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Sleep Quality and the Content of Autobiographical Memory:

Differential Associations by Memory Valence and Temporality

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ABSTRACT OF THE THESIS

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By

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Although sleep after learning has been associated with memory for emotional stimuli in the laboratory, research has not yet been conducted to examine relations between sleep and the subjective experience of autobiographical memories. The present study was conducted to determine whether sleep quality was associated with the subjective experience of autobiographical memory and whether the demonstrated associations were mediated by depression. One hundred twenty-one female university students reported on their most significant positive and negative memories as well as memories of positive and negative events that occurred during the previous 2 weeks; they also completed measures of sleep quality and depression. The results revealed that participants with poor sleep quality reported events that occurred more frequently relative to participants with good sleep quality. The former group was also less confident that the reported memories were not influenced by pictures or conversations with others relative to the latter. In addition, participants with poor sleep quality thought more about their negative experiences and used more negative emotion words when describing recent negative events relative to participants with good sleep quality. Depressive symptoms mediated

the relation between sleep quality and (a) frequency of thought about negative events and (b) the percent of negative emotion words used when discussing recent positive events. Given that the process of evaluating and making meaning of past emotional events is associated with mental health, future research should examine whether sleep interventions might serve to improve sleep quality, reduce indices of depression, and facilitate the processing of negative events.

Sleep Quality and the Content of Autobiographical Memory:

Differential Associations by Memory Valence and Temporality

Laboratory studies indicate that sleep after exposure to emotional stimuli preferentially facilitates memory for negative information (narratives: Wagner, Gais, & Born, 2001; Wagner, Hallschmid, Rasch, & Born, 2006; pictures: Hu, Stylos-Allan, & Walker, 2006; scenes: Payne, Stickgold, Swanberg, & Kensinger, 2008; Payne & Kensinger, 2011; Payne, Chambers, & Kensinger, 2012). Despite these findings, work has not yet been conducted to our knowledge to examine relations between sleep and memory for the emotional content of autobiographical memories. Autobiographical memories are episodic memories for particular events that are part of a personal history and define the self (Williams & Conway, 2009). Reports of autobiographical events oftentimes include efforts to evaluate or make meaning of past experiences (see Bohanek, Fivush, & Walker, 2005; Fivush & Haden, 1997; McAdams, 1992). The manner in which individuals discuss significant past events has been related to psychological well-being, such that evidence of greater meaning-making of past events is associated with better mental health outcomes (Francis & Pennebaker, 1992). Sleep quality has also been associated with mental health, such that reduced sleep quality co-occurs with increased depression, anxiety, and stress, among others (Barclay, Eley, Maughan, Rowe, & Gregory, 2011; Lund, Reider, Whiting, & Prichard, 2010; Milojevich & Lukowski, 2015; Pilcher, Ginter, & Sadowsky, 1997; Stein, Belik, Jacobi, & Sareen, 2008; Tsuno, Besset, & Ritchie, 2005). For these reasons, the present research was conducted to determine (a) whether sleep quality was associated with the subjective experience of autobiographical events and (b) whether any demonstrated associations were mediated by participant depression.

Previous research has indicated that sleep after exposure to novel information enhances memory for emotional stimuli. In terms of narrative recall, adults read four texts (two neutral

and 2 negative) and were asked to memorize the presented information in a study by Wagner and colleagues (2001). Recall was tested following a 3-hour period of either sleep or wake. Participants who slept after learning recalled more information relative to participants who remained awake, and the facilitative effect of sleep on recall was particularly evident for negative information (Wagner et al., 2001). When memory was assessed in the same participants four years later, those who slept after learning demonstrated better recognition of emotional stimuli relative to participants who remained awake; group differences were not found when considering neutral stimuli (Wagner et al., 2006).

Similar findings have been obtained when participants were presented with pictorial stimuli. Payne and Kensinger (2011) presented participants with neutral and negative scenes on neutral backgrounds before administering an unexpected recognition task. Participants indicated whether they had previously studied the scene after a 12-hour delay during which they either slept or remained awake. In agreement with previous findings, the results indicated that sleep after learning facilitated recognition, and that the effects were more pronounced for negative relative to neutral scenes (see also Payne et al., 2008). Taken together, the findings obtained from laboratory studies indicate that sleep not only serves to facilitate recall more generally, but may preferentially impact memory for the emotional aspects of events.

Although relations between sleep and memory for emotional stimuli have been well-established, there is a paucity of work examining associations between sleep and memory for personal emotional events. When such work has been conducted, the focus has been on the accuracy of the provided information instead of its content. In one study, Aly and Moscovitch (2010) examined the accuracy of participant report of personal events (a recent phone call or information about recent media consumption) both before and after a 12-hour delay that did or did not include a period of sleep. Participants who slept after initially reporting on the events

recalled more information about their previous experiences relative to participants who remained awake when tested after the delay. More recently, Murre, Kristo, and Janssen (2014) examined associations between participant reported sleep quality and the accuracy of autobiographical memory over short (2-15 days) or extended (30-46 days) delays. The results revealed a significant interaction between sleep quality and delay length, such that participants with good sleep quality remembered more details about their narratives over lengthy delays relative to participants with poor sleep quality. Taken together, these findings indicate that sleep is an important factor in the recall of personally salient information. However, they do not inform the question of whether variability in sleep quality is associated with the content or emotionality of reported autobiographical memories.

Understanding the association between sleep quality and the content of autobiographical memories is important in that sleep may impact the manner in which individuals make meaning of and integrate past events into their established autobiographies. Individuals evaluate and make sense of past events through the use of internal states language, including words associated with emotion and cognition (Fivush & Baker-Ward, 2005). The use of internal states language varies in relation to the valence of the reported event (positive or negative). For example, individuals tend to use a greater amount of internal states language overall when discussing negative events relative to positive events (Fivush, Sales, & Bohanek, 2008). As might be expected, individuals also use a greater percentage of negative emotion words when discussing negative relative to positive events, and a greater percentage of positive emotion words when discussing positive relative to negative events (Bohanek et al., 2005; Fivush et al., 2008; Sales, Fivush, & Peterson, 2003).

Reports of the past also vary in terms of cognition words. The use of cognitive process words in association with emotion words when reporting on the past is indicative of greater

processing and meaning-making. Meaning-making allows an individual to cope with potentially difficult experiences (Bohanek et al., 2005; Fivush & Baker-Ward, 2005; Fivush et al., 2008) and is associated with enhanced psychological and physical well-being (Pennebaker, 1993; Pennebaker & Beall, 1986; Francis & Pennebaker, 1992; Pennebaker & Francis, 1996). That is, adults report negative memories that contain more cognitive process words relative to positive memories (Baker-Ward, Eaton, & Banks, 2005; Bohanek et al., 2005; Fivush et al., 2008). In one study, young adults recalled personal narratives that were intensely negative and positive and moderately negative and positive (Bohanek et al., 2005). The content of the narratives were examined for internal states language use and the results indicated that negative narratives contained a greater percentage of cognitive process words than positive narratives; participants used more cognitive process words when reporting intensely negative narratives than intensely positive narratives. Additionally, Fivush and colleagues (2008) found similar results when examining narratives about scary, frustrating, and happy events, such that negative (scary) narratives contained more cognition words relative to positive (happy) narratives. The increased use of cognitive process words when describing negative events suggest that individuals may be continuing to process, evaluate, and make meaning of the negative events relative to positive events in order to cope with the experiences. However, none of the work conducted to date has examined whether or how sleep quality is associated with the content of autobiographical memory.

