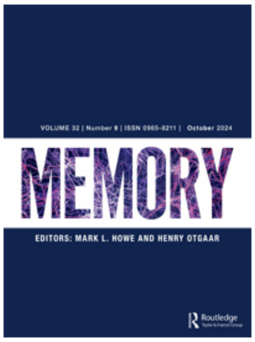

Memory

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/pmem20

Inducing positive involuntary mental imagery in daily life using personalized photograph stimuli

Mahdi Bagheri, Marcella L. Woud, Jolina Simon, Lilah Abdalla, Mats Dombrowe, Cem Woinek, Jürgen Margraf & Simon E. Blackwell

To cite this article: Mahdi Bagheri, Marcella L. Woud, Jolina Simon, Lilah Abdalla, Mats Dombrowe, Cem Woinek, Jürgen Margraf & Simon E. Blackwell (17 Sep 2024): Inducing positive involuntary mental imagery in daily life using personalized photograph stimuli, Memory, DOI: 10.1080/09658211.2024.2402920

To link to this article: https://doi.org/10.1080/09658211.2024.2402920

Published online: 17 Sep 2024.

MEMORY
https://doi.org/10.1080/09658211.2024.2402920

Inducing positive involuntary mental imagery in daily life using personalized photograph stimuli

Mahdi Bagheri, Marcella L. Woud, Jolina Simon, Lilah Abdalla, Mats Dombrowe, Cem Woinek, Jürgen Margraf and Simon E. Blackwell

Faculty of Psychology, Mental Health Research and Treatment Center, Ruhr-Universität Bochum, Bochum, Germany

ABSTRACT

Most people experience positive involuntary mental imagery (IMI) frequently in daily life; however, evidence for the importance and effects of positive IMI is largely indirect. The current study adapted a paradigm to experimentally induce positive IMI in participants' daily lives. This could in turn provide a means to directly test positive IMI's effects. In a within-subjects design, participants (*N* = 41) generated positive mental images (imagery condition) and sentences (verbal condition) from photo cues, half of which participants provided from their own living environment. Participants then recorded involuntary memories of the previously generated images or sentences in a seven-day diary, before returning to the lab and completing some measures including an involuntary memory task. In the diary, participants reported more involuntary memories from the imagery condition than from the verbal condition, and more involuntary memories from their own photos compared to the other photos. A more mixed pattern of findings was found across other tasks in the lab. The study indicates that the paradigm can be used as a means to induce positive IMI and that using photos as the basis for generating positive imagery increases the amount of IMI in daily life. Theoretical and potential clinical implications are discussed.

ARTICLE HISTORY
Received 8 February 2024
Accepted 5 September 2024

KEYWORDS
Involuntary imagery; mental imagery; involuntary memories; processing mode; positive mood

Introduction

People often experience positive mental imagery in daily life, and much of this occurs without any conscious effort in the context of involuntary memories or future projections (e.g., Berntsen & Jacobsen, 2008). For example, seeing a photo of a friend could automatically trigger a spontaneous memory of an enjoyable evening out you spent with them the previous week. This memory might include not only the visual impressions of the evening but also a broader sensory experience such as sounds, tastes and a re-experiencing of some of the positive emotions you experienced at the time; potentially, this might then influence you to send your friend a message suggesting meeting up again the following week.

The positive involuntary mental imagery (IMI) that is experienced in daily life occurs in the context of involuntary memories and episodic future-oriented events and is thought to play a number of functional roles, for example, in problem-solving, decision-making and emotion regulation (e.g., Barsics et al., 2016; Duffy & Cole, 2021; see Blackwell, 2019). However, the evidence for the assumed functions and importance of positive IMI is largely indirect, derived from observational and correlational data. For example, Barsics et al. (2016) conducted a study in which participants reported emotional future-oriented thoughts in a diary over the course of three days. Spontaneous positive future-oriented thoughts were often image-based, and participants evaluated these as fulfilling important functions, for example, in relation to pursuing their goals and regulating their emotions. Further, future-oriented thoughts with a greater amount of visual imagery were associated with greater intensity of anticipated emotions. Support for the importance of positive IMI also comes from work investigating psychopathology and wellbeing, which has found that higher levels of optimism are associated with more vivid and more frequent positive future-oriented thoughts in daily life (Beaty et al., 2019) and that higher levels of depression symptoms are associated with reduced frequency for spontaneous positive future-oriented imagery (Ji et al., 2019). While these data are consistent with the idea that positive IMI plays important functional roles in daily life, the evidence they provide is indirect; more direct evidence would require experimental induction of such imagery and assessment of the effects.

CONTACT Mahdi Bagheri mahdi.bagheri-m9i@rub.de Faculty of Psychology, Mental Health Research and Treatment Center, Ruhr-Universität Bochum, Massenbergstrasse 9-13, 44787 Bochum, Germany

Supplemental data for this article can be accessed online at https://doi.org/10.1080/09658211.2024.2402920.

Several paradigms have been used to induce positive IMI experimentally in daily life, for example, via asking participants to watch films with positive content (Davies et al., 2012) or imagine positive scenarios guided by audio scripts (Bagheri et al., 2023; Blackwell et al., 2020). Participants are then asked to record subsequent involuntary memories of these imagined scenes in a diary. However, studies using these paradigms have been primarily concerned with investigating factors that modulate the frequency of positive IMI (e.g., imagery vividness; Bagheri et al., 2023) rather than investigating the effects of this imagery when it occurs. Furthermore, in order to draw conclusions about the importance or effects of positive IMI, ideally it would be advantageous to contrast these effects to those of positive involuntary thoughts that *do not* take the form of mental images. In fact, accounts of the roles of positive IMI generally place great importance on the image-based representation of these cognitions. That is, it is assumed that these involuntary thoughts have the effects that they do *because* they are image-based. Evidence for this assumption comes from studies contrasting the effects of deliberately generated mental imagery to those of deliberately generated verbal thoughts (as a non-imagery counterpart). Such studies have generally found that the generation of positive mental images has a greater impact on emotion than the generation of positive verbal thoughts in healthy participants (e.g., Holmes et al., 2009) and mildly anhedonic individuals (Blackwell et al., 2023). However, even if such differences are found between imagery and verbal thoughts that are generated *deliberately*, it cannot be assumed that they will also be found for images and verbal thoughts that are experienced *involuntarily*. Theoretical accounts of episodic memory retrieval, which forms the basis for mental imagery, often assume differences in retrieval processes between voluntary and involuntary memories, with involuntary memory retrieval associated with less effort (e.g., Conway, 2005). Consistent with this, neuroimaging research shows that involuntary memory retrieval is associated with less prefrontal cortex activation than voluntary memory retrieval (Hall et al., 2014). While differences in retrieval processes may not necessarily mean differences in the quality or impact of involuntary versus voluntary memories or by extension mental imagery, from a clinical perspective, it does seem that patients often interpret the fact that involuntary images and thoughts pop into mind effortlessly as giving them special significance or meaning, e.g., they say something about them as a person or have some kind of prophetic quality, which then amplifies their emotional impact (Rachman, 2007). This suggests that we should investigate potential differences between involuntary and voluntary (i.e., deliberately generated) mental imagery rather than assuming that they are equivalent. To test the impact of involuntary mental, directly it would be necessary to induce both image-based and non-imagery (e.g., verbal) involuntary thoughts experimentally and contrast their effects.

To this end, Bagheri et al. (in press) devised a paradigm that aimed to allow direct experimental testing of the impact of involuntary images versus involuntary verbal thoughts using a within-subjects design. In an initial phase, participants completed a Picture–Word Task (PWT; adapted from Holmes et al., 2008), in which they saw a series of pictures with word captions underneath. For each picture–word pair, participants were asked to generate either a mental image (imagery condition) or a sentence (verbal condition) that combined the picture and word. Later on, participants completed a vigilance-intrusion task (VIT; adapted from Lau-Zhu et al., 2019), in which blurred versions of the pictures from the PWT were used to trigger involuntary memories of the previously generated images and sentences. Via the manipulation of processing mode during the PWT (generation of images vs. sentence), the paradigm provides experimental control over the representational format of what is stored in memory (imagery vs. non-imagery) and thus what later returns to mind in the form of involuntary memories (IMs). This therefore allows experimental investigation of the effects of positive involuntary mental imagery via comparison of this to the effects of positive involuntary verbal thoughts. In this initial lab-based study, Bagheri et al. (in press) found that the paradigm could be used to induce involuntary memories of the previously generated images and sentences in the lab and thus potentially provide a means to test their effects directly.

