EFFECTS OF SLEEP RESTRICTION ON SOCIAL CONTAGION OF EMOTIONAL MEMORY

by

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ABSTRACT

The amount of sleep that one gets affects their emotional perception, emotional learning and memory, and interactions with others. The current research study examines the effects of sleep restriction on the social contagion of emotional memory. Participants first came to the lab to complete a series of questionnaires to determine eligibility, collect demographics, and to be trained on how to use the sleep watches and sleep diaries for a week of sleep monitoring. Participants completed one week of sleep monitoring using sleep diaries and actigraphy, and then were randomly assigned to either one night of either adequate sleep (8h) or restricted sleep (4h) before returning to the lab. Then, participants learned and recalled a series of emotional images alongside a confederate who recalled both correct and incorrect images. On later individual recall tests, participants were equally likely to incorporate the negative, positive, and neutral images suggested by the confederate, but on recognition tests, social contagion effects were larger for the negative and positive images. Additionally, our findings support a negativity bias in memory on both recall and recognition tests. There was no significant effect of sleep restriction. The results of this study are consistent with source monitoring theories of memory and have important implications for understanding how sleep influences social emotional memory.

INTRODUCTION

Sleep is a basic human need, but over 35% of Americans do not get enough sleep (CDC, 2020). This is important because sleep can influence how we learn and remember. Previous research investigating sleep suggests that restricting sleep before encoding (or learning) influences memory for emotional stimuli (Cunningham et al., 2022). However, little is known about how retrieval factors might influence the relationship between sleep and emotional memory. Conversely, cognitive and social psychology have thoroughly evaluated the importance of retrieval, including the role of social factors on memory performance. Previous research suggests that social factors (such as remembering in collaboration with other people) may disrupt memory, causing individuals to remember false information suggested by others; this is known as the social contagion of memory (Roediger, et al., 2001). The purpose of the current study is to examine how sleep influences the magnitude of the social contagion effect for emotional stimuli.

Social Contagion of Memory

The social contagion of memory literature suggests that remembering with inaccurate partners can be disruptive to individual memory because individuals later remember their partners' errors (Roediger, et al., 2001; see Meade, et al., 2023 for review). For example, Meade and Roediger (2002) asked participants to recall household scenes in collaboration with a confederate, who introduced both accurate and inaccurate items. On subsequent individual memory tests, participants incorporated the confederate's misleading suggestions into their recall, demonstrating social contagion. Further, on a final source monitoring recognition test, participants were asked to identify the source of each item within the duration of the experiment.

Participants attributed the source of the contagion items as having occurred in the original scenes, demonstrating that social contagion influences memory above and beyond bias.

Social contagion errors can be explained by source monitoring theory (Johnson et al., 1993). Source monitoring theory asserts that when learning information, participants encode the information itself plus additional memory characteristics associated with the information. At retrieval, participants can use memory characteristics to help determine the source of the information. Source monitoring theory also states that response criteria can influence source judgements. That is, participants may require more or less evidence to attribute information to a particular source. In terms of the social contagion of memory, the memory characteristics associated with the false information (e.g., the other person's voice) may be misleading because participants correctly remember talking about the item in the context of the experiment, but they misattribute the item to having occurred in the original presentation.

The magnitude of the social contagion of memory has been extensively investigated across many different situations. For example, there are greater social contagion effects with faster presentation rates of the false information (Roediger et al., 2001), when recall is delayed by two weeks compared to two days from the original exposure to the false information (Paterson, et al., 2009), and when the false information is presented by an in-group partner rather than an out-group partner (Andrews & Rapp, 2014). Further, social contagion persists even when participants are given additional study periods for the correct information (McNabb & Meade, 2014), when participants are told prior to the group recall that their partner is not reliable (e.g., Echterhoff et al., 2005), and when participants are allowed to test their knowledge of the learned material prior to recalling with the misleading confederate (Huff et al., 2013). Taken together,

these findings support the social contagion of memory as a robust memory phenomenon that is influenced by a variety of factors that influence the memory characteristics associated with the contagion items and/or the response criterion of the participants. However, limited previous research has investigated the effects of emotion and sleep on the social contagion of memory phenomenon. In the current study, we extend the research on social contagion to examine if the magnitude of the effect differs across emotional and neutral information. Further, we are interested in how sleep restriction influences social contagion for emotional materials.

Social Contagion of Memory and Emotion

To our knowledge, only one study has investigated the effects of social contagion on emotional memory. Using emotional images fitted into semantic categories, Kensinger et al., (2016) had participants learn images, then after a two-day delay participants recalled the images alone or with a virtual confederate who provided 0-2 contagion items for every category recalled. Participants then completed an individual recognition test. They found smaller social contagion effects for emotional images relative to neutral images (there were no differences in the social contagion effect across positive and negative images). This suggests that emotion does influence social contagion.

Importantly, however, the methods and analyses used in Kensinger et al., 2016 varied from the typical social contagion paradigm. Specifically, they used a between-subjects manipulation of social contagion so that half of the participants completed the recall test alone and half of the participants recalled with a confederate who provided false information for some of the studied categories. Using a between -subject design not only reduces power, but it is less realistic to recall and share information with someone who is always correct. Moreover, they

included a 2-day delay between study and test. Finally, Kensinger et al., 2016 only analyzed recognition memory (i.e., whether an item was an old or new item), and it is unknown if their results generalize to recall or source recognition (i.e., where in the experiment an item appeared).

In the current experiment, we aim to further examine the role of emotion on the social contagion of memory. We manipulate contagion within subjects, and we rely on immediate tests of recall and source recognition to be consistent with the paradigm used in the majority of social contagion studies. Further, we extend this literature to examine the role of sleep. Do sleep-restricted and well-rested individuals differ in how likely they are to incorporate emotional misinformation from others?

Sleep and Emotional Memory

Current research shows that people who are sleep deprived are more likely to remember negative stimuli than they are to remember neutral or positive stimuli (Cunningham et al., 2022; Kaida et al., 2015). For example, Tempesta et al. (2015) presented participants with negative, positive, and neutral film clips. Half of the participants were sleep deprived (no sleep for a night) and half were well-rested (full eight hours of sleep). They found that the sleep deprived participants showed worse memory overall, but this was driven by differences in positive and neutral memory. The sleep deprived participants did not differ from well-rested participants for negative film clips. This pattern of results (sleep impairs positive and neutral memory, but not negative memory) is referred to as the negativity bias.

In a recent review, Cunningham et al. (2022) concluded that the negativity bias is most likely to occur when sleep is manipulated prior to encoding the emotional materials (sleep is disrupted before individuals see the materials for the first time, rather than later in the memory

process). However, there are relatively few studies examining the negativity bias and sleep and the evidence is somewhat mixed. As one example, in a sample of male participants, Kaida et al., (2015) manipulated whether participants underwent total sleep deprivation (TSD), disruption of rapid eye movement (REM) sleep using a sleep fragmentation paradigm, or well rested prior to learning different emotional scenes. All participants took an immediate recognition test for half of the learned scenes, and then they all returned a week later for another recognition test for the remaining half of the learned scenes. They found that TSD participants showed no negativity bias (they had overall poorer recognition memory performance than well rested participants across all emotion conditions). However, the REM disrupted participants initially remembered more negative images but fewer negative images on the later recognition test.

One possible explanation for the negativity bias is that sleep influences emotional reactivity and emotion regulation (Palmer & Alfano, 2017: see Palmer, et al., 2023 for review). Palmer and Alfano (2017) outline the many processes that influence reactivity and emotion regulation before, during, and after an emotional experience. Especially relevant to the current study, sleep restriction may influence attention to emotional stimuli, which may then lead to more salient memories for negative stimuli. For example, Cote et al. (2015) found that sleep deprived participants had a harder time directing their attention away from negative stimuli. Increased attention to negative stimuli should have carryover effects in how likely participants are to later remember the stimulus. However, further research is necessary to understand this relationship between sleep loss and emotional experiences because past research has produced mixed results where sometimes sleep deprivation can cause an amplified emotional reaction and, at other times, a dampened reaction (Deliens, et al., 2014; Baran et al., 2012).

Notably, most negativity bias studies rely on total sleep deprivation paradigms. Total sleep deprivation is characterized when participants are kept awake for the complete duration of the night (Wilkens, et al., 2015). In the current study, we extend this research to examine the effects of sleep restriction on the negativity bias. Sleep restriction occurs when participants sleep for less than six hours of sleep in a night (Wilkens, et al., 2015). Understanding the impact of sleep restriction on the negativity bias is important because it is more common in our everyday experience to experience sleep restriction (not receiving adequate amounts of sleep) than sleep deprivation (not receiving any sleep). To our knowledge, there are no studies examining sleep restriction prior to encoding on the negativity bias; however, existing evidence suggests sleep restriction broadly impacts cognition. For example, in their meta-analytic review, Wickens et al. (2015) analyzed the effects of three sleep disruption types (i.e., total sleep deprivation, sleep restriction, etc.) on an array of cognitive functions, such as attention and long-term memory. They found that disruptive sleep had larger negative effects on complex cognitive tasks (e.g., decision making, multi-tasking, etc.) rather than simple cognitive tasks (e.g., declarative knowledge tasks, etc.). However, these studies are focused broadly on cognition and do not address affective memory specifically. Given that sleep restriction does influence cognition, we expect similar effects will extend to emotional memory tasks, and that we will find negativity bias with sleep restriction in the current study.

Regarding false memory, we know of no research that has examined the negativity bias on false memory. However, source monitoring theory suggests that emotion could influence memory characteristics. Specifically, affective stimuli may elicit emotion-based memory characteristics that are absent from neutral stimuli. To the extent that sleep restricted participants

are paying more attention to the negative stimuli (e.g., Cote et al., 2015), these emotional memory characteristics might be especially salient and useful in determining source for negative information. Additionally, sleep restriction could influence response criterion; sleep restricted individuals may recognize that their overall memory is poor and be more to willing accept related, false information from an outside source. Together, this suggests that sleep restricted individuals should show less false memory for negative information. This hypothesis is further consistent with the wider false memory literature that shows false memory is generally lower when veridical memory is higher (cf. Gallo, 2004; Roediger, et al., 2001).

Sleep and Social Processing

Past sleep research has primarily focused on individual memory, and little research has examined negativity bias in social memory paradigms. In individual memory paradigms, participants learn, practice, and recall the learned information all on their own. This means that participants can only use the material and their own subjective experience as a reference during their recall period. Conversely, in a social memory paradigm, participants may study on their own, but then practice and/or recall with another participant. This now allows the participant to not only use their own subjective experience, but also the other person's memory is now an additional cue for their final recall, regardless of the validity of the other person's memory.

Sleep has profound effects on social interactions (e.g., Palmer et al., 2023; see Gordon et al., 2021 for review). For example, Gordon et al., (2021) reviewed research investigating the role of sleep quality across different relationship types (e.g., peer relations in adolescents, romantic relations, work relations). Specifically, adults reported higher rates of sleep disturbances on days when they experienced more negative, hostile interactions with others (Brissette & Cohen,

2002). Other studies found that perceived loneliness (i.e., the notion that someone is disconnected from others) was a strong predictor for poor sleep in older adults (Yu, et al., 2018) and Native Americans (John-Henderson et al., 2019). Taken together, these data signal that sleep is related to more negative social interactions, less perceived support, and lower productivity. Importantly, there is also more causal evidence that experimentally induced sleep restriction reduces motivation to connect with others (Palmer et al., 2023). However, none of these studies have examined the impact of sleep restriction on social memory performance.

