Journal of Sleep Research / Volume 23, Issue 6

Empathy and sleep | Free Access

The effects of sleep deprivation on emotional empathy

Veronica Guadagni, Ford Burles, Michele Ferrara, Giuseppe Iaria

First published:13 August 2014
https://doi.org/10.1111/jsr.12192

Summary

Previous studies have shown that sleep loss has a detrimental effect on the ability of the individuals to process emotional information. In this study, we tested the hypothesis that this negative effect extends to the ability of experiencing emotions while observing other individuals, i.e. emotional empathy. To test this hypothesis, we assessed emotional empathy in 37 healthy volunteers who were assigned randomly to one of three experimental groups: one group was tested before and after a night of total sleep deprivation (sleep deprivation group), a second group was tested before and after a usual night of sleep spent at home (sleep group) and the third group was tested twice during the same day (day group). Emotional empathy was assessed by using two parallel versions of a computerized test measuring direct (i.e. explicit evaluation of empathic concern) and indirect (i.e. the observer's reported physiological arousal) emotional empathy. The results revealed that the post measurements of both direct and indirect emotional empathy of participants in the sleep deprivation group were significantly lower than those of the sleep and day groups; post measurement scores of participants in the day and sleep groups did not differ significantly for either direct or indirect emotional empathy. These data are consistent with previous studies showing the negative effect of sleep deprivation on the processing of emotional information, and extend these effects to emotional empathy. The findings reported in our study are relevant to healthy individuals with poor sleep habits, as well as clinical populations suffering from sleep disturbances.

Introduction

Sleep is important for our mental, physical and emotional wellbeing. It plays a critical role in a variety of functions, including restoration of the endocrine and metabolic processes (Spiegel *et al* ., 1999), energy conservation (Moorcroft, 2013), memory consolidation (Diekelmann and

Born, 2010) and recovery of cortical functioning (Drummond *et al* ., 1999). In support of such a critical role, it has long been established that sleep deprivation degrades several aspects of neurocognitive performance: it reduces learning capacity, impedes divergent thinking, increases ineffective response perseveration (Durmer and Dinges, 2005), increases attention lapses and reaction time (Lim and Dinges, 2010) and decreases hand–eye coordination (Elmenhorst *et al* ., 2009). Although cognitive tasks vary considerably in their sensitivity to sleep loss, to date the fundamental role of sleep on the proper functioning of our daily life is widely accepted (Durmer and Dinges, 2005).

Sleep deprivation appears to have the largest adverse effects on performance when the executed tasks depend upon the functional integrity of the prefrontal cortex (PFC) (Couyoumdjian *et al* ., 2010; Drummond *et al* ., 2006; Harrison *et al* ., 2007; Killgore *et al* ., 2006). The PFC is well known to be involved in executive functions (Yuan and Raz, 2014), as well as in the regulation of emotions, and particularly in the ability to shift to someone else's perspective (Ochsner, 2013). Accordingly, sleep deprivation has been shown to greatly influence the ability to process emotional information (Kahn *et al* ., 2013), and its negative effects on mood seem to be more prominent than its effects on cognitive and motor performance (Pilcher and Huffcutt, 1996). More specifically, sleep loss seems to increase the propensity of the individuals to experience negative emotions (Babson and Feldner, 2010) and decrease their capacity to recognize emotions from facial expressions (Minkel *et al* ., 2010). Sleep deprivation also alters pitch and vocal energy of spoken word (McGlinchey *et al* ., 2011), as well as sympathetic responses (e.g. pupillary dilation) triggered by negative stimuli (Franzen *et al* ., 2009). In addition, recent studies have shown that sleep loss affects the ability to recognize and categorize other people's emotions (Tempesta *et al* ., 2010; Van Der Helm *et al* ., 2010), and reduces the individual's self-perceived emotional intelligence by affecting the ability to be empathetic towards others (Killgore *et al* ., 2008), which may result in a higher number of conflicts following a poor night of sleep in young couples (Gordon and Chen, 2014). Altogether, these studies provide clear evidence that sleep deprivation is detrimental to mood and emotion processing in general (Kahn *et al* ., 2013) and may have significant negative effects on some more complex emotion processes, such as those involved in empathy.

