Daydreams incorporate recent waking life concerns but do not show delayed ('dream-lag') incorporations

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Abstract (150/150)

This study investigates the time course of incorporation of waking life experiences into daydreams. Thirty-one participants kept a diary for 10 days, reporting major daily activities (MDAs), personally significant events (PSEs) and major concerns (MCs). They were then cued for daydream, Rapid Eye Movement (REM) and N2 dream reports in the sleep laboratory. There was a higher incorporation into daydreams of MCs from the previous two days (day-residue effect), but no day-residue effect for MDAs or PSEs, supporting a function for daydreams of processing current concerns. A day-residue effect for PSEs and the delayed incorporation of PSEs from 5-7 days before the dream (the dream-lag effect) have previously been found for REM dreams. Delayed incorporation was not found in this study for daydreams. Daydreams might thus differ in function from REM sleep dreams. However, the REM dream-lag effect was not replicated here, possibly due to design differences from previous studies.

Keywords: daydreaming, dreaming, day-residue, dream-lag, memory consolidation, functions of dreaming, functions of sleep, REM sleep

1. Introduction

Daydreaming is a form of non-directed or task irrelevant thinking (Antrobus, Singer, & Greenberg, 1966; Christoff, Ream, & Gabrieli, 2004; McMillan, Kaufman, & Singer, 2013; Singer, 1975), in which attention shifts to internal stimuli (Cunningham, Scerbo, & Freeman, 2000). A related concept is mind wandering, which occurs when thoughts are not controlled, but instead drift off to inner thoughts, fantasies and feelings (Foulkes & Fleisher, 1975; Smallwood & Schooler, 2006). Mind wandering and daydreaming can occur both when a task is present or is not present (Christoff, 2012). A distinction has been made between mind wandering and focused daydreaming. Mind wandering is believed to lack purpose, involves decreased control over thought flow, is more spontaneous and has frequently changing content. Focused daydreaming, on the other hand, occurs when one actively imagines situations, objects and events. In the latter, the order and content of the thoughts is directed and has a narrative structure (Dorsch, 2015). The terms mind wandering and daydreaming are often used interchangeably, even though they do not always have exactly the same meaning (Christoff, 2012; Fox, Nijeboer, Solomonova, Domhoff, & Christoff, 2013). In the present study, daydream reports are collected from quiet wakefulness and can be both directed, as in focused daydreaming, or spontaneous, as in mind wandering. The terms daydreaming and mind wandering are thus used interchangeably in the current study.

Daydreaming is often related to an individual’s future-related concerns (Andrews-Hanna, Reidler, Huang, & Buckner, 2010; Klinger, Barta, & Maxeiner, 1980; Stawarczyk, Majerus, & D'Argembeau, 2013), and the amount of daydreaming increases with induced negative affect relating to a future concern (Stawarczyk et al., 2013). For example, Antrobus, Singer and Greenberg (1966) played a mock news broadcast to male participants which stated they would be drafted to the Vietnam War. Participants’ subsequent daydreams involved increased concern about the implications of this broadcast for their future, and included feelings such as panic, despair, hopelessness, worry, fear, terror, anxiety, and anger. Similarly, Jordano and Touron (2017) examined the effect of priming personal, performance-related concerns on mind-wandering. Female participants were primed with a math-gender stereotype threat and were subsequently probed for mind-wandering during a mathematical task. This priming was found to increase task-related concerns, and participants had decreased task performance.

Whereas the general conclusion from the literature is that daydreaming predominantly relates to people's recent past and immediate future (e.g., Andrews-Hanna et al., 2010; Klinger, 2013; Stawarczyk et al., 2013), hitherto, the timescale of incorporation of waking life events and concerns into daydreams has not been systematically investigated. The first aim of the current study is to investigate the time course of incorporations, using the sophisticated designs and methods that are typically used in dream research.