In the current study, we aimed to build on these previous results and investigate whether the paradigm developed by Bagheri et al. (in press) could be used to investigate positive IMI not only in the lab but also in daily life, which would allow more direct testing of the hypothesised effects and functions of such imagery. While there had been previous reports of people experiencing positive IMI from a PWT in their daily lives in the context of a clinical trial involving depressed participants (Blackwell & Holmes, 2017), this was only anecdotal and not measured formally. We made one main adaption to the PWT to facilitate investigating IMI in daily life, specifically in relation to the pictures used as the basis for image and sentence generation. While Bagheri et al. (in press) used photographs from a standardised picture database, we additionally included photographs that participants had taken themselves in their daily living environments. We anticipated that this would increase the likelihood of participants experiencing involuntary memories of the images and sentences in their daily lives, based on literature indicating that involuntary memories are often triggered via external cues that have perceptual or thematic overlap with the content of the memory (Baddeley et al., 2015; Berntsen, 2009). Specifically, if the participants generated images and sentences that incorporated the photographed object or scene, when they then encountered these objects or scenes in their daily life, the overlap with the content of the images and sentences (as well as with the photograph cue used for their generation) might trigger their involuntary recall. Furthermore, the use of participants' own photos in the PWT could facilitate the generation of more vivid images (McLelland et al., 2015), which in turn could increase the likelihood of their later involuntary retrieval (Blackwell et al., 2020).

The current study involved two lab-based testing sessions one week apart. In the first session, participants completed a version of the PWT in which half of the pictures used were from a standardised image database and half of them were photos participants had been instructed to take themselves from their daily living environment. All pictures were paired with a positive word caption. For half of the pictures, participants were asked to combine the picture and word to form a mental image (imagery condition), and for the other half, participants were asked to combine the picture and word to form a sentence (verbal condition). In the subsequent week, participants completed an online diary in which they were asked to report involuntary memories of the previously generated images or sentences, including their content, emotional valence, and the participants' subsequent action. These kinds of involuntary memories could be classified as involuntary memories of previously generated (imagined or verbally constructed) episodic future-oriented events. In the second lab session, participants completed a form of the VIT in which pictures from the PWT were presented, with the aim of triggering involuntary memories of the previously generated images and sentences. Ratings of state mood were used to investigate the effect of involuntary retrieval of images versus sentences on mood during the VIT. We also asked participants to complete a number of questionnaires including measures of mental imagery to help characterise the sample.

To summarise, in the current study, we aimed to investigate whether we could induce positive involuntary mental images and verbal thoughts in participants' daily life using an adapted version of the picture–word task in which half of the picture stimuli presented were photos the participants had taken themselves.

We formulated several main hypotheses. Following the literature indicating that involuntary memories tend to be imagery-based (e.g., Harris & Berntsen, 2019; Ji et al., 2022) and research demonstrating greater effects on the emotion of imagery than verbal thought (e.g., Holmes et al., 2008), we predicted that participants would report more involuntary memories of picture–word pairs for which they had generated images, compared with pairs for which they had generated sentences (both in the diary and during the VIT). Based on literature highlighting the importance of external cues in triggering involuntary memories, we predicted that participants would report more involuntary memories in their daily lives (as reported in the diary) of images and sentences generated from their own photos than those generated from other photos in the PWT. We expected this effect of photo type to be greater for the diary than for the VIT (where cues for both photo types were presented equally often, and for which we did not have any specific hypothesis about the effect of photo type). Overall, we expected a correlation between the number of IMs reported in the diary and the number recorded in the VIT.

A number of further hypotheses concerned the relationship between imagery and emotion. For the diary, we predicted that participants would rate IMs from the imagery condition of the PWT as having greater positive emotional valence than IMs from the verbal condition. For the VIT, we predicted that participants would show greater increases in positive state mood following presentation of picture cues from which they had generated mental images compared to those from which they had generated sentences.

A final set of hypotheses concerned the vividness of images generated during the PWT. We predicted that participants would generate more vivid mental images in the PWT when the picture cues were their own photos than when the cues were other photos, and we predicted that higher ratings of imagery vividness during the PWT would be associated with greater numbers of imagery-based IMs in the diary and in the VIT.

Method

Design

The study used a 2 (processing mode: imagery vs. verbal) × 2 (photo type: own vs. other) within-subject experimental design. Furthermore, participants were randomly allocated to one of two counterbalance orders (imagery-first or verbal-first) to control for possible order effects (see task descriptions below).

Participants

A sample of $N = 41$ university students (7 male, 33 female, 1 non-binary/other, mean age = 23.46, $SD = 3.72$, range = 19–38) was recruited via advertising on social media platforms and the website of the psychology faculty at Ruhr University Bochum. Inclusion criteria were (a) aged at least 18 years old and (b) sufficient German language knowledge.

Materials

Experimental tasks

All laboratory tasks were programmed using the PsychoPy software (Peirce et al., 2019) version 2021.2.3, with the exception of the diary, which was presented using the Qualtrics ^{XM} platform.

Picture–word task. The picture–word task (PWT) was adapted from Holmes et al. (2008) and Bagheri et al. (in press). Each trial of the PWT comprised a picture with a word caption beneath it. Participants were required to combine the picture–word pair to generate a mental image (in the imagery condition) or sentence (in the verbal condition). Each trial started with an instruction reminder ("imagine" or "make a sentence" in the imagery and verbal conditions, respectively) presented for 1 s. The picture and word caption were then shown for 3.5 s. During this time the participants either closed their eyes and generated a mental image (imagery condition) or generated a sentence (silently, verbal condition). The picture–word pair was followed by a beep sound for 1 s as a sign to stop image/sentence generation. Participants were then prompted to rate vividness of their mental image/ease of sentence construction on a 7-point scale, ranged from 1 (*not at all vivid/not at all easy*) to 7 (*extremely vivid/extremely easy*) and rate its time-orientation (how far in the future: 1 = *in the past*; 7 = *more than one year*).

The picture–word task consisted of two blocks which differed based on processing mode (imagery vs. verbal). Order of processing mode was counterbalanced between participants, i.e., half the participants completed the imagery block first (imagery-first) and the others completed the verbal block first (verbal-first). At the end of each block, participants completed ratings related to the images/sentences (see Supplementary Material and Table 1).

Imagery condition. In the imagery condition, participants were instructed that after seeing each picture–word pair they should shut their eyes immediately and generate a mental image with the following features: (a) included both the picture and word; (b) involved themselves (including seeing the situation through their own eyes, i.e., "field" perspective) and (c) situated in the future. For instance, for a picture of a theatre salon and the word of "pleasant" someone could imagine sitting in the front row and enjoying watching a show in the theatre the following weekend.

Verbal condition. In the verbal condition, participants were instructed that after seeing the picture–word pair they should construct a sentence that was: (a) combination of both the picture and word; (b) self-relevant (e.g., using pronouns "I", "me" etc); (c) grammatically correct and (d) future-oriented. For instance, for the picture of theatre salon and the word of "pleasant" someone could make a sentence such as "I will have a pleasant time in the theatre next weekend".

Picture stimuli. There were 64 pictures in the picture–word task. The picture stimuli comprised two different sets of 32 pictures. One set were standardised across all participants (here termed "other" pictures) and were derived from the pictures used in Bagheri et al. (in press). These were selected from the Open Affective Standardized Image Set (OASIS; Kurdi et al., 2017) to be relatively ambiguous (only mildly positive or negative; further details about the criteria used to choose the pictures from the OASIS, see Bagheri et al., in press). These sets of 32 pictures were divided into 8 subsets comparable in terms of the mean and standard deviation of the published valence and arousal. Four of these, 8 subsets were randomly allocated to the imagery block, with the remaining four allocated to the verbal block.

The other sets of pictures were provided by participants themselves ("own" pictures). Therefore, this set was unique for each participant. Prior to the first testing session, participants were provided with written instructions as to scenes/objects they should photograph, which related to situations the participants might encounter in daily life. For example, one theme was "journey scene", and participants were asked to "take a picture from a scene on your way to study/work" (see supplementary materials for the full list of themes and their instructions). The 32 pictures were randomly divided into two sets and one set was randomly allocated to the imagery block and the other set was used in the verbal block. To have the size of the photos comparable with the *other* pictures for the PWT, the photos were resized to 750 × 600 pixels and saved as 24-bit Bitmap files.

Word stimuli. There were 64 positive words, used in Bagheri et al. (in press), chosen from the Leipzig Affective Norms for German (LANG; Kanske & Kotz, 2010). For details about how the words were originally selected, see Bagheri et al. (in press). We divided the 64 words into 8 subsets balanced in the mean and standard deviation of published valence, arousal, concreteness and number of letters. Four subsets were randomly allocated to the imagery block, and the remaining subsets were allocated to the verbal block.