Current Study

Overall, little research has investigated whether the memory effects of social contagion extend to emotional memory, and to our knowledge, no research has considered how sleep influences emotional memory in social settings. In the present study, we directly compare the magnitude of emotional social contagion effects across well-rested and sleep restricted participants. We rely on an emotional social contagion paradigm to elicit differences in social contagion for negative and positive stimuli, relative to neutral (Kensinger et al., 2016), and we utilize a sleep restriction procedure that has been shown to influence cognitive performance (e.g. Wickens, et al., 2015). Our primary interest is whether sleep restriction influences the pattern of the social contagion effect across emotional valence.

Based off prior cognitive and sleep research, we make three main hypotheses: **first**: for correct recall, sleep restricted participants will express a negativity bias, specifically, they will have the most accurate memory for the negative images over the positive and neutral images; **second**: for false recall, or social contagion, sleep restricted participants will be more susceptible to positive and neutral contagion items than negative items; while well-rested participants will be

less susceptible to positive and negative stimuli contagion effects compared to neutral stimuli, replicating Kensinger, et al., (2016); and **third**: for source monitoring recognition, well-rested participants will have better source monitoring for positive and neutral images than sleep restricted participants.

METHODS & METHODOLOGY

Participants

Sample size was determined by consulting past research and computing a power analysis. Kensinger et al., (2016) reported an effect size of .17 for correct recognition, and .22 for social contagion. Using the more conservative estimate (partial $\eta^2 = .17$), we computed a power analysis using MorePower (Campbell & Thompson, 2012). To achieve .90 power, using a 2x3x2 mixed factorial design, we would need a sample size of 36 participants. However, 36 participants is smaller than what is typically used in past research. Specifically, Kensinger et al. (2016) recruited 48 participants, and sleep deprivation research typically includes 40-46 participants (Cunningham, et al., 2022). Sleep deprivation effects are likely stronger than the sleep restriction effects in the current study, and so we rounded up for a final sample size of 72.The final sample size of 72 allowed for an equal distribution throughout the counterbalanced conditions for all of our variables.

Seventy eight participants were recruited through Montana State University's SONA pool and psychological courses, in exchange for partial course credit. Twenty five participants were deemed ineligible to participate in the full study (Seventeen participants were ineligible due high scores on the Pittsburgh Sleep Quality Index. One participant was ineligible due to high scores on the Epworth Sleepiness Scale and the Composite Morningness Scale. Two participants were ineligible due to a physical condition, both with asthma. One participant was ineligible due to medication, Lexapro, which can affect sleep. Two participants were ineligible due to psychiatric diagnoses or could not schedule a part two of the study. Two participants were unable to run the social contagion portion of the experiment due to late arrivals). These 25 participants did not

complete the experiment. Six participants started the current experiment at the start of the writing process of this thesis, but are not included in any reported analyses and will not be discussed further. Of those participants who did complete the entire experiment, five participants did not follow the sleep manipulation: two participants were instructed to sleep only four hours but actigraphy data showed that they slept 6 or more hours, and 3 participants were instructed to sleep for eight hours but actigraphy data showed that they slept less than 6 hours. This was confirmed with the actigraphy data and the completed morning and night diary when applicable. Thus, 42 participants (21 Females, *M age* = 19.40, *SD* =1.66) are analyzed for this current study. Data collection is in progress and will continue until the total sample size of 72 participants is achieved.

Design

The current study uses a 2 (Sleep: 8 hour sleep opportunity or 4 hour sleep opportunity, between-subject) X 2 (Social Contagion: contagion or control, within-subject) X 3 (Emotional Affect: positive, negative, or neutral, within-subject) mixed factorial design. The primary dependent variables include correct recall, false recall, and correct and false recognition on the source monitoring test.

Materials

Intake Materials

To participate in the current experiment, participants must complete a series of questionnaires to establish that participants have relatively healthy sleep and ensure that participation in the current study does not inflict health risks to the participant. The following

questionnaires were referenced to determine eligibility prior to participation. Complete copies of all questionnaires are available in Appendix A.

Health History. The health history questionnaire ensures that participants do not have any of the following: self-reported diagnosed sleep disorder, currently on any medications that affect their sleep, have chronic illness, or currently pregnant.

Epworth Sleepiness Scale (ESS). The ESS is an 8-item questionnaire that assesses how likely participants are to fall asleep while performing normal tasks for leisure (e.g., reading, watching TV, etc.,) (Johns, 1991). Participants were given a series of activities and asked to rate how likely they are to fall asleep while partaking in these activities on a scale of 0 to 3. A score greater than 10 made a participant ineligible to move forward with the experiment.

Pittsburgh Sleep Quality Index (PSQI). The PSQI is a 10-item questionnaire that assesses participants on their typical sleep patterns, sleep duration, and numerous scales to self-report their sleep quality (Buysse, et al.,1989). Scores were re-coded in accordance with the PSQI scoring and total scores higher than five were ineligible to move forward with the experiment.

Composite Morningness Scale. The Composite Morningness scale is a 13-item questionnaire (ranging from 4 to 5 options) that assesses participants' morning activities, morning affect and eveningness (Pornpitakpan, 1998). Participants in the intermediate range (a score between 22 and 44) to be eligible. Participants with scores lower than 22 or higher than 44 were ineligible to move forward with the experiment.

Additional questionnaires were completed via Qualtrics once participants completed the preceding questionnaires by hand. These data from Qualtrics were used in post-hoc analyses (conducted at the end of the entire study) to inform the characteristics of each group (i.e., sleep

restricted participants and well-rested participants). The additional questionnaires: State Trait Anxiety Inventory (measures state and trait anxiety while distinguishing symptoms from depression, Spielberger, 1983); Personal Health Questionnaire Depression Scale ("PHQ-8"; measures current state of depression, Kroenke, 2008); Positive and Negative Affect Schedule – Serenity Subscale ("PANAS-X "; measures current mood and emotion, David & Clark, 1994); Modified Alcohol, Smoking, and Substance Involvement Screening Test ("NM-ASSIST"; screens for alcohol and drug use, Group 2002).

Sleep Monitoring

Participants used Philips Actigraphy watches to monitor their sleep at home (Actiwatch 2; Philips Respironics, Bend, OR). Additionally, participants completed daily diaries in the morning and night. These diaries are taken from the National Sleep Foundation (NSF). The morning diary contains 7 questions asking about the participants sleep and mood when falling asleep and waking up. The nighttime diary contains 8 questions asking about their activity throughout the day (e.g., exercise, mood, etc.). See Appendix B for complete diaries.

Social Contagion Materials

Emotional Images. Emotional stimuli included 108 images that were selected from the International Affective Picture System (IAPS) (Lang, et al., 1998;2006) and from Kensinger, et al., (2016). Images were selected to fit into semantic categories of positive, negative, and neutral affect. There are a total of 12 categories, four categories for each affect. Each category included 9 study items and 3 contagion items.

To test the emotional affect and arousal for the images, pilot data was collected on 143 images (11-12 images per category). Fifty MSU students (25 Female, $M = 18.78$, $SD = 1.26$)

completed pilot testing via Qualtrics. Participants received partial course credit for their participation. Participants viewed each image and used the Self-Assessment Manikin (SAM) scales to make judgements on affect and arousal (Gatti, et al., 2018). For affect, participants were given 9-item scale to rate how each image makes them feel, with 1 being the most happy/positive and 9 being the most sad/negative. For arousal, participants were given a 9-item scale to rate how excited the image makes them feel, with 1 being the most excited and 9 being no excitement at all. Image presentation and judgements were self-paced.

Affect results from this pilot testing are depicted in Figure 1. Significance testing revealed that positive images were rated as significantly more positive than negative and neutral images ($t(49) = 15.82$ $p < .001$; $t(49) = 14.67$ $p < .001$, respectively), and negative images were rated as significantly more negative than positive and neutral images ($t(49) = 6.53$; $p < .001$). Arousal results from this pilot testing are depicted in Figure 2. Arousal ratings were not significantly different across positive and negative images ($t(49) = 0.13$; $p = .450$); however, arousal ratings were significantly higher for positive and negative images compared to the neutral images ($t(49) = 10.17$ $p < .001$; $t(49) = 9.79$ $p < .001$, respectively).

Figure 1. Mean Ratings as a Function of Affect (N = 50).

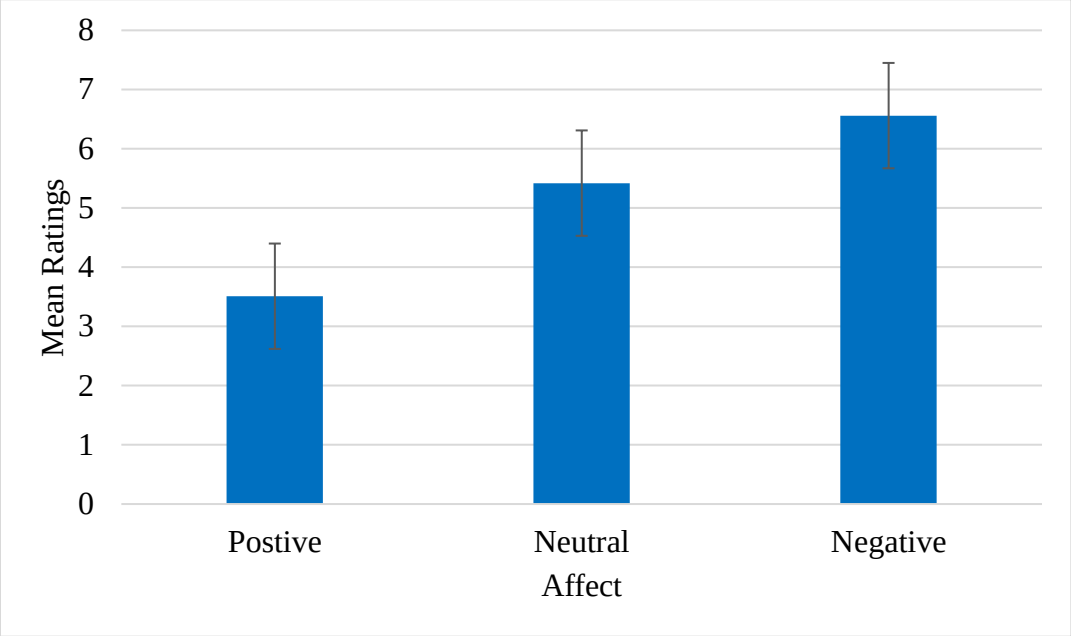
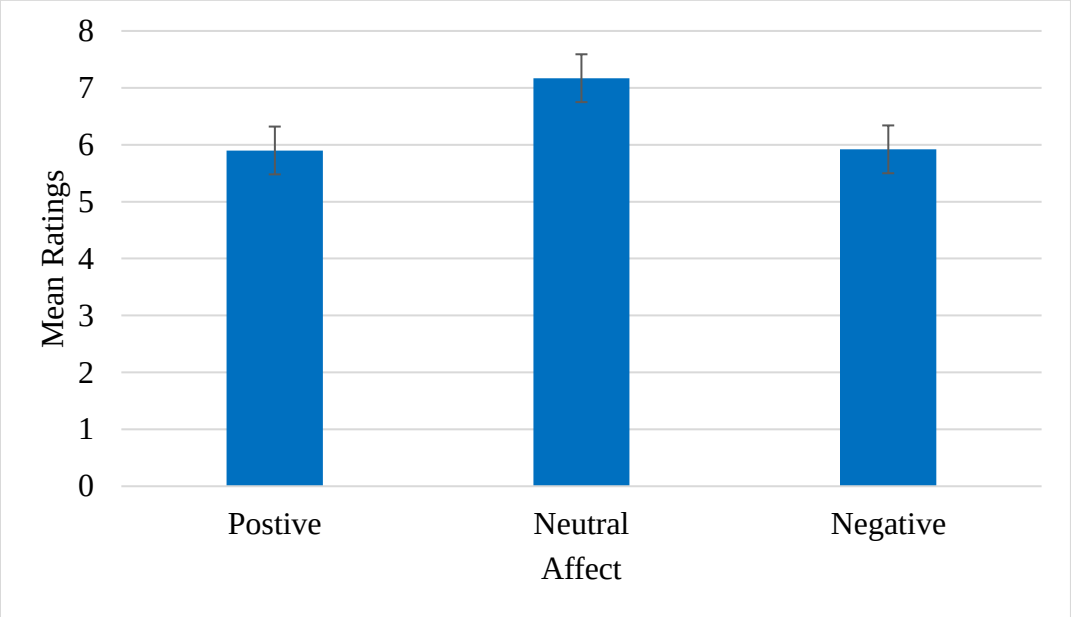


Figure 2. Mean Ratings as a Function of Arousal (N = 50).