Individuals' subjective evaluations of autobiographical events also vary by memory valence. Participants in a study by Byrne, Hyman, and Scott (2001) reported and provided ratings of traumatic, negative, and positive memories on several dimensions (emotional responses, importance, confidence, and rehearsal among others). Results demonstrated the participants' ratings varied by memory type, such that positive events were rated as more positive

relative to traumatic and negative memories, traumatic and negative events were rated as more important relative to positive memories, and traumatic events were less frequently talked about relative to positive memories. Bohanek, Fivush, and Walker (2005) examined reports and ratings of intensely and moderately positive and negative memories on the frequency with which adults talked and thought about the event as well as the significance, uniqueness, emotionality, and vividness of the event. Results indicate that adults rated the intensely positive and negative memories as more significant, unique, and vivid relative to the moderately emotional memories. Additionally, intensely positive memories were talked and thought about more often than moderately positive memories, but no differences were found between negative memories. These findings indicate that in addition to variability in the content of emotional events, individuals also differ in the manner in which they evaluate and rate their positive and negative past events. The perceived differences among events may be differentially associated with sleep quality.

The primary goal of the present study was to examine associations between sleep quality, as assessed using the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989), and the manner in which young adults discuss and evaluate self-nominated autobiographical events that varied by valence (positive or negative) and temporality (significant or recent). Dependent measures obtained from the reported narratives concerned (a) ratings of the frequency with which participants thought and talked about the reported events, the frequency with which they experienced the same or similar events in the past month, affect associated with the event, the vividness or vagueness of the memory, and their confidence that the reported memory was their own and was not due to pictures or conversations with others, as well as the duration of time since the event had occurred; (b) the use of internal states language, specifically including the number of words used in the narrative and the percentage of words pertaining to cognitive mechanisms, negative emotion, and positive emotion; and (c) indices of the complexity of the

event, including the percent of passive sentences used, reading ease, and grade level as well as coder-rated coherence of the reported event. Based on previous work demonstrating associations between sleep quality and the accuracy of memories (Aly & Moscovitch, 2010; Murre et al., 2014), we predicted that participants with good sleep quality would remember more details of their past memories and would thus rate the events as more unique than participants with poor sleep quality and would be more confident that their memories were not based on pictures or conversations with others. Work conducted on associations between sleep and memory for emotional stimuli (Payne et al., 2008; Payne & Kensinger, 2011; Wagner et al., 2001; Wagner et al., 2006) led to our prediction that reduced sleep quality would be associated with increased focus on the negative aspects of events. In particular, we expected that participants with reduced sleep quality would spend more time thinking about negative events from the past and that they would use more negative affect words when describing past negative experiences. We also expected that participants with good sleep quality would use more cognitive process words when describing negative events from the past, indicating an increased tendency towards making sense of and integrating these experiences into their autobiography. When these predictions were realized, we anticipated that the demonstrated associations between sleep quality and the content of autobiographical memories would be more apparent for recent relative to significant memories, given the temporal proximity between the reports of sleep quality and memory for recent autobiographical events.

Finally, when significant associations were found between sleep quality and dependent measures obtained from the reported narratives, we then examined whether participant depression mediated the obtained relation or whether sleep quality was directly responsible for the effect in question. Indeed, previous research has indicated that poor sleep quality is associated with negative mental health outcomes in university students, including increased

anger, confusion, depression, fatigue, and tension, among others (see Barclay et al., 2011; Lund et al., 2010; Milojevich & Lukowski, 2015; Pilcher et al., 1997; Stein et al., 2008; Tsuno et al., 2005). This last study aim was primarily exploratory in nature, as we did not make specific predictions as to which outcomes would be best explained by the direct effect of sleep quality or the mediating influence of depression.

METHOD

Participants

Three hundred eighty-six undergraduate students (316 females) were recruited through the undergraduate participant pool maintained by a large public university in the southwest. The data from the 70 male participants are not included in the present report given research documenting differences in the manner in which males and females report on past events (Bauer, Stennes, & Haight, 2003; Bohanek & Fivush, 2010). The data from 134 females were excluded due to incomplete data (83 participants did not provide narratives that conformed to the provided prompt, 45 participants did not complete the second session, and 6 participants did not respond to all of the questions on two standardized questionnaires), the data from 56 participants were excluded due to procedural errors (50 participants were sent questionnaires that did not include all of the necessary questions, 3 were sent the incorrect second session questionnaire, and 3 were allowed too much time to complete the surveys), and the data from 3 participants were excluded because they were over 25 years old. The involvement of 2 additional students was terminated based on consultation with the Institutional Review Board after the students reported suicidal thoughts on the depression questionnaire.

The final sample included 121 females (mean age = 20.03 years, range = 18-25 years).[1] Fifty-four percent (n = 65) of participants indicated that they were of Asian descent, 29% percent (n = 35) were Caucasian, 3% (n = 4) were of mixed race, and 14% (n = 17) chose not to provide race information. Twenty-five percent (n = 30) of participants identified as Hispanic, including

14% (n = 17) of participants who did not provide information on race.

Materials

In addition to providing demographic information, participants completed questionnaires to assess their sleep quality and depression; other mental health questionnaires were also included but are not the focus of the present report.

The Pittsburgh Sleep Quality Index (Buysse et al., 1989) is a 19-item measure that assesses quantitative and qualitative indices of self-reported sleep quality over the past month. Quantitative measures include participant reports of bed time, rise time, nighttime sleep duration, and the frequency of sleep disruptions, whereas qualitative measures inquire as to perceived sleep quality and enthusiasm for completing daytime activities. The reported values were reduced to yield global sleep quality scores ranging from 0 to 21 (higher scores indicate poorer sleep quality). Composite scores greater than 5 demonstrated adequate sensitivity and specificity in differentiating between good (healthy controls) and poor (depressed participants and those with sleep disorders) sleepers (Buysse et al., 1989). We classified participants using the same criteria, such that participants with global sleep quality scores less than or equal to 5 had good sleep quality (n = 63) whereas those with global sleep quality scores greater than 5 had poor sleep quality (n = 58).[2] This measure is the gold standard for assessing subjective sleep quality and has demonstrated adequate internal homogeneity and test-retest.

Depressive symptoms were assessed using the Beck Depression Inventory-II (BDI-II; Beck & Steer, 1993). Participants were presented with 21 items that assessed feelings associated with depressive symptoms such as sadness, pessimism, and loss of pleasure over the past 2 weeks. Participants rated the extent to which they identified with the description on 4-point scales that were summed to yield a composite score ranging from 0 to 63 (higher scores indicate

more severe depressive symptoms). The BDI-II has high internal consistency and test-retest reliability (Beck, Steer, & Ranieri, 1996)

Procedure

The study procedures were approved by the university Institutional Review Board. A waiver of written informed consent was granted such that participants indicated their willingness to participate by clicking forward after reading an electronic study information sheet. Participants were also presented with information about the services offered by the university counseling center as some of the included questions were somewhat sensitive in nature.

Students initially indicated their interest in participating by responding to an electronic advertisement on the website maintained by the Social Sciences Human Subject Pool. A research assistant emailed the student a unique link to the first session questionnaire along with a study-specific identification number. The links included in the emails were active for two days from the time the email was sent.

