0.031$ respectively, suggesting that, in the no-imagery control condition, participants with high stress/depression scores engaged in fewer planned activities than participants with low stress/depression scores. Tables with all zero order correlations examined are reported in Appendix 1.

Imagery Vividness and Pleasantness

Imagery vividness and imagery pleasantness ratings were obtained from participants in the imagery conditions immediately after completion of the respective imagery scripts. Imagery vividness ratings did not differ between the affective forecasting imagery condition ($M = 83.0$, $SD = 11.3$) and the neutral process imagery condition (M = 80.6, $SD = 11.9$; $t(77.77) = 0.92$, $p = 0.360$, $d = 0.21$). By contrast, there was a significant difference in ratings of imagery pleasantness

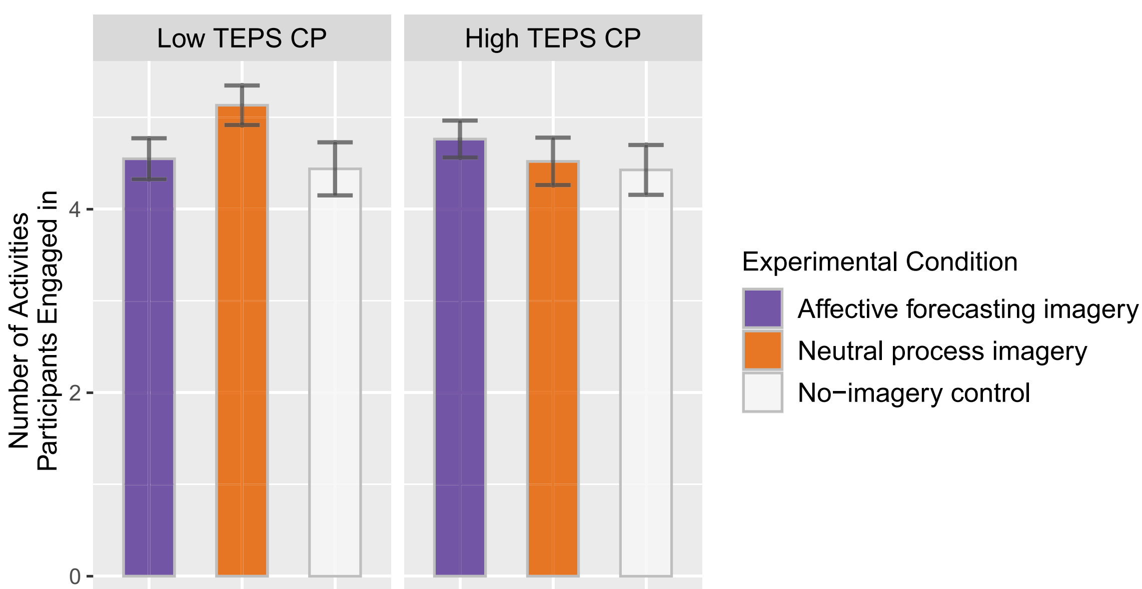

Fig. 3 Number of activities participants engaged in for low vs. high TEPS consummatory pleasure scores; Number of activities participants engaged in as a function of low/high TEPS Consummatory Pleasure scores (based on median split calculated across all participants) and experimental condition (affective forecasting imagery, neutral process imagery, no-imagery control). Error bars represent standard errors of the mean

between the affective forecasting condition ($M = 73.7$, $SD = 12.8$) and the neutral process imagery condition ($M = 67.8$, $SD = 13.1$, $t(77.96) = 2.03$, $p = 0.046$, $d = 0.45$), suggesting that participants in the affective forecasting condition found the imagery more pleasant.

Experimental Effects on Mood

To assess whether the experimental conditions in the present study differed in their effect on participants' mood, we conducted individual repeated measures ANOVAs for happiness, sadness, anxiousness, and calmness ratings obtained pre and post experimental condition. There was no significant interaction of time (pre vs. post) and experimental condition (affective forecasting imagery vs. neutral process imagery vs. no-imagery control) for any of these ratings (happiness: $F(2, 117) = 0.57$, $p = 0.568$; sadness: $F(2, 117) = 1.38$, $p = 0.255$; anxiousness: $F(2, 117) = 0.73$, $p = 0.486$; calmness: $F(2, 117) = 2.31$, $p = 0.104$), suggesting that changes in mood state did not differ between conditions.