Note. The rating scale for arousal is reverse coded, meaning that the higher the rating the less arousing the reaction.

Additionally, images were shown with word labels (e.g., an image of a Ferris wheel was labelled underneath as “Ferris Wheel”). An additional analysis was done to ensure that the image

labels were matched on lexical characteristics across affect and categories using the English Lexicon Project (ELP) (Balota, et al., 2007). The ELP revealed no difference in image labels on word length, frequency, or log frequency ($F's < 1.0, p's > .05$).

Source Monitoring. The source monitoring test included 96 items (48 studied items, 36 contagion items, 12 new). Four studied items were chosen randomly from each category, and all three contagion items from each category were included. Finally, 12 new items were selected at random, with no semantic overlap to the categories studied.

Experimental Questionnaires. The first questionnaire given during the experiment is the Karolinska Sleepiness Scale (KSS) which is a single item questionnaire used to determine the alertness of participants (Kaida et al., 2006). The KSS was followed up with four additional questions which accessed participants' feelings of sleepiness, fatigue, and anything that could have disrupted their sleep from the night prior. The second questionnaire was a post-experimental questionnaire that asked participants metacognitive questions to rate their own and their partner's memory, effort, and how helpful it was to work with a partner. All the questions had the same rating scale ranging from 1 (*lowest or least favorable*) to 5 (*highest or most favorable*). See Appendix C for full questionnaires.

Procedure

This experiment consisted of three main parts: Intake Process, Sleep Monitoring, and Social Contagion Paradigm. The procedure described is in accordance with Montana State University's IRB ethics procedure.

Intake Process

Participants arrived at the lab for time 1 to fill out a series of sleep health and mental health questionnaires. These questionnaires were filled out by the participants individually with up to five other participants in the room. Participants filled out a portion of the questionnaires (e.g., a health history, ESS, PSQI, Composite Morningness Scale) by hand and finished the remaining questionnaires on their mobile phone via Qualtrics. These additional questionnaires addressed general demographics, alcohol and substance use, and mental health. Those participants who are not eligible to participate were awarded partial credit and did not participate further. Those eligible continued to the experiment's Sleep Monitoring and Social Contagion portions.

Sleep Monitoring

Sleep was monitored for one week using an actigraph watch. Participants were instructed to press the button on the watch once at night when they are starting to try to go to bed and again in the morning right when they wake up. The first six nights were used to monitor the participants' normal sleep pattern to establish a baseline. On the seventh night, participants were sent a text informing them if they were in the well-rested condition and instructed to sleep from 11pm to 7am, or the sleep restricted condition and instructed to sleep from 3am to 7am. There was a 50/50 chance, which was randomly assigned, that participants will be in the sleep restriction condition or well-rested condition. Throughout the week of sleep monitoring and the sleep manipulation night, participants were required to fill out the NSF's morning and night sleep diaries via Qualtrics. All participants were asked to refrain from any caffeine or driving the

morning of returning to the lab, but they were allowed to partake in their typical morning routine (i.e., eating breakfast, working out, etc.).

Social Contagion Paradigm

Participants returned to the lab one week following their intake, and the morning following the night of sleep manipulation. All memory tests took place between 9am and 12pm. Participants were directed to the front computer and the confederate sat at the back computer. Once seated, participants completed the Karolinska Sleepiness Scale (KSS). This was done to ensure that sleep restricted participants are more tired than the well-rested participants the morning of the experiment. Then, participants began the study phase, and learned the images from the computer screens in front of them. The images were blocked by category and counterbalanced by affect. The category name was displayed followed by all the respective category images. The experimenter verbally announced the progression of categories. Images were presented against a black background, with the image name at the bottom of the image in a white font. Each image was displayed for 5 seconds with a 1 second interstimulus interval (ISI). Participants were instructed to pay attention to the images for the entire time that the image was presented on the screen because their memory for the images will be tested later. Additionally, participants were told to pay attention to their emotions to the images as some may elicit an emotional response and others may seem relatively neutral. This was done to elicit a bottom-up processing to focus participants towards their emotional reaction to the images, rather than, a top-down process to focus participants on the subject of the image, which was done by Kensinger, et al., 2016.

Once all the categories were presented, the participant and confederate were given a four-minute distractor task consisting of mathematical problems.

Next, participants had a group recall with the confederate. The experimenter announced the categories in the same order as the studied presentation. The participant and the confederate took turns verbally recalling items from each category until a total of six words per category is recalled. The experimenter recorded by hand each response. The confederate provided 3 false items for half of the categories, and they provided 3 correct items for the other half of the categories. The categories with false items were counter balanced.

Following the group recall, the experimenter explained that for the individual recall the participant and the confederate were to be separated and then escorted the confederate out of the room. Once the experimenter returned to the room with the participant, they began the individual recall test. Participants were given sheets of paper with the category listed at the top and given one minute and 30 seconds to recall as many items as possible. For every item recalled, participants were instructed to give a confidence judgement, based on how confident they were that the item was part of the originally studied images. Confidence judgements were made using a scale of 1 to 3, 1 being slightly confident; 2 being fairly confident; 3 being extremely confident. Note the confidence ratings are not reported in this thesis because data analysis is on-going. This was repeated until all 12 categories were recalled, following the same order that the categories were initially presented and studied.

Next, participants completed a self-timed source monitoring task. Participants were given a list of 96 words and asked where in the experiment, if anywhere, did the item appear. They were given four options: “Image”, meaning that it was a studied item, “Self”, meaning that they,

the participant, recalled the item during the group recall, “Other Subject”, meaning that the other participant recalled the item during the group recall, or "Neither”, meaning the item is new and appeared nowhere in the experiment. Participants were told to choose the most appropriate option and that they could choose multiple options. For example, if the item was studied, and the other participant recalled the item in the group recall, they should mark down both “Image” and “Other Subject”.

Finally, participants completed the KSS once more. The Karolinska Sleepiness Scale (see Appendix C) is done before and after the memory manipulations to ensure sleep restricted individuals are more tired than the well-rested participants at the start of the experiment, and to track changes in sleepiness during the experiment. Additionally, participants completed a post-experiment questionnaire (see Appendix C) that assesses their thoughts on both their personal performance and the performance of the “Other Participant”, the confederate. Participant data for the KSS, taken at the beginning of and at the end of the experiment, and the post-experiment questionnaire are shown in *Table 3* and *Table 4*, respectively.

Debriefing

Participants were given a manipulation check, in which the experimenter asked the participant “What do you think we were trying to do today?” or “What do you think we were researching today?”, and then participants were debriefed and informed of the use of a confederate, they were given a sleep recovery form, MSU counseling information, and a debriefing form.

RESULTS

Results are reported for 42 participants. Please note that data collection is on-going and the current analyses are underpowered and should be considered with caution. This section will review the statistical findings that can be concluded from the current study which tested our three main hypotheses: **first**: for correct recall, sleep restricted participants will express a negativity bias, specifically, they will have the best memory for the negative images over the positive and neutral images; **second**: for false recall, or social contagion, sleep restricted participants will be more susceptible to positive and neutral contagion items than negative items; while, well-rested participants will be less susceptible to positive and negative stimuli contagion effects compared to neutral stimuli, replicating Kensinger, et al., (2016) findings; and **third**: for source monitoring recognition, well-rested participants will have better source monitoring for positive and neutral images than sleep restricted participants.

Sleep Analyses

Self-Report Measures

All participants took a series of tests to measure their health and sleep habits. See *Table 1* for means and standard deviations for each measure by sleep condition. T-tests were conducted to test for any differences between the sleep restricted and well-rested participants. There were no differences in any of the following measures: Pittsburgh Sleep Quality Index (PSQI), $t(40) = 1.01$, $p = 0.32$; Epworth Sleepiness Scale (ESS), $t(40) = 1.38$, $p = 0.18$; Composite Morningness Scale (CMS), $t(40) = 0.42$, $p = 0.68$; Trait Anxiety (TRAIT), $t(40) = 1.22$, $p = 0.23$; Patient Health Questionnaire-8 (PHQ), $t(40) = 0.11$, $p = 0.91$; Positive Affect (PA), $t(40) = 1.46$, $p =$

0.15; Negative Affect (NA), $t(40) = 1.30$, $p = 0.20$; Substance Use (DrugUse), $t(40) = 1.35$, $p = 0.19$. There were two measures in which we observed significant differences. First, well-rested participants scored significantly higher than sleep restricted participants on the State Anxiety (STATE) scale, $t(40) = 2.50$, $p = 0.02$. Second, well-rested participants scored significantly lower than sleep restricted participants on the Serenity scale, $t(40) = 0.32$, $p = 0.008$. Both of these questionnaires were given at intake prior to the sleep manipulation.

Table 1. Participant Demographic Data as a Function of Sleep Condition (N =42).

	Mean (SD)	
	Sleep Restricted (N = 20)	Well Rested (N =22)
PSQI	4.65 (1.46)	4.14 (1.81)
ESS	5.80 (2.44)	6.86 (2.55)
CMS	34.95 (6.15)	34.23 (5.00)
STATE*	32.50 (5.84)	38.59 (9.36)
TRAIT	36.50 (7.67)	39.64 (8.82)
PHQ-8	11.40 (2.39)	11.32 (2.38)
PA	36.30 (6.15)	33.41 (6.65)
NA	15.70 (3.99)	17.45 (4.68)
Serenity*	11.30 (2.20)	9.18 (2.67)
Drug Use	15.25 (2.57)	14.32 (1.89)

Note. *p < 0.05.

Actigraphy Data

Actigraphy data are presented in *Table 2.* The actigraphy watches collected light (i.e., the white light present in the room throughout the data collection period) and movement data (i.e., the movement of the participants while they wear the watch on their wrist), along with participant-initiated event markers. Accelerometer movement data is then used to estimate sleep-wake patterns, including total sleep time, which is the amount of time spent asleep, sleep onset latency, which is the amount of time that it takes to fall asleep, sleep efficiency, which is the

percentage of time in bed spent asleep, wake after sleep onset (WASO), which is the amount of time awake after going to sleep (i.e., if a participant woke up in the middle of the night), and number of awakenings, the amount of times a participant awakes throughout the night after going to sleep for more than five minutes. These measures are reported for a total of seven days and nights. The first six days of monitoring act as a baseline in which participants sleep their normal sleep patterns. The seventh night is the sleep manipulation, in which participants slept four or eight hours as instructed by the experimenter.