Participants provided demographic information and completed the BDI-II at the first session; they also completed questionnaires associated with other aspects of mental health that are not the focus of the present report. They were then asked to report on one negative and one positive event that occurred once (or very infrequently) and happened in one place at one time. Participants were asked to report as many details as they could, including details such as who was there, what they were doing, where they were, why they were doing what they were doing, and how they were feeling as the event occurred. Participants were randomly assigned to report on either (a) recent memories that occurred within the past two weeks or (b) their most significant memories. After providing the details of the requested memory, participants indicated the date on which the memory occurred and rated the event on a number of dimensions. They reported the number of times they experienced the event, how often they

thought about the event, and how often they talked about the event with others on a scale ranging from 1 (never) to 5 (many times). They also reported on the valence of the event (-3 as very negative to 3 as very positive), how vivid or vague their memory of the event was (-3 as very vague to 3 as very vivid), and how confident they were that the reported memory was based on their own experience and was not due to pictures or conversations with others (-3 as not very confident to 3 as very confident). Participants always reported on their negative memories before their positive memories.

After a delay of approximately one week (mean = 7 days, range = 6-8 days), a research assistant emailed the student with a unique link to the second session questionnaire along with his or her study-specific identification number. The links included in the emails were active for two days from the time the email was sent.

Participants completed the PSQI before providing information about either negative and positive memories from the past two weeks or their most significant negative and positive memories (whichever memories were not reported on at the first session). The PSQI was included at the second session so that participant-reported sleep habits over the previous 30 days were relevant when considering the memories reported at the first and second sessions. Participants reported on their memories in the same manner as they did on the first session questionnaire.

Data Reduction

Narratives were reviewed to ensure that each report referenced one specific event that was of the appropriate valence (positive or negative). Narratives that did not meet the criteria were excluded from analysis (n = 83). Acceptable narratives were cleaned in preparation for content assessment by the Linguistic Inquiry and Word Count program (LIWC-2007; Pennebaker & Francis, 1996) as indicated in the accompanying manual. In particular, spelling

and grammar errors were corrected, and words that would be coded incorrectly based on the context in which they were used were marked for exclusion from analysis (for example, without manual correction, LIWC-2007 would incorrectly categorize the word "like" as a positive emotion word in the sentence, "I felt like my mind would be so preoccupied with housing…"). In addition to these corrections, abbreviations were expanded and digits were changed from numerical to word format. Cleaned narratives were reviewed by a second research assistant to ensure accuracy and then were reduced by LIWC-2007 to determine the total number of words included in the narrative, the percent of negative emotion words, the percent of positive emotion words and the percent of words pertaining to cognitive processing. Narratives were reduced separately by valence (positive and negative) and temporality (significant or recent).

Information regarding the complexity of each narrative was obtained using the spell-check feature of Microsoft Word 2010 as was done in Bohanek and colleagues (2005). Variables pertained to the grade level at which the narrative was written (Flesch-Kincaid Grade Level; FKGL) and the ease with which the narrative could be read (Flesch Reading Ease; FRE). Both scores are computed using the total words-to-sentences ratio and total syllables-to-words ratio in the narratives. FKGL provides a score that is equivalent to a U.S. grade level, such that higher grade pieces are more difficult to read (e.g., a narrative assigned a score of 8 could be understood by an eighth grader). FRE provides a score ranging from 0 to 100, with higher scores indicating that narratives are easier to understand.

The content of the narratives were coded for overall coherence based on dimensions examined by Bohanek and colleagues (2005). Coherence was assessed on a 4-point scale, such that narratives that were off topic, minimally developed, and did not contain emotion words received lower scores than narratives that were related to the topic, well developed, included emotion words, and provided a resolution (or connection to other autobiographical experiences

or self-concept). Three independent researchers were trained to code the narratives for levels of coherence. The reliability among the researchers was assessed by computing an interclass correlation coefficient for 25% of the narratives.

RESULTS

Preliminary analyses of variance were conducted to determine whether the order in which participants reported on their memories (significant or recent memories first) was associated with any of the dependent measures (53% of the participants reported on their recent memories first). None of the examined associations were significant. As such, the following analyses are presented collapsed across order. Significant effects are presented when $p < .05$. Although all significant main effects and interactions are presented below, the results are only interpreted within the context of the highest-order significant interaction.

Sleep Quality

Descriptive statistics and group differences concerning participant sleep quality are presented in Table 1. Between-subjects analyses of variance (ANOVAs) and chi square analyses were conducted to determine whether participants with good or poor global sleep quality differed on individual components of sleep quality. The results revealed that participants with good sleep quality reported significantly earlier bed times, shorter sleep latencies, better sleep efficiency, greater nighttime sleep duration, and less frequent nighttime sleep disruptions relative to participants with poor sleep quality. Participants with good sleep quality also reported experiencing better sleep quality, less difficulty staying awake during the day, and more enthusiasm for daytime activities relative to those with poor sleep quality.

Associations between Sleep Quality and Autobiographical Memory

Narrative ratings. We first considered whether participant sleep quality (good or poor) was associated with participant ratings of reported narratives in combination with factors

pertaining to memory valence (positive and negative) and temporality (significant and recent). We conducted six mixed ANOVAs on dependent variables pertaining to the frequency with which participants thought about the reported events, the frequency with which participants talked about the reported events, the frequency with which they experienced the same or similar events in the past month, affect associated with the event, the vividness or vagueness of the memory, and confidence that the reported memory was not based on pictures or conversations with others; one additional ANOVA was conducted on the number of days since the event occurred. These data are shown in Table 2.

Main effects of sleep quality revealed that participants with good sleep quality were more confident that their memories were not due to pictures or conversations with others than were participants with poor sleep quality: $F(1, 117) = 5.02$, $p = .03$, $r = .20$. Participants with good sleep quality also reported events that were less likely to have been experienced previously, and were thus more unique, relative to participants with poor sleep quality: $F(1, 117) = 5.78$, $p = .02$, $r = .22$.

Main effects of temporality revealed that participants thought: $F(1, 117) = 39.98$, $p = .0001$, $r = .50$, and talked: $F(1, 115) = 22.09$, $p = .0001$, $r = .40$, more about significant events relative to recent events; participants also rated their memories of recent events as more vivid than those of significant events: $F(1, 115) = 10.13$, $p = .002$, $r = .28$. Participants also reported that recent events were more frequently experienced, and were thus less unique, relative to significant events. In addition, participants were more confident that recent memories were not influenced by pictures or conversations with others than was true for significant memories: $F(1, 117) = 10.37$, $p = .002$, $r = .28$. A main effect of temporality was found when considering the number of days since the event occurred: $F(1, 114) = 131.68$, $p = .0001$, $r = .73$, but was qualified by an interaction with valence.

Main effects of valence indicated that participants talked more about positive memories relative to negative memories: $F(1, 115) = 6.82$, $p = .01$, $r = .23$; they also reported that their positive memories were more vivid than their negative memories: $F(1, 114) = 17.44$, $p = .0001$, $r = .36$. Main effects of valence associated with the frequency with which participants thought about past events: $F(1, 117) = 6.78$, $p = .01$, $r = .23$, and self-reported affect about the event: $F(1, 118) = 1408.60$, $p = .0001$, $r = .96$, were further qualified by interactions. A main effect of valence was found when considering the number of days since the event occurred: $F(1, 114) = 13.93$, $p = .0001$, $r = .33$, but was qualified by an interaction with temporality.

