Consciousness and Cognition 39 (2016) 8–17

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

On the alleged memory-undermining effects of daydreaming ☆

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ARTICLE INFO

Article history:
Received 8 April 2015
Revised 8 November 2015
Accepted 9 November 2015

Keywords:
Memory
Daydreaming
False memory
Forgetting

ABSTRACT

In three experiments, we examined the memory-undermining effects of daydreaming for (un)related stimuli. In Experiments 1 and 2, we tested whether daydreaming fosters forgetting of semantically interrelated material and hence, catalyzes false memory production. In Experiment 3, we examined the memory effects of different daydreaming instructions. In Experiment 1, daydreaming did not undermine correct recall of semantically interrelated words, nor did it affect false memories. In Experiment 2, we again failed to find that daydreaming exerted memory-undermining effects a. In Experiment 3, no memory effects were obtained using different daydreaming instructions. Together, our studies fail to show appreciable memory-undermining effects of daydreaming.

1. Introduction

The vast majority of people engage in daydreaming on a daily basis (Singer, 1975). Klinger (2009) estimated that roughly half of all mental activities of humans involve some type of mind wandering. Thus, daydreaming appears to be a common phenomenon. Although daydreaming might have beneficial effects (e.g., Mooneyham & Schooler, 2013), it also has a negative side, including increased levels of aversive cognitive intrusions (Meyer, Otgaar, & Smeets, 2015). Of particular interest for the current investigation is the idea that daydreaming is linked to impaired memory functioning.

Recent experimentation suggests that daydreaming is related to various memory phenomena. For example, Rummel and Boywitt (2014) showed that higher working memory capacity results in people being better able to control their thoughts engendered by daydreaming. Risko and co-workers found that daydreaming during lectures impairs memory for the lecture material (Risko, Anderson, Sarwal, Engelhardt, & Kingstone, 2012). As another example, and most relevant for the current article, Delaney, Sahakyan, Kelley, and Zimmerman (2010) showed that daydreaming exerted memory-undermining effects. In two experiments, these authors instructed undergraduates to study two lists of 16 unrelated words. Between studying list 1 and list 2, the experimental groups were instructed to perform a task that mirrored the act of daydreaming. Thus, in the first study, the experimental group was instructed to think for 45 s about their parents' home, whereas control participants either read a text about psychology or were instructed to think for 45 s about their current home. Next groups were provided with a second list of words to study and performed a filler task. Finally, participants freely recalled words from list 1 and 2. Whereas the control and experimental groups did not differ with regard to the number of correctly recalled words from list

☆ This paper has been supported by a grant from the Netherlands Organization for Scientific Research (NWO 415-12-003) to the first author.
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http://dx.doi.org/10.1016/j.concog.2015.11.004
1053-8100/

2, the experimental group recollected fewer words from list 1 than either control group. In fact, the more distant in the past graduates had visited their parents' house, the stronger was the forgetting of list 1 words.

In the second experiment, Delaney et al. (2010) instructed their control participants either to perform a multiplication task or to think about a recent short distance trip, whereas the experimental group was instructed to think about a long distance trip. Again, there were no differences with regard to the recall of list 2 words. However, participants who had thought about a long distance trip recalled fewer list 1 words than did the control groups.

In explaining the memory-disrupting effects of thinking about your parents' house or about a long distance vacation, Delaney et al. (2010) argued that these activities induce diversionary thought, which equals daydreaming. Because daydreaming changes the mental context (i.e., during daydreaming, people imagine and think about other contexts than the current context), it has the potential to undermine subsequent attempts to recall items (see also Masicampo & Sahakyan, 2014). The authors wrote: "The more that one's mental context is changed by daydreaming, the more difficult it becomes to access what one has just experienced" (Delaney et al., 2010; p. 1041).

Sahakyan and Kelly (2002) were the first to use this context-change procedure to explain the mechanisms underlying directed forgetting. Since then, many studies have confirmed that a shift in context results in robust forgetting rates (e.g., Sahakyan, Delaney, & Waldum, 2008; Sahakyan & Foster, 2009). The paradigm used by Delaney et al. (2010) to study daydreaming effects on memory is another version of the context effect. However, Delaney et al. (2010) and other researchers using this paradigm have mainly examined the memory-impairing effect of daydreaming on *unrelated* material. Memory impairments such as amnesia, in contrast, are commonly characterized by deficits in recalling information that is not only unrelated but also episodically or semantically related (Squire & Zola, 1998). A more critical test of whether daydreaming propels other and clinically relevant variants of forgetting would therefore be to employ *semantically interrelated* material.

