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Original Article

Sleep deprivation reduces perceived emotional intelligence and constructive thinking skills

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Abstract

Background and purpose: Insufficient sleep can adversely affect a variety of cognitive abilities, ranging from simple alertness to higher-order executive functions. Although the effects of sleep loss on mood and cognition are well documented, there have been no controlled studies examining its effects on perceived emotional intelligence (EQ) and constructive thinking, abilities that require the integration of affect and cognition and are central to adaptive functioning.
Patients and methods: Twenty-six healthy volunteers completed the Bar-On Emotional Quotient Inventory (EQi) and the Constructive Thinking Inventory (CTI) at rested baseline and again after 55.5 and 58 h of continuous wakefulness, respectively.
Results: Relative to baseline, sleep deprivation was associated with lower scores on Total EQ (decreased global emotional intelligence), Intrapersonal functioning (reduced self-regard, assertiveness, sense of independence, and self-actualization), Interpersonal functioning (reduced empathy toward others and quality of interpersonal relationships), Stress Management skills (reduced impulse control and difficulty with delay of gratification), and Behavioral Coping (reduced positive thinking and action orientation). Esoteric Thinking (greater reliance on formal superstitions and magical thinking processes) was increased.
Conclusions: These findings are consistent with the neurobehavioral model suggesting that sleep loss produces temporary changes in cerebral metabolism, cognition, emotion, and behavior consistent with mild prefrontal lobe dysfunction.
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Keywords: Sleep deprivation; Emotional intelligence; EQ; Constructive thinking; Coping; Stress

1. Introduction

Insufficient sleep can have deleterious effects on personal health, cognitive performance, and safety [1–3]. Without adequate sleep, individuals show significant impairment in a variety of cognitive abilities, most notably including simple alertness, vigilance, attention, and concentration [4–8]. There is also evidence suggesting that sleep loss can adversely affect a variety of higher-order cognitive processes, including problem-solving [9], inhibitory control [10,11], and complex decision-making [12–14], although there continues to be debate on this subject and findings for executive function tasks have not always been consistent [15–18]. Many of these higher-order capacities are believed to be mediated by the prefrontal cortex [19], a complex region of the brain that appears to be particularly affected by prolonged wakefulness [20–22].

Perhaps because logical reasoning has long been considered to be the foundation of human rationality [23], the field of sleep deprivation research has focused

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primarily on the logical, rational, and purely mechanistic aspects of intellectual and cognitive performance (e.g., working memory, concentration, logical processing, set shifting, etc.). However, emerging evidence suggests that effective human judgment and decision-making involves more than dispassionate logic and rational intellect [24,25]. While traditional forms of cognitive intelligence are critical to the ability to adapt and survive, most individuals that succeed in modern society demonstrate a number of other capacities as well. Successful individuals are able to regulate their own emotional behaviors in constructive ways, are adept at utilizing their affective processes to guide their judgments and streamline their decision-making, are skilled at identifying and understanding the emotional needs of others, and are effective at acting upon this information in pro-social and self-enhancing ways [26–28]. Such people are said to think and act in constructive ways [29] and demonstrate qualities of "emotional intelligence" [30].

It has been suggested that emotional intelligence abilities, including self-awareness, interpersonal skills, and adaptive coping skills, are related to better adjustment, and may be as important, if not more so, to a variety of successful life outcomes than traditional cognitive intelligence [30]. In fact, it has been observed that formally measured intellectual capacity is often not the best predictor of many aspects integral to successful living. For example, measures of adjustment including job success, relationship satisfaction, and mental health have been shown to not be significantly associated with intellectual ability [31,32]. Rather, individuals that show a combination of adaptive problem-solving and emotional and behavioral coping skills appear to be the most successful when faced with highly stressful experiences, a set of skills that have been described as "Constructive Thinking" [29]. Epstein and Meier conceptualize Constructive Thinking as the habitual thought processes that help a person construe and respond to events adaptively and with minimal stress [29]. Because emotionally intelligent individuals are attuned to the subtle nuances of emotions in others and in themselves and can use this information to facilitate effective judgment and streamline decision-making [28], they would also be expected to rely heavily on the emotional and behavioral coping skills involved in constructive thinking.