The significant interaction between temporality and valence on the number of days since the event occurred was statistically significant: $F(1, 114) = 13.76$, $p = .0001$, $r = .33$. Follow-up pairwise comparisons conducted by temporality revealed that significant negative events occurred in the more distant past relative to significant positive events ($p = .0001$); differences were not found by valence when considering recent events. Pairwise comparisons conducted by valence revealed that significant events occurred in the most distant past relative to recent events when considering both positive and negative events (ps = .0001).

The main effect of valence found when considering the frequency with which participants thought about past events was qualified by an interaction with sleep quality: $F(1, 117) = 5.50$, $p = .02$, $r = .21$. These data are shown in Figure 1. Pairwise comparisons conducted by sleep quality revealed that participants with poor sleep quality thought more about their negative memories relative to their positive memories: ($p = .001$); differences were not found by valence when considering participants with good sleep quality. Pairwise comparisons conducted by valence revealed that participants with poor sleep quality also thought more about their negative memories relative to participants with good sleep quality ($p = .04$); group differences were not found when considering positive memories.

The main effect of valence found when considering self-reported affect about the event was further qualified by an interaction with temporality: $F(1, 118) = 6.78$, $p = .01$, $r = .23$. Pairwise comparisons conducted by valence revealed that significant positive events were rated as more positive than recent positive events ($p = .03$); differences were not found when considering negative events. Pairwise comparisons conducted by temporality revealed that positive memories were rated as more positive relative to negative memories when considering events from both the significant and recent past (ps = .0001).

Internal states language. We then considered whether participant sleep quality (good or poor) was associated with the use of internal states language in combination with factors pertaining to memory valence (positive and negative) and temporality (significant and recent). We conducted four mixed ANOVAs on dependent variables obtained from LIWC (Pennebaker & Francis, 1996) concerning the number of words used in the narrative and the percentage of words pertaining to cognitive mechanisms, negative emotion, and positive emotion. These data are shown in Table 3.

Main effects of valence and temporality revealed that narratives of negative events were longer than narratives of positive events: $F(1, 119) = 36.05$, $p = .0001$, $r = .48$, and narratives of significant events were longer than narratives of recent events: $F(1, 119) = 14.15$, $p = .0001$, $r = .33$. Additional main effects of valence indicated that narratives of positive events included a greater percentage of positive emotion words relative to narratives of negative events: $F(1, 119) = 282.97$, $p = .0001$, $r = .84$. Main effects of valence: $F(1, 119) = 176.27$, $p = .0001$, $r = .77$, and sleep quality: $F(1, 119) = 5.44$, $p = .02$, $r = .21$, were also found when considering the percentage of negative emotion words used but were qualified by an interaction with temporality. Significant effects were not found when considering the percentage of positive emotion words included in the narratives.

The three-way interaction among valence, temporality, and sleep quality was statistically significant: $F(1, 119) = 6.03$, $p = .02$, $r = .22$. Follow-up simple effects analyses were conducted by each of the included independent variables but are only presented by temporality given our prediction that sleep quality would be preferentially associated with memories from the recent relative to the distant past. These data are shown in Figure 2. A significant main effect of valence was found when considering narratives of significant events: $F(1, 119) = 68.41$, $p = .0001$, $r = .60$, such that a greater percentage of negative words were included in narratives of negative relative to positive events.

When considering recent events, main effects of valence: $F(1, 119) = 158.68$, $p = .0001$, $r = .76$, and sleep quality: $F(1, 119) = 11.19$, $p = .001$, $r = .29$, were obtained and were further qualified by an interaction with one another: $F(1, 119) = 7.35$, $p = .008$, $r = .24$. Follow-up pairwise comparisons conducted by sleep quality revealed that participants in both groups used a greater percentage of negative emotion words in narratives of recent negative relative to recent positive events (ps = .0001). Follow-up pairwise comparisons conducted by valence indicated that participants with poor sleep quality used a greater percentage of negative emotion words in narratives of recent negative events relative to participants with good sleep quality ($p = .001$); group differences were not found when considering narratives of recent positive events.

When considering word use associated with cognitive mechanisms, a significant interaction was obtained between valence and temporality: $F(1, 119) = 8.07$, $p = .005$, $r = .25$. Follow-up pairwise comparisons conducted by valence revealed that narratives of significant positive events included a greater percentage of words associated with cognitive processing relative to narratives of recent positive events ($p = .006$); no differences were found when considering narratives of recent events. Follow-up pairwise comparisons conducted by temporality revealed that narratives of recent negative events included a greater percentage of

cognitive mechanism words relative to narratives of recent positive events (p = .01); no differences were found when considering narratives of significant events.

Narrative complexity. An additional set of analyses examined whether participant sleep quality (good or poor) was associated with the complexity of reported narratives in combination with factors pertaining to memory valence (positive and negative) and temporality (significant and recent). We conducted three mixed ANOVAs on dependent variables obtained from Microsoft Word concerning the reading ease and grade level. One additional ANOVA was conducted to examine coder-rated coherence of the reported narratives. These data are shown in Table 4.

A significant interaction between valence and temporality was obtained for grade level: $F(1, 119) = 4.42$, $p = .04$, $r = .19$. Follow-up pairwise comparisons conducted by valence revealed no differences by temporality, whereas pairwise comparisons conducted by temporality indicated that narratives of recent negative events received higher ratings, and were thus written at a higher grade level, relative to narratives of recent positive events (p = .01). Differences by valence were not apparent when considering narratives of significant events.

A main effect of valence was found for reading ease: $F(1, 119) = 4.63$, $p = .03$, $r = .19$, such that narratives of negative events received higher ratings, and were thus easier to read, relative to narratives of positive events. An interaction between temporality and sleep quality was also found for reading ease: $F(1, 119) = 4.99$, $p = .03$, $r = .20$. Follow-up pairwise comparisons conducted by temporality revealed no differences, whereas pairwise comparisons conducted by sleep quality indicated that participants with good sleep quality reported significant events that were easier to read relative to recent events ($p < .05$). No differences were apparent when considering participants with poor sleep quality.

The analysis concerning coder-rated narrative coherence revealed only a main effect of temporality: $F(1, 122) = 5.13$, $p = .03$, $r = .20$, such that narratives of significant events were rated as more coherent than narratives of recent events.

Mediation Models

Given the documented associations between reduced sleep quality and indices of depression, we conducted a one-way between-subjects ANOVA by sleep quality (good or poor) to determine whether participants differed on self-reported depressive symptoms on the BDI-II. The results indicated that participants with poor sleep quality (14.77 ± 1.25) had higher depression scores relative to those with good sleep quality (7.90 ± 1.22): $F(1, 114) = 15.50$, $p = .0001$, $r = .36$. Based on this finding, we conducted mediation analyses to determine whether variability in depression mediated the relation between participant sleep quality and autobiographical memory (see Figure 3). Mediation analyses were conducted only on those variables that were significantly associated with sleep quality as reported in the ANOVAs described previously for those participants who had complete BDI-II questionnaires (n = 116). Analyses were conducted using the regression-based approach described in Hayes (2013), such that mediation occurred when bias-corrected confidence intervals (k = 10,000 resamples) did not include zero.