Discussion

The present study tested the extent to which the motivational effects of guided prospective mental imagery simulating engagement in everyday activities are facilitated by 'affective forecasting', that is, mental imagery's capacity to provide rich multisensory experiences of our individual emotional responses to the imagined activities. Based on previous studies suggesting that mental imagery can amplify experienced emotion (Holmes & Mathews, 2005; Holmes et al., 2008) and motivation for planned activities (Renner et al., 2019) we aimed to disentangle the specific role of affective forecasting from a presumed general imagery effect by contrasting two versions of mental imagery: one with explicit references to emotions (affective forecasting imagery) and one without (neutral process imagery). Similar to Renner et al. (2019), we predicted that completion of either mental imagery script should improve *appraisal of* and *engagement in* target activities compared to the no-imagery control condition (hypotheses 1 a/b and 2 a/b, respectively). Furthermore, we predicted that the observed effects should be stronger for affective forecasting imagery than for neutral process imagery (hypotheses 1 c and 2 c, respectively), reflecting the impact of explicitly instructed affective forecasting. In terms of activity appraisal, as indexed by changes in ratings of motivation, anticipated pleasure, and anticipated reward from pre to post experimental manipulation, results were generally in line with predictions on a descriptive level; the observed differences between conditions were statistically significant in six out of nine comparisons involved. For the crucial contrast between imagery conditions, the expected superiority of affective forecasting imagery could only be confirmed for the changes in motivation ratings. In terms of activity engagement, recorded as the number of scheduled activities participants actually engaged in, no significant difference between conditions could be detected.

How can these results be interpreted in light of the proposed mechanism of affective forecasting? With regard to changes in activity appraisal, our experimental data support the previous finding that guided mental imagery scripts of everyday activities improve ratings of motivation, anticipated pleasure, and anticipated reward. Crucially, and extending previous findings by Renner et al. (2019), we could confirm that for ratings of motivation, this effect is significantly stronger if participants are explicitly instructed to imagine the emotional impact of target activities. Exploratory analyses showed that the imagery conditions did not differ in vividness of imagery or in their influence on mood state (as indexed by ratings of happiness, sadness, anxiety, calmness), ruling out alternative explanations that the effects of affective forecasting vs. neutral process imagery on motivation reflect a positive mood induction or more vivid imagery in the affective forecasting condition.

We could, however, not confirm an additional effect of affective forecasting for changes in ratings of pleasure and reward; even if results followed the predicted pattern on a descriptive level. One explanation might be that in the case of anticipated reward, the relatively high level of pre ratings suggests a possible ceiling effect that may have restricted the range of post/change scores. Moreover, measuring the expected changes in anticipated pleasure and anticipated reward may have been more difficult than detecting these changes in motivation: Considering the highly transient nature of emotional states (Harmon-Jones et al., 2016) and the theory-based expectation that changes in anticipated pleasure and reward should precede motivational changes (Renner et al., 2021), the present study may have been ill-equipped to detect any short-lived effects on anticipated pleasure and reward, thus capturing only the resulting increase in motivation. Finally, participant characteristics, such as symptoms of anhedonia, may interact with affective forecasting. A potential indication of this, albeit on a descriptive level and resulting from an exploratory post-hoc analysis, may be seen in the described trend that individuals with stronger symptoms of anhedonia engaged in more activities following *neutral* instead of *affective forecasting* imagery. This suggests that the interplay of mental imagery, affective forecasting, and anhedonia—representing a key symptom of depression—remains to be fully understood.

Contrary to our predictions, there were no differences between conditions in the number of scheduled activities participants actually engaged in, indicating that the observed increases in motivation did not consistently translate into behaviour. Explanations for this motivation-behaviour gap include the possibility that factors extraneous to the present study (such as organizational constraints, scarcity of time) may have trumped any more modest effects of mental imagery. Furthermore, considering this study's non-clinical sample and the relatively high average of 4.6 activities participants engaged in, it is conceivable that adding six activities to this particular sample's weekly schedule was not sufficiently challenging. As a result, any potential effects of mental imagery may not have been readily apparent. Moreover, the detection of the presumed mental imagery effect on a behavioural level might also require a stronger imagery intervention; possibilities to achieve this include increasing session duration, adding more sessions, and/or adapting the imagery script to individual participant characteristics.