There is accumulating evidence that a significant proportion of the variance in Emotional Intelligence is rooted in neurobiology. The ability to integrate emotional information with cognitive processing appears to require the interaction of several key brain regions, particularly the ventromedial prefrontal cortex, the insular cortex, and the amygdala [33]. These three brain regions comprise a neural system that integrates emotional states, prior learning, and conscious cognition to guide decision-making [24,25]. Of these regions, the ventromedial prefrontal cortex is thought to function as the critical integrator of emotional and cognitive information in the service of decision-making [34,35]. Despite relatively normal levels of cognitive intelligence, patients with damage to the ventromedial prefrontal cortex often exhibit profound impairments in social judgment and deficits in emotionally based decision-making [24,25,34,36]. Thus, dysfunction within the ventromedial prefrontal cortex is associated with impaired emotional intelligence and poor constructive thinking processes, while intact functioning of this region allows the individual to cope flexibly with changing demands.

Interestingly, the prefrontal cortex appears to be particularly sensitive to the effects of sleep loss, with significant declines in metabolic activity evident following as few as 24 h of continuous wakefulness [22,37]. Functionally, the prefrontal cortex appears to become less efficient at neural processing during prolonged sleep deprivation [38,39], necessitating the recruitment of additional brain regions to compensate for these deficiencies [40–42]. Likewise, tests of complex cognitive functions mediated by the prefrontal region often show decrements in performance after one to two nights of sleep loss [20,21]. This appears to be particularly true for tasks requiring divergent thinking and mental flexibility [43] rather than novel logic-based executive function tasks such as the Wisconsin Card Sorting Test [15,16]. Recent findings suggest that deficits in emotional decision-making [13], inhibitory control [44], mood regulation [45,46], moral judgment [47], and responses to frustration [48] also emerge after sleep deprivation. These findings suggest that it is not only pure cognitive abilities that are affected by sleep loss, but also affective functions that are central to personality and social interaction, capacities that are likely to play a central role in emotional intelligence. To address this more directly, the effects of two nights of sleep loss were examined on two well-validated commercially available tests of perceived emotional intelligence and constructive thinking skills. The tests were administered at rested baseline and again following 55.5 h of continuous wakefulness. It was hypothesized that sleep deprivation would produce significant declines in perceived emotional intelligence and constructive thinking scores.

2. Method

2.1. Participants

Twenty-six healthy military volunteers (21 males and 5 females) participated in a larger investigation of the effects of caffeine on psychomotor vigilance. The participants ranged in age from 20 to 35 years (mean [M] = 25.3, standard deviation [SD] = 4.1) and had an average of 14.1 years of education (SD = 1.6). Other data from this sample of volunteers have been presented elsewhere [48–50], although the results reported herein represent novel and never before published findings about perceived emotional intelligence and constructive thinking skills. All participants were native English speakers and had at least a sixth-grade reading level as measured by the Wide Range Achievement Test-3rd Edition (WRAT-3). Exclusion criteria were as follows: high caffeine use (>300 mg/day in the past 2 years), cigarette/nicotine use, or significant history of medical, neurological, or psychiatric problems as determined by the study physician. Volunteers were excluded if they showed signs of possible depression [i.e., Beck Depression Inventory (BDI) >9 [51] and/or >40 on the Spielberger State/Trait Anxiety Inventory (STAI)] [52]. A study physician medically cleared each of the participants prior to the start of the study. Participants were asked to abstain from stimulants, alcohol, and other psychoactive substances during the 48 h preceding the study, and urine drug screens were collected upon initial arrival at the laboratory to confirm that all participants were free of any illicit substances or stimulant medications. Volunteers received monetary compensation upon the completion of the study (or prorated for early withdrawal). All volunteers provided written informed consent prior to participation. The investigation was approved by the Walter Reed Army Institute of Research Human Use Review Committee and the US Army Human Subjects Research Review Board.