From a theoretical vantage point, this would be relevant given the following considerations. First, previous work on related forgetting effects, such as directed forgetting, have shown that when semantically interrelated words are used as stimuli, similar forgetting effects emerge as when unrelated words are used. However, using this material also catalyzes the production of false memories (i.e., memories for related, but not presented words; Kimball & Bjork, 2002). The explanation for this pattern is that the forgetting manipulation only affects the episodic traces of the stimuli, yet does not impact the semantic memory traces. Because of this, participants are unable to use episodic memory traces to decide that that the related, but not presented, words are not part of the studied material. This leads then to elevated false memory levels. Following the idea that daydreaming is linked to directed forgetting (Sahakyan & Kelly, 2002), one might reason that daydreaming will also produce an increase in false memories and a decrease in memories of presented semantically interrelated words.

Second, there is much literature showing that memory for semantically interrelated words outperforms memory for unrelated words (Brainerd, Reyna, & Ceci, 2008). This finding could suggest that forgetting effects are less likely to occur because participants are likely to retrieve many correct semantically interrelated words, which would decrease the susceptibility to false memory formation. Hence, we conducted two experiments (Experiments 1 and 2) in which participants were exposed to lists of semantically interrelated words (i.e., Deese/Roediger–McDermott (DRM) wordlists; Deese, 1959; Roediger & McDermott, 1995) and participated in the same procedure as Delaney et al. (2010). Because DRM lists have been shown to effectively induce semantically-induced false memories, we could simultaneously examine the impact of daydreaming on faulty recollections.

Furthermore, although Delaney and colleagues interpreted their effects in terms of daydreaming, it is unclear whether this shift in context is truly related to daydreaming or is affected by other factors such as, for example, dissociation. Indeed, daydreaming and memory impairments have been extensively discussed in the context of the literature on dissociative symptoms (e.g., Holmes et al., 2005; Lynn, Lilienfeld, Merckelbach, Giesbrecht, & van der Kloet, 2012). These symptoms form a heterogeneous group of experiences, but the core feature they have in common is a disruption in the normal integration of consciousness, memory, emotion, and behavior (DSM-5; American Psychiatric Association, 2013; p. 29). Absorption – a close cousin of daydreaming – and amnesia are usually considered dissociative experiences, although many authors assume that the first is a more benign manifestation of dissociation than the second (Waller, Putnam, & Carlson, 1996).

In the current set of experiments, our primary purpose was to replicate and extend research on the memory-undermining effect of daydreaming documented by Delaney et al. (2010) using different stimuli (related stimuli: Experiments 1 and 2) and different instructions (Experiment 3). More specifically, in Experiments 1 and 2, we tested whether this effect (1) can be obtained for semantically interrelated material, which would indicate that daydreaming might have memory-undermining effects beyond simple unrelated material (Squire & Zola, 1998); (2) is related to false memory, as one would predict on the basis of the discrepancy-detection principle (Tousignant, Hall, & Loftus, 1986; Van Bergen, Horselenberg, Merckelbach, Jelicic, & Beckers, 2010), which implies that amnesic gaps make people vulnerable to false recollections; and (3) is related to individual differences in dissociativity. In Experiment 1, participants received only semantically interrelated words to encode, and we were interested in whether the memory disruptive effects of daydreaming would also obtain when using this material. In Experiment 2, we compared the memory effects of daydreaming on both unrelated and semantically interrelated material. If daydreaming, indeed, leads to forgetting, then one would expect to find similar forgetting rates in unrelated and semantically interrelated material.

In Experiment 3, we examined whether different types of daydreaming instructions would produce similar forgetting effects. By doing so, we could test whether the memory-undermining effects of daydreaming are restricted to the instruction typically used in this area (Delaney et al., 2010) or that such forgetting effects also appear in response to instructions related to other variants of daydreaming. Therefore, we examined both positive and negative experiences of daydreaming that required cognitive shifts. More specifically, we invited participants to relive either a positive or negative encounter with a friend or imagine a positive or negative future encounter with a friend. This experimental design reflected the idea that much dreaming activity involves not only musing about past occurrences, but also thinking about and anticipating future events. Moreover, daydreaming activity ranges in content from highly positive and gratifying to negative and anxiety-producing (Singer & Antrobus, 1963). Accordingly, Experiment 3 permitted an examination of the effects of future versus past-oriented daydreaming and positive vs. negative daydreaming on memory performance. Our research afforded the opportunity to examine whether future-oriented daydreaming produces greater recall-disruption, compared with retrieving autobiographical memories, as the imaginal activity may involve a greater contextual-shift than a focus on previously experienced and possibly rehearsed events. Furthermore, as imagination exercises frequently boost false memory formation, one could anticipate that future-daydreaming might also engender more false memories than daydreaming of past events (Schacter, 2012). We also examined the possibility that negative daydreaming would produce larger forgetting effects and memory commission errors than positive daydreaming, insofar as negative daydreaming may represent a greater contextual shift from the relatively benign experimental context compared with positive daydreaming. Germane to this possibility is research showing that negative experience might boost false memory rates (e.g., Howe, Candel, Otgaar, Malone, & Wimmer, 2010; Otgaar, Candel, & Merckelbach, 2008).