Empathy refers to the ability of an individual to understand another person's mental state in terms of emotions, feelings and thoughts, which is important for an effective interpersonal interaction (Shamay-Tsoory, 2011). Recently, the general concept of empathy has been conceptualized into two different components, i.e. cognitive and emotional empathy (Dziobek *et al* ., 2008; Shamay-Tsoory, 2011; Shamay-Tsoory *et al* ., 2009). Cognitive empathy (also referred to as theory of mind) refers to the individual's ability to understand another person's perspective, feelings and state of mind (Baron-Cohen, 2004). It underpins the ability to predict others' behaviour, to manipulate or deceive people to our own advantage, and to understand when individuals are lying or holding a false belief. Conversely, emotional empathy refers to the ability to understand the emotions of others by vicariously sharing them (Smith, 2006). It can manifest as increased feelings of distress while observing someone else in a negative situation, and does not require an explicit understanding of why the individual is suffering (Rankin *et al* ., 2005). Recently, Dziobek and colleagues (Dziobek *et al* ., 2008) further divided emotional empathy into direct and indirect components. The direct emotional empathy component refers to the explicit evaluation of the observer's feelings while attending someone else in an emotional situation (e.g. I am concerned/angry that this person is being harmed). Indirect emotional empathy refers to the physiological arousal of the observer while attending someone else in an emotional situation (e.g. my heart is racing/I felt an adrenaline rush when I saw a person being harmed).

This recent bi-dimensional conceptualization of empathy into cognitive and emotional components has theoretically evolved from a more traditional measurement of empathy, as developed by Davis in 1980 (Davis, 1980). In his Interpersonal Reactivity Index (IRI) questionnaire, Davis highlights four different aspects of empathy: (1) perspective-taking, which is defined as the individual's spontaneous attempt to take the perspective of others; (2) fantasy, which refers to the ability of individuals to identify themselves with characters encountered in movies and books; (3) empathic concern, defined as the feelings of concern and compassion that individuals may experience for others; and (4) personal distress, which refers to the negative feeling of anxiety and distress that people undergo while observing someone in a negative situation. Within the most recent categorization of empathy, Davis' dimensions of perspective-taking and fantasy are conceptualized as cognitive empathy and empathic concern and personal distress as emotional empathy (Kaplan and Iacoboni, 2006).

To date, although an increasing number of studies suggests that sleep loss may be indeed detrimental to some aspects of empathy (Gordon and Chen, 2014; Killgore *et al* ., 2008; Tempesta *et al* ., 2010; Van Der Helm *et al* ., 2010), the effect of sleep loss on emotional empathy has been never specifically probed. In this study, we adopted the emotional empathy test developed by Dziobek *et al* . (2008) to test the specific hypothesis that sleep deprivation results in a reduced emotional empathic response, compared to the measures obtained from the same individuals before the night of sleep loss and the measures obtained in a different group of individuals who underwent a usual night of sleep.

Methods

Participants

We recruited 37 healthy volunteers [15 males and 22 females, mean age = 22.05, SD = 4.08 years, mean education = 15.47, SD = 2.43 years]. At the time of testing, none of the participants were taking any psychoactive medication, nor had a history of medical, neurological or psychiatric disorder. The study was approved by the local research ethics board and participants were required to provide informed consent before the experiment began.