Limitations. While providing promising initial evidence for the affective forecasting hypothesis, some limitations of the present study need to be considered. In particular, the current design did not prevent or control for spontaneously occurring affective forecasting in either of the two conditions in which it was not explicitly instructed. This problem could be addressed in future research through the implementation of an effective manipulation check, e.g. by probing mental imagery content through self-report or, ideally, more objective measures such as pupil diameter (Henderson et al., 2018). Furthermore, a detailed monitoring of (spontaneous) imagery use during the week following the lab session would have helped to assess possibly transient effects on emotion (i.e., anticipated pleasure and reward) and their down-stream effects on motivation. This kind of dynamic process data, that could be recorded using ecological momentary assessment (EMA), might enable future research to narrow the motivation-behaviour gap observed in our study. Moreover, systematic recording and variation of imagery script duration and/or imagery use frequency would allow investigation of possible dose–response relationships.

Implications for Future (Clinical) Research

The present study's findings are relevant for future studies examining mechanisms underlying the effects of mental imagery interventions. Specifically, our results provide further support of mental imagery's potential to influence emotional and motivational states (Holmes & Mathews, 2005; Holmes et al., 2008). One relevant question for future research in this context is to contrast the influence of guided mental imagery on emotions and motivation with a more closely matched no-imagery control condition.

For studies continuing down the road towards clinical applications of mental imagery, our results indicate that researchers should carefully consider the nature of anhedonic symptoms present in their treatment sample. While further replication is needed, exploratory post-hoc analyses in the current study suggest that with rising levels of anhedonia, affective forecasting imagery might lose some of its effectiveness. We note that for clinical samples, and in particular for individuals with depression, this tentative finding, if replicated, may be highly relevant. Future clinically oriented research should examine, ideally in (sub)clinical samples, *if* and *how* increased levels of anhedonia, which are typically observed in depression (Wang et al., 2021), influence the emotional and motivational effects of mental imagery.

Future clinical research should also probe whether existing therapies, such as BA or other CBT treatments, could benefit from the mechanism of affective forecasting. One possible approach could be to include prospective mental imagery in the process of selecting and scheduling adaptive activities. Following a similar rationale, Colombo et al. (2022) report promising results from a single case design study that tested the effectiveness of Virtual Reality to support a brief BA treatment. Studies like this and our results suggest that mental imagery techniques may hold great potential and may be highly relevant for clinical practitioners as guided imagery scripts could enable patients to identify worthwhile, rewarding activities more accurately and, once they have committed to them, increase behavioral motivation and engagement.

In summary, the present study provides promising initial evidence that mental imagery's capacity to provide affective forecasts (i.e., perceptually rich multisensory experiences of our individual emotional responses to activities) can be used to increase motivation for adaptive behaviours. These findings warrant further investigation in future research aiming to harness prospective mental imagery for clinical applications.

Appendix 1

Zero Order Correlations Examined for Exploratory Analyses

(See Tables 3, 4, 5, 6).

Table 3 Zero order correlations for all participants ($N = 120$)

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Number of activities engaged in	–												
2.	Motivation (pre-post change)	0.15	–											
3.	Pleasure (pre-post change)	−0.06	0.56**	–										
4.	Reward (pre-post change)	−0.07	0.31**	0.40**	–									
5.	BADS	0.16	−0.08	−0.03	0.11	–								
6.	DARS	0.11	0.10	0.21*	0.07	0.28**	–							
7.	DASS-21 Depression	−0.13	0.03	−0.06	−0.08	−0.63**	−0.22**	–						
8.	DASS-21 Anxiety	−0.15	0.12	−0.02	0.02	−0.51**	−0.14	0.40**	–					
9.	DASS-21 Stress	−0.17	0.15	0.05	−0.03	−0.56**	−0.21**	0.58**	0.59**	–				
10.	PSIQ	−0.01	0.04	0.06	0.05	0.16	0.42**	−0.03	0.03	−0.02	–			
11.	SUIS	0.03	0.12	0.25*	0.11	0.09	0.30**	0.00	0.05	−0.04	0.39**	–		
12.	TEPS AP	0.05	0.35**	0.22*	0.15	0.11	0.47**	−0.04	0.11	0.16	0.34**	0.29**	–	
13.	TEPS CP	0.04	0.19*	0.25*	0.15*	0.05	0.39**	−0.02	−0.02	0.01	0.11	0.32**	0.41**	–

*$p < 0.05$. **$p < 0.01$

Table 4 Zero order correlations for participants in the affective forecasting condition ($n = 40$)