Similarities have been found in the content and form of dream and daydream reports (Foulkes & Fleisher, 1975), with dreaming being proposed to be an intensified form of daydreaming (Domhoff & Fox, 2015; Fox et al., 2013). Both incorporate references to events and concerns of the individual's life (Malinowski & Horton, 2014), and current waking concerns are incorporated into dreams and daydreams more than are non-concerns (Cartwright, Agargun, Kirkby, & Friedman, 2006; Hoelscher, Klinger, & Barta, 1981; Nikles II Brecht, Klinger, & Bursell, 1998; Klinger, 2013). Both have a typically audio-visual nature (Fox et al., 2013; Stawarczyk, Majerus, Maj, van der Linden, & D'Argembeau, 2011), can contain bizarre elements (Fox et al., 2013) and include both positive and negative emotions (Killingsworth & Gilbert, 2010; Marcusson-Clavertz, Cardeña, & Terhune, 2016; Nielsen, Deslauriers, & Baylor, 1991; Schredl & Doll, 1998). Although there are considerable qualitative similarities between dreaming and daydreaming, these elements appear to be more intense for dreams (Fox et al., 2013). Rapid Eye Movement (REM) nap dreams have higher sensory experience (auditory, visual and movement) than daydreams, which have higher sensory experience than N2 nap dreams. Mechanisms of imagery generation thus seem to differ between sleep and wake (Carr & Nielsen, 2015).

In investigations of the timescale of incorporations of waking life events and concerns into dreams, the occurrence in dreams of references to waking life events from 1-2 days before the dream, known as the day-residue effect, has consistently been reported (e.g., Nielsen, Kuiken, Alain, Stenstrom, & Powell, 2004; Blagrove et al., 2014; van Rijn et al., 2015). The current study uses a prospective diary and incorporation identification method, previously used in dream research (van Rijn et al., 2015), so as to investigate the timescale of incorporation of waking life events and concerns into daydreams. The method used here distinguishes between major concerns (MCs) and personally significant events (PSEs), a distinction emphasised by Domhoff (2017), using the structured diary method of Fosse, Fosse, Hobson and Stickgold (2003). The main hypothesis is that daydreams will show a day-residue effect, that is, recent experiences will have a greater level of representation in daydreams than do older experiences. However, whereas for REM dreams the day-residue effect is found for PSEs and not MCs, we do not specify which of PSEs or MCs will show this day-residue effect, or whether both will.

Importantly, there is a second timescale effect of delayed incorporation into dreams of events from 5 to 7 days before the dream, known as the dream-lag effect (e.g., Blagrove et al., 2011a; Nielsen et al., 2004; see Eichenlaub, Cash & Blagrove, 2017, for a review). The dream-lag effect is specific to REM dreams (van Rijn et al., 2015), as it has not been found for slow wave sleep (SWS) dreams (van Rijn et al, 2015) or N2 dreams (Blagrove et al., 2011a). It has been proposed that dreaming reflects the reactivation and consolidation of memories during sleep (Wamsley, Perry, Djonlagic, Babkes Reaven, & Stickgold, 2010a; Wamsley & Stickgold, 2011; Wamsley, Tucker, Payne, Benavides, & Stickgold, 2010b). The dream-lag effect has thus been speculated to represent a shift in memory representations across a series of nights from the hippocampus to neocortical structures (Nielsen & Stenstrom, 2005). Alternatively, it could reflect some other processing of emotionally important events (van Rijn et al., 2015).

The second aim of the present study is thus to assess whether the 5-7 day delayed incorporation of references to waking life also occurs for daydreams, and whether it occurs for PSEs or MCs. The second aim is important for two reasons. Firstly, so as to characterise fully the timescale of incorporations that influence daydream content and the implications of this for possible functions of daydreams. Secondly, to test the speculative possibility that the dream-lag effect might arise because thoughts about events reoccur during wakefulness on the 5-7 day timescale, and references to them thus appear in dreams on the same timescale as a result of their daytime availability (Frankland & Bontempi, 2005; Horton & Malinowski, 2015). This possibility would provide an explanation for the dream-lag effect that is not based on memory-consolidation processes during sleep, as it is possible that the effect results from a more general delayed memory availability, which is also present during wakefulness. Such an endogenous process of memory availability during wake would need to be tested for when attention is not being driven by external stimuli, and hence daydreams are used to test this in the present study.

In this study, daydreams were collected in the sleep laboratory. After daydreams were collected, participants went to sleep and REM and N2 dreams were collected during the night. This enabled data to be collected for the third aim of the current study, to replicate findings that the dream-lag effect is found for REM dreams, but not for N2 dreams (Blagrove et al., 2011a; van Rijn et al., 2015).

2. Methods

2.1. Participants

Thirty-three participants (17 males, 16 females; aged 18-30, mean age = 20.61, SD = 3.07) took part in the experiment. All participants were native English speakers and were students at Swansea University. Participants were self-reported frequent dream recallers (defined as recalling dreams 4-7 days per week); sleeping a minimum of 7 hours per night; with no disorders that could affect their sleep; non-smokers; not taking recreational drugs and not having an excessive alcohol intake (defined as intake greater than 6 units of alcohol per night, or greater than 21 units per week). Participants gave written informed consent and were paid for their participation. Ethical approval for the study was obtained from the Research Ethics Committee at the Swansea University Department of Psychology.