2.2. Materials: Bar-On Emotional Quotient Inventory (EQi)

The perceived emotional intelligence of volunteers was assessed using the Bar-On Emotional Quotient Inventory (EQi) [53]. The EQi is an objective self-report inventory that was designed to assess the construct of self-perceived emotional intelligence and the underlying factors that contribute to emotionally intelligent behavior. Participants responded to statements such as "it's hard for me to understand the way I feel" by endorsing one of the following five response options: "Very Seldom or Not true of Me", "Seldom True of Me", "Sometimes True of Me", "Often True of Me", and "Very Often True of Me or True of Me." The EQi provides several scores, including a general measure of perceived emotional intelligence or Total EQ (i.e., the perceived capacity to understand the emotions of oneself and others, to use that information to deal effectively with interpersonal relationships, and the ability to cope with stresses), and five composite scales assessing Intrapersonal functioning (i.e., self-knowledge), Interpersonal functioning (i.e., perceived ability to understand and relate to others), Adaptability (i.e., ability to assess problems and respond flexibly), Stress Management (i.e., perceived ability to maintain calm and function well under pressure), and General Mood (i.e., enjoyment of life and a healthy positive outlook). Each composite scale comprises several subscales as well, each measuring specific components of emotionally intelligent behavior and thinking. The EQi also includes four validity index scales to assess participant motivation and response sets. These validity scales include the number of Omissions, as well as an Inconsistency Index, Positive Impression Scale, and Negative Impression Scale. The test manual for the EQi reports that the subscales show good reliability, with Cronbach's alpha ranging from 0.69 for the Social Responsibility subscale to 0.86 for the Self-Regard subscale. The EQi also shows good stability over repeated testing, with test-retest reliability ranging from 0.85 at one-month retesting to 0.75 after 4 months [53]. Several studies have demonstrated the validity of the EQi as a subjective measure of emotional intelligence [53–55]. For the present study, raw scores on the EQi were converted to standardized scale scores with a population mean of 100 and a standard deviation of 15 points, based on a North American normative sample of 3831 adults [53]. These scaled scores were norm-referenced by age and sex.

2.3. Constructive Thinking Inventory (CTI)

To assess the effect of sleep deprivation on flexibility of thought and constructive thinking patterns, volunteers were administered the CTI [56], a 108-item self-report inventory that includes a global scale of constructive versus destructive automatic thinking and six factor scales: Emotional Coping, Behavioral Coping, Categorical Thinking, Personal Superstitious Thinking, Esoteric Thinking, and Naïve Optimism. Participants responded to statements such as "unless I do a perfect job, I feel like a failure" by endorsing one of the following five response options: "Definitely False", "Mostly False", "Undecided", "Mostly True", and "Definitely True". The internal reliability across the scales ranges from 0.71 to 0.90 [57,58], with a test–retest reliability of 0.86 [58]. The CTI scales are positively correlated with factors associated with successful life experiences and functioning (e.g., work, love, social relationships) and negatively correlated with factors that contribute to less successful functioning (e.g., psychiatric symptoms, physical/somatic symptoms, self-discipline problems, and alcohol and drug problems) [29]. The CTI was specifically designed to assess automatic thought processes that lead to constructive versus destructive outcomes. For the present study, raw scores on the CTI were converted to standardized T-scores with a population mean of 50 and a standard deviation of 10 points, based on the gender-specific normative sample of 908 census matched adults from the United States, as provided in the test manual and computer scoring program [56].

2.4. Procedure

Volunteers arrived on the evening of the acclimation day (Day 0), received an explanation of the basic study procedures, and were trained on several cognitive tasks. Participants lived in-residence in the Sleep Laboratory of the Walter Reed Army Institute of Research for the full duration of the study. While in the study, participants were provided a wide selection of controlled food and drinks (all free of caffeine or other stimulants). Light levels were maintained at approximately 500 lux in all laboratory areas and ambient temperature was maintained at approximately 23 °C throughout the study. Throughout the course of the study, volunteers remained in a lounge area and were allowed to play games, interact with other participants, watch television, or read quietly, although no vigorous exercise was permitted. Participants were run in groups of three to four at a time and were monitored continuously by trained technicians throughout the duration of the study.