2. Experiment 1

2.1. Method

2.1.1. Participants

Our sample consisted of 163 undergraduates (139 women), with a mean age of 21.3 years (*SD* = 4.9; range: 17–64), who volunteered in exchange for course credits. The experiment was approved by the standing human subjects committee of the Faculty of Psychology and Neuroscience, Maastricht University, The Netherlands.

2.2. Materials

2.2.1. Deese/Roediger–McDermott (DRM) task

We used two DRM semantically interrelated wordlists as stimulus material (critical lures: *needle*, *soft*). The DRM word lists have effectively been used in previous research. Furthermore, the lists have been proven to successfully elicit robust levels of false memories (Peters, Jelicic, & Merckelbach, 2014; Peters et al., 2008). The order of list presentation was counterbalanced.

2.2.2. Dissociative Experiences Scale (DES)

All participants filled out the DES (Bernstein & Putnam, 1986), which is widely used for measuring self-reported dissociative disturbances in memory (e.g., not sure if remembered event happened or was a dream), perception (e.g., hearing voices inside one's head), and awareness (e.g., finding oneself in a place but unaware how one got there). It contains 28 items that ask participants to rate the frequency of these experiences. An illustrative item is: "Some people find that they sometimes sit staring off into space, thinking of nothing, and are not aware of the passage of time. Mark the line to show what percentage of the time this happens to you." In the current study, participants used 100-mm visual analogue scales (anchors: 0 = *not at all*; 100 = *very much*) to indicate the percentage of time they experienced dissociative phenomena. Scores were averaged across items to obtain a total DES score (*range*: 0–100), with higher DES scores indicating a higher frequency of dissociative experiences.

2.2.3. Design and procedure

Experiment 1 relied on a between-subjects design (daydream (n = 82) vs. control group (n = 81) in which participants were randomly allocated to the two groups.

We used a procedure similar to that of Delaney et al. (2010). Participants were instructed to study two wordlists. The order of the lists was counterbalanced across participants, meaning that each participant was randomly assigned to one of two list orders. All participants were tested individually.

Words (font size: 54, Arial) were presented sequentially via PowerPoint on the centre of a computer screen for a duration of 5 s with 500 ms stimulus intervals. After the first list presentation, control participants had to complete a multiplication task for 45 s. Participants in the daydream group received instructions to daydream, which they were instructed to do for 45 s. Specifically, they were instructed to think about their parents' house, imagine themselves there, and make a drawing of the house with a pen or pencil on a piece of paper. That is, the daydreaming group had to mind-wander when walking imaginatively through the house. In order to help participants with this task, they could make a sketch of the house during the 45 s, although it was not important that the sketches were detailed. Specifically, they received a Dutch translation of the instructions used in previous daydreaming-memory work (e.g., Delaney et al., 2010; Sahakyan & Kelley, 2002), which were as follows:

> *"Please close your eyes for a second and try to picture your parents' house. If you see it clearly, you may open your eyes. Now please describe your parents' house from the moment you enter through the front door. Describe what you would see if you walked through every room including the details about the furniture and their location.*
> *Mentally walk through the house and draw a layout of all the rooms including the furniture. To save time, do not draw the pictures of furniture items, but instead use rectangles, squares, or circles to indicate a furniture item. Make sure you label them and explain the appropriate labels somewhere on your drawing. Please use the next 45 s to draw as much as possible"*

The experimenter made sure that the daydream group was involved in 'daydreaming' by paying attention to whether they followed the instruction (i.e., make drawing). If they, for example, did not draw, they were reminded of the instruction. Following this, participants were given the second list.

After the second list presentation, all participants received a filler task for 90 s (solve difficult mazes). Next, they were instructed to freely recall all the words they could remember by writing down the words they could still recollect. Participants had to use a separate sheet for each list with the words of the first lists being asked first. Next, participants were instructed to complete the DES. Finally, participants were fully debriefed.