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Number of activities engaged in	–												
2.	Motivation (pre-post change)	0.02	–											
3.	Pleasure (pre-post change)	–0.30	0.76**	–										
4.	Reward (pre-post change)	–0.27	0.51**	0.49**	–									
5.	BADS	0.11	-0.18	–0.03	–0.22	–								
6.	DARS	0.12	0.20	0.26	0.07	0.34*	–							
7.	DASS-21 Depression	–0.06	0.01	–0.13	0.12	–0.76**	–0.46**	–						
8.	DASS-21 Anxiety	–0.22	0.10	–0.02	0.26	–0.65**	–0.32	0.50**	–					
9.	DASS-21 Stress	–0.23	0.18	0.11	0.23	–0.57**	–0.20	0.73**	0.55**	–				
10.	PSIQ	–0.11	0.10	0.17	0.01	0.24	0.31	–0.22	–0.17	–0.01	–			
11.	SUIS	–0.07	0.17	0.32	0.02	0.25	0.24	–0.22	–0.14	0.05	0.27**	–		
12.	TEPS AP	–0.13	0.45**	0.44*	0.17	0.04	0.46**	–0.08	0.03	0.34	0.27*	0.35*	–	
13.	TEPS CP	0.15	0.40*	0.51**	0.03	0.05	0.48**	–0.09	–0.14	0.13	0.17	0.50**	0.55**	–

*$p < 0.05$. **$p < 0.01$

Table 5 Zero order correlations for participants in the neutral process imagery condition ($n = 40$)

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Number of activities engaged in	–												
2.	Motivation (pre-post change)	0.28	–											
3.	Pleasure (pre-post change)	0.16	0.29	–										
4.	Reward (pre-post change)	–0.01	–0.05	0.06	–									
5.	BADS	0.13	–0.23	–0.07	0.34	–								
6.	DARS	–0.14	–0.19	0.13	–0.21	0.01	–							
7.	DASS-21 Depression	–0.07	0.14	–0.08	–0.26	–0.60**	–0.07	–						
8.	DASS-21 Anxiety	0.01	0.33	–0.22	–0.18	–0.44**	0.01	0.29*	–					
9.	DASS-21 Stress	0.09	0.35*	–0.12	–0.41*	–0.60**	–0.08	0.47**	0.74**	–				
10.	PSIQ	–0.23	–0.11	–0.10	–0.07	0.13	0.45**	0.03	0.15	–0.01	–			
11.	SUIS	–0.23	–0.22	–0.16	–0.16	0.04	0.35*	0.22	0.13	0.07	0.39*	–		
12.	TEPS AP	–0.03	0.20	–0.22	–0.12	0.03	0.33*	0.05	0.38	0.19	0.35*	0.14	–	
13.	TEPS CP	–0.35*	–0.07	–0.24	–0.03	–0.36*	0.11	0.14	0.12	0.13	–0.18	0.05	0.12	–

*$p < 0.05$. **$p < 0.01$

Table 6 Zero order correlations for participants in the no-imagery control condition ($n = 40$)

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Number of activities engaged in	–												
2.	Motivation (pre-post change)	0.12	–											
3.	Pleasure (pre-post change)	–0.15	0.40*	–										
4.	Reward (pre-post change)	–0.10	0.21	0.30	–									
5.	BADS	0.22	0.15	–0.07	0.30	–								
6.	DARS	0.26	0.18	0.12	0.19	0.45**	–							
7.	DASS-21 Depression	–0.34*	–0.06	0.02	–0.13	–0.67**	–0.27*	–						
8.	DASS-21 Anxiety	–0.25	–0.09	0.10	–0.08	–0.40**	–0.12	0.54**	–					
9.	DASS-21 Stress	–0.35*	–0.03	0.14	0.01	–0.51**	–0.33*	0.66**	0.54**	–				
10.	PSIQ	0.25	0.05	–0.06	0.10	0.08	0.46**	0.11	0.12	–0.03	–			
11.	SUIS	0.21	–0.03	0.10	0.01	–0.07	0.25	–0.06	0.12	–0.21	0.49**	–		
12.	TEPS AP	0.21	0.21	0.09	0.16	0.28	0.59**	–0.17	–0.11	–0.09	0.38*	0.14	–	
13.	TEPS CP	0.22	0.18	0.24	0.27	0.33*	0.51**	–0.26	–0.04	–0.21	0.31*	0.32*	0.54**	–

*$p < 0.05$. **$p < 0.01$

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Data Availability Data, analysis script, study protocol, and non-copyrighted materials are available via the Open Science Framework and can be accessed at https://osf.io/nwx3z or will be made available by the authors on reasonable request. For the use of the study protocol, training is required.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the local ethics committee (No.: 342/18). There were no animals involved in the present study.