Of the 42 participants, actigraphy data was only recorded for 15 participants due to technical issues. For the 15 participants with the logged data, participants in the sleep restricted group (N= 7) and the well-rested group (N = 8) showed no difference in baseline total sleep time, $t(13) = 0.29$, $p = 0.77$; onset latency, $t(13) = 1.48$, $p = 0.16$; Sleep efficiency, $t(13) = 0.89$, $p = 0.2$; WASO, $t(13) = 0.09$, $p = 0.93$; Number of awakenings $t(13) = 0.50$, $p = 0.63$. For the manipulation night participants in the sleep restriction group and the well-rested groups were matched in Onset Latency, $t(13) = 0.98$, $p = 0.35$; Sleep Efficiency, $t(13) = 1.18$, $p = 0.13$; WASO, $t(13) = 0.48$, $p = 0.32$; Number of Awakenings, $t(13) = 2.13$, $p = 0.05$. However, for the manipulation night there was a significant difference in total sleep time, such that sleep restricted participants slept significantly less than the well-rested participants, $t(13) = 7.73$, $p < 0.001$.

For the remaining participants (those with no actigraphy data), we used their self-reported time of sleep in their sleep diaries to compare their baseline (the first six days of recording) to their manipulation night (the night before returning to the lab). This accounted for 25 participants for their baseline (12 sleep restricted and 13 well-rested), and 20 participants for their night of manipulation (9 sleep restricted and 11 well-rested). There were two remaining participants (one

sleep restricted and one well-rested participant) who did not have recorded actigraphy data or completed sleep diary data. At baseline, there were no significant differences between the sleep restricted participants (M =8.13, SD = 0.63) and the well-rested participants (M = 7.98, SD = 1.11), $t(23) = 0.38$, $p = 0.70$. However, for the manipulation night there was a significant difference between sleep restricted participants (M = 4.04, SD = 0.10) and the well-rested participants (M = 8.01, SD = 0.66), $t(18) = 17.95$, $p < 0.001$.

Importantly, having no differences in participants baseline sleep activity, both actigraphy data and sleep diary data, ensures that there are no pre-existing sleep issues which can influence the current data findings outside of our sleep manipulation. Additionally, having no differences across participants on the night of the manipulation except for their total sleep time, ensures that any differences observed are due to our sleep manipulation.

Table 2. Participant Actigraphy Data as a Function of Sleep Condition (N = 15).

		Mean (SD)	
		Sleep Restricted	Well Rested
Manipulation Night	Total Sleep Time*	274.71 (43.77)	427.88 (32.87)
	Onset Latency	24.71 (49.32)	7.00 (13.62)
	Sleep Efficiency	80.78 (12.28)	86.38 (5.18)
	WASO*	46.00 (38.12)	53.25 (17.91)
	Number of Awakenings	21.00 (10.89)	31.75 (8.62)
Baseline Sleep	Total Sleep Time	2431.86 (318.55)	2484.63 (385.44)
	Onset Latency	21.00 (20.23)	9.86 (6.56)
	Sleep Efficiency	82.47 (5.40)	84.54 (3.39)
	WASO	55.40 (22.64)	54.45 (19.67)
	Number of Awakenings	26.89 (7.74)	20.08 (9.08)

Note. *p < 0.001. Total sleep time, Onset latency, and WASO are reporting in minutes. Sleep Efficiency is reported as percentage of sleep time after onset of sleep. Number of awakenings is reported by the number of awake episodes after onset of sleep.

Karolinska Sleepiness Scale

Both at the start and at the end of the experiment, participants took the KSS along with additional follow up questions. See *Table 3* for means and standard deviations for each sleep condition. At the beginning of the experiment sleep restricted participants reported significantly lower rates of alertness, $t(40) = 4.10$, $p < 0.001$; harder to fall asleep, $t(40) = 3.30$, $p = 0.002$; fewer minutes to fall asleep, $t(38) = 2.03$, $p = 0.05$; more fatigue, $t(40) = 5.36$, $p < 0.001$, than the well-rested participants. At the end of the experiment, sleep restricted participants reported significantly lower rates of alertness, $t(40) = 3.19$, $p = 0.003$; harder to fall asleep, $t(40) = 2.20$, $p = 0.03$; marginally fewer minutes to fall asleep, $t(38) = 1.94$, $p = 0.06$; more fatigue, $t(40) = 3.07$, $p = 0.004$, than the well-rested participants. Altogether, the sleep restricted participants self-reported at both the beginning and the end of the experiment they had lower levels of alertness and they reported higher levels of fatigue than the well-rested participants at awakening the morning of the social contagion of memory portion of the experiment.

Table 3. Mean Scores of KSS as a Function of Sleep Conditions (N = 42).

		Mean (SD)	
		Sleep Restricted	Well Rested
Beginning KSS	Alertness**	5.10 (1.80)	3.00 (1.54)
	Ease to Sleep*	1.00 (0)	1.36 (0.49)
	Minutes to Sleep*	7.68 (4.62)	11.43 (6.74)
	Refreshed/ Fatigued**	2.85 (0.37)	2.00 (0.62)
End KSS	Alertness*	4.90 (2.17)	2.91 (1.88)
	Ease to Sleep*	1.00 (0.32)	1.32 (0.57)
	Minutes to Sleep	7.53 (4.84)	11.43 (7.44)
	Refreshed/ Fatigued*	2.65 (0.81)	1.95 (0.65)

Note. *p < 0.05, **p < 0.001.Alertness was reported on a scale of 1 (*Extremely alert*) to 9 (*Extremely sleepy, can't keep awake)*. Ease to Sleep was reported on a scale of 1 (*Easily*) to 3 (*With Difficulty*). Refreshed/ Fatigue was reported on a scale of 1(*Refreshed)* to 3 (*Fatigued)*.

Free Recall

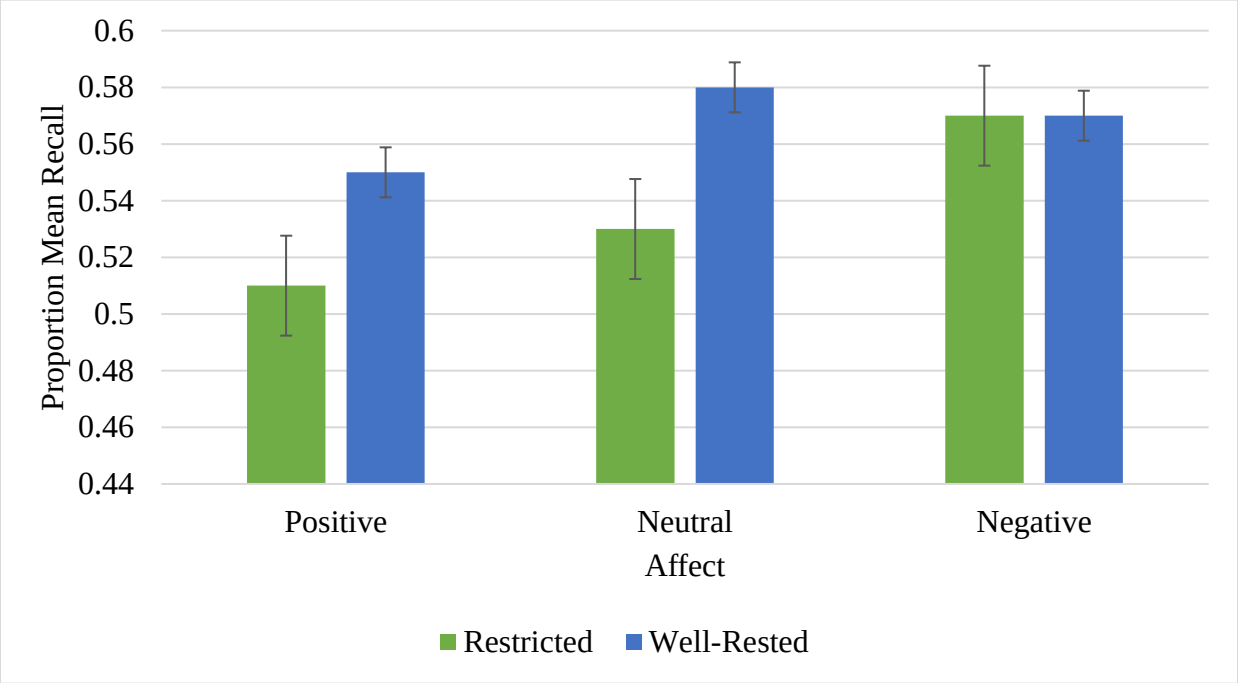
Correct Recall

Correct recall data are presented in *Figure 3*. First, we conducted a 3 (Affect: positive, negative, neutral) X 2 (Sleep: restricted, well-rested) mixed factorial analysis of variance (ANOVA) on correct recall to test for any differences. A main effect of affect was found, $F(2,40) = 3.30$, $p = 0.04$, $\eta^2 = 0.76$. Follow-up planned comparisons revealed that participants were less likely to recall positive images ($M = 0.57$, $SD = 0.10$) relative to negative images ($M = 0.53$, $SD = 0.13$, $t(41) = 2.31$, $p = 0.03$, $d = 0.36$) and neutral images ($M = 0.56$, $SD = 0.13$, $t(41) = 2.07$, $p = 0.05$, $d = 0.32$. There was no significant difference between negative and neutral images, $t(41) = 0.80$, $p = 0.43$, $d = 0.12$.

We did not find a main effect of sleep for correct recall, $F(1,40) = 0.91$, $p = 0.35$, $\eta^2 = 0.02$, nor did we find a significant interaction between affect and sleep $F(2,40) = 1.21$, $p = 0.31$,

$\eta^2 = 0.04$. Sleep restricted participants and well-rested participants did not differ in their correct recall. These findings do not align with previous sleep research that illustrate a negativity bias (e.g., Kaida, et al. 2015; Puig, et al., 2020). However, we note that data collection is on-going, and the current trends in the data are numerically consistent with negativity bias: sleep restricted participants are performing numerically worse for positive and neutral items than well-rested participants, but both sleep conditions are matched for negative items (see Figure 3).

Figure 3. Proportion of Correct Mean Recall as a Function of Affect (N = 42).



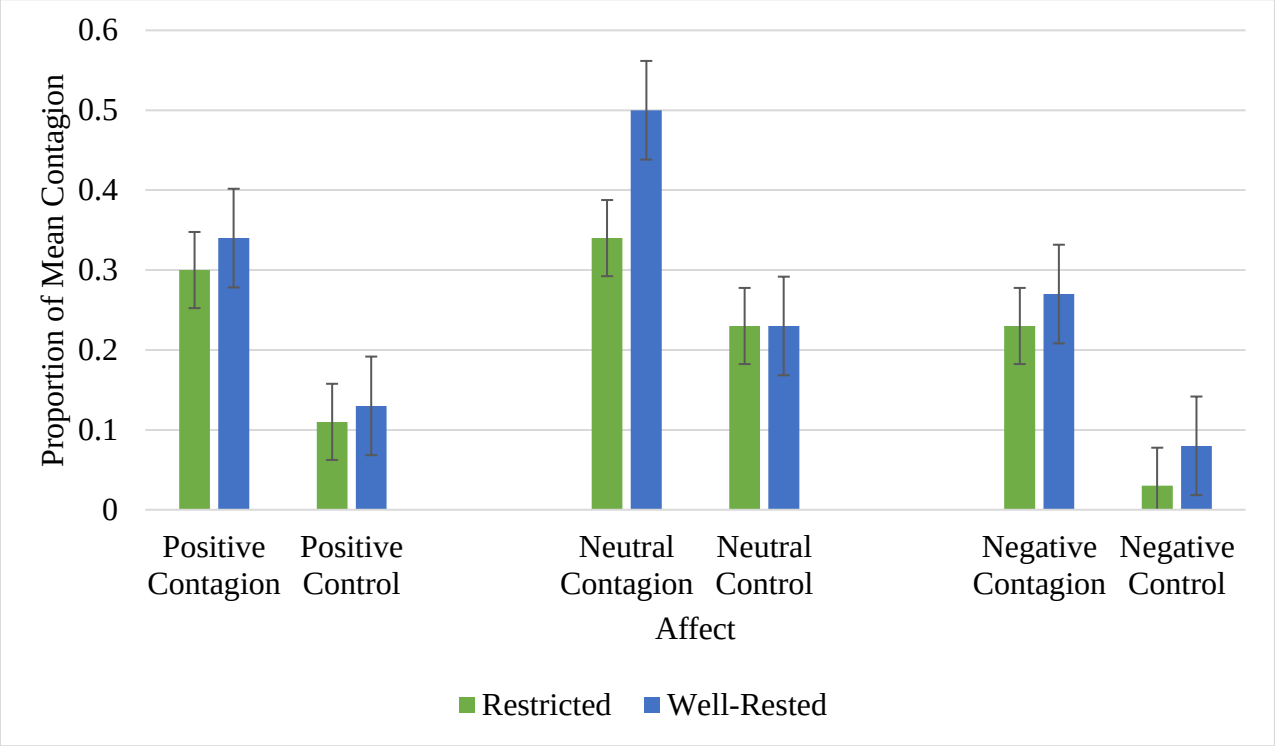
Contagion Effects

Next, we conducted a separate mixed factorial 3 (Affect: positive, negative, neutral) X 2 (Sleep: restricted, well-rested) x 2 (Contagion: contagion, control) ANOVA to observe any differences across contagion items. False recall data are presented in *Figure 4*. The ANOVA revealed a main effect contagion, $F(1,40) = 69.96$, $p < 0.001$, $\eta^2 = 0.64$. Replicating the social contagion effect, participants were more likely to recall the false contagion items when they were