Groups

Participants were assigned randomly to one of three different groups: the sleep deprivation group ($n = 13$), the sleep group ($n = 12$) and the day group ($n = 12$). Participants in all groups were tested twice. Subjects in the sleep deprivation group were tested at 9 pm, before a night of total sleep deprivation, and 8 am on the following morning. The sleep deprivation night occurred in the laboratory where participants were monitored by two experimenters. The laboratory had no windows and was constantly illuminated by full-spectrum fluorescent lamps. Throughout the night of sleep deprivation, subjects were allowed to perform activities such walking, surfing the internet, watching movies and playing board games. Lying down, sleeping and engaging in vigorous physical activities were not permitted. They were allowed to consume snacks and caffeine-free soft drinks; caffeinated drinks, large amounts of chocolate and sweets, alcohol and psychoactive medications were not allowed. Cigarettes were limited to three for the entire duration of the study. Subjects in the sleep group were tested at 6 pm and 10 am on the morning following a usual night of sleep. Participants in this group spent a night of undisturbed sleep at home and provided a sleep log to ensure that their quality of sleep was adequate. The time slept during the experimental night (mean = 6:38, SD = 1:38) was not significantly different from the average sleep duration (mean = 7:40, SD = 1:50) reported for the month preceding the study ($t_{11} = -1.672$, $P = 0.48$). Finally, participants in the day group performed the pre and post sessions of the study during the same day at 10 am and 6 pm, respectively; this group served as a control for the passage of time and fatigue. The experimental groups did not differ in the average sleep duration reported for the month preceding the study ($F_{2,34} = 1.570$, $P = 0.22$).

Questionnaires

Before performing the experimental tasks, we asked participants to complete the State–Trait Anxiety Inventory (STAI; Spielberger *et al* ., 1970) in both STAI Y-1 (State) and STAI Y-2 (Trait) forms, to control for abnormal anxiety (scores > 48). We also asked participants to complete the Beck Depression Scale (Beck *et al* ., 1961) to check for the presence of abnormal depressive traits (scores > 17), and the Online Alexithymia Questionnaire (OAQ-G2) (Paula-Perez *et al* ., 2010) to ensure that participants were not alexithymic (scores > 113), a condition characterized by difficulty in distinguishing and appreciating the emotions of others. In addition, we asked participants to complete the IRI (Davis, 1980). Each participant's quality of sleep was assessed by the Pittsburgh Sleep Quality Index (PSQI; Buysse *et al* ., 1989), which evaluated sleep quality throughout the month preceding the study; this scale confirmed that all participants included in our study had a fair quality of sleep (PSQI score mean = 5.38, SD = 2.12), with an average sleep onset time of 12:12 am (SD = 1:19) and an average sleep duration of 7 h 6 min (SD = 1:11). No instances of sleep during the day occurred in any of the participants.

Experimental tasks

The experimental tasks consisted of a modified version of the Multifaceted Empathy Test (MET) (Dziobek *et al* ., 2008), which is used to assess direct and indirect emotional empathy. Our experimental tasks were created by using 120 coloured images selected from the International Affective Picture System (IAPS) (Lang and Bradley, 2007). An equal number of images depicted people in positive (valence mean = 8.0; arousal mean = 5.1), neutral (valence mean = 5.0; arousal mean = 3.6) and negative (valence mean = 2.0; arousal mean = 6.0) scenes, as categorized by the IAPS normative data. We selected only pictures that included people and in which emotional expressions were clearly visible. We used this set of images to create two parallel versions of the same task, the administration order of which was balanced across testing sessions. The two tasks consisted of 60 images each, matched for image valence and arousal, as provided by the IAPS normative data.

In each task, the 60 images were presented three times, each time paired with a specific question that aimed to measure either direct emotional empathy (i.e. 'how strong is the emotion you feel about this person?'), indirect emotional empathy (i.e. 'how calm/aroused does this picture make you feel?') or a mere image valence judgement (i.e. 'how would you judge this image?' positive/negative/neutral). The image valence query was included to ensure that the participants' image judgements were consistent with the normative ratings provided by the IAPS. Therefore, each task consisted of 180 trials. In each trial, participants were shown an image and asked to answer one of the three questions described above as quick as possible, using the keyboard. Participants responded to the direct and indirect emotional empathy questions by using a reduced version of the Self-Assessment Manikin (SAM) valence scale. The SAM valence scale (Bradley and Lang, 1994) is a cartoon-type figure in which nine human emotional expressions, ranging from calm and not concerned to anxious and very concerned, are represented. In our study we utilized a reduced version consisting of four figures that captured the entire range of the full version. Participants were required to answer the three questions on randomized blocks of 10 trials each. Each task included 18 blocks, and each block only had one question posed. Each block was initiated with an on-screen query for the duration of 4000 ms, followed by a fixation cross (range 1000–3000 ms, mean = 2000 ms, within each block) and the image stimulus, which remained on-screen until participants responded, or until 10 s had elapsed. In each experimental task the presentation of the blocks was randomized, and the task began with a practice session consisting of six trials. Fig. 1 contains samples of trials used in the tasks.