Picture–word pairs. Two fixed sets of picture–word pairs were made using the photo and word stimuli described above, with allocation of the sets to each processing mode (imagery vs. verbal) counterbalanced across participants. For example, the picture–word pairs used in the imagery block for half participants were used in the verbal block for the other half, and vice versa. Within a block, picture–word pairs were presented in a randomised order for each participant (for further information, see Supplementary Appendix B).

Involuntary memory diary. An involuntary memory diary, adapted from Blackwell et al. (2020) and Bagheri et al. (2023), was used to record the occurrence of involuntary memories in daily life of images/sentences generated during the PWT. At the end of session 1, participants received verbal instructions from the researcher about spontaneous memories and how these are different from voluntary memories. They were requested to report only memories that popped into their mind spontaneously (i.e., not deliberate recall), and only spontaneous memories from the PWT (i.e., not spontaneous memories of other events). The researcher sent participants a link to the diary page three times per day, in the morning, afternoon and evening. The first diary link was emailed in the evening of session 1. Clicking on the link took participants to the online diary in which they recorded any IMs they had experienced from the PWT since completing their last diary by first writing a brief summary of each

Table 1. Manipulation checks (broken down by processing mode).

Variable	Imagery block		Verbal block		Omnibus effects	
	Own M (SD)	Other M (SD)	Own M (SD)	Other M (SD)	$F(1, 39)$[a]	η_p^2
Vividness					O: 4.32*	.10
Imagery-first	4.67 (0.95)	4.49 (0.87)	–	–		
Verbal-first	5.16 (0.69)	5.03 (0.86)	–	–		
Easiness					P: 10.53**	.21
Imagery-first	–	–	4.98 (1.05)	4.71 (0.92)		
Verbal-first	–	–	4.95 (0.82)	4.66 (0.62)		
Time-orientation						
Imagery-first	4.55 (0.68)	5.61 (0.74)	4.35 (0.51)	5.38 (0.64)	M: 6.83*	.12
Verbal-first	4.35 (0.52)	5.22 (0.55)	4.28 (0.53)	4.98 (0.53)	P: 191.18***	.83
	Imagery block[b]		Verbal block			
State mood						
Imagery-first (pre: post)	7.00 (0.58): 6.74 (0.56)		6.74 (0.81): 6.63 (0.83)		$O \times M \times T = 6.61$*	.14
Verbal-first (pre: post)	7.14 (1.08): 7.32 (0.95)		7.14 (1.25): 6.82 (1.26)		M: 5.78*	.13
Emotionality						
Imagery-first	2.84 (1.12)		2.63 (0.96)		O: 6.73*	.15
Verbal-first	3.95 (1.50)		3.14 (1.13)		M: 5.97*	.13
Thinking in images						
Imagery-first	5.47 (0.96)		2.53 (1.17)		M: 160.88***	.80
Verbal-first	5.95 (0.90)		3.05 (1.68)			
Thinking verbally					M: 75.85***	.66
Imagery-first	3.16 (1.86)		5.79 (1.18)			
Verbal-first	2.64 (0.85)		5.45 (1.57)			
					t (df)	Hedges g
Personal involvement in images						
Imagery-first	4.68 (1.42)		–		1.61 (36.36)	.50
Verbal-first	5.36 (1.26)		–			
Self-relevance of sentences						
Imagery-first	–		6.37 (0.76)		2.01 (32.09)	.59
Verbal-first	–		5.64 (1.50)			

Note: [a]For simplicity, only statistically significant interactions/main effects are presented. O: Order of presentation, M: Processing mode, P: Photo type, T: Time. [b]The rest of variables in the table, i.e., emotionality and its subsequent ones, were rated on the block basis (not separated by photo type).
*$p < .05$. **$p < .01$. ***$p < .001$.

memory and then making ratings about its characteristics: (a) when they experienced the memory (last night, morning, afternoon, and evening); (b) valence of the memory (from −5 = *very negative*, to 5 = *very positive*) and (c) their next behaviour, i.e., what they did after the experience of memory (free text). Participants could also indicate that they had experienced no involuntary memories since the last diary by clicking a button. If participant completed the diary, the next time they were sent a link they were thanked for filling in the last diary. Otherwise, the link for the new diary included a reminder that they had missed the last one. Participants completed the last diary in the lab at the beginning of session 2.

After participants had made the last diary entry in the lab, they were asked a question about their diary compliance, “How carefully did you fill in the diary?” rated from 1 (*not at all carefully*) to 9 (*very carefully*). At the end of the second session, the researcher looked through the online diary entries with the participant and asked two questions about each memory to: (i) ascertain whether the memory was from the PWT, and if so, which stimulus it related to, and (ii) whether the behaviour noted in the diary was related to the involuntary memory (in the participant’s opinion).

Later, we matched the stimulus indicated by each participant to the relevant block of the PWT, allowing us to code whether the memory was related to own/other and imagery/verbal conditions.

Vigilance-intrusion task. The vigilance-intrusion task (VIT), adapted from Lau-Zhu et al. (2019) and Bagheri et al. (in press), was used to trigger involuntary memories of the images/sentences participants generated during the PWT. Each trial started with the presentation of a digit from 1 to 9 for 250 ms in the middle of the screen with a black background, followed by the black background alone for a further 1500 ms on the screen. Each trial therefore lasted a total of 1750 ms. Every three successive trials there was a picture, rather than a black background, behind the digit, and this picture was replaced by the black background after 250 ms. Participants were asked to respond to all digits, except 3, by pressing “G” button on the keyboard. The digit 3 was never presented in trials that had a picture background. Participants were told that during the task they may experience spontaneous memories. When it happened, they should press the “S” button. After pressing this they were prompted to type in a brief summary of their memory.

The VIT comprised two blocks. Within each block, there were 22 pictures from the PWT (11 own and 11 other pictures) and 22 foil pictures chosen from the OASIS. That is, in total there 44 pictures from the PWT and 44 new pictures from the OASIS. We blurred all 88 pictures using the ImageMagick software (Gaussian blur 0.2).

Other experimental tasks. While our main focus was involuntary memories, we also measured a number of other processes to better characterise and explore the effects of the experimental manipulations. In addition to the tasks described above, we also assessed voluntary memory for the PWT stimuli, as research sometime shows dissociations between voluntary and involuntary memory (Lau-Zhu et al., 2021). We also asked participants to rate the valence of all pictures used in the PWT at the start of the session 1 in the lab and at the end of session 2. These tasks and results related to them are described in the supplementary material.

Questionnaires

All questionnaire measures were presented and completed using the Qualtrics ^{XM} platform. The following questionnaires were used in the current study: The Depression Anxiety Stress Scales-Short Version (DASS-21; Lovibond & Lovibond, 1995; German translation; Nilges & Essau, 2015); the Spontaneous Use of Imagery Scale (SUIS; Reisberg et al., 2003; German version by Görgen et al., 2016); the Involuntary Autobiographical Memory Inventory (IAMI; Berntsen et al., 2015) and the Self-Assessment Manikin (SAM; Bradley & Lang, 1994). Detailed questionnaire descriptions are in the supplementary material. See results of the questionnaires in Table 2.

Procedure

The study involved two lab-based testing sessions. Before session 1, participants were asked to take photos of daily activities/situations and send them to the researcher at most one day before the first session. The researcher checked whether the pictures were complete and correctly labelled and then prepared them for use in the lab-based tasks. On arrival at the laboratory, participants provided written informed consent. They then completed the demographic questionnaire, DASS-21, SUIS and IAMI. Participants then completed the picture–word task (PWT). Participants rated their state mood using the SAM before and after each of the two blocks of the PWT. At the end of session 1, participants received the instructions as to how they should record their involuntary memories in the online seven-day diary.

After seven days, participants returned to the lab for session 2, which started with completion of the last diary in the laboratory. Participants then completed the vigilance-intrusion task (VIT). They rated their state mood using the SAM before and after each of the two blocks of the VIT. At the end of the session, they were debriefed and received cash payment (€40) or course credit for their participation.

Transparency and openness

To comply with open science rules and increase research transparency and reproducibility in line with guidelines of Transparency and Openness Promotion (TOP: Nosek et al., 2015), we report planned sample size, tasks and questionnaires used in the study. We post materials, data and analysis codes on the Open Science Framework

Table 2. Participant characteristics (separated by counterbalance order).