suggested by the confederate relative to when the same items were not suggested by the confederate (control items). The interaction between contagion and affect was not significant, $F(2,40) = 0.01$, $p = 0.99$, demonstrating that the magnitude of the social contagion effect did not differ across emotion. We also found a main effect of affect, $F(2,40) = 34.46$, $p < 0.001$, $\eta^2 = 0.46$. Follow-up planned comparisons found that false recall for both positive ($M = 0.22$, $SE = 0.12$) and negative ($M = 0.15$, $SD = 0.11$) items were significantly lower than neutral items, ($M = 0.33$, $SD = 0.15$), $t(41) = 4.63$, $p < .001$, $d = 0.15$; $t(41) = 7.47$, $p < .001$ $d = 0.15$, respectively. Further, false recall for negative items was significantly lower than positive items, $t(41) = 4.33$, $p < .001$, $d = 0.10$, demonstrating that overall, false recall was lowest for negative items.

Similar to correct recall, there was not a significant main effect of sleep, $F(1,40) = 2.56$, $p = 0.12$, $\eta^2 = 0.06$. Additionally, there was not a significant interaction between affect and sleep, $F(2,40) = 0.88$, $p = 0.42$, $\eta^2 = 0.03$, or between contagion and sleep, $F(1,40) = 1.17$, $p = 0.29$, $\eta^2 = 0.03$. Finally the three way interaction between sleep, affect, and contagion was not significant, $F(2,40) = 1.99$, $p = 0.14$, $\eta^2 = 0.05$, demonstrating that both sleep restricted and well rested participants recalled similar rates of the false items.

Figure 4. Proportion of Mean Contagion as a Function of False Recall Across Affect (N = 42).



Source Monitoring

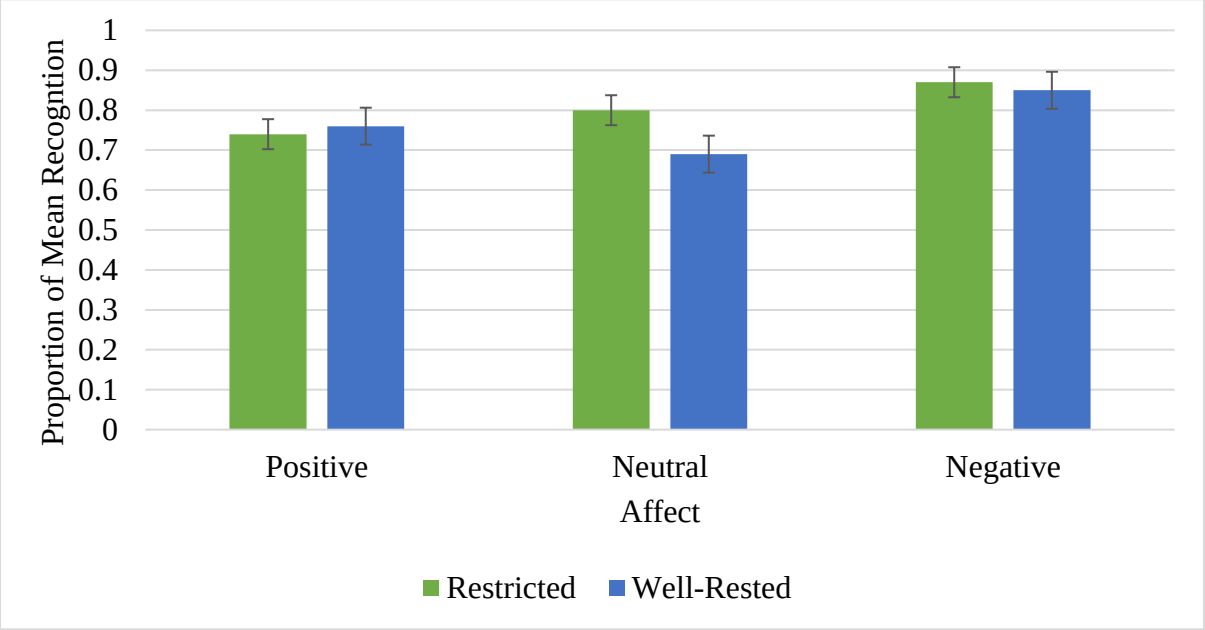
Correct Recognition

Correct recognition is presented in *Figure 5*. Correct recognition was measured as the proportion of times participants attributed a studied item as having occurred in the slide presentation. Specifically, correct recognition was determined by participants marking studied items as being one of the presented items (i.e., "image"), or as marking items as being one of the presented items and the participant verbally recalled the item during the group recall (i.e., "image" and self"), or as marking items as being one of the presented items and the other participant verbally recalled the item during the group recall (i.e., "image" and "other participant").

A mixed factorial 3 (Affect: positive, negative, neutral) X 2 (Sleep: restricted, well-rested) ANOVA was conducted to test the differences in source monitoring for correctly identifying studied words. We found a significant main effect of affect, $F(2,40) = 15.12$, $p < 0.001$, $\eta^2 = 0.27$. Follow-up planned comparisons revealed that negative ($M = 0.86$, $SD = 0.17$) studied items were correctly recognized significantly more than both positive studied items ($M = 0.75$, $SD = 0.21$) and neutral studied items ($M = 0.74$, $SD = 0.20$), $t(41) = 4.63$, $p < .001$, $d =$; $t(41) = 4.64$, $p < .001$, respectively. There was no significant difference in correct recognition between positive and neutral studied items, $p = 0.31$.

Similar to correct recall, we did not find a main effect of sleep restriction, $F(1,40) = 0.41$, $p = 0.53$, $\eta^2 = 0.01$. However, this is qualified by a significant interaction between affect and sleep, $F(2,40) = 4.39$, $p = 0.02$, $\eta^2 = 0.09$. Follow up t-tests revealed that for negative items, sleep restricted participants ($M = 0.87$, $SD = 0.14$) performed similarly to well-rested participants ($M = 0.85$, $SD = 0.19$), $t(40) = 0.30$, $p = 0.76$, $d = 0.17$. For positive items, sleep restricted participants ($M = 0.74$, $SD = 0.18$) performed similar to well-rested participants ($M = 0.76$, $SD = 0.24$), $t(40) = 0.35$, $p = 0.73$, $d = 0.22$. However, for neutral items, sleep restricted participants ($M = 0.80$, $SD = 0.19$) performed marginally better than well-rested participants ($M = 0.69$, $SD = 0.19$), $t(40) = 1.87$, $p = 0.07$, $d = 0.19$.

Figure 5. Proportion of Mean Correct Recognition as a Function of Affect (N = 42).

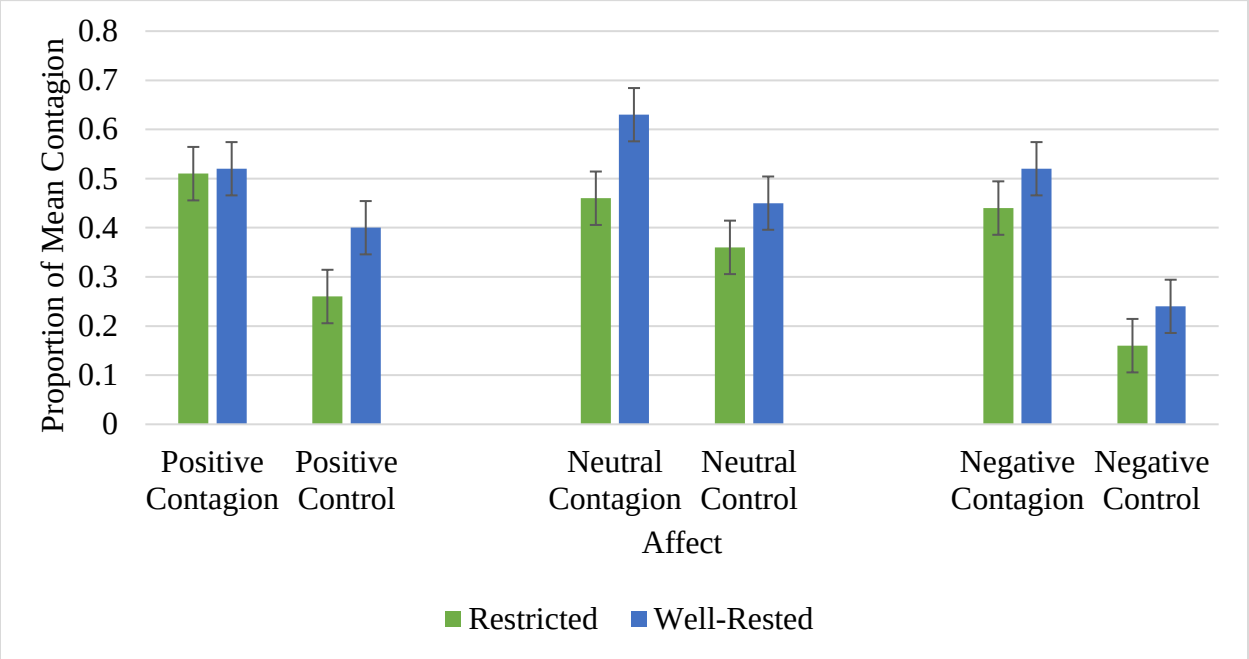


Contagion Effects

False recognition is presented in *Figure 6*. False recognition was determined by participants marking contagion items (i.e., false items not presented in the study episode) as being one of the presented items (i.e., "image"), or as marking items as being one of the presented items and the participant verbally recalled the item during the group recall (i.e., "image" and self"), or as marking items as being one of the presented items and the other participant verbally recalled the item during the group recall (i.e., "image" and "other participant").

A mixed factor 3 (Affect: positive, negative, neutral) X 2 (Sleep: restricted, well-rested) x 2 (Contagion: contagion, control) ANOVA was conducted for false recognition of contagion and control items. We found a significant main effect of contagion, $F(1,40) = 27.10$, $p < 0.001$, $\eta^2 = 0.22$. This means participants had higher false recognition for suggested false items than false items that were not presented by the confederate.

Figure 6. Proportion of Mean Contagion as a Function of False Recognition Across Affect (N = 42).