2.2. Materials and procedure

2.2.1. Stanford Sleepiness Scale

Participants completed the Stanford Sleepiness Scale (SSS; Hoddes et al., 1973) before their daydream collection. This scale assesses how alert one is feeling at that moment on a scale from 1 (feeling active, vital, alert, or wide awake) to 7 (no longer fighting sleep, sleep onset soon; having dream-like thoughts). The SSS was used to measure levels of sleepiness just prior to collection of daydream reports so as to ensure participants did not fall asleep while the 10-minutes daydream period was occurring. Participants filled in the SSS immediately after electrode application, just before daydream report collection.

2.2.2. Daily logs

All participants were instructed to keep a daily log for the 10 consecutive days before coming to the sleep laboratory, recording their waking experiences from each day. On the tenth day of keeping the log, participants slept for a night in the sleep laboratory, where dream and daydream reports were collected. The daily log was taken from Fosse et al. (2003) and consists of the following three categories:

1. Major daily activities (MDAs): activities that took up most of the participants' time during the day (for example, going to work or university, meals, shopping).
2. Personally significant events (PSEs): important daily events that may or may not have taken up much time (for example, emotional events).
3. Major concerns (MCs): concerns or thoughts that participants had on their mind during the day that may not have taken up much time, but were still considered important to them (for example, money problems, exam stress).

Participants reported up to five events per category on each daily log. Any accompanying emotions were reported next to the event and were scored by the participant for intensity on a scale from 1 (low) to 3 (high).

2.2.3. Instrumental awakenings and (day)dream report collections

In the laboratory, night sleep was monitored using polysomnography. Electroencephalography (EEG), electrooculography (EOG), and electromyography (EMG) were continuously recorded using a Trackit^{TM} 18/8 system (Lifelines Ltd, UK, sampling rate 200Hz, high-pass filter 0.16 Hz). EEG electrodes were placed according to the standard 10-20 system at C3, C4, F3, F4, M1 and M2. EOG Electrodes were applied above the right outer canthus and below the left outer canthus, and EMG electrodes on the chin muscles. The common reference was placed at CPz and the ground electrode on the forehead. Online sleep scoring followed the AASM Manual for the Scoring of Sleep (Iber et al., 2007). Sleep stages were subsequently confirmed offline.

For daydream report collection, participants were informed that before going to sleep, the equipment would need to be checked. They were told to lie on the bed in the bedroom, and that while the equipment was checked they would be given the opportunity to experience how the dream reports would be collected during the night. They were instructed to lie down and keep their eyes closed, but to not fall asleep, and to let their minds wander (Noreika et al., 2010). The following text was read out to the participants:

> 'We need you to lie down while we check the connections and that the recordings are free of interference, and that the muscle recordings work. Please lie down, we need you to have your eyes closed, but it is very important that you stay awake. Just think of anything, let your mind wander, but please don't fall asleep! Once we have checked everything we will sound the buzzer and play you the messages that we will play during the night. We will ask you what was going through your mind before the buzzer went. Although you will have been awake, please answer in as much detail as you can.'

The EEG signal was monitored to ensure participants did not fall asleep before the daydreaming report was cued. After 10 minutes, participants were signalled with a buzzer and received the following recorded audio message played from a digital recorder through an intercom: 'What was going through your mind before the buzzer?' If participants made a report, when they had finished speaking they were next played the recorded message: 'Can you remember anything else?’ If a daydream report was less than 20 words, another attempt to collect a report was made following another 10 minutes of lying down in bed. The following prompts were also available to use where appropriate:

‘Can you remember anything about thoughts, images, people, places, scenes, actions, feelings, or anything else?’

‘Please elaborate, if you can.’

‘Can you remember anything?’

During the night, participants’ dream reports were collected, with the aim of achieving one dream from N2 sleep and two from REM sleep. The rationale for the awakenings schedule was so that one pair of counterbalanced REM and N2 awakenings was obtained, followed by an end of night REM awakening as the dream-lag effect has been shown to be specific to REM sleep and we wished to maximise sample size and hence power for that sleep stage. Awakenings were not scheduled during the first two sleep cycles, so as not to disrupt SWS. The order of the N2 and first REM awakening was counterbalanced as follows:

(1) N2 and then REM from the 3rd sleep cycle: two REM periods (or 3 hours of sleep) were counted, followed by an N2 awakening, and then a REM awakening in the 3rd REM period of the night;

or

(2) REM from the 3rd sleep cycle and then N2 from the 4th sleep cycle: two REM periods (or 3 hours of sleep) were counted, followed by a REM awakening, and then an N2 awakening after the 3rd REM period and hence in the 4th sleep cycle of the night.