Consent to Participate Written informed consent was obtained from all individual participants included in the study.

References

Addis, M. E., & Martell, C. R. (2004). *Overcoming depression one step at a time: The new behavioral activation approach to getting your life back*. New Harbinger Publications.

Admon, R., & Pizzagalli, D. A. (2015). Dysfunctional reward processing in depression. *Current Opinion in Psychology, 4*, 114–118. https://doi.org/10.1016/j.copsyc.2014.12.011

Ali, S., Rhodes, L., Moreea, O., McMillan, D., Gilbody, S., Leach, C., Lucock, M., Lutz, W., & Delgadillo, J. (2017). How durable is the effect of low intensity CBT for depression and anxiety? Remission and relapse in a longitudinal cohort study. *Behaviour Research and Therapy, 94*, 1–8. https://doi.org/10.1016/j.brat.2017.04.006

Andrade, J., May, J., Deeprose, C., Baugh, S.-J., & Ganis, G. (2014). Assessing vividness of mental imagery: The Plymouth Sensory Imagery Questionnaire. *British Journal of Psychology, 105*(4), 547–563. https://doi.org/10.1111/bjop.12050

Bauer, M., Severus, E., Köhler, S., Whybrow, P. C., Angst, J., & Möller, H.-J. (2015). World Federation of Societies of Biological Psychiatry (WFSBP) guidelines for biological treatment of unipolar depressive disorders. Part 2: Maintenance treatment of major depressive disorder-update 2015. *The World Journal of Biological Psychiatry, 16*(2), 76–95. https://doi.org/10.3109/15622975.2014.1001786

Berridge, K. C., Robinson, T. E., & Aldridge, J. W. (2009). Dissecting components of reward: 'Liking', 'wanting', and learning. *Current Opinion in Pharmacology, 9*(1), 65–73. https://doi.org/10.1016/j.coph.2008.12.014

Blackwell, S. E. (2021). Mental imagery in the science and practice of cognitive behaviour therapy: Past, present, and future perspectives. *International Journal of Cognitive Therapy, 14*, 160–181. https://doi.org/10.1007/s41811-021-00102-0

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Routledge Academic.

Colombo, D., Suso-Ribera, C., Ortigosa-Beltrán, I., Fernández-Álvarez, J., García-Palacios, A., & Botella, C. (2022). Behavioral activation through virtual reality for depression: A single case experimental design with multiple baselines. *Journal of Clinical Medicine, 11*(5), 1262. https://doi.org/10.3390/jcm11051262

Craske, M. G., Meuret, A. E., Ritz, T., Treanor, M., Dour, H., & Rosenfield, D. (2019). Positive affect treatment for depression and anxiety: A randomized clinical trial for a core feature of anhedonia. *Journal of Consulting and Clinical Psychology, 87*(5), 457–471. https://doi.org/10.1037/ccp0000396

Cuijpers, P. (2017). Four decades of outcome research on psychotherapies for adult depression: An overview of a series of meta-analyses. *Canadian Psychology/psychologie Canadienne, 58*(1), 7–19. https://doi.org/10.1037/cap0000096

Cuijpers, P., Karyotaki, E., Ciharova, M., Miguel, C., Noma, H., & Furukawa, T. A. (2021). The effects of psychotherapies for depression on response, remission, reliable change, and deterioration: A meta-analysis. *Acta Psychiatrica Scandinavica*. https://doi.org/10.1111/acps.13335

Dijkstra, N., Bosch, S. E., & van Gerven, M. A. J. (2019). Shared neural mechanisms of visual perception and imagery. *Trends in Cognitive Sciences, 23*(5), 423–434. https://doi.org/10.1016/j.tics.2019.02.004

Dijkstra, N., Mazor, M., Kok, P., & Fleming, S. (2021). Mistaking imagination for reality: Congruent mental imagery leads to more liberal perceptual detection. *Cognition, 212*, 104719. https://doi.org/10.1016/j.cognition.2021.104719

EFS Survey (Spring). (2019). [Computer software]. Questback GmbH. https://www.unipark.de

Forbes, C. N. (2020). New directions in behavioral activation: Using findings from basic science and translational neuroscience to inform the exploration of potential mechanisms of change. *Clinical Psychology Review, 79*, 101860. https://doi.org/10.1016/j.cpr.2020.101860