We also found a significant main effect of affect, $F(2,40) = 11.36$, $p < 0.001$, $\eta^2 = 0.40$. Follow-up planned comparisons revealed that negative ($M = 0.34$, $SD = 0.20$) false items were recognized significantly less than both neutral ($M = 0.48$, $SD = 0.28$) and positive ($M = 0.42$, $SD = 0.27$) false items, $t(41) = 3.12$, $p = 0.003$, $d = 0.17$; $t(41) = 4.51$, $p < 0.001$, $d = 0.20$, respectively. Positive false items were recognized marginally less than neutral false items, $t(41) = 1.96$, $p = 0.056$, $d = 0.19$. The main effects of contagion and affect were qualified by a marginally significant interaction, $F(2,40) = 2.66$, $p = 0.076$, $\eta^2 = 0.06$. Follow up tests revealed that, for negative items, significantly more negative false items ($M = 0.48$, $SD = 0.30$) were recognized than non-suggested negative false items ($M = 0.21$, $SD = 0.19$), $t(41) = 5.64$, $p < 0.001$, $d = 0.32$. For positive items, significantly more positive false items ($M = 0.52$, $SD = 0.42$) were better recognized than non-suggested positive false items ($M = 0.33$, $SD = 0.24$), $t(41) = 2.89$, $p = 0.006$, $d = 0.41$. Finally, for neutral items, significantly more neutral false items ($M =$

0.55, *SD* = 0.35) were better recognized than non-suggested neutral false items (*M* = 0.41, *SD* = 0.27), $t(41) = 3.67$, $p < 0.001$, $d = 0.26$. We interpret the interaction to mean that the social contagion effect was relatively larger for the negative and positive images compared to the neutral images.

We did not find a significant main effect of sleep, $F(1,40) = 1.78$, $p = 0.19$, $\eta^2 = 0.04$, nor did sleep interact with affect, $F(2,40) = 0.44$, $p = 0.65$, $\eta^2 = 0.01$ or contagion, $F(1,40) = 0.02$, $p = 0.89$, $\eta^2 = 0.00$. Finally, the three way interaction between sleep, affect, and contagion was not significant, $F(2,40) = 1.72$, $p = 0.19$, $\eta^2 = 0.04$. This demonstrates that regardless of the sleep manipulation (i.e., sleep restriction or well-rested) there was no effect on false recognition performance.

Post-Experiment Questionnaire

At the end of the experiment all participants took a post-experiment questionnaire, which they self-reported opinions for themselves and their partner (the confederate). There were no differences in responses between the sleep restricted and well-rested participants for self confidence, $t(40) = 0.72$, $p = 0.72$; partner confidence, $t(40) = 0.27$, $p = 0.08$; self accuracy, $t(40) = 0.97$, $p = 0.75$; partner accuracy, $t(40) = 0.25$, $p = 0.26$; self effort, $t(40) = 0.51$, $p = 0.57$; partner effort, $t(40) = 0.43$, $p = 0.52$; partner credibility, $t(40) = 0.77$, $p = 0.43$; partner trust, $t(40) = 1.02$, $p = 0.32$; partner helpfulness, $t(40) = 1.02$, $p = 0.32$. See *Table 4* for means and standard deviations for each sleep condition.

Table 4. Mean Scores of Post-Experiment Questionnaire as a Function of Sleep Condition (N = 42).

		Mean (SD)	
		Sleep Restricted	Well Rested
Post-Experiment Questionnaire	Self Confidence	2.75 (0.97)	2.64 (1.09)
	Partner Confidence	3.20 (1.06)	2.55 (1.26)
	Self Accuracy	2.75 (0.97)	2.64 (1.09)
	Partner Accuracy	3.25 (1.07)	2.82 (1.33)
	Self Effort	3.90 (1.11)	3.68 (1.32)
	Partner Effort	3.95 (1.19)	3.68 (1.43)
	Partner Credibility	3.55 (1.23)	3.23 (1.38)
	Partner Trust	3.40 (1.27)	3.00 (1.27)
	Partner Helpfulness	3.85 (1.50)	3.36 (1.59)

Note. Participants were able to respond from 1 to 5. 1 (lowest or least favorable) to 5 (highest or most favorable), all question responses were in the same direction.

Exploratory Analyses

We found no main effects of sleep restriction. However, we did find that sleep restricted participants self reported less momentary alertness and greater fatigue from when they woke up that morning. Due to this difference in subjective alertness and fatigue, we ran follow up analyses using self-reported morning alertness and fatigue from the start and end of the experiment as a predictor of later correct and false recall and recognition across affect.

First, for correct recall, morning alertness and fatigue reported at both beginning and end of the experiment were not significant predictors for studied positive or neutral items, $F(3,41) = 71$, $p = 0.59$, with an adjusted $R^2 = 0.07$; $F(3,41) = 0.73$, $p = 0.58$, with an adjusted $R^2 = 0.07$, respectfully. However, they were marginally significant predictors for studied negative items, $F(3,41) = 2.43$, $p = 0.06$, with an adjusted $R^2 = 0.15$. Specifically, morning alertness reported at the start of the experiment was a significant predictor for recall of correct, negative items, $t(41) = -2.27$, $p = 0.03$, $\beta = -0.56$, 95% CI [-0.05, -0.003]. Further, morning fatigue reported at the start

of the experiment was a marginally significant predictor for recall of correct negative items, t(41) = 1.75, $p = 0.088$, $\beta = 0.43$, 95% CI [-0.01, 0.13].

Then, for false recall, morning alertness and fatigue reported at both beginning and end of the experiment were significant predictors for positive and neutral items, $F(3,41) = 3.89$, $p = 0.01$, with an adjusted $R^2 = 0.30$; $F(3,41) = 3.04$, $p = 0.03$, with an adjusted $R^2 = 0.25$. Specifically, alertness and fatigue reported at the start were significant predictors for false, positive items, $t(41) = 2.62$, $p = 0.01$, $\beta = 0.61$, 95% CI [0.014, 0.113]; , $t(41) = -2.80$, $p = 0.01$, $\beta = -0.65$, 95% CI [-0.34, -0.05], respectfully, and for false, neutral items, $t(41) = 2.17$, $p = 0.04$, $\beta = 0.53$, 95% CI [0.04, 0.11]; , $t(41) = -3.05$, $p = 0.004$, $\beta = -0.73$, 95% CI [-0.392, -0.079], respectfully. However, morning alertness and fatigue were not significant predictors for false, negative items, $F(3,41) = 1.60$, $p = 0.20$, with an adjusted $R^2 = 0.15$. Altogether, these findings support the idea that the data is trending such that as participants are more tired, they have an exaggerated negativity bias which expresses better memory for negative studied items and not for negative contagion items.

For correct recognition, morning alertness and fatigue reported at both beginning and end of the experiment were not significant predictors for positive, negative, or neutral items, $F(3,41) = 1.21$, $p = 0.32$, with an adjusted $R^2 = 0.02$; $F(3,41) = 1.28$, $p = 0.30$, with an adjusted $R^2 = 0.03$; $F(3,41) = 0.44$, $p = 0.78$, with an adjusted $R^2 = -0.06$. Additionally, for false recognition, morning alertness and fatigue were not significant predictors for positive and negative contagion items, $F(3,41) = 3.04$, $p = 0.03$, with an adjusted $R^2 = 0.17$; $F(3,41) = 3.04$, $p = 0.03$, with an adjusted $R^2 = 0.16$. However, morning alertness and fatigue were significant predictors for neutral contagion items, $F(3,41) = 4.03$, $p = 0.01$, with an adjusted $R^2 = 0.23$. Specifically,

morning alertness and fatigue at the beginning of the experiment were significant predictors for neutral contagion items, $t(41) = 3.49$, $p = 0.001$, $\beta = 0.82$, 95% CI [0.06, 0.023]; $t(41) = -3.23$, $p = 0.003$, $\beta = -0.74$, 95% CI [-0.63, -0.15], respectively. Altogether, the recognition findings suggest that alertness is positively associated with neutral, contagion items; while, fatigue is negatively associated with neutral, contagion items.

DICUSSION

The current study aimed to bridge converging areas of research in sleep and social cognitive psychology, while understanding their influence on one another. To our knowledge, this is the first experiment to examine the effects of sleep restriction on the social contagion of emotional memory. The study revealed several interesting findings. First, we found support for a negativity bias in both recall and recognition memory. That is, when compared to positive information, negative information was more likely to be correctly recalled and recognized, and negative information was less likely to be falsely recalled and recognized. Also, we found social contagion effects for positive, neutral, and negative information and these effects were not influenced by sleep restriction. Further, the magnitude of the social contagion effects across emotional valence differed across recall and recognition. For recall, social contagion effects were equivalent across negative, neutral, and positive information, but for recognition, social contagion effects were inflated when studying emotional stimuli.

Recall

In the current study we found that participants, regardless of if they were sleep restricted or well-rested, had better correct recall performance for negative stimuli than positive stimuli. This finding aligns with past research which has found a negativity bias (i.e., better memory for negative information than positive or neutral information) (Kaida, et al., 2015; Puig, et al., 2019). Interestingly, the current study found only a marginal increase of positive stimuli recall over neutral stimuli and no difference between negative and neutral stimuli. These findings are inconsistent with past emotion research, which would suggest that emotionally valanced stimuli

should have larger effects over neutral stimuli (Palmer & Alfano, 2017; Palmer et al., 2023). The most likely explanation for the lack of positive effects in the current study is the stimuli. The positive images used in the current study were pilot tested and matched to the negative images on valence and arousal. Nonetheless, there could be idiosyncratic effects that worked against finding enhanced recall for the positive images.

For false recall of contagion items, we found the standard contagion effect such that participants, regardless of sleep condition, recalled more false items that were suggested by a confederate than control items (the same items when they were not suggested by the confederate). This finding supports the social contagion of memory as a robust memory phenomenon and is in line with past research (Hart, et al., 2023; Huff, et al., 2013; Meade, et al., 2023; Roediger, Meade, et al., 2001). Novel to the current experiment is that the magnitude of social contagion did not differ across emotional valence—social contagion effects on recall were equivalent for negative, neutral, and positive information. Also important is that the magnitude of social contagion did not differ for sleep restricted and well rested participants. These findings do not support our hypotheses. We predicted that sleep restricted participants would be less susceptible to false negative information because the negativity bias associated with sleep loss would influence reactivity and attention to negative images. This, in turn, could create more distinctive memory characteristics that participants can use to reject the false items. Perhaps we found no evidence of this because the retrieval demands of the recall test did not explicitly encourage participants to consider the source of the images.

Additionally, we found that emotional valance influenced false recall. Specifically, negative false items were recalled less than positive false items. These findings are in line with

past research showing a negativity bias (Kaida, et al., 2015; Puig, et al., 2019). Further, when considered in relation to our correct recall findings, this supports past theories that if there is an increase in accurate memory, then there will be a decrease in false memory (see Gallo, 2004; Roediger, Watson, et al., 2001). Specifically, with this better memory for negative items, it is easier for participants to reject the suggestion of false items into their memory. However, it is uncertain why the relative effects of the neutral items differ across correct and false recall. Past research would suggest that there should be poorer memory for neutral items, thus making them more susceptible to false memory. One possible explanation is that there are item effects in the current study that are influencing the patterns of recall across negative, neutral, and positive images.

Recognition

In addition to recall memory, we investigated recognition memory. We found that for recognition of studied items, negative items were more correctly recognized than both positive and neutral studied items, which had no difference between the two. This finding supports past research finding a negativity bias (Kaida, et al., 2015; Kensinger, et al., 2016; Puig, et al., 2019) and is consistent with our recall findings. Also, we found a marginally significant interaction with affect and sleep. Specifically, sleep restricted participants had better recognition memory for neutral items than well-rested participants. This finding counters past research in both sleep research (see for review, Cunningham, 2020) and emotion research (Kaida, et al., 2015; Kensinger, et al., 2016; van Der Helm, et al., 2010). For these reasons, in addition to ongoing data collection, we make no claims to explain these current findings.