If 3 hours of sleep were obtained but zero or only one REM period had occurred in that time, an awakening was scheduled in the next REM or N2 period, counterbalanced across participants, and then N2 or REM after that. If a dream report was less than 20 words, an awakening was conducted the next time that sleep stage occurred. The awakening from the other sleep stage then occurred after participants were woken up for the second time from the awakening in the scheduled first sleep stage. Irrespective of what occurred for dream report collection during the night, a REM sleep awakening was scheduled for the last REM period of the night before getting up in the morning, approximately 7 hours after sleep onset. There was no minimal word count for dreams from this final awakening, as there would not be a possibility to collect another final REM dream.

For all awakenings participants were woken up by a buzzer 10 minutes into the N2 or REM period. After awakening, the same recorded audio message as used for daydream report collection was played through the intercom, followed by any of the same prompts available for daydream reports where appropriate. When participants could not report anything, the following message was played: ‘Do you think that you were having a dream when you were woken, or that you weren’t dreaming?’ After giving their dream report, or response that no dream could be recalled, the participant was invited to go back to sleep until the next awakening. Dream recordings were given a randomised code and were transcribed by a researcher blind to the sleep stage in which the awakening occurred. Two to six days after the dream report collection, participants returned to the laboratory so as to clarify and discuss the content of their daydream and N2 and REM dream reports. Data for this are presented elsewhere (Blagrove et al., 2016), note that for participants with two REM dreams only one of these was clarified and discussed. After the discussions they were given the transcripts of the daydream and dream reports, and their diary records completed in the

10 days before sleeping in the sleep laboratory, so as to identify correspondences between the two sets of records, as detailed in the next section.

2.2.4. Correspondence identification task

Two to six days after the sleep laboratory night, participants were provided with the materials to perform the correspondence task, following the method described in van Rijn et al. (2015). Examples sheets and instructions on how to perform the correspondence task were provided. For this task, participants were asked to identify correspondences between each of their 10 daily logs and the daydream and dream reports collected in the sleep laboratory. Participants were presented with a randomized series of A3 sheets (42.0 × 29.7 cm), each with a daily log on the left side and a transcript of a daydream or dream report on the right side, including any amendments made during the discussion of the reports. Depending on the number of daydream and dream reports collected in the sleep laboratory, participants rated 10-40 sheets of paired daily logs and daydream and dream reports for correspondences. Correspondences could be identified between any elements in the (day)dream reports and in the daily logs, such as, characters, objects, actions, locations, emotions, concerns or themes. If participants identified a correspondence, they were instructed to draw boxes around the matched words or sentences in the daily log and around the matched words or sentences in the dream report, and then to rate the level of correspondence between the two parts using a scale from 1 (extremely weak) to 8 (extremely strong). Zero, one or more than one correspondence(s) could be identified for each A3 sheet.

2.3. Statistical analyses

For each of the three daily log categories separately, the total number of incorporations identified by the participant for each sheet was summed, so as to obtain the number of incorporations in each daily log category for each of the 10 periods between daily log and sleep lab night (1 day, 2 days, ….., 10 days). Next, the mean number of these incorporations was calculated for each of four combined time periods, namely, 1 – 2, 3 – 4, 5 – 7, and 8 – 9 days between daily log completion and sleep laboratory night. These four comparison periods include the day-residue period, defined as days 1 - 2, with day 1 being the day of coming to the sleep laboratory, and the dream-lag period, defined as days 5 - 7. Analyses were conducted for these four specific periods so as to accord with previous studies (e.g., Blagrove et al., 2011a). Following Henley-Einion and Blagrove (2014) a median split was used to divide the participants into low and high incorporators. Blagrove et al. (2014) and van Rijn et al. (2015) had shown that the dream-lag is only identifiable for low incorporator participants, in designs that allow for multiple comparisons between each daily log and dream report, possibly due to dilution of timescale effects when some individuals identify large numbers of correspondences. To calculate the median, the total number of correspondences identified by each participant for all reports (daydream and dreams) was computed and divided by the number of reports for that participant. Friedman tests were then conducted to compare rankings of the four time periods for the low and high incorporators separately. If the Friedman test achieved significance, Wilcoxon signed-rank tests were conducted to compare the mean number of incorporations of the 1-2 days period with the mean of the 3-4 days period (to test the day-residue effect) and the mean of the 5-7 days period with the means of the 3-4 and 8-9 days periods (to test the dream-lag effect). The effect size *r* of the Wilcoxon test was computed by dividing the *z*-statistic value by the square root of the total number of observations. Non-parametric tests were used, as in van