At the end of the first evening they were allowed to sleep (eight hours of uninterrupted time in bed) from 11:00 p.m. to 7:00 a.m. The next day (Day 1), the participants completed the standard commercially available forms of the CTI and EQi. The baseline CTI was administered from 2:30 p.m. to 3:00 p.m. (i.e., 7.5 h awake) and the EQi from 5:00 p.m. to 5:30 p.m. (i.e., 10 h awake). As part of a larger study examining the effects of caffeine on cognitive and vigilance performance after sleep deprivation, the participants were kept awake continuously for a total of 77 h. On Day 3, the participants completed the sleep-deprived administration of the CTI at 2:30 p.m., following 55.5 h awake, and completed the EQi at 5:00 p.m., following 58 h of continuous wakefulness. Both tasks were administered according to the standard format provided by the test publisher in order to ensure that the scores were comparable to the test norms. We did not use a split-half design because such a procedure would invalidate the multidimensional factorial design of the questionnaires, and there currently exist no published norms for split-half alternate forms of the instruments. Consequently, the test items were administered in the same order and format at both administrations.

Between 1:00 a.m. and 7:00 a.m. during each night of sleep deprivation, half of the sample ($n = 12$) received repeated double-blind administrations of caffeine (200 mg), while ($n = 14$) the other participants received an identical placebo in a cinnamon-flavored chewing gum (four doses equally spaced over an 8-h period for a total of 800 mg caffeine each night). Because the half-life of caffeine is approximately four to six hours in healthy adults [59], it was expected that caffeine would have no discernible effects by the time the CTI (7.5 h since last administration) and EQi (10 h since last administration) were completed on Day 3. Nonetheless, the potential effects of caffeine were evaluated in the statistical analyses.

2.5. Statistical Analyses

The analyses proceeded in two stages. First, we examined potential nuisance variables to ensure that the results were not unduly influenced by the drug group or by the age of the participants. Caffeine administration was not expected to have any discernable effects on EQi or CTI scores, as the last dose had been administered 7.5 h prior to the CTI and 10 h prior to the EQi, durations which exceed the demonstrated 4–6 h half-life of caffeine [59,60]. However, to directly assess this possibility, we calculated change scores for each scale from baseline to sleep-deprived sessions (i.e., Test 2–Test 1) and then compared the change scores of the caffeine and placebo groups on every primary scale from the EQi and CTI, using multiple independent group *t*-tests, with a liberal statistical threshold of $\alpha = .05$ to detect any possible effects on each of the scales. Of all of the scale comparisons, only the change score for the Personal Superstitious Thinking (PST) scale of the CTI showed a significant difference between drug groups ($t_{24} = 2.69$, $p = .013$), with those administered caffeine showing reduction of 2.7 (SD = 6.6) T-score points, whereas the placebo group showed an increase of 4.2 (SD = 6.4) points. Thus, caffeine group was entered as a factor in subsequent analyses only for the PST scale and its subscales.

Similarly, the effect of age was evaluated by correlating each participant's age with the change scores from baseline to sleep-deprived sessions for each scale, with $\alpha = .05$. If age was found to be significantly correlated with the change in a scale score from baseline to sleep-deprived sessions, then age was entered as a covariate in all subsequent analyses for that particular scale. Age was found to correlate significantly with change scores for the following scales and subscales of the EQi: Total EQ ($r = .42$, $p = .03$), Interpersonal Scale ($r = .39$, $p = .05$), Stress Management Scale ($r = .49$, $p = .01$), Self-Regard Subscale ($r = .46$, $p = .02$), Interpersonal Relationship Subscale ($r = .45$, $p = .02$), Impulse Control Subscale ($r = .42$, $p = .03$). Thus, age was entered as a nuisance covariate in the analysis of these scales. None of the change scores for the CTI scales or subscales were correlated with age.