Variable	Imagery-first ($n = 19$) M (SD)	Verbal-first ($n = 22$) M (SD)	$t(df)$	p	Hedges g
Age	23.89 (2.66)	23.09 (4.47)	0.71 (34.93)	.48	0.21
DASS-21-depression	2.47 (3.99)	2.64 (3.06)	0.14 (33.54)	.89	0.04
DASS-21-anxiety	1.26 (2.16)	1.82 (2.86)	0.71 (38.37)	.48	0.22
DASS-21-stress	3.32 (3.70)	3.73 (3.28)	0.37 (36.39)	.71	0.12
SUIS	39.21 (8.58)	38.73 (7.29)	0.19 (35.59)	.85	0.06
IAMI-past	20.95 (5.30)	22.82 (5.89)	1.07 (38.93)	.29	0.33
IAMI-future	17.74 (8.02)	18.50 (7.84)	0.31 (37.86)	.76	0.09
	n (%)	n (%)	Fisher's exact test	p	
Gender					
Male	3 (15.79)	4 (18.18)		.83	
Female	15 (78.95)	18 (81.82)			
Other or X	1 (5.26)	0 (0.00)			
Relationship status					
Single	8 (42.11)	13 (59.09)	0.51	.35	
Single but in a stable relationship	11 (57.89)	9 (40.91)			
Educational degree					
High school	11 (57.89)	16 (72.73)		.77	
College	3 (15.79)	2 (9.09)			
Bachelor	3 (15.79)	2 (9.09)			
Master	2 (10.53)	2 (9.09)			
Native German speaker	18 (94.74)	21 (95.45)	0.86	1.00	
German nationality	18 (94.74)	22 (100.00)	0.00	.46	

Note: DASS-21-depression/anxiety/stress: depression/anxiety/stress scales of depression anxiety stress scales-short version; SUIS: spontaneous use of imagery scale; IAMI-past/future: past/future subscales of involuntary autobiographical memory inventory.

(OSF): https://osf.io/8xwgk/. A pre-registration was completed for the study (https://osf.io/c9d65), comprising the study protocol document.

Statistical analysis plan

Participant inclusion in analysis

One participant completed the verbal block first for the PWT, but in the other tasks, when counterbalance was applicable, they were in error allocated to do the imagery block first. For analyses, the data of this participant was coded based on their allocation in the PWT, i.e., verbal block first. One participant attended the second session a day earlier and another attended the second session three days later than the expected day. In the picture rating task in the beginning of session 1, some pictures from a participant were upside down, but they were put in the correct form for use in other tasks including the encoding and retrieval tasks. All participants were included in the analyses.

Planned and exploratory statistical analyses

The planned statistical analyses in the pre-registered protocol were run, unless otherwise described. We ran exploratory analyses when there were interactions between independent variables and to further explore the data, alongside analyses reported in the supplementary materials.

We tested the potential differences between two counterbalance orders in terms of their demographics and baseline characteristics using Welch's t-tests (for continuous variables) and Fisher's exact test (for categorical variables, as the prerequisites for using the Chi-squared tests were not met). As planned, we ran mixed ANOVAs to test effect of photo type on vividness of mental images generated using the afex package (Singmann et al., 2021), and we ran (mixed) ANOVAs and Welch's t-tests to examine further manipulation impacts.

As planned, we ran mixed ANOVAs to test effect of processing mode on state mood change during the VIT. We had originally planned to test the effect of processing mode and photo type on number of involuntary memories using mixed ANOVAs. However, the distribution of the involuntary memory data meant that these were not appropriate and instead we analysed these data via Poisson regression analyses using the package lme4 (Bates et al., 2015). As planned, we ran a mixed effects model to test the impact of processing mode and photo type on the valence of involuntary memories, using the package lmerTest (Kuznetsova et al., 2017), and we ran a binary logistic regression to investigate the effect of imagery vividness on the likelihood of occurrence of involuntary mental imagery, using the package lme4.

Results

Participant characteristics

Participant characteristics (grouped by counterbalance order: imagery-first vs. verbal-first) are presented in Table 2. Participant characteristics were generally comparable across the two counterbalance orders.

Manipulation checks

The results of the manipulation checks are shown in Table 1. Overall, participants reported thinking in each processing mode (imagery vs. verbal) as instructed. That is, they rated themselves as thinking in images in the imagery block more than the verbal block and they rated themselves as thinking verbally in the verbal block more than the imagery block. On average participants generated mental images/sentences that were situated in the future, although the time-orientation ratings for the mental images were further in the future than those for the sentences. Additionally, as expected participants rated generating mental images as more emotionally arousing than generating sentences.

Analyses also showed some effects of photo type (own vs. other). Participants rated mental images/sentences generated in response to their own pictures as nearer in the future than those mental images/sentences generated in response to the other pictures. On average they reported higher easiness ratings for own, compared with other, pictures (see Table 1).

However, analyses also showed some effects of counterbalance order. Participants who completed the verbal block first rated generation of images and sentences as more emotionally arousing than those who completed the imagery block first. Finally, for state mood, there was an interaction between counterbalance order, processing mode and time (pre vs. post block). When the interaction was broken down by counterbalance order, there was an interaction effect of processing mode and time, $F(1,21) = 6.60$, $p = .02$, η^2_p [90% CIs] = .24 [.03, .47], amongst those who did the verbal block first. However, when this interaction was then broken down by processing mode, there was no effect of time either for the improvement in mood in the imagery block, $t(21) = 1.45$, $p = .16$, g [95% CIs] = 0.30 [−0.12, 0.72], or the worsening of mood in the verbal block, $t(21) = 1.67$, $p = .11$, g [95% CIs] = 0.34 [−0.08, 0.77]. For participants who completed the imagery block first, there were no interaction effect of processing mode and time, $F(1, 18) = 1.00$, $p = .33$, η^2_p [90% CIs] = .05 [.00, .28], and no main effect of processing mode, $F(1, 18) = 2.52$, $p = .13$, $\eta^2_p = .05$ [.00, .37], or time, $F(1, 18) = 2.52$, $p = .13$, $\eta^2_p = .12$ [.00, .37], indicating that there was no effect of processing mode or time on state mood.

Diary compliance

Participants generally reported high compliance in completing the diary, and the compliance ratings did not differ between the counterbalance orders, $t(38.69) = .65$, $p = .52$, g = [95% CIs] = 0.20 [−0.40, 0.80], see Table 3.

Effects of processing mode and photo type on number of involuntary memories

Involuntary memories in the diary

Twenty-seven participants reported no involuntary memories of the mental images/sentences they made during the PWT in their diary, 7 reported one, and 7 reported more than one (max = 14, total = 49). As an initial Poisson regression including all main effects and interactions

Table 3. Measures and ratings from the diary and the vigilance-intrusion task (broken down by counterbalance order).

Variable	Imagery-first *M (SD)*	Verbal-first *M (SD)*
Diary compliance	8.42 (0.84)	8.23 (1.07)
Valence of IMs in diary		
Imagery block	2.70 (1.59)	1.50 (1.87)
Verbal block	1.53 (1.13)	1.80 (1.30)
State mood in VIT		
Imagery block (pre: post)	7.32 (0.82): 6.74 (1.45)	6.18 (1.56): 5.95 (1.46)
Verbal block (pre: post)	6.74 (1.45): 6.68 (1.57)	6.59 (1.74): 6.18 (1.56)
	Own[a]	Other
IMs in diary		
Imagery block	0.71 (1.90)	0.15 (0.48)
Verbal block	0.27 (0.87)	0.07 (0.26)
IMs in VIT		
Imagery block	0.17 (0.44)	0.17 (0.44)
Verbal block	0.34 (1.04)	0.51 (1.27)

Note: [a]The rest of variables in the table are presented on the photo type basis. This data was broken down by photo type (own vs. other) as effects of photo type on number of involuntary memories was one of our main hypotheses and there was no effect of counterbalance order (imagery-first vs. verbal-first) on number of involuntary memories. IMs: involuntary memories; VIT: vigilance-intrusion task.

showed no significant interactions (and the interactions were not relevant to our hypotheses), we ran our main analysis without the interaction terms. In line with our hypotheses about effects of processing mode and of photo type, a Poisson regression with the number of involuntary memories as the dependent variable, and processing mode, photo type and counterbalance order as independent variables found a main effect of processing mode, *OR* [95% CIs] = 0.40 [0.22, 0.74], $p = .004$, indicating that participants reported more involuntary memories of picture–word pairs for which they generated mental images than those pairs for which they generated sentences. There was also a main effect of photo type, *OR* [95% CIs] = 4.44 [2.16, 9.16], $p < .001$, indicating that participants had more involuntary memories related to their own photos than those related to other photos in the diary (see Figure 1). There was no effect of counterbalance order, *OR* [95% CIs] = 0.57 [0.12, 2.76], $p = .48$.