Rijn et al. (2015) and Blagrove et al. (2011b), because participants differ in their general levels of ratings of incorporations, and what is important is the relative ranking between the four time-periods for the number of incorporations, on a within-subjects basis. For the data collation and analyses incorporations of references to the sleep laboratory experience were not included in the calculations, as laboratory references can occur due to the contemporaneous laboratory related stimuli and environment occurring during sleep (Blagrove et al., 2011a; Dement, Kahn, & Roffwarg, 1965; Schredl, 2008).

3. Results

One participant did not manage to fall asleep and one participant did not complete the correspondence task; data from these two participants were thus not included in the analyses, resulting in a final sample of 31 participants. The mean SSS score, reported immediately after electrode application, was 3.45 (SD = 1.12), corresponding to *awake, but relaxed; responsive but not fully alert.* The mean times in decimal hours since sleep onset (SSO) for the two types of dreams were: N2 dreams, mean = 3.52 hours SSO (SD = 2.22); REM dreams, mean = 5.00 hours SSO (SD = 1.73).

3.1. Word count

Number of awakenings, number of reports and report length in words are presented in Table 1. The length of each report in words was calculated using Antrobus' (1983) definition: "the count of all words in sentences or phrases in which the subject was describing something that had occurred just before waking. It excluded 'ahs,' 'uhms,' repeated and corrected words, and all commentary on the experience, the report, or the current status of the subject." A Repeated-Measures ANOVA was used to compare the mean number of words for the daydreams, N2 dreams and REM dreams. For participants with two REM dreams, the mean number of words for the two REM dreams was used. There was a significant difference between the number of words of the three types of report ($F(2,46) = 6.91$, $p = .002$). Paired-samples *t*-tests demonstrated that REM dreams were significantly longer than daydreams ($t(28) = 3.91$, $p = .001$) and N2 dreams ($t(24) = 2.37$, $p = .03$). No difference in word length was found between daydreams and N2 dreams ($t(23) = 1.19$, $p = .25$).

Table 1 Number of reports attempted and collected, and mean (SD), minimum and maximum word length of reports as a function of type of dream/daydream report

	Daydreams	N2 dreams	REM dreams
Total number of attempts to collect reports	38	43	52
Total number of reports	30	25	50
Mean (SD) report length in words	84.97 (41.68)**	97.16 (40.43)*	142.38 (94.92)
Minimum report length in words	26	51	17
Maximum report length in words	232	245	718

Note: Compared to REM dreams, ** $p = .001$, * $p = .03$

3.2. Incorporator types

To divide the participants into low and high incorporators, the total number of incorporations for each participant across the 10 diaries for the REM and N2 dreams and daydreams was divided by their number of reports. At the group level, the median number of incorporations per report was 8.33 (minimum = 0.00, maximum = 23.00), and the median split resulted in 16 low (below median) and 15 high (above median) incorporators (one participants scored the median and was added to the low incorporator group). Table 2 presents the means and standard deviations of the number of incorporations of the three daily log categories as a function of daydream, N2 dream and REM dream condition, for the four time periods, for low and high incorporators separately. Note that participants are defined as low and high incorporators on the basis of mean number of incorporations across all reports, and characterisation as low or high incorporator is constant across the three separate report types (daydream, N2 dream, REM dream) in Table 2. However, as some participants did not provide a report for each of the daydream, N2 and REM conditions, the number of participants in the low and high incorporator categories differs across the daydream, N2 and REM conditions.