Two of the tested mediation models were significant: one concerning frequency of thought and another concerning the percentage of negative emotion words used when describing significant positive events. In the former, global sleep quality was positively associated with depressive symptoms (a = 2.05, $p = .0001$) and depressive symptoms were positively associated with the frequency of thought about negative events (b = .03, $p = .004$). Depressive symptoms mediated the association between global sleep quality and frequency of thought about negative events (ab = .06; confidence interval from .0188 to .0957). In addition, global sleep quality was

not associated with frequency of thought about negative events when controlling for depressive symptoms (c' = .00, *p* = .90). Mediation was not found when considering frequency of thought about positive events.

In the significant mediation model concerning the percentage of negative emotion words used when describing past events, depressive symptoms were positively associated with the percentage of negative affect words used when describing significant positive events (b = .03, *p* = .03). Depressive symptoms mediated the association between global sleep quality and the percent of negative emotion words used to describe significant past events (ab = .06; confidence interval from .0141 to .1382). In addition, global sleep quality was not associated with the percent of negative emotion words used when controlling for depressive symptoms (c' = -.03, *p* = .55). Mediation was not found when considering the percent of negative emotion words used for significant negative events, recent positive events, or recent negative events. Evidence of mediation was also not apparent when considering the other variables that were related to sleep quality through ANOVAs.

DISCUSSION

The present study examined relations between sleep quality and the manner in which female young adults discussed and evaluated autobiographical memories that varied on dimensions associated with temporality (significant or recent) and valence (positive or negative). The conducted research is unique in that the majority of the work examining associations between sleep and autobiographical memory has focused on relations between sleep and the accuracy of remembered information (Aly & Moscovitch, 2010; Murre et al., 2014). However, reduced sleep quality is also associated with poorer mental health (Barclay et al., 2011; Lund et al., 2010; Milojevich & Lukowski, 2015; Pilcher et al., 1997; Stein et al., 2008; Tsuno et al., 2005). As such, the study of associations between sleep quality and the subjective experience of

autobiographical memory may have significant implications for understanding how individuals process past events and incorporate them into their life stories.

When considering ratings of past events, participants with good sleep quality reported that they were more confident that their memories were their own and were not influenced by pictures or conversations with others more so than were participants with poor sleep quality. Participants with good sleep quality also reported events that were experienced less frequently – and were, as such, more unique – relative to participants with poor sleep quality. These findings may be related to the general consolidating effect of sleep on episodic memory more generally (Diekelmann, Wilhelm, & Born, 2009; Ellenbogen, Hulbert, Stickgold, Dinges, & Thompson-Schill, 2006; Stickgold, 2005; Walker & Stickgold, 2008) and for the emotional aspects of events in particular (Hu et al., 2006; Payne et al., 2008; Wagner et al., 2001).

Participant ratings of past events also revealed a significant interaction between group and valence when considering the frequency with which participants thought about past events. Follow-up pairwise comparisons indicated that participants with poor sleep quality thought about their negative memories more frequently than their positive memories; they also thought about their negative memories more frequently relative to participants with good sleep quality. Analyses of the content of the reported narratives also made apparent group differences in the percent of negative emotion words used when discussing past events. The three-way interaction amongst group, temporality, and valence revealed a significant interaction among group and valence for recent events, as we had predicted. Follow-up analyses revealed that participants with poor sleep quality used a greater percent of negative emotion words in narratives of recent negative events relative to participants with good sleep quality; group differences were also not found when considering narratives of recent positive events. Taken together, these findings indicate that participants with poor sleep quality spent more time thinking about negative events

relative to participants with good sleep quality regardless of temporality, whereas group differences in the percent of negative words used to describe the past were only found when considering narratives of recent negative events.

Associations between reduced sleep quality and increased focus on negative events was expected based on previous work documenting relations between poor sleep quality and reduced mental health (Barclay et al., 2011; Lund et al., 2010; Milojevich & Lukowski, 2015; Pilcher et al., 1997; Stein et al., 2008; Tsuno et al., 2005). We also found associations between sleep quality and depression in our sample, such that participants with poor sleep quality reported higher scores on the BDI-III (Beck & Steer, 1993) relative to participants with good sleep quality. Based on this finding, we examined whether participant depression mediated associations between sleep quality and the significant findings obtained through ANOVAs. Depressive symptoms mediated the relation between global sleep quality and the frequency of thought about negative events; evidence of mediation was not obtained when considering frequency of thought about positive events. Depressive symptoms also mediated the association between global sleep quality and the percent of negative emotion words used to describe significant positive events; mediation was not found when considering the percent of negative emotion words used to describe significant negative events, recent positive events, or recent negative events.

One possible mechanism through which depression might impact the processing of negative events is through rumination, or excessive unconscious focus on negative emotion (Nolen-Hoeksema, 1991, 2000). Previous experimental work has demonstrated that rumination increases the recall of negative relative to positive memories as well as the reported frequency of experiencing negative events in young adults with depressive tendencies (BDI scores > 16) relative to those with lower depression scores (BDI scores < 5) (Lyubomirsky, Caldwell, &

Nolen-Hoeksema, 1998). Importantly, the effects of rumination on recall were not exclusive to negative events: when asked to report on both positive and negative memories, depression in combination with experimentally-manipulated rumination resulted in reports of positive memories that were experienced as more negative in relation to those reported by participants from the other tested groups. Taken together, these findings indicate that the pattern through which depression exerts an influence on autobiographical memory is complex and is not uniquely associated with negative memories of the past.

Understanding associations among sleep quality, mental health, and autobiographical memory may be particularly important for helping individuals evaluate past events and integrate them into their life story. Although participants with poor sleep quality reported thinking more about their negative events and used more negative emotion words when discussing negative events from the recent past relative to participants with good sleep quality, differences by group, valence, and temporality were not found when considering words associated with cognitive processing. The combined use of emotion and cognition words in reports of the past indicates attempts to process and create meaning from those experiences (Fivush et al., 2008), and the ability to create meaning from and incorporate past experiences into a coherent life story is associated with enhanced psychological and physical well-being (Francis & Pennebaker, 1992; Pennebaker, 1993; Pennebaker & Beall, 1986; Pennebaker & Francis, 1996).

Future research should be conducted to further explore associations between sleep quality, mental health, and autobiographical memory in young adults to address the limitations of the present study as well as to replicate and extend our findings. One potential limitation of the conducted study is that participants reported on past events using a temporal dimension that was not orthogonal. That is, participants reported on their most significant positive and negative memories as well as positive and negative events that occurred within the past 2 weeks. This

distinction is potentially problematic in that significant and recent events may not only vary on the meaning or impact of the event but also on the duration of time since the event occurred. We did not ask participants to reflect on the significance of each reported event and, as such, as unable to evaluate whether the meaningfulness of the selected events varied by temporality. However, our results indicated that significant events occurred in the more distant past relative to recent events regardless of valence, as we had anticipated. To remedy this methodological limitation in future research, participants should be asked to report on (a) the most significant positive and negative event that occurred more than 2 weeks ago as well as (b) the most significant positive and negative event that occurred within the past 2 weeks so as to isolate the effects of temporality when examining associations with sleep quality.

An additional possible limitation of the present study was our focus on participant-nominated events that could not be verified for accuracy. As such, our analyses focus on associations between global sleep quality and the subjective experience of the reported events without concern for the accuracy of the provided information. Although previous research has examined associations between sleep quality and the accuracy of autobiographical information, such estimates may be flawed (for example, because participants may report accurate details of an event at test that they failed to report at encoding). Future research should examine associations amongst global sleep quality, the content of autobiographical memories, and the accuracy of reported information. Future research should also supplement the participant-report measure of sleep quality used in this study with objective sleep data obtained through actigraphy (Sadeh & Acebo, 2002) so as to inform the question of whether participant perceptions or objective data are better predictors of memory for emotional information.