The next stage involved examining the effect of sleep deprivation on the change in EQi and CTI scores from the baseline to sleep-deprived sessions using a repeated measures analysis of variance (ANOVA). To protect against inflation of Type I error, subscale scores were only evaluated if the primary parent scale was shown to change significantly from baseline to sleep-deprived sessions. In addition, given the exploratory nature of this investigation, a Bonferroni correction for multiple comparisons was also undertaken based on the 13 primary scales of interest. This resulted in a corrected $p < .05$ alpha threshold of $p < .004$ to be considered statistically significant. Differences exceeding the corrected threshold are identified in Tables 1 and 2 with asterisks (*). Finally, the change scores were also compared to available data regarding the standard error of prediction for retesting. For the EQi, change scores for each scale were compared directly to the published standard error of prediction in the test manual [53]. For the CTI, the change score for each scale was compared to the published test-retest reliability coefficient for the Global Constructive Thinking scale (i.e., 0.86) [58]. Differences exceeding one or more standard errors are indicated in the tables.

3. Results

3.1. Perceived emotional intelligence

First, to provide an evaluation of changes in response set as a function of sleep deprivation, several validity and response indices were compared across sessions. No significant change was found for Omissions, Inconsistency Index, Positive Impression Scale, or Negative Impression Scale of the EQi between baseline and

Table 1
Means and standard deviations for the Bar-On Emotional Quotient Inventory scales at baseline and sleep-deprived testing sessions

Scale	Baseline mean (SD)	Sleep-deprived mean (SD)	*p*
Total EQ	110.08 (13.23)	105.96 (14.57)	.012
Intrapersonal	109.31 (13.27)	104.31 (15.37)	.004*
Self-regard	107.12 (12.72)	103.96 (15.05)	.008
Emotional self-awareness	108.23 (15.01)	107.15 (15.84)	.598
Assertiveness	106.69 (12.80)	100.15 (14.97)	.002*,b
Independence	105.31 (13.46)	101.23 (15.58)	.027a
Self-actualization	108.96 (13.58)	102.46 (14.55)	.002*,b
Interpersonal	106.50 (13.96)	102.96 (13.82)	.026
Empathy	104.58 (13.01)	99.00 (13.95)	.046b
Social responsibility	105.69 (12.72)	103.69 (13.80)	.346
Interpersonal relationship	106.58 (13.57)	103.77 (13.95)	.012
Adaptability	109.46 (12.49)	105.38 (14.69)	.105
Stress Management	110.85 (10.57)	109.73 (11.52)	.010
Stress tolerance	108.85 (13.86)	109.12 (13.66)	.898
Impulse control	109.77 (12.49)	107.81 (13.56)	.025
General Mood	106.54 (11.97)	105.62 (12.85)	.517
Omissions	0.15 (0.46)	0.04 (0.20)	.083
Inconsistency	5.35 (3.11)	6.38 (2.94)	.054
Positive impression index	92.50 (12.13)	90.88 (9.95)	.521
Negative impression index	98.19 (13.62)	97.85 (12.09)	.844

Note: $^*p < .05$ Bonferroni corrected. Difference is greater than [a]2 or [b]3 standard errors of prediction for the scale or subscale based on the values reported in the test manual [53].

Table 2
Means and standard deviations for the constructive thinking inventory scales at baseline and sleep-deprived testing sessions

Variable	Baseline mean (SD)	Sleep-deprived mean (SD)	*p*
Global constructive thinking	51.04 (8.00)	49.69 (8.99)	.185
Emotional coping	52.65 (6.95)	52.19 (7.63)	.616
Behavioral coping	52.00 (8.35)	47.85 (10.24)	.007a
Positive thinking	52.38 (9.30)	47.96 (9.99)	.003*,a
Action orientation	52.12 (7.55)	48.81 (9.06)	.045
Conscientiousness	50.35 (8.30)	48.50 (11.10)	.205
Personal superstitious thinking	48.15 (9.03)	49.19 (9.01)	.551
Categorical thinking	50.08 (8.16)	50.31 (10.88)	.880
Esoteric thinking	47.31 (5.11)	49.08 (6.32)	.041
Belief in the unusual	44.92 (6.58)	44.46 (8.47)	.664
Formal superstitious thinking	49.88 (5.58)	53.50 (6.54)	.001*
Naïve optimism	48.96 (9.93)	50.42 (9.62)	.262
Defensiveness index	51.31 (11.81)	55.81 (8.85)	.033a
Validity index	51.54 (7.33)	47.31 (13.20)	.040a