Forte, A., Baldessarini, R. J., Tondo, L., Vázquez, G. H., Pompili, M., & Girardi, P. (2015). Long-term morbidity in bipolar-I, bipolar-II, and unipolar major depressive disorders. *Journal of Affective Disorders, 178*, 71–78. https://doi.org/10.1016/j.jad.2015.02.011

Gard, D. E., Gard, M. G., Kring, A. M., & John, O. P. (2006). Anticipatory and consummatory components of the experience of pleasure: A scale development study. *Journal of Research in Personality, 40*(6), 1086–1102. https://doi.org/10.1016/j.jrp.2005.11.001

Global Burden of Disease Collaborative Network. (2019). Global Burden of Disease Study 2019 (GBD 2019) Data Resources. Institute for Health Metrics and Evaluation (IHME). http://ghdx.healthdata.org/gbd-2019

Görgen, S. M., Hiller, W., & Witthöft, M. (2015a). Die Spontaneous Use of Imagery Scale (SUIS)–Entwicklung und teststatistische Prüfung einer deutschen Adaption. *Diagnostica, 62*(1), 31–43. https://doi.org/10.1026/0012-1924/a000135

Görgen, S. M., Joormann, J., Hiller, W., & Witthöft, M. (2015b). The role of mental imagery in depression: Negative mental imagery induces strong implicit and explicit affect in depression. *Frontiers in Psychiatry*. https://doi.org/10.3389/fpsyt.2015.00094

Hallford, D. J., Farrell, H., & Lynch, E. (2020). Increasing anticipated and anticipatory pleasure through episodic thinking. *Emotion*. https://doi.org/10.1037/emo0000765

Harmon-Jones, C., Bastian, B., & Harmon-Jones, E. (2016). Detecting transient emotional responses with improved self-report measures and instructions. *Emotion, 16*(7), 1086–1096. https://doi.org/10.1037/emo0000216

Henderson, R. R., Bradley, M. M., & Lang, P. J. (2018). Emotional imagery and pupil diameter. *Psychophysiology, 55*(6), e13050. https://doi.org/10.1111/psyp.13050

Henry, J. D., & Crawford, J. R. (2005). The short-form version of the Depression Anxiety Stress Scales (DASS-21): Construct validity and normative data in a large non-clinical sample. *British Journal of Clinical Psychology, 44*(2), 227–239. https://doi.org/10.1348/014466505X29657

Holmes, E. A., Blackwell, S. E., Burnett Heyes, S., Renner, F., & Raes, F. (2016). Mental imagery in depression: Phenomenology, potential mechanisms, and treatment implications. *Annual Review of Clinical Psychology, 12*(1), 249–280. https://doi.org/10.1146/annurev-clinpsy-021815-092925

Holmes, E. A., Ghaderi, A., Harmer, C. J., Ramchandani, P. G., Cuijpers, P., Morrison, A. P., Roiser, J. P., Bockting, C. L., O'Connor, R. C., & Shafran, R. (2018). The Lancet psychiatry commission on psychological treatments research in tomorrow's science. *The Lancet Psychiatry, 5*(3), 237–286.

Holmes, E. A., & Mathews, A. (2005). Mental imagery and emotion: A special relationship? *Emotion, 5*(4), 489–497. https://doi.org/10.1037/1528-3542.5.4.489

Holmes, E. A., & Mathews, A. (2010). Mental imagery in emotion and emotional disorders. *Clinical Psychology Review, 30*(3), 349–362. https://doi.org/10.1016/j.cpr.2010.01.001

Holmes, E. A., Mathews, A., Mackintosh, B., & Dalgleish, T. (2008). The causal effect of mental imagery on emotion assessed using picture-word cues. *Emotion, 8*(3), 395–409. https://doi.org/10.1037/1528-3542.8.3.395

Insel, T., Cuthbert, B., Garvey, M., Heinssen, R., Pine, D. S., Quinn, K., Sanislow, C., & Wang, P. (2010). Research Domain Criteria (RDoC): Toward a new classification framework for research on mental disorders. *American Journal of Psychiatry, 167*(7), 748–751. https://doi.org/10.1176/appi.ajp.2010.09091379

Ji, J. L., Geiles, D., & Saulsman, L. M. (2021a). Mental imagery-based episodic simulation amplifies motivation and behavioural engagement in planned reward activities. *Behaviour Research and Therapy*. https://doi.org/10.1016/j.brat.2021.103947