Involuntary memories in the VIT

Twenty-seven participants reported no involuntary memories of the mental images/sentences they made within the PWT during the VIT, 5 reported one and 9 reported more than one (max = 12, total = 49). A Poisson regression with number of involuntary memories as the dependent variable and processing mode, photo type and counterbalance order as independent variables found a main effect of processing mode, *OR* [95% CIs] = 2.50 [1.35, 4.64], $p = .004$, but the direction was contrary to our hypothesis, i.e., participants reported more involuntary memories in the block that had pictures from the verbal block of the PWT than in the block that had pictures from the imagery block of the PWT. There was no effect of photo type, *OR* [95% CIs] = 0.75 [0.43, 1.32], $p = .32$, or counterbalance order, *OR* [95% CIs] = 2.24 [0.44, 11.41], $p = .33$.

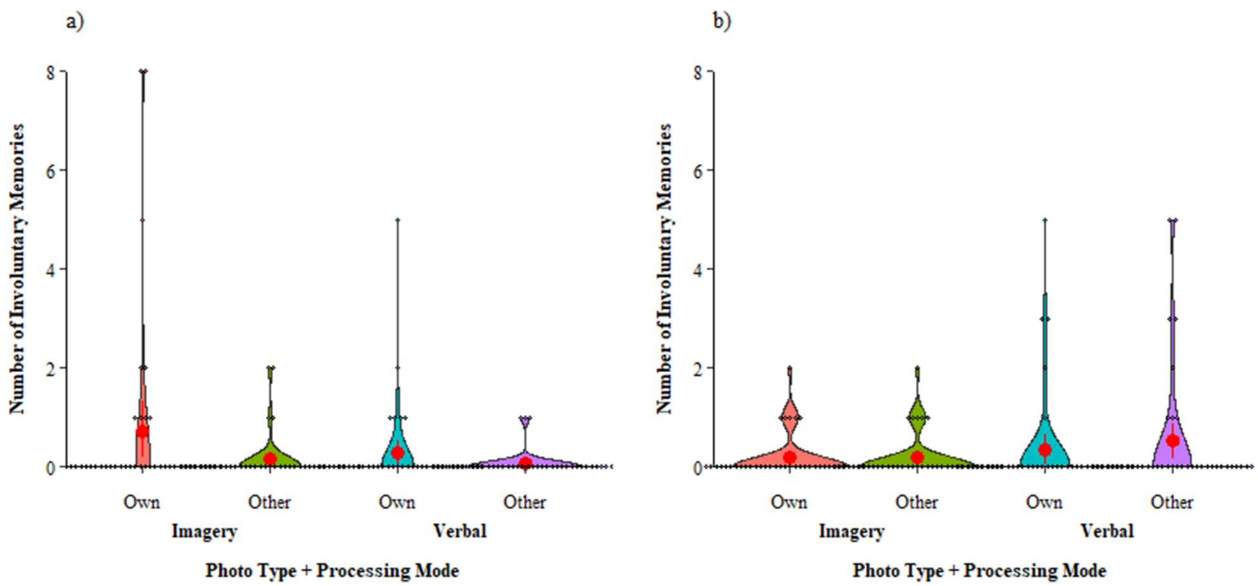

Figure 1. Effects of presence of only own picture cues (in the diary, left panel) or both own and other picture cues (in the vigilance-intrusion task, right panel) from the picture–word task on number of involuntary memories.

Difference between the diary and VIT in involuntary memories of different photo types

A Poisson regression with number of involuntary memories as the dependent variable and processing mode, photo type, record form (daily life vs. laboratory) and counterbalance order as independent variables found an interaction effect of photo type and record form, *OR* [95% CIs] = 0.21 [0.05, 0.81], $p = .02$. There was also an interaction effect of processing mode and record form, *OR* [95% CIs] = 6.00 [1.18, 30.58], $p = .03$. As the breakdown of these interactions by record form is presenting in the sections above, they are not repeated here. Overall, they indicate that the effects of photo type and processing mode differed between the diary and VIT.

Correlation between number of involuntary memories in the diary and VIT

Contrary to our hypothesis, there was no significant correlation between number of involuntary memories reported in the diary and number reported in the VIT either for those from the imagery block of the PWT, $\tau = .20$, $p = .17$, or for those from the verbal block of the PWT, $\tau = -.15$, $p = .32$.

Valence of involuntary memories and effects of involuntary memories on mood

Valence of involuntary memories in the diary

IMs were generally rated as positive (i.e., valence ratings > 0; 75.5%), with some rated as neutral (rated 0; 20.4%), and 2 rated as negative (i.e., ratings < 0; 4.1%), with valence ratings ranging from −3 to +5. A mixed effects model with processing mode and photo type as within-subject factors, and counterbalance order as the between subject factor was run, with a random intercept at the participant level and picture stimulus as a (nested) random intercept. The dependent variable was the valence ratings for each individual memory recorded. This model was chosen (as opposed to comparing the mean valence ratings for memories for each processing mode, photo type, and counterbalance order combination) as the small number of involuntary memories resulted in too few mean values to run such an analysis. Contrary to our hypothesis, the mixed effects model showed that there were no effects of processing mode, $t(43.73) = 0.91$, $p = .37$, d [95% CIs] = 0.26 [−0.32, 0.85], or photo type, $t(41.02) = 0.39$, $p = .70$, d [95% CIs] = 0.12 [−0.48, 0.72], on the valence of involuntary memories recorded in the diary (see Table 3).

Mood change in the VIT

To analyse mood change during the VIT, we used a 2 (processing mode: imagery vs. verbal) × 2 (time: pre vs. post) × 2 (counterbalance order: imagery-first vs. verbal-first) mixed ANOVA.[1] This found a main effect of time, $F(1, 39) = 12.41$, $p = .001$, η^2_p [90% CIs] = .24 [.07, .42], indicating that from pre- to post-test mood ratings decreased (i.e., became less positive). There was also an interaction between processing mode and counterbalance order, $F(1, 39) = 12.41$, $p = .001$, η^2_p [90% CIs] = .24 [.07, .42]. We repeated the mixed ANOVA separately for each counterbalance order. In the verbal-first order, there was a main effect of processing mode, $F(1, 21) = 9.80$, $p = .005$, η^2_p [90% CIs] = .32 [.07, .54], and time, $F(1, 21) = 9.80$, $p = .005$, η^2_p [90% CIs] = .32 [.07, .54], but no effect of processing mode and time interaction, $F(1, 21) = 0.39$, $p = .54$, η^2_p [90% CIs] = .02 [.00, .19]. In the imagery-first order, there was no significant effect of processing mode, $F(1, 18) =$

4.21, $p = .055$, η_p^2 [90% CIs] = .19 [.00, .44], time, $F(1, 18) = 4.21$, $p = .055$, η_p^2 [90% CIs] = .19 [.00, .44], or their interaction, $F(1, 18) = 4.17$, $p = .056$, η_p^2 [90% CIs] = .19 [.00, .44]. Generally, there was no consistent effect of processing mode on mood in different counterbalance order, and mood rating score was reduced from pre to post after each block, regardless of processing mode and counterbalance order.

Analyses of vividness

Effects of photo type on vividness rating during mental imagery generation

A 2 (photo type: own vs. other) × 2 (counterbalance order: imagery-first vs. verbal-first) mixed ANOVA, with imagery vividness as the dependent variable, and photo type and counterbalance order as independent variables, showed that there was no effect of photo type (own vs. other) and there was only a main effect of order (see Table 1), indicating that participants who completed the imagery block after the verbal block rated their mental images as more vivid on average than those who completed the imagery block first.

Vividness during mental imagery generation and number of involuntary memories in the diary and VIT

Contrary to our hypothesis, there was no significant correlation between the vividness of mental images participants generated during the picture–word task and the number of involuntary memories from the imagery block of the PWT in the diary, $\tau = .14$, $p = .26$, or in the VIT, $\tau = .07$, $p = .58$. As there was no correlation between vividness of mental images based on photo type and number of involuntary memories in the diary/lab (see supplementary material), we did not run a planned exploratory analysis to test the moderator role of imagery vividness in the relationship between photo type and the frequency of IMs from the imagery block of the PWT.