Note: $^*p < .05$ Bonferroni corrected. Difference is greater than [a]1 standard error of prediction for the scale or subscale estimated from the test–retest reliability for the Global Constructive Thinking scale reported in the test manual [58].

sleep-deprived sessions (all p-values $> .05$), suggesting that the data from the EQi are valid and interpretable. Overall, Total EQ scores declined significantly as a function of sleep deprivation ($F_{1,24} = 7.32$, $p = .012$), with participants showing an average drop in their total perceived emotional intelligence of 4.12 scale score points. Table 1 provides the means and standard deviations for Total EQ and the composite scale scores for the baseline and sleep-deprived sessions. Analysis of the primary composite scale scores showed that this decline in perceived emotional intelligence involved significant decreases on three of the five composite factor indices, including Intrapersonal functioning ($F_{1,24} = 9.99$, $p = .004$), Interpersonal functioning ($F_{1,24} = 5.65$, $p = .026$), and Stress Management ($F_{1,24} = 7.92$, $p = .010$). In contrast, sleep deprivation had no significant effect on composite scales measuring Adaptability ($F_{1,25} = 2.83$, $p = .105$) or General Mood ($F_{1,25} = 0.43$, $p = .517$).

Subscale differences were examined only for those composite scales showing significant differences (see Table 1). For the Intrapersonal composite scale, four of the five subscales showed significant declines as a function of sleep deprivation, including Self-Regard ($F_{1,24} = 8.45$, $p = .008$), Assertiveness ($F_{1,25} = 11.92$, $p = .002$), Independence ($F_{1,25} = 5.54$, $p = .027$), and Self-Actualization ($F_{1,25} = 11.75$, $p = .002$). In contrast, there was no significant change in Emotional Self-Awareness ($F_{1,25} = 0.29$, $p = .598$). For the Interpersonal composite scale, two of the three subscales showed significant declines from baseline to sleep-deprived testing, including Empathy ($F_{1,25} = 4.41$, $p = .046$) and the Interpersonal Relationship scale ($F_{1,24} = 7.35$, $p = .012$). No significant difference was found between testing sessions for the Social Responsibility subscale ($F_{1,25} = 0.92$, $p = .346$). As mentioned previously, there were no effects of sleep deprivation on the Adaptability composite scale, including its subscales of Reality Testing, Flexibility, or Problem-Solving. Of the two subscales comprising the Stress Management composite score, there was a significant decline in Impulse Control ($F_{1,24} = 5.75$, $p = .025$) but not Stress Tolerance ($F_{1,25} = 0.02$, $p = .898$) following two nights of sleep loss. Finally, as described earlier, no differences were found between the baseline and sleep-deprived conditions for the composite scale of General Mood, including the Happiness and Optimism subscales.

3.2. Constructive thinking

Validity and response bias scales were examined first. There was a significant increase in the Defensiveness scale of the CTI between the baseline ($M = 51.3$, $SD = 11.8$) and sleep-deprived ($M = 55.8$, $SD = 8.9$) sessions ($F_{1,25} = 5.12$, $p = .033$), suggesting a greater tendency to present an unrealistically positive self-description, and a decrease in the Validity Index, suggesting greater carelessness in responding from baseline ($M = 51.5$, $SD = 7.3$) to sleep-deprived ($M = 47.3$, $SD = 13.2$) sessions ($F_{1,25} = 4.68$, $p = .04$). Although the declines are statistically significant, the group means at each session, however, all remained well within normal limits relative to the normative populations described in the test manuals [53,56].