Ji, J. L., Murphy, F. C., Grafton, B., MacLeod, C., & Holmes, E. A. (2021b). Emotional mental imagery generation during spontaneous future thinking: Relationship with optimism and negative mood. *Psychological Research Psychologische Forschung*. https://doi.org/10.1007/s00426-021-01501-w

Ji, J. L., Heyes, S. B., MacLeod, C., & Holmes, E. A. (2016). Emotional mental imagery as simulation of reality: Fear and beyond—a tribute to Peter Lang. *Behavior Therapy, 47*(5), 702–719. https://doi.org/10.1016/j.beth.2015.11.004

Kanter, J. W., Mulick, P. S., Busch, A. M., Berlin, K. S., & Martell, C. R. (2006). The Behavioral Activation for Depression Scale (BADS): Psychometric properties and factor structure. *Journal of Psychopathology and Behavioral Assessment, 29*(3), 191–202. https://doi.org/10.1007/s10862-006-9038-5

Kaya, S., & McCabe, C. (2019). Can understanding reward help illuminate anhedonia? *Current Behavioral Neuroscience Reports, 6*(4), 236–242. https://doi.org/10.1007/s40473-019-00186-1

Kelley, K. (2022). MBESS: The MBESS R Package. https://CRAN.R-project.org/package=MBESS

Khazanov, G. K., Forbes, C. N., Dunn, B. D., & Thase, M. E. (2021). Addressing anhedonia to increase depression treatment engagement. *British Journal of Clinical Psychology*. https://doi.org/10.1111/bjc.12335

Kosslyn, S. M., Ganis, G., & Thompson, W. L. (2001). Neural foundations of imagery. *Nature Reviews Neuroscience, 2*(9), 635.

Krohne, H. W., Egloff, B., Kohlmann, C.-W., & Tausch, A. (1996). Untersuchungen mit einer deutschen Version der 'Positive and Negative Affect Schedule' (PANAS). *Diagnostica, 42*(2), 139–156.

Lovibond, P. F., & Lovibond, S. H. (1995). The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the beck depression and anxiety inventories. *Behaviour Research and Therapy, 33*(3), 335–343. https://doi.org/10.1016/0005-7967(94)00075-U

Martell, C. R., Addis, M. E., & Jacobson, N. S. (2001). *Depression in context: Strategies for guided action* (p. 223). W W Norton & Co.

McCarthy-Jones, S., Knowles, R., & Rowse, G. (2012). More than words? Hypomanic personality traits, visual imagery and verbal thought in young adults. *Consciousness and Cognition, 21*(3), 1375–1381. https://doi.org/10.1016/j.concog.2012.07.004

McMakin, D. L., Olino, T. M., Porta, G., Dietz, L. J., Emslie, G., Clarke, G., Wagner, K. D., Asarnow, J. R., Ryan, N. D., Birmaher, B., Shamseddeen, W., Mayes, T., Kennard, B., Spirito, A., Keller, M., Lynch, F. L., Dickerson, J. F., & Brent, D. A. (2012). Anhedonia predicts poorer recovery among youth with selective serotonin reuptake inhibitor treatment-resistant depression. *Journal of the American Academy of Child & Adolescent Psychiatry, 51*(4), 404–411. https://doi.org/10.1016/j.jaac.2012.01.011

National Institute of Mental Health. (2018). RDoC Changes to the Matrix (CMAT) Workgroup update: Proposed positive valence domain revisions. NIMH. https://www.nimh.nih.gov/sites/default/files/documents/about/advisory-boards-and-groups/namhc/reports/cmat-pvs-report-508.pdf

Nilges, P., & Essau, C. (2015). Die depressions-Angst-Stress-Skalen. *Der Schmerz, 29*(6), 649–657. https://doi.org/10.1007/s00482-015-0019-z

Pearson, J., Naselaris, T., Holmes, E. A., & Kosslyn, S. M. (2015). Mental imagery: Functional mechanisms and clinical applications. *Trends in Cognitive Sciences, 19*(10), 590–602. https://doi.org/10.1016/j.tics.2015.08.003

Pizzagalli, D. A., Iosifescu, D., Hallett, L. A., Ratner, K. G., & Fava, M. (2008). Reduced hedonic capacity in major depressive disorder: Evidence from a probabilistic reward task. *Journal of Psychiatric Research, 43*(1), 76–87. https://doi.org/10.1016/j.jpsychires.2008.03.001