Although additional research is needed to identify the manner in which sleep quality impacts the subjective experience and accurate reporting of autobiographical memories, the

present study contributes significantly to the literature on emotion-cognition associations by indicating that poor global sleep quality is associated with the subjective experience of autobiographical events. Findings indicating that participants with poor sleep quality engage in more frequent thought about past negative events and use more negative emotion words when describing negative events from the recent past is concerning, particularly when considering that participants with poor sleep quality did not use more cognitive process words when discussing the past relative to participants with good sleep quality. When considered in combination, these findings are significant: the process of evaluating and making meaning of past emotional events is associated with psychological well-being (Pennebaker, 1993; Pennebaker & Beall, 1986; Francis & Pennebaker, 1992; Pennebaker & Francis, 1996). For this reason, future research should examine whether the implementation of existing sleep interventions might serve to improve sleep quality and reduce indices of depression (Trockel, Manber, Chang, Thurston, & Tailor, 2011), either directly or indirectly allows for differences in the reflection on and processing of past experiences that might in turn facilitate other aspects of mental health.

FOOTNOTE

[1] Participants in the final sample did not significantly differ from those who were excluded on measures of global sleep quality (p = .51) and depressive symptoms (p = .23).

[2] Global sleep quality on the PSQI was computed excluding responses to the free-recall question associated with nighttime sleep disruptions. We excluded these responses because a subset of the participants (n = 136) was sent questionnaires that did not include this question. Because all questions on the PSQI must be answered for the inventory to be scored, all inventories were scored omitting the response to this question. For those participants who received the complete questionnaire including this question (n = 184) and provided complete data (n = 175), measures of global sleep quality were highly correlated when global sleep quality was computed including and excluding the item in question (r = .99, p =.0001).

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Table 1

Descriptive Information and Group Differences on the Pittsburgh Sleep Quality Index

	Sleep Quality			Between-Group Differences		
	Overall (n = 121)	Good (n = 63)	Poor (n = 58)	Statistic	*p*-value	*r* effect size
Rise time	8:32 (:08)	8:38 (:11)	8:26 (:12)	F =.46	.50	.06
Bed time*	12:58 (:08)	12:38 (:11)	1:17 (:11)	F = 5.76	.02	.21
Sleep latency (minutes)*	26.97 (3.88)	15.05 (5.37)	36.89 (5.60)	F = 7.93	.006	.25
Sleep efficiency*	91.19 (.85)	94.01 (1.18)	88.37 (1.23)	F = 10.91	.001	.29
Sleep duration*	6.91 (.09)	7.50 (.12)	6.32 (.13)	F = 44.10	.0001	.52
Sleep disruptions*	7.09 (.36)	5.16 (.49)	9.02 (.51)	F = 29.60	.0001	.45
Reported sleep quality percent reporting fairly good or very good sleep quality over the past month)*	78%	97%	57%	$\chi^2 = 27.77$	.0001	.48
Sleep medication (percent reporting no use during the past month)	96%	98%	93%	$\chi^2 = 2.15$	.14	.13
Staying awake (percent reporting no problems during the past month)*	70%	84%	55%	$\chi^2 = 12.11$	.001	.32
Enthusiasm (percent reporting no problems during the past month)*	26%	40%	10%	$\chi^2 = 13.64$	.0001	.34
Global sleep quality*	5.61 (.15)	3.65 (.20)	7.57 (.21)	F = 177.66	.0001	.77

Note: Means and standard deviations are reported for continuous variables; percentages are reported for categorical variables.

Table 2

Narrative Ratings for Autobiographical Memories by Sleep Quality and Memory Type (Means and Standard Errors)

	Significant		Recent		Significant	Recent	Overall (across Temporality)	
	Positive	Negative	Positive	Negative	Overall (across Valence)		Positive	Negative
<u>Good Sleep Quality</u>								
Affect	6.81 (.07)	2.11 (.20)	6.79 (.08)	2.42 (.18)	4.46 (.10)	4.61 (.10)	6.80 (.06)	2.23 (.15)
Confidence	6.57 (.11)	6.56 (.11)	6.85 (.08)	6.75 (.11)	6.57 (.10)	6.80 (.08)	6.71 (.08)	6.66 (.09)
Experienced	1.20 (.08)	1.07 (.07)	1.59 (.10)	1.40 (.08)	1.13 (.05)	1.49 (.07)	1.39 (.07)	1.23 (.06)
Talked	3.16 (.16)	2.64 (.16)	2.61 (.13)	2.33 (.13)	2.90 (.12)	2.47 (.10)	2.88 (.11)	2.48 (.11)
Thought	3.57 (.15)	3.52 (.14)	2.98 (.13)	3.08 (.14)	3.54 (.11)	3.03 (.10)	3.27 (.10)	3.30 (.10)
Vivid	6.21 (.16)	5.63 (.20)	6.47 (.12)	6.00 (.17)	5.92 (.15)	6.23 (.11)	6.34 (.10)	5.82 (.14)
Time (days since occurrence)	961.08 (137.21)	1764.19 (230.16)	5.40 (1.06)	8.50 (.70)	1362.64 (146.09)	6.95 (.61)	483.24 (68.64)	886.35 (115.07)

Table 2, continued

Narrative Ratings for Autobiographical Memories by Sleep Quality and Memory Type (Means and Standard Errors)

	Significant		Recent		Significant	Recent	Overall (across Temporality)	
	Positive	Negative	Positive	Negative	Overall (across Valence)		Positive	Negative
<u>Poor Sleep Quality</u>								
Affect	6.71 (.07)	2.09 (.21)	6.41 (.08)	2.43 (.19)	4.40 (.11)	4.42 (.10)	6.56 (.06)	2.26 (.16)
Confidence	6.28 (.11)	6.40 (.12)	6.48 (.09)	6.60 (.11)	6.34 (.10)	6.54 (.08)	6.38 (.08)	6.50 (.09)
Experienced	1.33 (.08)	1.28 (.07)	1.59 (.11)	1.69 (.09)	1.30 (.05)	1.64 (.07)	1.46 (.07)	1.48 (.06)
Talked	3.21 (.16)	3.00 (.16)	2.54 (.14)	2.50 (.14)	3.11 (.13)	2.52 (.10)	2.88 (.11)	2.75 (.11)
Thought	3.47 (.15)	3.95 (.15)	2.84 (.13)	3.30 (.15)	3.71 (.12)	3.07 (.10)	3.16 (.11)	3.62 (.11)
Vivid	5.69 (.17)	5.60 (.22)	6.33 (.13)	5.83 (.19)	5.63 (.16)	6.08 (.12)	6.01 (.11)	5.70 (.15)
Time (days since occurrence)	850.11 (147.03)	1362.98 (246.62)	7.09 (1.14)	6.94 (.75)	1106.55 (156.54)	7.02 (.65)	428.60 (73.60)	684.96 (123.30)

Table 2, continued

Narrative Ratings for Autobiographical Memories by Sleep Quality and Memory Type (Means and Standard Errors)