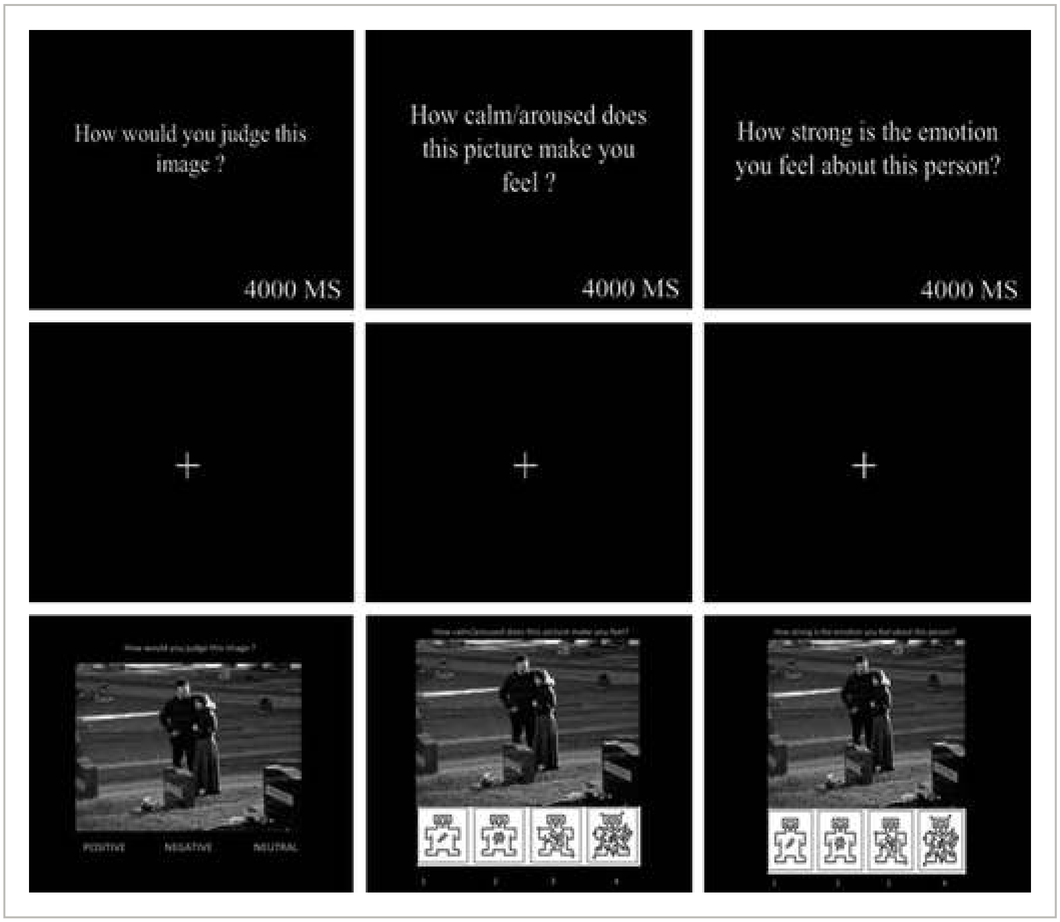

Figure 1

Open in figure viewer | PowerPoint

The figure depicts the sample of a trial assessing the ability of participants to recognize the image valence (left column), emotional empathy indirect (centre column) and emotional empathy direct (right column).