Discussion

The current study investigated the possibility of inducing positive involuntary mental imagery (IMI) in daily life via an adapted version of a picture–word task (PWT) in which participants combined pictures with positive word captions to form either mental images (imagery condition) or sentences (verbal condition). Half of the pictures were photographs of objects and scenes from the participants' own living environments. Participants completed the PWT in a first lab-based session and then reported any involuntary memories (IMs) from the PWT in a diary over the following week before returning to the lab for a second assessment including a vigilance-intrusion task (VIT). Participants did report IMs of the images and sentences from the PWT in the diary, albeit only a small number, and two-thirds of the participants reported no IMs at all. As hypothesised, participants reported more IMs in the diary from the imagery condition of the PWT than from the verbal condition. Furthermore, participants reported more IMs in the diary from trials of the PWT that used their own photos than from those trials using photos from a standardised database. However, there was a more mixed pattern of results across other tasks. Overall, the current study indicates the potential of the PWT to induce positive IMI in people's daily lives, particularly when using photographs from participants' own living environments as cues for imagery generation. However, it also indicates limitations of the approach taken in the current study that could benefit from adaptation for future research.

Our finding that the adapted PWT could be used to induce positive IMI in people's daily lives in the current study extends previous anecdotal reports (Blackwell & Holmes, 2017), and results from a previous lab-based experimental study (Bagheri et al., in press). However, it is important to note that the number of IMs recorded in the current study was low, and the majority of participants did not record any IMs from the PWT. This indicates that further adaptations may be needed to the paradigm for it to be used for these experimental purposes (discussed further on).

There are several possible explanations for our finding that people had more IMs from the PWT in their daily lives from those trials for which they generated mental imagery compared to those for which they generated sentences. One possibility is that this is a consequence of mental imagery generation being more emotionally arousing at encoding (i.e., during the PWT) than sentence generation, as indicated by the arousal ratings made during the PWT. Previous research using positive film stimuli has found a greater level of emotional response at encoding (as indicated by change in state mood) to be associated with a larger number of IMs in the subsequent week in a diary (Clark et al., 2013), and similar results have also been found in relation to IMs resulting from positive imagery generation based on audio scripts (Bagheri et al., 2023; albeit not consistently, Blackwell et al., 2020). Another possible explanation could be that image-based memories have a largely sensory, visual, representation (Pearson, 2019) and thus are likely to have greater perceptual overlap with visual cues encountered in the environment. This greater perceptual overlap could in turn increase the likelihood that encountering these visual cues triggers involuntary retrieval of the memories. Another explanation would be the picture superiority effect (Paivio, 1971), i.e., that pictures/mental images are more likely to be later remembered than words/sentences. This is in line with the dual-encoding theory of Paivio (Paivio, 2007; Paivio & Csapo, 1973), that pictures or (mental) images are encoded as both images and verbally. Although this idea was suggested by Paivio and colleagues in relation to free recall of pictures and words (see Bagheri et al., in press), it could potentially be applicable to involuntary recall as well. A further possibility is that emotional

IMs with an imagery component are more likely to capture attention and thus be noticed, given that at least for externally-presented images and words there are differences in the extent to which these different kinds of stimuli capture attention (e.g., Okon-Singer et al., 2013).

In contrast to the results found for IMs in the diary, during the VIT in the second lab session participants reported more IMs from the verbal condition of the PWT than from the imagery condition. These findings also differ from those for the previous lab-based study (Bagheri et al., in press) in which there was no effect of processing mode (imagery vs. verbal) on number of IMs. In this previous study one explanation provided for the lack of an effect of processing mode on number of IMs was that the VIT was administered in the same session as the PWT; other research has found that the effects of emotion at encoding on IM frequency are only found after a retention interval of 24 hours or more (Staugaard & Berntsen, 2014). While this might help explain why we now found the expected effect of processing mode on number of IMs in the diary in the current study, it does not help explain the opposite pattern of results found in the VIT. However, it is worth noting that the number of IMs reported in the VIT in the current study were even lower than in the previous one, consistent with research showing that as retention time (i.e., the interval between encoding and retrieval) increases, the frequency of IMs reduces (Staugaard & Berntsen, 2014, 2019). Additionally, the number of IMs recorded in the VIT did not correlate with the number recorded in the diary, potentially indicating either different underlying mechanisms or lack of sensitivity. Given the unexpected nature of the results found in the VIT in the current study, especially given the low number of IMs reported, it may be best to await replication before speculating on the underlying mechanisms. It would also be useful to investigate whether repeating the VIT after a shorter time interval (e.g., 24 hours) would result in a more similar pattern of findings to the diary.

As predicted, participants recorded more IMs from the PWT in the diary when the picture stimuli had been participants' own photos, compared to when these had come from a standardised image database. We had hypothesised that such a result might emerge due to overlap between the content of what was encoded into memory during the PWT and the scenes that might be encountered during participants' daily lives, following research showing that environmental cues account for the experience of most involuntary memories (Vannucci et al., 2019). Overall, the pattern of findings we found across different tasks and measures are consistent with this explanation. First, in the VIT, in which cues for both photo types were presented equally often, there was no difference in the frequency of IMs generated from the different photo types. Second, an alternative explanation for the effect of photo type on number IMs, that this might be via participants generating more vivid imagery in response to their own photos, was not supported by the data. In fact, participants rated the imagery generated in response to their own photos as no more vivid than those generated in response to photos from the standardised database. Overall, these results provide further support for the importance of environmental cues in triggering involuntary memory retrieval, and further suggest that using photos from participants' daily living environments does provide a means to increase the number of IMs experienced in daily life.

We found that the generation of more vivid mental imagery during the picture–word task was not associated with a greater number of involuntary memories either in the diary and the VIT. While this is not consistent with findings from studies investigating IMs of imagery generated while listening to audio scripts (Bagheri et al., 2023; Blackwell et al., 2020), in retrospect it fits with previous results found using the PWT to induce IMs in the lab (Bagheri et al., in press). In this previous study, while there were correlations between vividness of *negative* mental images generated during a PWT and number of IMs recorded in a VIT, there was no relationship between the vividness of *positive* mental images and the number of IMs. It may be that for positive imagery at least, vividness is only a relevant predictor for subsequent IMs under circumstances where there is less external scaffolding for imagery generation (e.g., listening to scripts rather than seeing a picture).

We also did not find any difference for the change in state mood between the imagery and verbal blocks of the VIT. Via measurement of state mood before and after each block we aimed to investigate whether experience of image-based IMs would be associated with a greater impact on state mood than experience of verbal-based IMs. However, given the small number of IMs experienced it is possible that the task was insufficiently sensitive to detect any effect. Further, it is worth noting that during the PWT, although participants reported generating mental images as more emotionally arousing than generating sentences, there was no differential effect of image versus sentence generation on state mood, in contrast to previous studies (e.g., Bagheri et al., in press; Holmes et al., 2008). We also did not observe any effect of imagery vs. verbal processing on the positive valence of IMs recorded in the diary. These results may in part reflect a ceiling effect in the context of using only positive stimuli and a sample with relatively positive state mood at baseline. Given that that there was no differential effect on state mood of generating images versus sentences during the PWT, it is perhaps not surprising that no such effect was found during the VIT, in which the number of images and sentences experienced involuntarily was much lower. In addition to finding ways to increase the frequency of IMs experienced in the VIT, future research could increase the sensitivity of tasks such as the PWT and VIT to detecting changes in positive mood via using a negative mood induction beforehand or recruiting a depressed or dysphoric sample for whom baseline levels of mood would be less positive.

The results of the current study should be interpreted in light of several limitations. First, although using a within-subject design potentially carries advantages such as reducing variability in the data due to inter-individual differences in general tendency to experience IMs, it may have made it more difficult to examine the effects of processing mode (imagery vs. verbal). Given that we found some effects of counterbalance order (for imagery vs. verbal processing the PWT) it is possible that engaging in one experimental condition first had confounding effects on the other condition (similar to the results found by Bagheri et al., in press). Second, the sample size of the study was smaller than planned. The decrease from 54 to 41 participants would cause a reduction in power for a within-subjects effect (e.g., having 80% power to detect Cohen's *d* of 0.45 instead of 0.39). However, our findings indicate that our achieved sample size provided sufficient power for our main hypotheses (e.g., looking at the effects of processing mode or photo type on number of involuntary memories). Where other hypotheses were not supported, the pattern of results found does not suggest that the small increase in power provided by an additional 13 participants would change our conclusions. Third, recruiting unselected (mainly healthy) students may have reduced our chances of observe the potential impacts of IMs on mood. Fourth, although we used only positive word captions during the PWT, we cannot be certain that participants always generated positive images or sentences. Asking for valence ratings during the PWT could be used in future studies to assess whether the images and sentences generated were indeed positive.