R Core Team. (2021). R: A language and environment for statistical computing (version 4.0.4) [computer software]. R Foundation for Statistical Computing. https://www.R-project.org/

Reisberg, D., Pearson, D. G., & Kosslyn, S. M. (2003). Intuitions and introspections about imagery: The role of imagery experience in shaping an investigator's theoretical views. *Applied Cognitive Psychology, 17*(2), 147–160. https://doi.org/10.1002/acp.858

Renner, F., & Holmes, E. A. (2018). Mental imagery in cognitive therapy: Research and examples of imagery-focused emotion, cognition, and behavior change. In Robert L. Leahy (Ed.), *Science and practice in cognitive therapy: Foundations, mechanisms, and applications* (pp. 142–158). Guilford Press.

Renner, F., Murphy, F. C., Ji, J. L., Manly, T., & Holmes, E. A. (2019). Mental imagery as a "motivational amplifier" to promote activities. *Behaviour Research and Therapy, 114*, 51–59. https://doi.org/10.1016/j.brat.2019.02.002

Renner, F., Werthmann, J., Paetsch, A., Bär, H. E., Heise, M., & Bruijniks, S. J. E. (2021). Prospective mental imagery in depression: Impact on reward processing and reward-motivated behaviour. *Clinical Psychology in Europe, 3*(2), 1–16. https://doi.org/10.32872/cpe.3013

Revelle, W. (2021). Psych: Procedures for psychological, psychometric, and personality research. Northwestern University. https://CRAN.R-project.org/package=psych

Rizvi, S. J., Quilty, L. C., Sproule, B. A., Cyriac, A., Michael Bagby, R., & Kennedy, S. H. (2015). Development and validation of the Dimensional Anhedonia Rating Scale (DARS) in a community sample and individuals with major depression. *Psychiatry Research, 229*(1), 109–119. https://doi.org/10.1016/j.psychres.2015.07.062

Saulsman, L. M., Ji, J. L., & McEvoy, P. M. (2019). The essential role of mental imagery in cognitive behaviour therapy: What is old is new again. *Australian Psychologist, 54*(4), 237–244. https://doi.org/10.1111/ap.12406

Teismann, T., Ertle, A., Furka, N., Willutzki, U., & Hoyer, J. (2016). The German Version of the Behavioral Activation for Depression Scale (BADS): A psychometric and clinical investigation. *Clinical Psychology & Psychotherapy, 23*(3), 217–225. https://doi.org/10.1002/cpp.1948

Treadway, M. T., Bossaller, N. A., Shelton, R. C., & Zald, D. H. (2012). Effort-based decision-making in major depressive disorder: A translational model of motivational anhedonia. *Journal of Abnormal Psychology, 121*(3), 553–558. https://doi.org/10.1037/a0028813

Treadway, M. T., & Zald, D. H. (2011). Reconsidering anhedonia in depression: Lessons from translational neuroscience.

Neuroscience & Biobehavioral Reviews, 35(3), 537–555. https://doi.org/10.1016/j.neubiorev.2010.06.006

Uschner, D., Schindler, D., Hilgers, R.-D., & Heussen, N. (2018). RandomizeR: An R package for the assessment and implementation of randomization in clinical trials. *Journal of Statistical Software, 85*(8), 1–22. https://doi.org/10.18637/jss.v085.i08

Vos, T., Lim, S. S., Abbafati, C., Abbas, K. M., Abbasi, M., Abbasifard, M., Abbasi-Kangevari, M., Abbastabar, H., Abd-Allah, F., Abdelalim, A., Abdollahi, M., Abdollahpour, I., Abolhassani, H., Aboyans, V., Abrams, E. M., Abreu, L. G., Abrigo, M. R. M., Abu-Raddad, L. J., Abushouk, A. I., et al. (2020). Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019. *The Lancet, 396*(10258), 1204–1222. https://doi.org/10.1016/S0140-6736(20)30925-9

Wang, S., Leri, F., & Rizvi, S. J. (2021). Anhedonia as a central factor in depression: Neural mechanisms revealed from preclinical to clinical evidence. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 110*, 110289. https://doi.org/10.1016/j.pnpbp.2021.110289

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063–1070. https://doi.org/10.1037/0022-3514.54.6.1063

Wilson, T. D., & Gilbert, D. T. (2005). Affective forecasting: Knowing what to want. *Current Directions in Psychological Science, 14*(3), 131–134. https://doi.org/10.1111/j.0963-7214.2005.00355.x

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