2.3. Results and discussion

Using independent samples *t*-tests, we compared control and daydreaming groups in Study 1 with regard to their correct recall of the first list of DRM semantically interrelated words, the second list of DRM semantically interrelated words, the recall of lures (non-studied words semantically interrelated to the studied words), and the recall of unrelated word intrusions (see Table 1). The critical comparison fell short of significance. That is, the daydreaming group did not reproduce fewer words from list 1 than the control group ($t(161) = 1.26$, $p = 0.21$). Neither were group differences obtained with regard to the number of critical lures related to list 1, or the number of unrelated false recalls when reproducing list 1. Comparisons for list 2 parameters were similarly insignificant (all p's > 0.05, see Table 1.[1]

For our critical comparison, we also calculated a Bayes Factor that is often advocated as an alternative for the conventional *t*-test and that provides the evidential basis in favor of the null or alternative hypothesis (Rouder, Speckman, Sun, Morey, & Iverson, 2009). We obtained a Bayes Factor of 5.27, which indicates weak evidence in favor of the alternative hypothesis (difference between daydream and control).

Within the daydream group, we found no difference in the strength of the forgetting effect (defined as net recall list 2 minus net recall list 1) between participants who reported a critical lure (i.e., false memory) and participants who did not report a lure, $t(80) < 1.0$. Likewise, strength of forgetting did not differ between those who reported an unrelated intrusion and those who did not report an unrelated intrusion, $t(80) < 1.0$. The Pearson product-moment correlation between DES scores and the rate of forgetting in the daydream group remained non-significant ($r = -0.12$, $p = 0.28$; $n = 82$).

In contrast to what one would predict on the basis of Delaney et al. (2010), we found no memory-undermining effect of daydreaming on related material. Furthermore, there was no indication that false memories were related to the forgetting effects of daydreaming. Neither was there a notable relation between memory performance and dissociativity in the group that engaged in daydreaming. Perhaps, then, the memory-undermining effects of daydreaming are restricted to unrelated material, which if true, would lessen their significance with respect to clinical phenomena such as amnesia. To address this issue, we conducted a second experiment in which we included both unrelated and semantically interrelated material.

3. Experiment 2

3.1. Participants

Our sample consisted of 100 undergraduates (75 women), with a mean age of 21.7 years ($SD = 5.1$; range: 17–54), who received course credits in exchange for their participation. The experiment was approved by the standing human subjects committee.

3.2. Materials

3.2.1. Wordlists

Participants were provided with two lists: a list of DRM semantically interrelated words (critical lure: *cold*) and a 15-item list of Dutch unrelated words. Again, the lists were counterbalanced across participants.

[1] Participants in Experiment 1 were native Dutch or were Dutch speaking Germans (Experiment 1: Dutch: $n = 136$, German: $n = 27$). Delaney et al. (2010) found that participants who visited their home long ago showed more forgetting effects than participants who visited their home more recently. One could assume that Germans were more likely to be away from their parental home than Dutch and hence would show forgetting effects. However, we did not find that Germans receiving daydreaming instructions showed forgetting effects ($F(1,159) = .18$, $p = .67$, partial eta^2 = .001).

Table 1
Proportion correctly recalled words (standard deviations in parentheses), number of critical lures, number of unrelated intrusions, and DES scores in control ($n = 81$) and daydreaming participants ($n = 82$) (Experiment 1).

DES	Control 20.7 (12.7)	Daydreaming 18.7 (11.1)
Proportion recalled list 1	.48 (0.16)	.45 (0.17)
Proportion recalled list 2	.46 (0.18)	.47 (0.15)
Number critical lures list 1	.47 (0.50)	.48 (0.50)
Number critical lures list 2	.47 (0.50)	.41 (0.50)
Number unrelated intrusions list 1	.42 (0.82)	.41 (0.66)
Number unrelated intrusions list 2	.62 (1.14)	.52 (0.92)

3.2.2. Dissociative Experiences Scale (DES)

Like Experiment 1, we administered the DES to measure dissociation.

3.2.3. Design and procedure

Experiment 2 relied on a 2 (Group: Daydream vs. control) $\times$ 2 (List type: semantically interrelated vs. unrelated) split-plot design with the latter factor constituting a within-subjects variable. Participants were randomly assigned to the two groups (daydream: $n = 52$; control: $n = 48$).

A similar procedure was employed as in Experiment 1. That is, we provided two lists to participants in a counterbalanced order, and after the second list, participants received a memory test.

3.3. Results and discussion

Table 2 summarizes the data of Experiment 2. As a first step, we performed a 2 (Group: Daydreaming vs. control) $\times$ 2 (List type: DRM vs. unrelated material) ANOVA with the last factor being a repeated measure on the list 1 correct recall data. No significant interaction of Group and List type was observed ($F(1,96) = 0.30$, $p = 0.59$). As expected, we did find a significant list type effect ($F(1,97) = 17.95$, $p < .001$, partial $\text{eta}^2 = 0.16$), with lists of DRM semantically interrelated words ($M = 0.57$, $SD = 0.17$) eliciting higher correct recall levels than unrelated lists ($M = 0.41$, $SD = 0.21$). A follow-up test made clear that overall (lists 1 and 2 combined), semantically interrelated DRM words were better recollected than unrelated words, means being 0.58 ($SD = 0.16$) and 0.46 ($SD = 0.22$), $t(99) = 5.45$, $p < 0.001$. Most importantly, we found no statistically significant effect of daydreaming on recall rates of list 1 words. That is, daydreaming decreased recall levels of DRM and unrelated items ($F(1,97) = 3.84$, $p = 0.052$, $\text{eta}^2 = 0.04$) only to a small and nonsignificant extent.