Data analysis

First, a Pearson's χ^2 test was performed between IAPS normative image valence and participants' image valence ratings, to ensure that these ratings were consistent. Then, we performed a correlation analysis between the subscales of the IRI and our tasks for both direct and indirect emotional empathy to evaluate the relationship between these two different measures of empathy. Finally, although there were no pre-existing differences in the direct ($F_{2,33}$ = 1.168, $P = 0.32$) and the indirect ($F_{2,33}$ = 0.731, $P = 0.48$) emotional empathy scores between groups, we ran a series of analyses of covariance (ANCOVA s) in order to assess the effects of sleep deprivation on both components of emotional empathy. Pre session scores were used in the ANCOVA as covariates, and the scores on the post session were used as the dependent variable. This approach was chosen because of the strong correlation between the pre- and postscores for both direct (r_{34} = 0.861, $P < 0.01$) and indirect (r_{34} = 0.870, $P < 0.01$)

emotional empathy, which makes ANCOVA s more powerful than a mixed analysis of variance (Tu and Gilthorpe, 2011). Groups were compared pairwise. For all analyses, we set a two-tailed level of significance at $P = 0.05$ unless noted otherwise.

Results

Upon an initial overview of the data, one participant from the day group was excluded from further analyses due to extreme changes in responses from pre- to post session on both direct and indirect emotional empathy ($Z = 4.11$ and 8.36, respectively). Pearson's χ^2 analysis revealed that image affect ratings provided by the participants in the pre session were consistent with IAPS ratings (average $\chi^2 = 5.539$, $P_{\text{right-tailed}} = 0.06$).

The correlation analyses between the IRI and our empathy tasks revealed that pre session scores for both direct ($r_{34} = 0.334$, $P = 0.05$) and indirect ($r_{34} = 0.339$, $P = 0.04$) emotional empathy were correlated with the perspective-taking subscale of the IRI. The correlations between the other subscales of the IRI and both direct and indirect emotional empathy were not significant (fantasy: $r_{34} = -0.002$, $P = 0.99$ and $r_{34} = 0.059$, $P = 0.73$; empathic concern: $r_{34} = 0.236$, $P = 0.17$ and $r_{34} = 0.220$, $P = 0.20$; and personal distress: $r_{34} = 0.082$, $P = 0.63$ and $r_{34} = 0.151$, $P = 0.38$, respectively).

To assess the effects of sleep deprivation on direct and indirect emotional empathy, participants' pre scores were used as covariates when comparing post scores between groups (see 2). After testing gender as a predictor in each analysis and finding no significant differences, we removed the gender factor from further analyses. The ANCOVA s revealed that the indirect emotional empathy postscores of participants in the sleep deprivation group (mean =1.99, SD = 0.40) were significantly lower than scores of participants in both the day (mean = 2.37, SD = 0.41) ($F_{1,21} = 6.921$, $P = 0.01$) and sleep (mean = 2.25, SD = 0.32) ($F_{1,22} = 4.467$, $P = 0.04$) groups; post scores of participants in the day and sleep groups did not differ significantly ($F_{1,20} = 0.447$, $P = 0.51$). Similar results were found in the context of the direct emotional empathy, showing that post scores of participants in the sleep deprivation group (mean = 1.94, SD = 0.37) were significantly lower than scores of participants in both the day (mean = 2.45, SD = 0.49) ($F_{1,21} = 12.150$, $P = 0.00$) and sleep (mean = 2.26, SD = 0.35) ($F_{1,22} = 4.869$, $P = 0.03$) groups; post scores of participants in the day and sleep groups did not differ significantly ($F_{1,20} = 1.424$, $P = 0.24$). Changes in scores from the pre- to the post session in all groups are shown in Fig. 2. As expected, the ANCOVA s performed on participants' image valence ratings revealed that post scores of participants in the seep deprivation group did not differ significantly from the post scores of participants in the day ($F_{1, 21} = 1.512$, $P = 0.23$) and sleep ($F_{1,22} = 1.637$, $P = 0.21$) groups.