Table 2. Mean (SD) number of incorporations of waking life experiences in daydreams, N2 dreams and REM dreams for the three daily log categories, for low and high incorporators[a] separately, as a function of time between daily log and (day)dream report[b]

Time between daily log and (day)dream report	Major daily activities		Personally significant events		Major concerns	
Daydreams	*Low*	*High*	*Low*	*High*	*Low*	*High*
1-2 days	0.19 (0.25)	0.93 (0.62)	0.19 (0.25)	0.43 (0.39)	0.22 (0.31)*	0.75 (0.70)
3-4 days	0.34 (0.47)	0.68 (0.46)	0.09 (0.20)	0.39 (0.53)	0.00 (0.00)*	0.57 (0.58)
5-7 days	0.19 (0.24)	0.64 (0.42)	0.10 (0.23)	0.36 (0.38)	0.08 (0.26)	0.55 (0.61)
8-9 days	0.25 (0.48)	0.68 (0.54)	0.13 (0.29)	0.39 (0.45)	0.06 (0.25)	0.43 (0.62)
N2 dreams	*Low*	*High*	*Low*	*High*	*Low*	*High*
1-2 days	0.46 (0.50)	0.50 (0.55)	0.18 (0.25)	0.45 (0.57)	0.07 (0.27)	0.45 (0.35)
3-4 days	0.50 (0.59)	0.50 (0.55)	0.21 (0.43)	0.23 (0.34)	0.11 (0.21)	0.36 (0.39)
5-7 days	0.29 (0.45)	0.61 (0.42)	0.14 (0.28)	0.39 (0.39)	0.10 (0.20)	0.61 (0.25)
8-9 days	0.43 (0.58)	0.86 (0.81)	0.18 (0.25)	0.18 (0.25)	0.21 (0.38)	0.68 (0.56)
REM dreams	*Low*	*High*	*Low*	*High*	*Low*	*High*

1-2 days	0.25 (0.34)	0.64 (0.35)	0.19 (0.21)	0.36 (0.40)	0.05 (0.10)	0.36 (0.42)
3-4 days	0.44 (0.37)	0.88 (0.46)	0.25 (0.32)	0.39 (0.34)	0.19 (0.31)	0.30 (0.33)
5-7 days	0.46 (0.36)*	0.76 (0.61)	0.19 (0.20)	0.36 (0.34)	0.08 (0.19)	0.26 (0.31)
8-9 days	0.17 (0.24)*	0.65 (0.69)	0.13 (0.18)	0.34 (0.32)	0.09 (0.18)	0.38 (0.31)

Note.

[a]Low and high refer to scoring below or above the group median for total number of incorporations identified across all dream and daydream reports and averaged for number of reports.

[b]Total number of incorporations in each daily log category for the 1-2, 3-4 and 8-9 days combined periods are divided by 2, and number of incorporations for the 5-7 days combined period is divided by 3, to obtain the measure of mean incorporations per time period.

*$p < .025$ (Wilcoxon test).

3.3. Daydreams

All 16 low incorporators and 14 out of 15 high incorporators reported a daydream. For the low incorporators there was a significant difference between the mean number of incorporations of MCs across the four combined time periods (Friedman test, $\chi^2(3) = 8.87$, $p = .03$ see Figure 1). The mean number of incorporations for the period 1-2 days was higher than for the period 3-4 days (Wilcoxon test, $z = 2.33$, $p = .02$, $r = 0.58$) demonstrating a day-residue effect for MCs in low incorporators, while no significant differences were found between any of the other time periods. For the high incorporators there was no significant difference between the mean number of incorporations of MCs across the four time periods (Friedman test, $\chi^2(3) = 3.04$, $p = .39$). In addition, there were no significant incorporation differences for PSEs of low (Friedman test, $\chi^2(3) = 4.05$, $p = .26$) or high incorporators (Friedman test, $\chi^2(3) = 0.97$, $p = .81$), nor for MDAs of low (Friedman test, $\chi^2(3) = 1.07$, $p = .78$) or high incorporators (Friedman test, $\chi^2(3) = 2.48$, $p = .48$).