Follow-up tests for DRM and unrelated list 1 words separately, yielded the following pattern. First, replicating the null finding of Experiment 1, daydreaming participants did not recall fewer semantically interrelated related words from list 1 than controls ($t(50) = 1.15$, $p = 0.26$). For this critical comparison on related words (list 1), we obtained a Bayes Factor of 4.77, indicating weak evidence in favor of the alternative hypothesis. As to unrelated list 1 words, although descriptively daydreaming somewhat suppressed recall of words compared to the control condition this difference was not statistically different ($t(46) = 1.59$, $p = 0.06$, one-tailed). For unrelated words (list 1), a Bayes Factor of 2.68 was found, which reflects very weak support for the alternative hypothesis. When we examined list 1 DRM recall, we found that daydreaming was not associated with heightened recall of critical lures ($t(50) = 1.73$, $p = 0.09$) or unrelated intrusions compared with the control condition ($t(46) = 1.19$, $p = 0.24$).

We next differentiated within the daydreaming group between participants who reported lures or unrelated intrusions and those who did not. We formed separate groups for related and unrelated materials and compared these groups with regard the strength of forgetting (list 2 minus list 1). None of the comparisons achieved significance (related: $t(50) = -0.49$, $p = 0.63$; unrelated: $t(50) = -0.20$, $p = 0.85$).

In the daydreaming group, DES scores were not associated with the strength of forgetting in the cases of related and unrelated material (i.e., list 2-list 1; $r = -0.11$, $p = 0.43$). All other correlations between DES and memory parameters fell short of significance (all $ps > 0.05$).

As an exploratory analysis, we collapsed the data and examined whether daydreaming might undermine overall memory performance (i.e., lists 1 and 2 data combined). For the semantically interrelated words, we once more found no difference between the two groups ($t(98) = 1.81$, $p = 0.07$) with a Bayes Factor of 1.88 (very weak evidence for the alternative hypothesis). However, daydreaming was associated with less recall for the unrelated words (daydreaming: $M = .41$, $SD = 0.23$; control: $M = .51$, $SD = 0.19$; $t(98) = -2.39$, $p = 0.02$, Cohen' $d = 0.47$; Bayes Factor = 1.65).

In sum, we found again no support for the idea that daydreaming has a memory undermining effect for semantically interrelated material. Neither was daydreaming related to heightened false recalls. Also, memory performance after daydreaming was unrelated to dissociativity. It was only partially true that daydreaming was associated with lower memory performance for unrelated words. This effect did not reach statistical significance when focusing on list 1, and was only evident when list 1 and 2 were combined. Note that this suppression phenomenon was a small sized effect and that it runs counter to the Delaney et al.'s (2010) interpretation that it is the context change induced by daydreaming that creates for-

Table 2
Proportion correctly recalled words (standard deviations in parentheses), number of critical lures, number of unrelated intrusions, and DES scores in control ($n = 48$) and daydreaming participants ($n = 52$) as a function of list type (Experiment 2).

	Control	Daydreaming
DES	17.00 (9.90)	18.20 (13)
Unrelated		
Proportion recalled list 1	.46 (0.21)	.37 (0.21)
Proportion recalled list 2	.55 (0.16)	.45 (0.24)
Number unrelated intrusions list 1	.39 (0.66)	.84 (1.70)
Number unrelated intrusions list 2	.40 (0.50)	.63 (1.04)
Semantically interrelated		
Proportion recalled list 1	.60 (0.14)	.55 (0.20)
Proportion recalled list 2	.62 (0.12)	.56 (0.15)
Number critical lures list 1	.16 (0.37)	.37 (0.49)
Number critical lures list 2	.26 (0.45)	.44 (0.51)
Number unrelated intrusions list 1	.52 (0.85)	.48 (0.77)
Number unrelated intrusions list 2	.26 (0.54)	.60 (1.12)

getting of list 1, but not list 2 words. All in all, our results show that daydreaming does not produce any consistent memory undermining effects. Positive results obtained for only unrelated words in one study, and only when combined with the list 2 words, which runs counter to predictions.