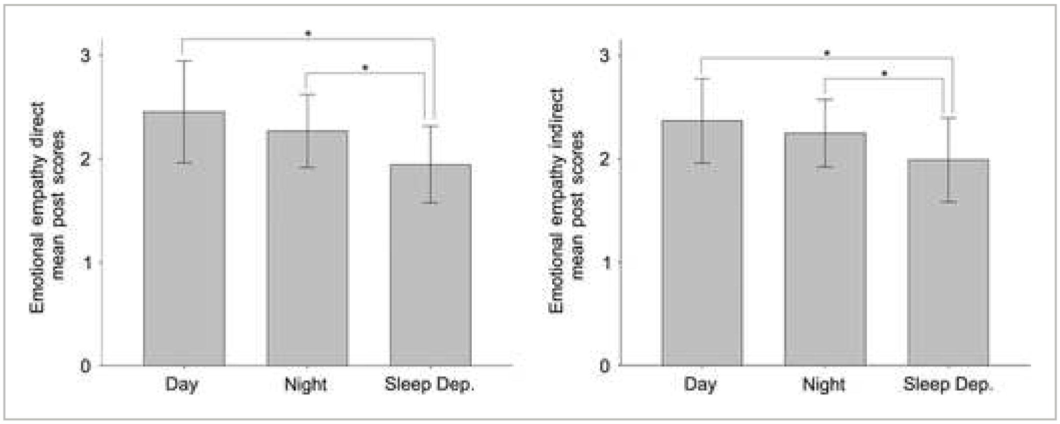

Figure 2

Open in figure viewer | PowerPoint

Experimental groups' postscores on measures of direct and indirect emotional empathy. Significant differences are marked with an asterisk. $n = 36$; error bars represent ± 1 standard deviation.

Discussion

In this study we tested the hypothesis that a night of total sleep deprivation has a detrimental effect on the capacity of the individuals to share other's emotions (i.e. emotional empathy). The results revealed that after a night of sleep deprivation participants were less emotionally empathetic than those who had slept, as well as those participants retested during the same day. The effects were similar for both direct and indirect components of emotional empathy. Our results indicate that a night of sleep loss impairs the ability to share the emotional state of others, which is an important skill in everyday social interactions in both the workplace and personal life. These findings are consistent with previous research revealing negative effects of sleep loss on cognition and emotional processing in general, and extend these effects to emotional empathy in particular.

Previous research has demonstrated how sleep loss may have a negative impact on the individual's ability to be empathetic towards others. In a recent study, Van der Helm and colleagues (Van Der Helm *et al* ., 2010) tested 37 healthy participants, assigning them randomly to the sleep control or total sleep deprivation groups. Participants performed an emotional face recognition task in which they were asked to evaluate the emotion shown by a subject in a photograph as sad, happy or angry. The findings revealed that sleep deprivation selectively impairs the judgement of facial emotions, particularly those threat-relevant (angry) and reward-relevant (happy). The authors argued for the susceptibility of the prefrontal lobe to sleep deprivation as an explanation for their results. This interpretation is in line with a recent neuroimaging study by Yoo et al. (Yoo *et al* ., 2007) showing that, during an emotional viewing task, hyperactivity in the amygdala can be detected due to a lack of inhibitory control from the medial prefrontal cortex (MPFC), as affected by sleep loss. In a different study, Gordon and Chen (2014) examined the effect of poor-quality sleep on conflict resolution in 78 individuals involved in a romantic relationship. The authors reported an increased number of conflicts following nights of poor sleep across the 14 days of the study. Moreover, poor sleep was associated with a lower ratio of positive to negative affect as well as decreased empathic accuracy while asking about partner's emotions during a conflict conversation. Altogether, the aforementioned studies provide evidence that sleep loss has a significant negative effect on some aspects of human empathy. Our study provides complementary evidence to the existing literature, extending previous findings to the concept of emotional empathy, by showing that sleep deprivation reduces the specific ability to share emotions experienced by others.