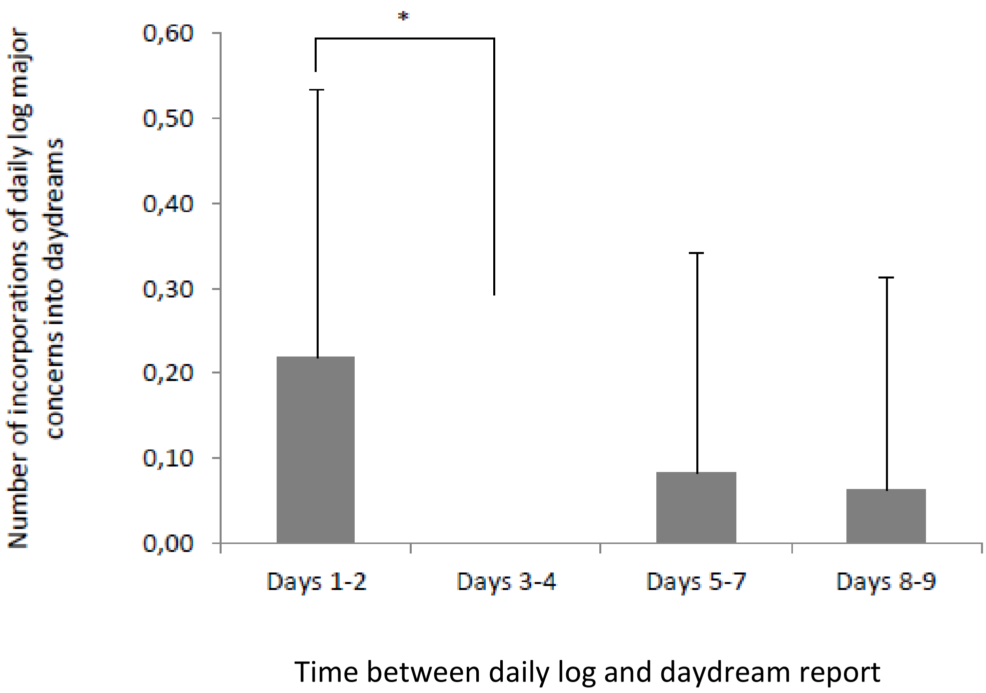

Figure 1. Mean number of incorporations of daily log major concerns into daydream reports for low incorporators. Error bars represent the standard deviation. *$p < .025$ (Wilcoxon test).

3.4. N2 dreams

For N2 dreams, there were 14 out of 16 low incorporators and 11 out of 15 high incorporators with an N2 dream. No significant differences were found between the mean number of incorporations across the four time periods for PSEs of low (Friedman test, $\chi^2(3) = 0.66$, $p = .88$), or high incorporators (Friedman test, $\chi^2(3) = 3.12$, $p = .37$). There were also no significant incorporation time course differences for MDAs of low (Friedman test, $\chi^2(3) = 2.01$, $p = .57$) or high incorporators (Friedman test, $\chi^2(3) = 2.67$, $p = .45$), nor for MCs of low (Friedman test, $\chi^2(3) = 4.07$, $p = .25$) or high incorporators (Friedman test, $\chi^2(3) = 6.28$, $p = .10$).

3.5. REM sleep dreams

The mean number of REM sleep dreams per participant was 1.67 (SD = 0.48). All 16 low incorporators and 14 out of 15 high incorporators had at least one REM dream. For participants who had two REM dreams, the mean number of incorporations for each of the four time periods was calculated. There was a significant incorporation time course difference for MDAs of low incorporators (Friedman test, $\chi^2(3) = 12.41$, $p = .006$), but not for high incorporators (Friedman test, $\chi^2(3) = 2.64$, $p = .45$). For low incorporators, the mean number of incorporations for the period 5-7 days was higher than for the period 8-9 days (Wilcoxon test, $z = 2.59$, $p = .01$, $r = 0.65$). No differences were found between any of the other time periods for MDAs. No significant differences were found between the mean number of incorporations across the four time periods for PSEs of low (Friedman test, $\chi^2(3) = 1.82$, $p = .61$) or high incorporators (Friedman test, $\chi^2(3) = 1.51$, $p = .68$), nor for MCs of low (Friedman test, $\chi^2(3) = 2.13$, $p = .55$) or high incorporators (Friedman test, $\chi^2(3) = 0.82$, $p = .84$).

4. Discussion

The first aim of the present study was to investigate the time course of the incorporation of waking life events and concerns into daydreams, using a prospective daily diary method. To our knowledge this is the first such study. A day-residue effect for incorporation of major concerns into daydreams was found for low incorporators, indicating that for daydreams there is a content selectivity for current concerns from the day itself or from the day before. This is in line with previous research on the content of daydreams (e.g., Andrews-Hanna et al., 2010; Klinger et al., 1980), but extends that work to elucidate the timescale of incorporations. One proposed function of mind wandering is to process current concerns and work through issues when external stimuli do not need attention (Andrews-

Hanna et al., 2010; Antrobus et al., 1966; Fox et al., 2013; Smallwood et al., 2009; Stawarczyk et al., 2011). Mind wandering can therefore be seen as a consequence of directing cognitive resources to process goal- and concern-related information (Stawarczyk et al., 2011, 2013; Christoff et al., 2009). Mind wandering is thus likely to be an adaptive phenomenon (Andrews-Hanna et al., 2010), supported by activation of the default network (Raichle, MacLeod, Snyder, Powers, Gusnard, & Shulman, 2001), during periods of mind wandering (Christoff et al., 2009; Fox et al., 2015).