Indeed, our Bayes Factors showed very weak evidence in favor of the hypothesis that daydreaming propels forgetting effects. Furthermore, when we compare the effect sizes reported by Delaney et al. (2010) and ours, it is obvious that their effects sizes are considerably larger than the ones we found (e.g., Delaney et al. (2010): Experiment 1: $eta^2 = .079$, Experiment 2: $eta^2 = .20$; our Experiment 2: $eta^2 = .04$). What can be concluded at most, is that, if daydreaming has memory-undermining effects, they are likely to be very fragile and/or ephemeral in nature. It is unclear what the cause of this fragile effect is, but it could be related to the instruction that the experimental and control group receive. That is, the experimental group receives a lengthy instruction and this could have distracted participants more from rehearsing the words than the control group. Nonetheless, even if this hypothesis is true, in general, we do not find that daydreaming undermines memory performance.

In Experiments 1 and 2, we found no evidence of memory-undermining effects of daydreaming for related words, and very limited support for such effects for unrelated words based on a single exploratory post-hoc analysis. The goal of the third experiment was to test whether memory-undermining effects of daydreaming for unrelated words will occur when participants receive different daydream instructions.

4. Experiment 3

4.1. Participants

In Experiment 3, participants were tested at a medium-sized university in the northeast United States. The sample consisted of 109 undergraduates (50 women; 53 men; 6 unidentified), with a mean age of 19.74 years ($SD = 1.5$; range: 18–28). The participants were recruited from the Human Subjects Testing Pool and volunteered in exchange for course credit.

4.2. Materials

4.2.1. Wordlists

Participants were shown three word lists: two lists of 15, unrelated, English nouns, and a third list containing words from the prior two lists, along with novel words. This allowed for participants to make errors of commission (i.e. reporting they saw a word they could not have seen) and errors of source monitoring (attributing a given word to the wrong word list). Lists 1 and 2 were counterbalanced across sessions.

4.2.2. The Clinician Administered Dissociative States Scales (CADSS: Bremner et al., 1998)

The CADSS contains a combination 19 self-report items designed to screen for the current presence of dissociative symptoms. The CADSS possesses acceptable inter-rater reliability (intraclass correlation coefficient (ICC) = .92), internal reliability (coefficient alpha = .94), and construct validity (Bremner et al., 1998).

4.3. Design and procedure

Each volunteer participated in one of five conditions (1: Positive Autobiographical Memory, $n = 27$; 2: Negative Autobiographical Memory, $n = 23$; 3: Positive Imagining, $n = 17$; 4: Negative Imagining, $n = 19$; 5: Control/Reading Passage, $n = 23$). Participants were run in groups of 2–12 by either a clinical psychology graduate student or by a trained and supervised undergraduate research assistant.

Prior to providing informed consent for the research, participants were told that the purpose of the study was to examine how various personal characteristics and cognitive tasks influence the recall of information. After providing consent, the participants completed the first CADSS. Following this, they were presented a slideshow of words (15 unrelated English nouns, presented at a rate of 5 s/word), and then were assigned to groups in which they either: (1) thought about a positive autobiographical memory about an encounter with a friend, (2) thought about a negative autobiographical memory about an encounter with a friend, (3) imagined a future positive encounter with a friend, (4) imagined a future negative encounter with a friend, or (5) read a passage from an article about the history of psychology as a science (control). After spending 5 min writing down the event they imagined or remembered, subjects then watched a second slideshow of 15 unrelated English nouns (presented at 5 s/word). Next, participants completed a filler task, during which they solved algebra problems for 90 s. They then completed 2 free-recall tasks (recall of lists 1 & 2) and devoted 60 s to the recall of list 1 and then another 60 s to the recall of list 2. Each list was recalled on a separate sheet of paper. Following this task, subjects were presented with the slide show depicting list 3, which included words from both prior lists and additional novel words. After viewing the slideshow, participants completed another 90-s algebra filler task. They then completed recall list 3, which required them to write down the words they could remember from list 3 in 60 s. Finally, participants completed a second measure of state dissociation (CADSS: Bremner et al., 1998).

4.4. Results and discussion

Tables 3 and 4 summarize the data of Study 3. A series of ANOVA's was conducted, with group treated as the independent variable and the various types of memory errors, across lists 1 and 2 (errors of commission and source monitoring with words from list 1 attributed to list 2) as within-subjects, dependent variables. No significant differences were found. To analyze the data associated with word list 3, a series of 5 (Group) $\times$ 1 (Word List 3) oneway ANOVAs were run, again with the various types of memory errors (errors of commission and errors of source monitoring with words from lists 1 and 2 misattributed to other word lists) serving as the dependent variables. Again, no significant differences were found, indicating that there was no effect for either past vs. future-oriented daydreaming or valence of daydreaming, relative to the control condition, thereby failing to find evidence consistent with the memory-undermining effect hypothesis.