Overall, sleep deprivation did not have a significant effect on constructive thinking as measured by the Global Constructive Thinking Scale ($F_{1,25} = 1.86$, $p = .185$). There were, however, significant changes in two of the six constructive thinking factor scales between the baseline and sleep-deprived conditions. As shown in Table 2, there was a significant decrease in Behavioral Coping ($F_{1,25} = 8.55$, $p = .007$) and a significant increase in Esoteric Thinking ($F_{1,25} = 4.66$, $p = .041$). In contrast, there were no significant changes in the factor scales measuring Emotional Coping, Categorical Thinking, or Naïve Optimism.

As described earlier in the analysis section, none of the EQi or CTI scales differed as a function of caffeine group membership, with the exception of the Personal Superstitious Thinking scale of the CTI. Consequently, the caffeine group was included as a factor in the formal analysis of this scale. The results yielded a significant interaction between the caffeine group and scores on the Personal Superstitious Thinking scale between the baseline and sleep-deprived CTI administrations. Specifically, for those who received caffeine, T-scores on the Personal Superstitious Thinking scale decreased an average of 2.7 points from baseline ($M = 49.67$, $SD = 6.32$) to sleep-deprived testing ($M = 47.00$, $SD = 5.03$). Conversely, for those in the placebo group, T-scores increased an average of 4.2 points on this scale from baseline ($M = 46.86$, $SD = 10.92$) to sleep-deprived sessions ($M = 51.07$, $SD = 11.25$).

Factor scales showing significant changes as a function of sleep loss were further analyzed for differences among the subscale scores. The observed decline in Behavioral Coping scores during sleep deprivation appeared to be driven primarily by a significant decrease in scores on the Positive Thinking ($F_{1,25} = 10.76$, $p = .003$) and Action Orientation ($F_{1,25} = 4.47$, $p = .045$) subscales. There was, however, no significant change in scores on the Conscientiousness subscale ($F_{1,25} = 1.70$, $p = .205$). Analyses of the subscales comprising the Esoteric Thinking factor suggested that the observed increase in scores was best explained by an increase in Formal Superstitious Thinking ($F_{1,25} = 15.91$, $p = .001$), and did not reflect any change in the belief in the unusual factor scale ($F_{1,25} = 0.19$, $p = .664$).

4. Discussion

Sleep deprivation produced statistically significant declines in several facets of perceived emotional intelligence and some aspects of subjectively assessed constructive thinking skills, including reduced self-reports of intrapersonal awareness, interpersonal functioning, stress management, and behavioral coping skills as well as an elevation in esoteric thought processes. The present scales were subjective in nature and may simply reflect the participant's own self-perception of declines in these skills rather than providing an objective indication of behavioral changes in emotional intelligence or coping skills. Although, at the levels of sleep deprivation studied here, there is much evidence that suggests that most individuals are able to adequately self-monitor and assess their cognitive status [61–63], some evidence also suggests that some aspects of self-assessment may be adversely affected [64,65]. In light of this fact, it would be particularly interesting for future studies to directly compare the effects of sleep loss on objective measures of emotional intelligence, such as the Meyer-Salovey Emotional Intelligence Test (MSCEIT) [66].

Although consistent with our hypotheses regarding the effects of sleep loss on functions mediated by the prefrontal cortex [12,20–22,41,43], these findings should be considered tentatively, in light of several methodological limitations. First, it is possible that situational demand characteristics may have led participants to endorse symptoms consistent with their expectations of the adverse effects of sleep deprivation. This possibility is supported by the decline on the Validity Index of the CTI, suggesting that participants were less consistent in their test taking approach after sleep loss. Attempts to conform to expectations about sleep deprivation might account for this decline, although it is also plausible that participants were simply more inconsistent due to reduced alertness, difficulty concentrating, and reduced efforts to correct errors [67]. This decline raises concern over the interpretability of the data from the CTI, particularly given that the present study did not include a non-sleep-deprived comparison group. Nevertheless, the fact that scores on the Defensiveness scale (i.e., the tendency to minimize symptoms and present an unrealistically favorable self-description) actually increased following sleep deprivation argues against the likelihood of demand characteristics leading participants toward more pathological responding. Finally, Omissions, Inconsistency Index scores, and Positive and Negative Impression Scales of the EQi did not change from baseline to sleep-deprived sessions. Thus, data from the EQi appear valid and interpretable, but caution is warranted with regard to the validity and interpretability of the CTI data.