The second aim of the present study was to assess delayed-incorporation of waking life PSEs and MCs into daydreams. No delayed-incorporation effect for PSEs or MCs was found, whereas delayed incorporation has been found for PSEs in REM dreams in previous research (van Rijn et al., 2015). Daydreams thus have a different time course of incorporation of waking experiences compared to REM sleep dreams, focusing instead on the incorporation of current concerns. The absence of delayed incorporations for daydreams in the current study is unlikely to be due to the length of daydream reports in number of words. The mean number of words for daydreams was approximately 85, and was sufficient for a day-residue effect to be demonstrated. The brain basis for daydreaming has some physiological differences from REM sleep, for example, areas of the executive network most active during waking goal-directed thought are less active during waking rest or mind wandering, and are comparatively quiet during REM sleep (Fox et al., 2013), and it may be that daydreaming does not have the physiological prerequisites for delayed incorporations to occur. Furthermore, if a function of daydreaming is to address and potentially work through current concerns, the reappearance of concerns from the previous 5 – 7 days might be counterproductive as these concerns might not be relevant or salient enough (anymore) to require processing through mind wandering. A further important theoretical consequence here is that the REM sleep dream-lag effect appears thus not to be a consequence of a general higher availability in waking life of memories from 5-7 days previously, the current study thus does indicate against that speculative non-functional explanation for the dream-lag effect.

The final aim of the present study was to replicate findings that the dream-lag effect holds for REM dreams, but not for N2 dreams. No dream-lag effect was found for dreams from stage N2 sleep in this study, which accords with Blagrove et al. (2011a). Though N2 sleep has been found to be involved in at least some aspects of memory consolidation (Ruch et al., 2012), the absence of the dream-lag effect in this sleep stage might be evidence that any memory processing functions of N2 differ from those of REM sleep, if the REM sleep dream-lag effect indeed reflects memory consolidation processes. The present study, however, did not replicate the REM sleep dream-lag effect. This failure to replicate might be due to the total number of awakenings and dream reports collected. In the present study, only one or two REM sleep dream reports were collected per participant, whereas, for example, in Blagrove et al. (2011a) and in the home awakenings studies of van Rijn et al. (2015), dream reports were collected from several or even all REM periods during the night. Some previous studies examining the dream-lag have used a small number of dreams for the crucial comparisons, but these were spontaneous or end of night home awakening reports which would predominantly have resulted in a final, long REM dream of the night (e.g., Nielsen & Powell, 1989, Powell, Nielsen, Cheung, & Cervenka, 1995). Furthermore, Nielsen et al. (2004) excluded dreams with a low memory confidence score. The current design may thus have a limitation of the number of REM dreams reported per participant.

A further design difference here, in comparison to previous dream-lag studies, is that participants in the present study discussed and clarified the content of their daydream, N2 dream and most REM dream reports during discussions taking place in the laboratory during the week after report collection. The correspondence task was completed after these discussions. The aim of these discussions was to assess insight and personal realizations through the consideration of the reports (see Blagrove et al., 2016). The dream and daydream reports used to identify correspondences included any amendments made during the discussions. Though the discussions were not aimed specifically at the content reported in the daily logs, waking life events noted in the logs may have come up during the discussion sessions. Discussing these events may have affected the scoring of incorporations in the present study.

Though there is considerable evidence for the dream-lag effect (Blagrove et al., 2011a; Blagrove et al., 2011b; Blagrove et al., 2014; Nielsen & Powell, 1989; Nielsen et al., 2004; Powell et al., 1995; van Rijn et al., 2015), there are also studies that find limited evidence (Nielsen & Powell, 1992) or that do not find the effect at all (Henley-Einion & Blagrove, 2014; Schredl, 2006). Despite methodological and sample size differences between previous research into the dream-lag and the present study, it is important to consider the possibility that the current non-replication shows that the dream-lag effect does not exist, and instead that waking life events gradually disappear from dreams across consecutive nights (Botman & Crovitz, 1989; Schredl, 2006). Alternatively, the results of the REM condition may indicate a caution that designs should include several REM dreams per participant for the effect to be evidenced. The daydream results from the present study suggest that the dream-lag effect, if true, is not due to a greater availability in waking life of memories from 5-7 days previously. The daydream results are further differentiated from previous research on the time course of incorporation of daytime experiences into dreams, in that a day-residue effect for major concerns was found, but not for personally significant events.

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