The data were also analyzed using a series of one-way ANOVAs, followed by planned contrasts. It should be noted that the Levene's Test of Homogeneity of Variances indicated that the assumption of homogeneity of variance was violated for several of the analyses. Using the Brown-Forsythe *F*, in no case were any differences significant. Critically, the one-way ANOVA on the number of correctly recalled list 1 words fell short of significance ($F(4,104) = .56$, $p = .69$, partial eta$^2 = .021$).

When we examined with planned contrasts to evaluate whether the groups exposed to instructions to "remember" or "imagine" would have more memory errors than the control group on lists 2 and 3, we found no difference in memory errors between the intervention groups and the control group. We further examined whether the groups asked to "imagine" a possible future event vs. "remember" an actual past event would exhibit more memory errors on lists 2 and 3. We found no differences across the memory measures with the exception of a single significant difference ($t(104) = 2.43$, $p < .05$, $r = 0.24$), between the memory and imagination groups, with respect to source monitoring errors; subjects in the imagination groups made a greater number of source monitoring errors compared with subjects in the memory groups, misattributing words that appeared on list 1 to list 3. We also examined whether participants asked to imagine a negative event exhibited the most memory errors of all. We found no support for this possibility. Planned contrasts revealed no significant difference between memory errors made by participants on word lists 2 and 3 in the negative imagined group and those made by participants in the other groups. Finally, a set of contrasts that paralleled those reported above was performed with respect to number of recalled words from list 1 and was similarly non-significant. In short, we failed to find evidence for memory-undermining effects of daydreaming across multiple comparisons, and found differences consistent with expectations on only one measure (source monitoring) when liberal planned comparisons were conducted.

Linear regressions were conducted to determine whether dissociation symptoms at any point during the study predicted memory errors across the word lists. We found that initial state dissociation ratings predicted the number of commission errors made on list 2 ($\beta = .016$, $p < .05$) and 3 ($\beta = .226$, $p < .05$). For commission errors on list 2, subjects' initial CADSS scores predicted 5% of the variance ($R^2 = .051$, $F(1,107) = 5.77$). For commission errors on list 3, subjects initial CADSS score predicted 4.1% of the variance ($R^2 = .041$, $F(1,107) = 4.52$).

4.5. General discussion

The main results of our study can be catalogued as follows. First, we found that recall of semantically interrelated words from so-called lists of DRM semantically interrelated words was unaffected by daydreaming. Second, daydreaming was generally not associated with raised levels of false recall. Third, increased false recall was not associated with daydreaming

Table 3
Mean proportion correctly recalled words (standard deviations in parentheses), number of source monitoring errors, number of commission errors, and CADSS scores in control ($n = 23$), positive memory ($n = 27$), negative memory ($n = 23$), positive imagination ($n = 17$), and negative imagination participants ($n = 19$) (Experiment 3).

	Control	+Memory	−Memory	+Imagination	−Imagination
Proportion recalled list 1	.30 (.19)	.32 (.18)	.33 (.19)	.33 (.19)	.26 (.17)
Proportion recalled list 2	.28 (.19)	.25 (.19)	.32 (.21)	.32 (.24)	.27 (.19)
Proportion recalled list 3	.57 (.16)	.64 (.16)	.56 (.18)	.67 (.23)	.60 (18)
Errors of commission list 1	.52 (.95)	.37 (.57)	.39 (.59)	.18 (.39)	.58 (.84)
Errors of commission list 2	.52 (.99)	.22 (.42)	.39 (.67)	.06 (.24)	.47 (.91)
Errors of source monitoring list 2	.26 (.69)	.22 (.56)	.35 (.65)	.29 (.47)	.16 (.38)
Errors of commission list 3	.35 (.71)	.19 (.48)	.17 (.49)	.06 (.24)	.11 (.32)
Errors of source monitoring list 3 (words from list 1)	.09 (.29)	.00 (.00)	.04 (.21)	.18 (.39)	.16 (.38)
Errors of source monitoring list 3 (words from list 2)	.04 (.21)	.00 (.00)	.09 (.29)	.18 (.39)	.00 (.00)

Note: +Memory = Positive Memory, −Memory = Negative Memory, +Imagination = Positive Imagination, and −Imagination = Negative Imagination.

Table 4
CADSS 1 scores as predictors of errors of commission for novel words during recall of word lists 1, 2 & 3 (Experiment 3).