With regard to the measures of empathy as used in our study, our findings revealed a significant correlation between our direct ($r_{34} = 0.334$, $P = 0.05$) and indirect ($r_{34} = 0.340$, $P = 0.04$) emotional empathy and the perspective-taking subscale of the IRI. This relationship may be explained by the role of the mirror neurone system (MNS) in emotional empathy. The MNS is comprised primarily of the inferior frontal gyrus (IFG; BA 44–46) and inferior parietal lobule (IPL; BA 39–40) (Rizzolatti and Craighero, 2004). In humans, it has been shown that the MNS is active not only while observing someone else's actions but also when attending to their emotional state. In fact, recent studies have shown that mirror neurones, together with regions of the limbic system such as the amygdala and the insula, are involved in emotion recognition and evaluation (Carr *et al* ., 2003), as well as in the processing of emotional empathy (Jabbi *et al* ., 2007). Patients with lesions in the IFG, particularly BA 44, show deficits in emotion recognition and emotional empathy (Shamay-Tsoory *et al* ., 2009), but not in second-order false-belief tasks. This suggests that the IFG plays a key role in the ability to relate emotionally to another individual. Interestingly, the MNS is reported to be more active in individuals with high scores on the perspective-taking subscale of the IRI (Gazzola *et al* ., 2006). Therefore, it is possible that the correlation between scores on the perspective-taking subscale of the IRI and direct and indirect emotional empathy tasks may be due to the MNS as a common neural substrate for both processes in young, healthy participants. Further research is required in order to test this hypothesis.

Future neuroimaging studies may test the hypothesis that reduced empathic responses (as an effect of sleep deprivation) may be related to functional and structural properties of selective neural mechanisms responsible for empathy. In fact, sleep deprivation has been shown to affect the resting state functional connectivity between a variety of brain areas including the thalamus, posterior cingulate cortex, anterior cingulate cortex, ventromedial prefrontal cortex and amygdala (Chee, 2013). In addition to changes in resting state connectivity, sleep loss has also been shown to alter task-related neural activity in the IFG (Habeck *et al* ., 2004). These findings seem to support the hypothesis that sleep deprivation may affect the functional proprieties and connectivity of the neural networks that are known to be critical for emotional empathy, which includes the IFG and the IPL, together with regions of the limbic system such as the insula and the amygdala. Future neuroimaging studies may be able to test this important hypothesis and shed more light on the neurological effects of sleep loss.

Acknowledgements

We would like to thank our participants for contributing to this study, especially those individuals included in the sleep deprivation group.

Conflict of interest

The authors declare the absence of financial support and off-label or investigational use, and the absence of any conflicts of interest.

Author contributions

VG conceived the study, performed data collection and analyses and wrote the manuscript. FB participated in data analyses and interpretation and assisted in drafting the manuscript. MF and GI contributed in conceiving the study, providing data interpretation and writing the manuscript.

References

Babson, K. A. and Feldner, M. T. Temporal relations between sleep problems and both traumatic event exposure and PTSD: a critical review of the empirical literature. *J. Anxiety Disord.*, 2010, **24**: 1–15.
Crossref | PubMed | Web of Science® | Google Scholar

Baron‐Cohen, S. *Essential Difference: Male and Female Brains and the Truth About Autism*. Basic Books, New York, 2004.
Google Scholar

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J. and Erbaugh, J. An inventory for measuring depression. *Arch. Gen. Psychiatry*, 1961, **4**: 561.
Crossref | CAS | PubMed | Web of Science® | Google Scholar

Bradley, M. M. and Lang, P. J. Measuring emotion: the self‐assessment manikin and the semantic differential. *J. Behav. Ther. Exp. Psychiatry*, 1994, **25**: 49– 59.
Crossref | CAS | PubMed | Web of Science® | Google Scholar

Buysse, D. J., Reynolds, C. F., III, Monk, T. H., Berman, S. R. and Kupfer, D. J. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res.*, 1989, **28**: 193– 213.
Crossref | CAS | PubMed | Web of Science® | Google Scholar

Carr, L., Iacoboni, M., Dubeau, M.-C., Mazziotta, J. C. and Lenzi, G. L. Neural mechanisms of empathy in humans: a relay from neural systems for imitation to limbic areas. *Proc. Natl Acad. Sci.*, 2003, **100**: 5497– 5502.
Crossref | CAS | PubMed | Web of Science® | Google Scholar

Chee, M. W. L. Imaging the sleep deprived brain: a brief review. *J Korean Sleep Res Soc.*, 2013, **10**: 1– 6.
Crossref | Google Scholar