A final limitation concerns the small number of IMs recorded by participants in the diary and VIT. We adapted the VIT from previous studies (e.g., Lau-Zhu et al., 2019, 2021), using blurred versions of pictures from PWT to imitate cues that catch one's sight in daily life when they are mainly outside of focal attention (Berntsen, 2009). However, such cues may be sub-optimal from a cue distinctiveness perspective. While we were able to match involuntary memories recorded in the diary or VIT to specific stimuli from the PWT, we do not know for certain whether the content of these was purely the previously generated image or sentence, or rather a memory of the stimulus, testing session, or taking the photograph, or some combination of these. This could be clarified in future studies by obtaining more descriptive details of the content of the involuntary memories. To some extent, given that one of the aims of the current study was to investigate whether the PWT *could* be used to induce IMs in daily life in a controlled experimental study, finding out that the number of IMs induced is small is an informative result in determining which direction future research using the paradigm should take. This result does indicate that if the PWT is to be used to conduct experimental investigations to test the effects or functions of IMs in daily life, in particular those of positive IMI, some adaptations may be necessary to increase the number of IMs induced and thus increase the paradigm's sensitivity. Clues as to how this could be achieved come from the literature on IMs. For example, research has shown that cue distinctiveness is linked to involuntarily recall of past events (Berntsen, 2009; Staugaard & Berntsen, 2019). That is, for a cue or combinations of cues to spontaneously activate a memory of previously encoded event, its overlap with the event should be sufficiently distinct to discriminate this event from alternatives. The cue distinctiveness approach would help to avoid cue overload, which happens when a cue matches several past events (see Berntsen, 2009). In relation to the paradigm used in the current study, it is possible that if participants provided more highly discriminable pictures, e.g., photos taken from an unusual perspective, this would increase the probability of occurrence of IMs in their everyday lives via cue distinctiveness. One possible way to do this would be to gather self-relevant photos via a tool such as SenseCam (Murphy et al., 2011), a wearable camera that takes photos automatically. Compared to pre-selected photo topics this might lead to photos of more unusual and spontaneous scenes. Furthermore, rehearsal of the images or sentences generated during the PWT could potentially also increase the likelihood of their later involuntary retrieval. In the current study, participants generated each image and sentence only once. However, observational research indicates that naturally-occurring IMs are in fact frequently rehearsed, at least more so than voluntarily-retrieved memories (Markostamou et al., 2023). Further, in exploratory analyses, Blackwell et al. (2020) found that recall testing of imagined scenarios increased the likelihood of them returning later as involuntary memories. Displaying each picture–word pair several times during the PWT, or repeated practice retrieving a previously generated image or sentence in response to the picture cues, may help increase the likelihood of future involuntary retrieval via facilitating encoding of more vivid imagery or strengthening the associative link with the picture cue.

Despite these limitations in interpreting the results of the current study, they do indicate the potential of the PWT to be used to induce IMs in daily life. Further, they highlight two factors associated with their likelihood of occurrence: generation of mental imagery, and use of photos from participants' living environments. This opens up a number of avenues for investigating IMs in daily life in future research. For example, a number of further manipulations of IM content could be carried out. In the current study, participants were asked to generate images with a future time-orientation. Although this time-orientation was not a major focus of the study, the rationale was that if this led to participants experiencing IMs with a future (rather than past) time-orientation, it would mean that the paradigm could be used to provide an experimental analogue of spontaneous future-oriented imagery. Interestingly, it has been argued that many spontaneous future thoughts may in fact be involuntary memories of thoughts that were previously deliberately generated (Cole & Kvavilashvili, 2021). This would imply that IMs with a future-orientation may indeed be an ecologically-valid analogue of spontaneous future thoughts. However, time-orientation is just one aspect of IMs that could potentially be manipulated experimentally. Manipulating other aspects such as valence, the specific emotion induced (e.g., happiness, self-assurance, excitement), and visual perspective could also provide a number of useful ways forward for future research.

Use of the PWT to induce positive IMI in daily life also has potential clinical applications. As mentioned previously, there have already been anecdotal reports from clinical studies in the context of depression of participants experiencing IMs from a PWT in daily life, with apparently positive effects on mood and behaviour (e.g., Blackwell & Holmes, 2017). Depression is associated with deficits in positive imagery (e.g., Holmes et al., 2016), and increasing the extent to which depressed individuals experience involuntary positive IMI in daily life could potentially have clinical benefits if this IMI is indeed associated with the effects reported anecdotally by participants in the clinical studies. It would therefore be useful for future research to examine the impact of positive IMI induced by the PWT in the daily life of depressed individuals and investigate whether there are beneficial effects that could be capitalised upon to improve treatments for depression.

In summary, the current study built upon previous lab-based experimental work and anecdotal clinical reports via investigating using a picture–word task to induce involuntary memories in daily life. Further, it provided experimental tests of the role of mental imagery generation and use of photographs from participants' daily living environments in the induction of these involuntary memories. With suitable adaptations, the PWT potentially provides a means to conduct studies investigating the assumed functions and impact of positive involuntary mental imagery, and involuntary memories more broadly, in daily life, and in particular provide the experimental control needed to go beyond observational and correlational data and start drawing causal conclusions.

Note

1. Originally, we had planned to analyse mood data via first computing change scores, as per Bagheri et al. (2023) but decided to run the ANOVA described here instead to provide more insight into the pattern of mood change during the VIT.

Acknowledgments

We thank Anton Hetzenegger, Lena M. Liedtke and Simeon M. Meister for their help with recruiting and testing participants.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Ethics approval

We had received approval for this study from ethics committee for the Faculty of Psychology, Ruhr University Bochum (Nr. 731).

Data availability statement

The data, analysis scripts and materials are accessible using this Open Science Framework (OSF) link: https://osf.io/8xwgk/

ORCID

Mahdi Bagheri http://orcid.org/0000-0002-7287-575X
Marcella L. Woud http://orcid.org/0000-0002-4974-505X
Jürgen Margraf http://orcid.org/0000-0001-5207-7016
Simon E. Blackwell http://orcid.org/0000-0002-3313-7084

References

Baddeley, A., Eysenck, M. W., & Anderson, M. C. (2015). *Memory* (2nd ed.). Psychology Press. https://doi.org/10.4324/9781315749860.

Bagheri, M., Woud, M. L., Feller, A.-L., Laudi, J., Kirchner, G. D., Schneider, H., Margraf, J., & Blackwell, S. (2023). Investigating the role of imagery vividness in the experience of involuntary memories of previously-imagined positive scenarios. OSF Preprints, https://doi.org/10.31219/osf.io/fkxat

Bagheri, M., Woud, M. L., Oglou, I. F., Oglou, F. F., Ratzkowski, J. D. J., Margraf, J., & Blackwell, S. (in press). An experimental investigation of the causal role of mental imagery in the experience of involuntary memories. *Journal of Emotion and Psychopathology*.

Barsics, C., Van der Linden, M., & D'Argembeau, A. (2016). Frequency, characteristics, and perceived functions of emotional future thinking in daily life. *Quarterly Journal of Experimental Psychology*, *69*(2), 217–233. https://doi.org/10.1080/17470218.2015.1051560

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), Article 1. https://doi.org/10.18637/jss.v067.i01

Beaty, R. E., Seli, P., & Schacter, D. L. (2019). Thinking about the past and future in daily life: An experience sampling study of individual differences in mental time travel. *Psychological Research*, *83*(4), 805–816. https://doi.org/10.1007/s00426-018-1075-7

Berntsen, D. (2009). *Involuntary autobiographical memories. An introduction to the unbidden past*. Cambridge University Press.

Berntsen, D., & Jacobsen, A. S. (2008). Involuntary (spontaneous) mental time travel into the past and future. *Consciousness and Cognition*, *17*(4), 1093–1104. https://doi.org/10.1016/j.concog.2008.03.001

Berntsen, D., Rubin, D. C., & Salgado, S. (2015). The frequency of involuntary autobiographical memories and future thoughts in relation to daydreaming, emotional distress, and age. *Consciousness and Cognition*, *36*, 352–372. https://doi.org/10.1016/j.concog.2015.07.007

Blackwell, S. E. (2019). Mental imagery: From basic research to clinical practice. *Journal of Psychotherapy Integration*, *29*(3), 235–247. https://doi.org/10.1037/int0000108

Blackwell, S. E., Dooley, D., Würtz, F., Woud, M. L., & Margraf, J. (2020). Inducing positive involuntary mental imagery in everyday life: An experimental investigation. *Memory*, *28*(9), 1157–1172. https://doi.org/10.1080/09658211.2020.1822413

Blackwell, S. E., & Holmes, E. A. (2017). Brightening the day with flashes of positive mental imagery: A case study of an individual with depression. *Journal of Clinical Psychology*, *73*(5), 579–589. https://doi.org/10.1002/jclp.22455

Blackwell, S. E., Rölver, A., Margraf, J., & Woud, M. L. (2023). The effect of positive mental imagery versus positive verbal thoughts on anhedonia. https://doi.org/10.31234/osf.io/5mqpt

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry*, *25*, 49–59. https://doi.org/10.1016/0005-7916(94)90063-9.