	List 1		List 2		List 3	
Constant	$B = .420$	(.089)	$B = .199$	(.088)	$B = .097$	(.062)
CADSS score 1	$B = -.001$	(.007)	$B = .016^{*}$	(.007)	$B = .010^{*}$	(.005)
	$R^2 = .000$		$R^2 = .051$		$R^2 = .41$	

(standard deviations).
* Indicates significance at $p < .05$.

about either past vs. future or positive versus negative daydreaming, although one statistical analysis, of the many performed, suggested that source monitoring errors are associated with imagining a future event versus remembering an actual past event. Third, individual differences in dissociativity as measured by the DES did not predict the absence of an effect of daydreaming on memory, although a state measure of dissociation did account for a small percentage of variance in commission errors on lists 2 and 3. This latter finding is consistent with research providing evidence for small-to-moderate correlations of measures of dissociation with measures of false memories or commission errors (see Giesbrecht, Lynn, Lilienfeld, & Merckelbach, 2008). Taken together, in contrast to Delaney et al. (2010), we do not find strong effects of daydreaming using different types of stimuli and instructions.

In Experiments 1 and 2, daydreaming was not associated with memory impairments for unrelated and related materials. Only when we combined the recall of the two lists (Experiment 2), did we find some evidence for forgetting resulting from daydreaming. This constellation of findings indicates that the memory disturbing effects of daydreaming do not extend to other forms of forgetting; ones that reflect more the quality of genuine amnesia, the key feature of which is retrieval difficulties for episodically or semantically related materials (Squire & Zola, 1998). Apparently, the phenomenon is subject to strict boundaries – it does not always occur with unrelated, and certainly not for related material – it is not convincingly linked to false recollections, and it is not predicted by dissociativity. Indeed, when we calculated Bayes Factor scores, we found very weak evidence that daydreaming results in memory-undermining effects. Moreover, in Experiment 3, we failed to find recall impairment using unrelated materials and using a number of other daydream instructions, implying that the daydreaming effect is not robust. So, unlike Delaney et al.'s strong claims, our findings imply that daydreaming exerts few, if any (and highly questionable), effects on memory across multiple analyses and across different laboratories conducting entirely independent research.

The null findings in Experiments 1 and 2 with regard to semantically interrelated materials are important in this respect. We included semantically interrelated material in our methodology because autobiographical memories frequently consist of related materials (Brainerd et al., 2008). Research shows that semantically interrelated material is better recollected than unrelated material because the relations among such material provide people with better retrieval opportunities (see Brainerd et al., 2008). Indeed, we found evidence for this in our own findings. Thus, when participants are confronted with related material, their memory performance for the to-be-remembered material will receive a boost. Apparently, such a memory enhancement protects people against the potential memory-undermining effect of daydreaming. However, because we also did not find that daydreaming led to forgetting effects for unrelated words, the act of daydreaming in general most probably does not undermine memory performance.

One might argue that our key finding that daydreaming is generally ineffective in lowering recall levels contradicts experimentation showing that true memory performance deteriorates and false memories increase when participants are instructed to intentionally forget material (Kimball & Bjork, 2002). However, in intentional forgetting studies, participants receive a strong instruction to *forget* items from learned material. In the current experiments, we did not give any instructions related to memory. So, although on a descriptive level exploratory post-hoc analyses suggest that memory performance for unrelated material may be somewhat lower after daydreaming, daydreaming is not as powerful as intentional instructions to induce forgetting of related material.

Delaney et al. (2010) speculated that the memory-undermining effects of daydreaming reflect diminished retrieval effectivity due to changed mental contexts. However, the fact that we obtained a memory-undermining effect only when data of list 1 and 2 in Experiment 2 were both considered argues against this interpretation. Moreover, in Experiment 3, although participants produced more source monitoring errors, the magnitude of the effect, in terms of number of source monitoring errors, could aptly be described as trivial (less than or equal to .35 out of 15 words). Additionally, even when the context in Experiment 3 was shifted to imagining a negative future encounter with a friend, recall was not impaired relative to the control condition. Together, our results suggest that daydreaming in ineffective in leading to forgetting effects.

Our experiments also showed that when using semantically interrelated wordlists, daydreaming did not amplify false recall levels. This is not surprising as research has shown that when using the context-change paradigm as we did, false recall levels are reduced in the forget condition (Lehman & Malmberg, 2009). The explanation for this is that the context-change instruction results in lists becoming more distinctive because list contexts share few features. False memories are generally reduced when stimuli are distinctive (Hunt & Smith, 2014). Although semantically interrelated stimuli generally elevate false memory levels (Brainerd et al., 2008), it is likely that these stimuli did not affect the distinctiveness of the lists when a context-change instruction was provided.

To recap, our experiments do not provide predicted, consistent, or convincing evidence that daydreaming produces forgetting. We also found that daydreaming did not result in amplified false recollections. In conclusion, across three studies conducted in two laboratories, our research can be aptly characterized as a failure to replicate previous findings regarding the apparent strong memory undermining effects of daydreaming on memory performance.

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