	Significant		Recent		Significant	Recent	Overall (across Temporality)	
	Positive	Negative	Positive	Negative	Overall (across Valence)		Positive	Negative
<u>Overall (across Groups)</u>								
Affect	6.76 (.05)	2.10 (.14)	6.60 (.06)	2.42 (.13)	4.43 (.07)	4.51 (.07)	6.68 (.04)	2.26 (.11)
Confidence	6.43 (.08)	6.48 (.08)	6.67 (.06)	6.68 (.08)	6.45 (.07)	6.67 (.06)	6.55 (.06)	6.58 (.07)
Experienced	1.26 (.05)	1.17 (.05)	1.59 (.07)	1.54 (.06)	1.22 (.04)	1.57 (.05)	1.43 (.05)	1.36 (.04)
Talked	3.19 (.11)	2.82 (.11)	2.57 (.10)	2.41 (.09)	3.00 (.09)	2.49 (.07)	2.88 (.08)	2.62 (.08)
Thought	3.52 (.10)	3.73 (.10)	2.91 (.09)	3.19 (.10)	3.63 (.08)	3.05 (.07)	3.22 (.08)	3.46 (.08)
Vivid	5.95 (.12)	5.60 (.15)	6.40 (.09)	5.92 (.13)	5.77 (.11)	6.16 (.08)	6.17 (.08)	5.76 (.10)
Time (days since occurrence)	905.60 (100.55)	1563.59 (168.67)	6.25 (.78)	7.72 (.51)	1234.59 (107.06)	6.98 (.45)	455.92 (50.34)	785.66 (84.33)

Table 3

Internal States Language Use by Sleep Quality and Memory Type (Means and Standard Errors)

	Significant		Recent		Significant	Recent	Overall (across Temporality)	
	Positive	Negative	Positive	Negative	Overall (across Valence)		Positive	Negative
<u>Good Sleep Quality</u>								
Cognitive process	17.99 (.66)	17.33 (.49)	17.40 (.64)	18.02 (.64)	17.66 (.42)	17.71 (.50)	17.69 (.49)	17.67 (.36)
Negative emotion	.80 (.17)	3.69 (.40)	.75 (.14)	3.12 (.31)	2.25 (.21)	1.93 (.17)	.77 (.12)	3.41 (.27)
Positive emotion	5.59 (.42)	1.77 (.20)	5.72 (.32)	1.82 (.22)	3.68 (.24)	3.77 (.19)	5.66 (.28)	1.79 (.14)
Word count	139.70 (14.64)	165.30 (18.35)	100.83 (7.75)	135.18 (11.46)	152.50 (15.09)	118.00 (8.72)	120.26 (9.98)	150.24 (12.97)
<u>Poor Sleep Quality</u>								
Cognitive process	18.88 (.69)	17.57 (.51)	15.98 (.67)	18.27 (.67)	18.23 (.43)	17.13 (.52)	17.43 (.51)	17.92 (.38)
Negative emotion	1.23 (.18)	3.61 (.42)	.92 (.15)	4.61 (.32)	2.42 (.22)	2.76 (.18)	1.08 (.12)	4.11 (.29)
Positive emotion	5.13 (.43)	1.65 (.21)	5.47 (.33)	2.01 (.22)	3.39 (.25)	3.74 (.20)	5.30 (.29)	1.83 (.14)
Word count	123.10 (15.26)	167.07 (19.13)	94.19 (8.08)	135.40 (11.94)	145.09 (15.73)	114.79 (9.09)	108.65 (10.40)	151.23 (13.51)

Table 3, continued

Internal States Language Use by Sleep Quality and Memory Type (Means and Standard Errors)

	Significant		Recent		Significant	Recent	Overall (across Temporality)	
	Positive	Negative	Positive	Negative	Overall (across Valence)		Positive	Negative
<u>Overall (across Groups)</u>								
Cognitive process	18.44 (.47)	17.45 (.35)	16.69 (.46)	18.14 (.46)	17.94 (.30)	17.42 (.36)	17.56 (.35)	17.80 (.26)
Negative emotion	1.02 (.12)	3.65 (.29)	.84 (.10)	3.87 (.22)	2.33 (.15)	2.35 (.12)	.93 (.08)	3.76 (.20)
Positive emotion	5.36 (.30)	1.71 (.15)	5.60 (.23)	1.91 (.16)	3.53 (.17)	3.76 (.14)	5.48 (.20)	1.81 (.10)
Word count	131.40 (10.57)	166.19 (13.25)	97.51 (5.60)	135.29 (8.28)	148.79 (10.90)	116.40 (6.30)	114.45 (7.20)	150.74 (9.37)

Table 4

Narrative Complexity by Sleep Quality and Memory Type (Means and Standard Errors)

	Significant		Recent		Significant	Recent	Overall (across Temporality)	
	Positive	Negative	Positive	Negative	Overall (across Valence)		Positive	Negative
Good Sleep Quality								
Coherence	2.14 (.11)	2.12 (.10)	2.09 (.10)	2.02 (.10)	2.13 (.09)	2.05 (.09)	2.12 (.09)	2.07 (.07)
FKGL	8.28 (.74)	7.34 (.42)	7.40 (.34)	8.25 (.43)	7.81 (.45)	7.83 (.31)	7.84 (.43)	7.79 (.34)
FRE	72.97 (1.41)	76.38 (1.35)	70.51 (1.72)	73.32 (1.41)	74.67 (1.09)	71.91 (1.28)	71.74 (1.19)	74.85 (1.10)
Poor Sleep Quality								
Coherence	2.22 (.11)	2.32 (.10)	1.98 (.11)	2.03 (.10)	2.27 (.09)	2.01 (.09)	2.10 (.09)	2.18 (.08)
FKGL	7.84 (.77)	7.64 (.44)	6.97 (.36)	7.89 (.45)	7.74 (.47)	7.43 (.32)	7.41 (.44)	7.76 (.35)
FRE	71.02 (1.47)	74.62 (1.40)	75.63 1.79	73.34 (1.47)	72.82 (1.14)	74.48 (1.34)	73.32 (1.24)	73.98 (1.14)
Overall (across Groups)								
Coherence	2.18 (.08)	2.22 (.07)	2.04 (.08)	2.03 (.07)	2.20 (.06)	2.03 (.06)	2.11 (.06)	2.14 (.05)
FKGL	8.06 (.53)	7.49 (.30)	7.18 (.25)	8.07 (.31)	7.78 (.32)	7.63 (.22)	7.62 (.31)	7.78 (.25)
FRE	71.99 (1.02)	75.50 (.97)	73.07 (1.24)	73.33 (1.02)	73.74 (.79)	73.20 (.93)	72.53 (.86)	74.41 (.79)

Note: Abbreviations are as follows: Flesch-Kincaid Grade Level (FKGL); Flesch Reading Ease (FRE).