After sleep deprivation, there was a statistically significant decline in perceived emotional intelligence, affecting three major areas of functioning, including Intrapersonal awareness, Interpersonal skills, and Stress Management. These findings are consistent with recent correlational research showing that higher levels of fatigue are associated with reduced emotional intelligence [68] and studies showing that sleep deprivation adversely affects mood [46,69], affective symptoms of psychopathology [70], responses to frustrating circumstances [48], and other affective processes [71]. Overall, sleep loss produced a decline in assertiveness, empathy, and the ability to control impulses and delay gratification, features common to prefrontal lobe dysfunction [72–75]. The average change, however, was on the order of 0.5 standard deviations and all mean scores remained within normal limits relative to published data [53], suggesting that the level of functioning produced by sleep deprivation was not within the clinically impaired range. Under highly stressful circumstances, however, it is possible that similar declines could affect the subjective perception of stress [76], the ability to cope effectively [77], and ability to work cooperatively with others [78]. Such declines could have implications for the optimal functioning of personnel in high-stress occupations.

Constructive thinking was also expected to be affected by sleep loss because of its correlations with prefrontal executive functioning [79] and relationship to the construct of emotional intelligence [80]. In light of the reduced validity scores on the CTI, we present these data tentatively and suggest caution in their interpretation. While there was no change in the Global Constructive Thinking scale, there were alterations of two specific thinking patterns after sleep loss. Sleep-deprived individuals endorsed fewer responses associated with positive Behavioral Coping, a thinking pattern that promotes active problem-solving and effective action, while minimizing ruminations and unproductive behavior. Conversely, the participants endorsed higher scores on Esoteric Thinking after sleep loss, a pattern that includes beliefs in magical, strange, and scientifically unfounded phenomena, such as paranormal occurrences and superstitions [56]. The present findings are consistent with research suggesting that the duration of sleep affects coping skills and the perception of daily hassles [81], and even with animal research suggesting that rapid eye movement (REM) deprivation is associated with reduced coping behaviors in laboratory rats [82]. The observed decreases in behavioral coping and concomitant increases in maladaptive esoteric thinking suggest that sleep deprivation may produce a general decline in adaptive cognition and effective coping, both of which are critical features of emotional intelligence [80].

Overall, the present results are consistent with neuroimaging [22,37,40–42] and neuropsychological [17,20,21,43,50,83] findings suggesting that the prefrontal cortex – most notably, the ventromedial sector, which is believed to mediate the integration of emotion with cognition [24,25] – is particularly susceptible to the adverse effects of prolonged wakefulness [13,47,71]. Our findings suggest that the previously documented declines in prefrontal functional activity produced by sleep loss may produce a temporary dysfunction of these systems analogous to, though less severe than, those often seen in clinical patients with prefrontal lobe lesions [36,84]. Because these systems are critical for emotionally intelligent behavior [33,85], it is not surprising to find that self-reported emotional intelligence and constructive thinking skills may decline during periods of prolonged wakefulness.

To our knowledge, the present study is the first to examine the effects of sleep loss on perceived emotional intelligence and adaptive coping under laboratory conditions. Sleep deprivation was associated with mild declines in several self-reported traits of emotional intelligence and, perhaps, some aspects of coping abilities, but without a fully rested comparison group, these findings must be considered preliminary. Ultimately, because critical decisions are often made in high-stress environments involving continuous operations (e.g., military combat, law enforcement, emergency responders), these findings underscore the importance of obtaining adequate sleep to sustain optimal emotional intelligence and effective coping.

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