For recognition of false items, we again found the standard contagion effect, such that suggested false items were better recognized than non-suggested false items. Again, this finding is consistent with our findings for recall memory and aligns with past social contagion of memory research (Hart, et al., 2023; Huff, et al., 2013; Meade, et al., 2023; Roediger, Meade, et al., 2001). Importantly, the magnitude of the social contagion effect interacted with affect. Specifically, for negative, positive, and neutral items there was a significant difference in recognition for false suggested items than false non-suggested items, but the social contagion effect was numerically larger for the negative and positive items. This finding may be explained through source monitoring theory, but not without some difficulty. Johnson (1993) discusses that certain features of information can act as additional cues for later memory. In the current study, the emotion of the image acted as an additional cue, as well as, having the confederate verbally say an image, both provide a richer memory. Perhaps these richer false memories were more easily confused with real memories. Further, this finding counters past research by Kensinger et al. (2016) who found that recognition of positive and negative false items was lower than neutral false items. A possible explanation for this disparity may be in the test that was used to observe recognition memory. Kensinger et al. (2016) used a recognition test that asked participants whether or not the item was included in the original study portion of the experiment and participants responded yes or no. In the current study, we use a source monitoring test that required participants to select where in the experiment, if anywhere, did they encounter the item. It is possible that requiring participants to think about the source rather than familiarity of the information may act on different mechanisms, which then are affected differently by affect. Also, Kensinger et al. (2016) manipulated social contagion between subjects, and they had a two-day

delay between study and test. Future research will be needed to understand whether these factors influence the pattern of effects.

Additionally, we found that positive and neutral false items (both suggested and non-suggested items) were recognized more than negative false items. This finding is consistent with our findings for correct recognition and our recall findings. Negative items had higher rates of correct recognition and lower rates of false recognition; thus, suggesting relatively better source memory for the negative items. Participants are better able to recognize the studied negative items and reject the false negative items. Again, this is consistent with our recall findings and past theory (cf., Gallo, 2004; Roediger, Watson, et al., 2001).

Sleep

For our sleep manipulation, the current study does not currently find support for sleep effects on memory performance (The only exception is that sleep interacted with correct recognition in the opposite direction from our predictions—sleep restricted individuals recognized more neutral items than well rested participants). There are a few possible explanations as to why we did not observe any sleep differences, as past research would suggest (see for review, Cunningham, 2020; Wickens, et al., 2015). First, not all the participants included in the current study had actigraphy data collected due to technical issues with the Philips watches. This means that we cannot for certain know whether the participants were compliant with their sleep group assignment (i.e., only slept for the assigned number of hours, four or eight hours). Second, there may not be a sleep restriction effect on social contagion. One night of sleep restriction may not be enough to disrupt one's memory performance on this task.

Although we did not find memory differences, we did find sleep differences in some self-reported measures. Specifically, sleep restricted participants reported lower levels of alertness and fatigue than well rested participants on the KSS. Although, sleep did not significantly influence participants' perceptions of their partners, data shows a numerical trend that sleep restricted participants may be more trusting of a partner than well-rested participants. All participants reported that they and their partners were similar in their effort and confidence throughout the memory tests (i.e., the group recall). These findings counter the findings of Gordon et al., 2019, who suggest that sleep restricted participants would have a more negative perception of social situations than well-rested individuals.

Limitations and Future Directions

The current study has a few limitations. First, data collection is ongoing, so the data currently presented should be considered with caution and expected to change once the goal of 72 participants is reached, specifically for our sleep effects. Along with data collection, participant compliance with the sleep manipulation was not always reliable. In the cases that sleep data was logged, roughly 25% of participants failed to properly follow the sleep manipulation, so it is likely that there may be participants in the current data set that did not follow the sleep procedure assigned.

Second, the sleep placement is at the end of the night, meaning participants in the sleep restricted condition sleep from 3am to 7am rather than 11pm to 3am, which may be less disruptive to their sleep quality (Cunningham, 2022). Students may be more adjusted to staying up, so without having a large enough disruption there may not be any cognitive deficits. Because they are more comfortable to nights like this of sleeping, they may not be as affected by the sleep

restriction. Future research can manipulate the sleep placement to be at the beginning of the night or a series of consecutive sleep restricted nights.

Third, the social contagion of memory uses a confederate to provide false memories. This brings concerns on how natural the spread of the misinformation into one's memory is in the current design. Future studies may want to use two to three participants recalling with one another using a Collaborative Inhibition design. Collaborative inhibition is a social, cognitive psychological phenomenon in which memory is hindered when one recalls in a group of peers than when recalling by oneself.

Although the current study has limitations, the practical implications for this study are vast. Through combining findings across research domains this study will add to the validity and generalizability of the social contagion findings, will add reliability to the sleep effects findings onto encoding and retrieval, and will create a new framework for understanding the conditions when misinformation is more widespread than when it is not.

Conclusion

In sum, the current study is the first step to bridge the current knowledge gaps between sleep, emotion, and social contagion research. First, this study provides greater insights in understanding the role of social interactions and the encoding and retrieval of emotional memories. Second, this study provides a deeper understanding of how the social contagion of memory mechanisms are affected, or not, when individuals are sleep restricted. Future work can build off this work in both cognitive psychology and sleep research, whilst knowing how the two realms inform one another. Overall, the current study provides an overarching groundwork for future studies observing the practical implications of remembering with others.

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APPENDICES

APPENDIX A

INTAKE MATERIALS

INSTRUCTIONS:

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

During the past month, what time have you usually gone to bed at night?

BED TIME _____

During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

NUMBER OF MINUTES _____

During the past month, what time have you usually gotten up in the morning?

GETTING UP TIME _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

HOURS OF SLEEP PER NIGHT _____

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you . . .

Cannot get to sleep within 30 minutes

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Wake up in the middle of the night or early morning

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Have to get up to use the bathroom

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Cannot breathe comfortably

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Cough or snore loudly

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Feel too cold

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Feel too hot

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Had bad dreams

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Have pain

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Other reason(s), please describe_____

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

How often during the past month have you had trouble sleeping because of this?

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

During the past month, how would you rate your sleep quality overall?

Very good _____

Fairly good _____

Fairly bad _____

Very bad _____

During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all _____

Only a very slight problem _____

Somewhat of a problem _____

A very big problem _____

10. Do you have a bed partner or room mate?

No bed partner or room mate _____

Partner/room mate in other room _____

Partner in same room, but not same bed _____

Partner in same bed _____

If you have a room mate or bed partner, ask him/her how often in the past month you have had .

. .

Loud snoring

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Long pauses between breaths while asleep

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Legs twitching or jerking while you sleep

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Episodes of disorientation or confusion during sleep

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

Other restlessness while you sleep; please describe_____

Not during the past month_____

Less than a week_____

Once or twice times a week_____

Three or more once a week_____

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Epworth Sleepiness Scale

Name: _____ Today's date: _____

Your age (Yrs): _____ Your sex (Male = M, Female = F): _____

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired?

This refers to your usual way of life in recent times.

Even if you haven't done some of these things recently try to work out how they would have affected you.

Use the following scale to choose the **most appropriate number** for each situation:

0 = would **never** doze
1 = **slight chance** of dozing
2 = **moderate chance** of dozing
3 = **high chance** of dozing

It is important that you answer each question as best you can.

Situation	**Chance of Dozing (0-3)**
Sitting and reading	___
Watching TV	___
Sitting, inactive in a public place (e.g. a theatre or a meeting)	___
As a passenger in a car for an hour without a break	___
Lying down to rest in the afternoon when circumstances permit	___
Sitting and talking to someone	___
Sitting quietly after a lunch without alcohol	___
In a car, while stopped for a few minutes in the traffic	

THANK YOU FOR YOUR COOPERATION

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SAMPLE COPY

Composite Morningness Questionnaire

Directions: Please *check* the response for *each* item that best describes *you*.

1. Considering only your own "feeling best" rhythm, at what time would you get up if you were entirely free to plan your day?

5:00-6:30 a.m.	_____ (5)
6:30-7:45 a.m.	_____ (4)
7:45-9:45 a.m.	_____ (3)
9:45-11:00 a.m.	_____ (2)
11:00 a.m. – 12:00 (noon)	_____ (1)

2. Considering your only "feeling best" rhythm, at what time would you go to bed if you were entirely free to plan your evening?

8:00-9:00 p.m.	_____ (5)
9:00-10:15 p.m.	_____ (4)
10:15 p.m. – 12:30 a.m.	_____ (3)
12:30–1:45 a.m.	_____ (2)
1:45-3:00 a.m.	_____ (1)

3. Assuming normal circumstance, how easy do you find getting up in the morning? (Check one.)

Not at all easy	_____ (1)
Slightly easy	_____ (2)
Fairly easy	_____ (3)
Very easy	_____ (4)

4. How alert do you feel during the first half hour after having awakened in the morning? (Check one.)

Not at all alert	_____ (1)
Slightly alert	_____ (2)
Fairly alert	_____ (3)
Very alert	_____ (4)

5. During the first half hour after having awakened in the morning, how tired do you feel? (Check one.)

Very tired	_____ (1)
Fairly tired	_____ (2)
Fairly refreshed	_____ (3)
Very refreshed	_____ (4)

6. You have decided to engage in some physical exercise. A friend suggests that you do this one hour twice a week and the best time for him is 7:00-8:00 a.m. Bearing in mind nothing else but your own "feeling best" rhythm, how do you think you would perform?

Would be in good form	_____ (4)
Would be in reasonable form	_____ (3)
Would find it difficult	_____ (2)
Would find it very difficult	_____ (1)

7. At what time in the evening do you feel tired and, as a result, in need of sleep?

8:00-9:00 p.m.	_____ (5)
9:00-10:15 p.m.	_____ (4)
10:15 p.m. – 12:30 a.m.	_____ (3)
12:30–1:45 a.m.	_____ (2)
1:45-3:00 a.m.	_____ (1)

8. You wish to be at your peak performance for a test which you know is going to be mentally exhausting and lasting for two hours. You are entirely free to plan your day, and considering only your own "feeling best" rhythm, which ONE of the four testing times would you choose?

8:00-10:00 a.m.	_____ (4)
11:00 a.m. – 1:00 p.m.	_____ (3)
3:00-5:00 p.m.	_____ (2)
7:00-9:00 p.m.	_____ (1)

9. One hears about "morning" and "evening" types of people. Which ONE of these types do you consider yourself to be?

Definitely a morning type	_____ (4)
More a morning than an evening type	_____ (3)
More an evening than a morning type	_____ (2)
Definitely an evening type	_____ (1)

10. When would you prefer to rise (provided you have a full day's work—8 hours) if you were totally free to arrange your time?

Before 6:30 a.m.	_____ (4)
6:30-7:30 a.m.	_____ (3)
7:30-8:30 a.m.	_____ (2)
8:30 a.m. or later	_____ (1)

11. If you always had to rise at 6:00 a.m., what do you think it would be like?

Very difficult and unpleasant	_____ (1)
Rather difficult and unpleasant	_____ (2)
A little unpleasant but no great problem	_____ (3)
Easy and not unpleasant	_____ (4)

12. How long a time does it usually take before you "recover your senses" in the morning after rising from a night's sleep?

0-10 minutes	_____ (4)
11-20 minutes	_____ (3)
21-40 minutes	_____ (2)
More than 40 minutes	_____ (1)

13. Please indicate to what extent you are a morning or evening *active* individual.

Pronounced morning active (morning alert and evening tired)	_____ (4)
To some extent, morning active	_____ (3)
To some extent, evening active	_____ (2)
Pronounced evening active (morning tired and evening alert)	_____ (1)

Note: Scoring is indicated in parentheses beside each score anchor.