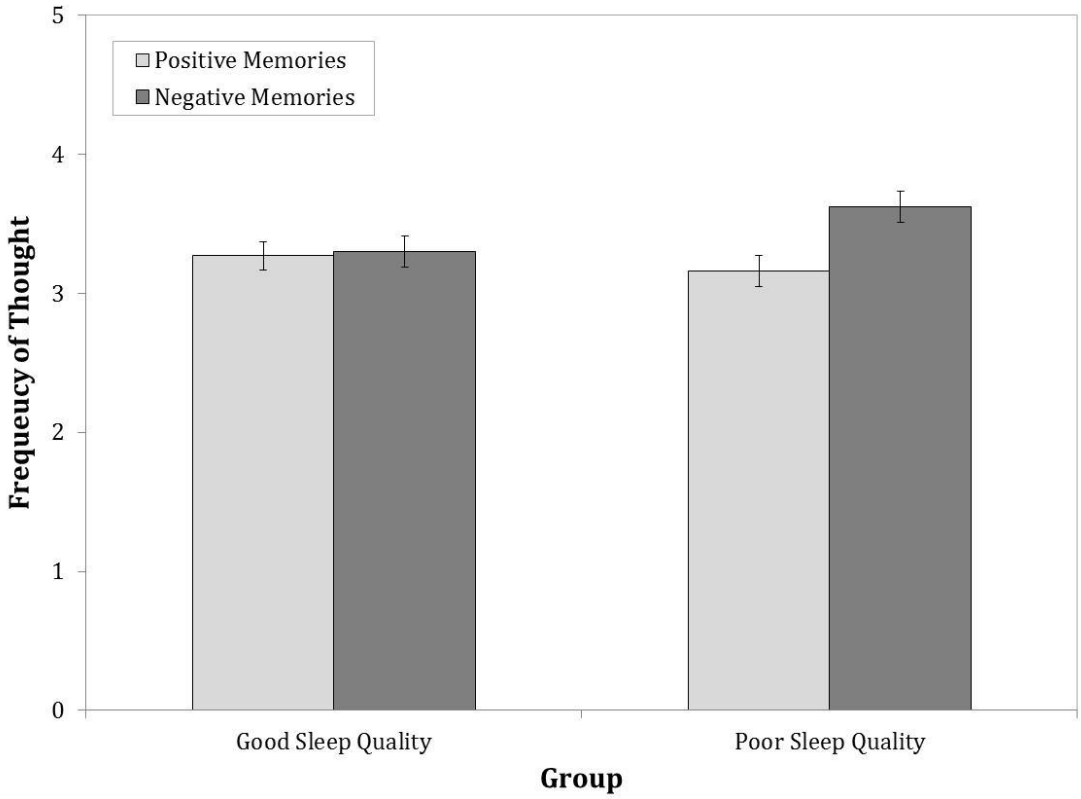

Figure 1. Sleep Quality x Valence interaction for the frequency of thought.

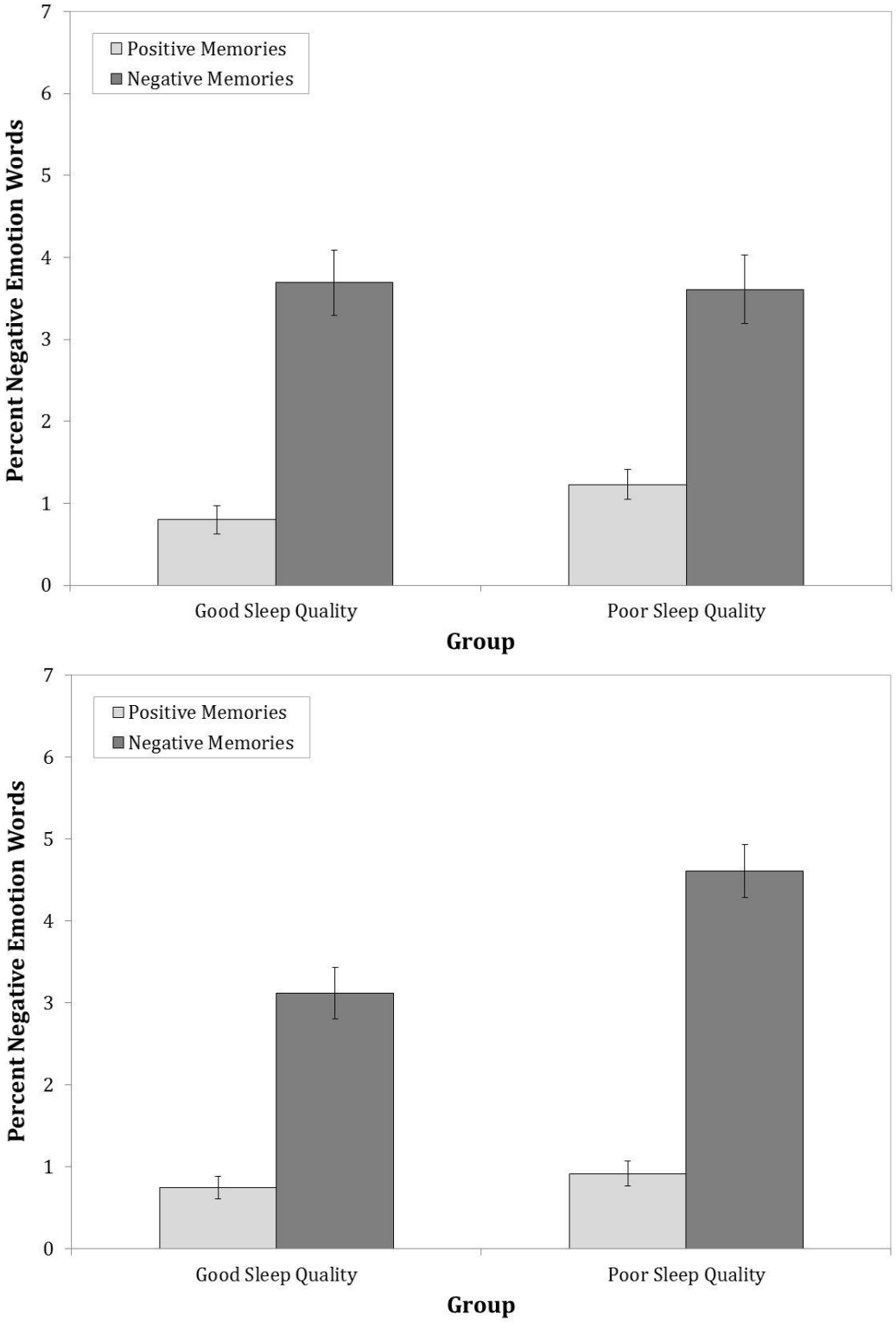

Figure 2. Sleep Quality x Valence interaction for the use of negative emotion words in recent (Panel A) and significant (Panel B) events.

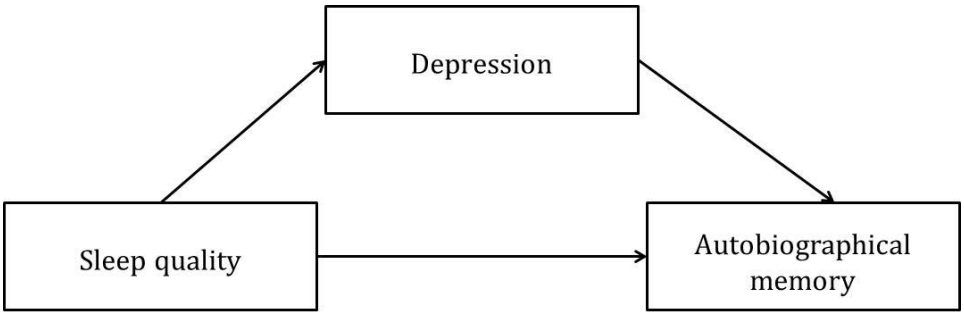

Figure 3. Mediation analyses were conducted to examine whether depression mediated the association between sleep quality (coded continuously) and autobiographical memory for those variables that were significantly associated with sleep quality as reported in ANOVAs.