Clark, I. A., Mackay, C. E., & Holmes, E. A. (2013). Positive involuntary autobiographical memories: You first have to live them. *Consciousness and Cognition*, *22*(2), 402–406. https://doi.org/10.1016/j.concog.2013.01.008

Cole, S., & Kvavilashvili, L. (2021). Spontaneous and deliberate future thinking: A dual process account. *Psychological Research*, *85*(2), 464–479. https://doi.org/10.1007/s00426-019-01262-7

Conway, M. A. (2005). Memory and the self★. *Journal of Memory and Language*, *53*(4), 594–628. https://doi.org/10.1016/j.jml.2005.08.005

Davies, C., Malik, A., Pictet, A., Blackwell, S. E., & Holmes, E. A. (2012). Involuntary memories after a positive film are dampened by a visuospatial task: Unhelpful in depression but helpful in mania? *Clinical Psychology & Psychotherapy*, *19*(4), 341–351. https://doi.org/10.1002/cpp.1800

Duffy, J., & Cole, S. N. (2021). Functions of spontaneous and voluntary future thinking: Evidence from subjective ratings. *Psychological Research*, *85*(4), 1583–1601. https://doi.org/10.1007/s00426-020-01338-9

Görgen, S. M., Hiller, W., & Witthöft, M. (2016). Die Spontaneous use of Imagery Scale (SUIS)–Entwicklung und teststatistische Prüfung einer deutschen Adaption. *Diagostica*, *62*(1), 31–43. https://doi.org/10.1026/0012-1924/a000135

Hall, S. A., Rubin, D. C., Miles, A., Davis, S. W., Wing, E. A., Cabeza, R., & Berntsen, D. (2014). The neural basis of involuntary episodic memories. *Journal of Cognitive Neuroscience*, *26*(10), 2385–2399. https://doi.org/10.1162/jocn_a_00633

Harris, C. B., & Berntsen, D. (2019). Direct and generative autobiographical memory retrieval: How different are they? *Consciousness and Cognition*, *74*, 102793. https://doi.org/10.1016/j.concog.2019.102793

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., Lang, T. J., & Shah, D. M. (2009). Developing interpretation bias modification as a "cognitive vaccine" for depressed mood: Imagining positive events makes you feel better than thinking about them verbally. *Journal of Abnormal Psychology*, *118*(1), 76–88. https://doi.org/10.1037/a0012590

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

Ji, J. L., Holmes, E. A., MacLeod, C., & Murphy, F. C. (2019). Spontaneous cognition in dysphoria: Reduced positive bias in imagining the future. *Psychological Research*, *83*(4), 817–831. https://doi.org/10.1007/s00426-018-1071-y

Ji, J. L., Murphy, F. C., Grafton, B., MacLeod, C., & Holmes, E. A. (2022). Emotional mental imagery generation during spontaneous future thinking: Relationship with optimism and negative mood. *Psychological Research*, *86*(2), 617–626. https://doi.org/10.1007/s00426-021-01501-w

Kanske, P., & Kotz, S. A. (2010). Leipzig affective norms for German: A reliability study. *Behavior Research Methods*, *42*(4), 987–991. https://doi.org/10.3758/BRM.42.4.987

Kurdi, B., Lozano, S., & Banaji, M. R. (2017). Introducing the Open Affective Standardized Image Set (OASIS). *Behavior Research Methods*, *49*(2), 457–470. https://doi.org/10.3758/s13428-016-0715-3

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software*, *82*(13), Article 13. https://doi.org/10.18637/jss.v082.i13

Lau-Zhu, A., Henson, R. N., & Holmes, E. A. (2019). Intrusive memories and voluntary memory of a trauma film: Differential effects of a cognitive interference task after encoding. *Journal of Experimental Psychology: General*, *148*(12), 2154–2180. https://doi.org/10.1037/xge0000598

Lau-Zhu, A., Henson, R. N., & Holmes, E. A. (2021). Selectively interfering with intrusive but not voluntary memories of a trauma film: Accounting for the role of associative memory. *Clinical Psychological Science*, *9*(6), 1128–1143. https://doi.org/10.1177/2167702621998315

Lovibond, S. H., & Lovibond, P. F. (1995). *Manual for the depression anxiety stress scales* (2nd ed.). Psychology Foundation.

Markostamou, I., Randall, C., & Kvavilashvili, L. (2023). Dissociations between directly and generatively retrieved autobiographical memories: Evidence from ageing. *Memory*, *31*(7), 931–947. https://doi.org/10.1080/09658211.2023.2212921

McLelland, V. C., Devitt, A. L., Schacter, D. L., & Addis, D. R. (2015). Making the future memorable: The phenomenology of remembered future events. *Memory*, *23*(8), 1255–1263. https://doi.org/10.1080/09658211.2014.972960

Murphy, F. C., Barnard, P. J., Terry, K. A. M., Carthery-Goulart, M. T., & Holmes, E. A. (2011). Sensecam, imagery and bias in memory for wellbeing. *Memory*, *19*(7), 768–777. https://doi.org/10.1080/09658211.2010.551130

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

Nosek, B. A., Alter, G., Banks, G. C., Borsboom, D., Bowman, S. D., Breckler, S. J., Buck, S., Chambers, C. D., Chin, G., Christensen, G., Contestabile, M., Dafoe, A., Eich, E., Freese, J., Glennerster, R., Goroff, D., Green, D. P., Hesse, B., Humphreys, M., … Yarkoni, T. (2015). Promoting an open research culture. *Science*, *348*(6242), 1422–1425. https://doi.org/10.1126/science.aab2374

Okon-Singer, H., Lichtenstein-Vidne, L., & Cohen, N. (2013). Dynamic modulation of emotional processing. *Biological Psychology*, *92*(3), 480–491. https://doi.org/10.1016/j.biopsycho.2012.05.010

Paivio, A. (1971). *Imagery and verbal processes*. Holt, Rinehart, and Winston.

Paivio, A. (2007). *Mind and its evolution. A dual coding theoretical approach*. Psychology Press.

Paivio, A., & Csapo, K. (1973). Picture superiority in free recall: Imagery or dual coding? *Cognitive Psychology*, *5*(2), 176–206. https://doi.org/10.1016/0010-0285(73)90032-7

Pearson, J. (2019). The human imagination: The cognitive neuroscience of visual mental imagery. *Nature Reviews Neuroscience*, *20*(10), 624–634. https://doi.org/10.1038/s41583-019-0202-9

Peirce, J., Gray, J. R., Simpson, S., MacAskill, M., Höchenberger, R., Sogo, H., Kastman, E., & Lindeløv, J. K. (2019). Psychopy2: Experiments in behavior made easy. *Behavior Research Methods*, *51*(1), 195–203. https://doi.org/10.3758/s13428-018-01193-y

Rachman, S. (2007). Unwanted intrusive images in obsessive compulsive disorders. *Journal of Behavior Therapy and Experimental Psychiatry*, *38*(4), 402–410. https://doi.org/10.1016/j.jbtep.2007.10.008

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

Singmann, H., Bolker, B., Westfall, J., Aust, F., & Ben-Shachar, M. S. (2021). *afex: Analysis of factorial experiments* (1.0-1) [Computer software]. https://CRAN.R-project.org/package=afex

Staugaard, S. R., & Berntsen, D. (2014). Involuntary memories of emotional scenes: The effects of cue discriminability and emotion over time. *Journal of Experimental Psychology: General*, *143*(5), 1939–1957. https://doi.org/10.1037/a0037185

Staugaard, S. R., & Berntsen, D. (2019). Retrieval intentionality and forgetting: How retention time and cue distinctiveness affect involuntary and voluntary retrieval of episodic memories. *Memory & Cognition*, *47*(5), 893–905. https://doi.org/10.3758/s13421-019-00904-w

Vannucci, M., Pelagatti, C., Hanczakowski, M., & Chiorri, C. (2019). Visual attentional load affects the frequency of involuntary autobiographical memories and their level of meta-awareness. *Memory & Cognition*, *47*(1), 117–129. https:/h/doi.org/10.3758s13421-018-0854-0