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Survey Type

This is the survey for initial intake. Please continue to begin.

Participant Number

Please enter your participant number (your experimenter will tell you).

Please enter today's date (MM/DD/YY)

Demographics

What is your age (in years)?

What is your birthdate?

What is your biological sex?

- ○ Male
- ○ Female

- ○ Other

What is your race?

- ○ White
- ○ African American/Black
- ○ American Indian or Alaska Native
- ○ Asian
- ○ Biracial or Mixed Race
- ○ Other
- ○ Prefer not to answer

What is your ethnicity?

- ○ Hispanic
- ○ Not Hispanic
- ○ Prefer not to answer

What is your father's (or another close male caregiver's) highest level of education?

- ○ Did not complete high school
- ○ Completed high school
- ○ Some college/vocational school
- ○ College degree
- ○ Some graduate or professional school
- ○ Completed graduate or professional school
- ○ Not applicable
- ○ Prefer not to answer

What is your mothers's (or another close female caregiver's) highest level of education?

- ○ Did not complete high school
- ○ Comp eted high school

- ◯ Some college/vocational school
- ◯ College degree
- ◯ Some graduate or professional school
- ◯ Completed graduate or professional school
- ◯ Not applicable
- ◯ Prefer not to answer

What is your family's annual income?

- ◯ below $20,000
- ◯ $20,000-$40,000
- ◯ $40,000-$60,000
- ◯ $60,000-$80,000
- ◯ $80,000-$100,000
- ◯ $100,000-$120,000
- ◯ $120,000-$140,000
- ◯ $140,000-$160,000
- ◯ $160,000 or above
- ◯ I don't know
- ◯ Prefer not to answer

What is your current college GPA (if you are a freshman in your first semester and do not have a GPA yet, please state: N/A

Normal Bed & Wake Time

What time do you usually go to bed at night?

What time do you usually wake up in the morning?

State Trait Anxiety Inventory

A number of statements which people have used to describe themselves are given below. Read each statement and then select the appropriate response below the statement to indicate how you feel right now, that is, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	Not al all (1)	Sometimes (2)	Moderately so (3)	Very much so (4)	Prefer not to answer
I feel calm	○	○	○	○	○
I feel secure	○	○	○	○	○
I am tense	○	○	○	○	○
I feel strained	○	○	○	○	○
I feel at ease	○	○	○	○	○
I feel upset	○	○	○	○	○
I am presently worrying over possible misfortunes	○	○	○	○	○
I feel satisfied	○	○	○	○	○
I feel frightened	○	○	○	○	○
I feel comfortable	○	○	○	○	○
I feel self-confident	○	○	○	○	○
I feel nervous	○	○	○	○	○
I am jittery	○	○	○	○	○
I feel indecisive	○	○	○	○	○
I am relaxed	○	○	○	○	○
I feel content	○	○	○	○	○
I am worried	○	○	○	○	○
I feel confused	○	○	○	○	○
I feel steady	○	○	○	○	○
I feel pleasant	○	○	○	○	○

A number of statements which people have used to describe themselves are given below. Read each statement and then select the appropriate response to the right of the statement to indicate *how you generally feel*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	Almost never (1)	Sometimes (2)	Often (3)	Almost always (4)	Prefer not to answer
I feel pleasant	○	○	○	○	○
I feel nervous and restless	○	○	○	○	○
I feel satisfied with myself	○	○	○	○	○
I wish I could be as happy as others seem to be	○	○	○	○	○
I feel like a failure	○	○	○	○	○
I feel rested	○	○	○	○	○
I am "calm, cool, and collected"	○	○	○	○	○
I feel that difficulties are piling up so that I cannot overcome them	○	○	○	○	○
I worry too much over something that doesn't really matter	○	○	○	○	○
I am happy	○	○	○	○	○
I have disturbing thoughts	○	○	○	○	○
I lack self-confidence	○	○	○	○	○
I feel secure	○	○	○	○	○
I make decisions easily	○	○	○	○	○
I feel inadequate	○	○	○	○	○
I am content	○	○	○	○	○
Some unimportant thought runs through my mind and bothers me	○	○	○	○	○
I take disappointments so keenly that I can't put them out of my mind	○	○	○	○	○
I am a steady person	○	○	○	○	○
I get in a state of tension or turmoil as I think over my recent concerns and interest	○	○	○	○	○

PHQ-8

Over the **last 2 weeks**, how often have you been bothered by any of the following problems? (choose one option)

	Not at all	Several days	More than half the days	Nearly every day
Little interest or pleasure in doing things	○	○	○	○
Feeling down, depressed, or hopeless	○	○	○	○
Trouble falling or staying asleep, or sleeping too much	○	○	○	○
Feeling tired or having little energy	○	○	○	○
Poor appetite or overeating	○	○	○	○
Feeling bad about yourself, or that you are a failure, or have let yourself or your family down	○	○	○	○
Trouble concentrating on things, such as reading the newspaper or watching television	○	○	○	○
Moving or speaking so slowly that other people could have noticed. Or the opposite- being so fidgety or restless that you have been moving around a lot more than usual	○	○	○	○

Positive and Negative Affect Schedule (PA, NA, Serenity subscales)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. Indicate the extent you have felt this way over the past week.

	1- very slightly or not at all	2- a little	3- moderately	4- quite a bit	5- extremely	Prefer not to answer
Interested	○	○	○	○	○	○
Distressed	○	○	○	○	○	○
Excited	○	○	○	○	○	○
Upset	○	○	○	○	○	○
Strong	○	○	○	○	○	○
Guilty	○	○	○	○	○	○
Scared	○	○	○	○	○	○
Hostile	○	○	○	○	○	○
Enthusiastic	○	○	○	○	○	○
Proud	○	○	○	○	○	○
Irritable	○	○	○	○	○	○
Alert	○	○	○	○	○	○
Ashamed	○	○	○	○	○	○
Inspired	○	○	○	○	○	○
Nervous	○	○	○	○	○	○
Determined	○	○	○	○	○	○
Attentive	○	○	○	○	○	○
Jittery	○	○	○	○	○	○
Active	○	○	○	○	○	○
Afraid	○	○	○	○	○	○
Calm	○	○	○	○	○	○

	1- very slightly or not at all	2- a little	3- moderately	4- quite a bit	5- extremely	Prefer not to answer
Relaxed	○	○	○	○	○	○
At ease	○	○	○	○	○	○

Modified Alcohol, Smoking and Substance Involvement Screening Test

During the past two (2) weeks, about how often did you use any of the following medicines **on your own**, that is, without a doctor's prescription, in greater amounts or longer than prescribed?

	Not at all	One or two days	Several days	More than half the days	Nearly everyday
Painkillers (like Vicodin)	○	○	○	○	○
Stimulants (like Ritalin, Adderall)	○	○	○	○	○
Sedatives or tranquilizers (like sleeping pills or Valium)	○	○	○	○	○
Marijuana	○	○	○	○	○
Caffeine (like coffee, caffeine pills)	○	○	○	○	○
Cocaine or crack	○	○	○	○	○
Club drugs (like ecstacy)	○	○	○	○	○
Hallucinogens (like LSD)	○	○	○	○	○
Heroin	○	○	○	○	○
Inhalants or solvents	○	○	○	○	○
Methamphetamine (like speed)	○	○	○	○	○
Nicotine (like cigarettes, chew)	○	○	○	○	○

APPENDIX B

NATIONAL SLEEP FOUNDATION (NSF) DIARIES

WEEK 1 Start date: _____/_____/_____

COMPLETE WHEN YOU WAKE UP						
Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**
I went to bed at: (Enter the time and circle am or pm)						
am/pm	am/pm	am/pm	am/pm	am/pm	am/pm	am/pm
When I went to bed, I fell asleep: (Circle one) **1** = With difficulty; **2** = After some time; **3** = Easily						
1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
I woke up during my sleep: (Enter # of times and # of minutes)						
# times_____ # mins _____	# times_____ # mins _____	# times_____ # mins _____	# times_____ # mins _____	# times_____ # mins _____	# times_____ # mins _____	# times_____ # mins _____
I got out of bed at: (Enter the time and circle am or pm)						
am/pm	am/pm	am/pm	am/pm	am/pm	am/pm	am/pm
I slept a total of: (Enter approximate hours/minutes)						
My sleep was disturbed by: (List any factors that made it hard to sleep including noise, lights, pets, allergies, temperature, pain, stress, medication, etc.)						
When I woke up, I felt: (Circle one) **1** = Still tired; **2** = Somewhat awake; **3** = Wide awake						
1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3

Complete at Bed Time

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
I exercised at least 30 minutes at: (Circle all that apply) = Morning; = Afternoon; = Evening						
Medications I used today:						
I took a nap today (Circle YES or NO. If YES, enter how long you napped).						
YES_____ NO	YES_____ NO	YES_____ NO	YES_____ NO	YES_____ NO	YES_____ NO	YES_____ NO
How likely was I to doze off while doing daily activities today: (Circle one) **1** = Not at all likely; **2** = Not very likely; **3** = Somewhat likely; **4** = Very likely						
1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
My mood today was: (Circle one) = Bad; = Okay; = Good						
Approximately 2-3 hours before going to bed I drank/ate: (Circle all that apply) = Alcohol; = Heavy meal; = Caffeine						
I drank/ate something with caffeine at: (Circle all that apply) = Morning; = Afternoon; = Evening						
In the hour before going to sleep, my bedtime routine included: (e.g. read book; used electronics; took bath; did relaxation exercises; etc.)						

APPENDIX C

EXPERIMENTAL QUESTIONNAIRES

Karolinska Sleepiness Scale (KSS)

Q1. Please indicate how you feel right now.

Extremely alert
Very alert
Alert
Rather alert
Neither alert nor sleepy
Some signs of sleepiness
Sleepy, but no effort to keep awake
Sleep, but some effort to keep awake
Very sleep, great effort to keep awake, fighting sleep
Extremely sleep, can't keep awake

Q2. Last night I fell asleep:

Easily
After some time
With difficulty

Q3. It took me ___ minutes to fall asleep

Q4. My sleep was disturbed by: (if nothing disturbed your sleep, indicate "not applicable")

Q5. I woke up today feeling:

Refreshed
Somewhat refreshed
Fatigued

Post- Experiment Questionnaire

1. How confident were you in your own ability to remember the images presented in today's experiment? (1-Not Very Confident to 5-Very Confident)

1 2 3 4 5

2. How confident were you in your partner's ability to remember the images presented in today's experiment? (1-Not Very Confident to 5-Very Confident)

1 2 3 4 5

3. How accurate would you rate your own memory for the images presented in today's experiment? (1-Not Very Accurate to 5-Very Accurate)

1 2 3 4 5

4. How accurate would you rate your partner's memory for the images presented in today's experiment? (1- Not Very Accurate to 5- Very Accurate)

1 2 3 4 5

5. How much effort did you put in during today's experiment? (1 – Not Very Much Effort to 5- Very Much Effort)

1 2 3 4 5

6. How much effort do you think your partner put in during today's experiment? (1 – Not Very Much Effort to 5- Very Much Effort)

1 2 3 4 5

7. How credible would you say your partner from today's study was? (1-Not Very Credible to 5-Very Credible).

1 2 3 4 5

8. How much did you trust your partner? (1- Not Very Much Trust to 5-Very Much Trust)

1 2 3 4 5

9. How helpful was it to work with your partner to remember word lists in today's experiment? (1-Very Unhelpful to 5-Very Helpful)

1 2 3 4 5