Couyoumdjian, A., Sdoia, S., Tempesta, D. *et al* . The effects of sleep and sleep deprivation on task switching performance. *J. Sleep Res.*, 2010, **19**: 64– 70.
Wiley Online Library | CAS | PubMed | Web of Science® | Google Scholar

Davis, M. H. A multidimensional approach to individual differences in empathy. *JSAS*, 1980, **10**: 85.
Google Scholar

Diekelmann, S. and Born, J. The memory function of sleep. *Nat. Rev. Neurosci.*, 2010, **11**: 114– 126.
Crossref | CAS | PubMed | Web of Science® | Google Scholar

Drummond, S. P. A., Brown, G. G., Stricker, J. L., Buxton, R. B., Wong, E. C. and Gillin, J. C. Sleep deprivation-induced reduction in cortical functional response to serial subtraction. *NeuroReport*, 1999, **10**: 3745– 3748.
Crossref | CAS | PubMed | Web of Science® | Google Scholar

Drummond, S., Paulus, M. P. and Tapert, S. F. Effects of two nights sleep deprivation and two nights recovery sleep on response inhibition. *J. Sleep Res.*, 2006, **15**: 261– 265.
Wiley Online Library | PubMed | Web of Science® | Google Scholar

Durmer, J. S. and Dinges, D. F. Neurocognitive consequences of sleep deprivation. *Semin. Neurol.*, 2005, **25**: 117– 129.
Crossref | PubMed | Web of Science® | Google Scholar

Dziobek, I., Rogers, K., Fleck, S. *et al* . Dissociation of cognitive and emotional empathy in adults with Asperger syndrome using the Multifaceted Empathy Test (MET). *J. Autism Dev. Disord.*, 2008, **38**: 464– 473.
Crossref | PubMed | Web of Science® | Google Scholar

Elmenhorst, D., Elmenhorst, E.-M., Luks, N. *et al* . Performance impairment during four days partial sleep deprivation compared with the acute effects of alcohol and hypoxia. *Sleep Med.*, 2009, **10**: 189– 197.
Crossref | PubMed | Web of Science® | Google Scholar

Franzen, P. L., Buysse, D. J., Dahl, R. E., Thompson, W. and Siegle, G. J. Sleep deprivation alters pupillary reactivity to emotional stimuli in healthy young adults. *Biol. Psychol.*, 2009, **80**: 300– 305.
Crossref | PubMed | Web of Science® | Google Scholar

Gazzola, V., Aziz-Zadeh, L. and Keysers, C. Empathy and the somatotopic auditory mirror system in humans. *Curr. Biol.*, 2006, **16**: 1824– 1829.
Crossref | CAS | PubMed | Web of Science® | Google Scholar

Gordon, A. M. and Chen, S. The role of sleep in interpersonal conflict: do sleepless nights mean worse fights? *SPPS*, 2014, **5**: 168– 175.
Web of Science® | Google Scholar

Habeck, C., Rakitin, B. C., Moeller, J. *et al* . An event-related fMRI study of the neurobehavioral impact of sleep deprivation on performance of a delayed-match-to-sample task. *Cognitive. Brain Res.*, 2004, **18**: 306– 321.
Crossref | PubMed | Web of Science® | Google Scholar

Harrison, Y., Jones, K. and Waterhouse, J. The influence of time awake and circadian rhythm upon performance on a frontal lobe task. *Neuropsychologia*, 2007, **45**: 1966– 1972.
Crossref | PubMed | Web of Science® | Google Scholar

Jabbi, M., Swart, M. and Keysers, C. Empathy for positive and negative emotions in the gustatory cortex. *Neuroimage*, 2007, **34**: 1744– 1753.
Crossref | PubMed | Web of Science® | Google Scholar

Kahn, M., Sheppes, G. and Sadeh, A. Sleep and emotions: bidirectional links and underlying mechanisms. *Int. J. Psychophysiol.*, 2013, **89**: 218– 228.
Crossref | PubMed | Web of Science® | Google Scholar

Kaplan, J. T. and Iacoboni, M. Getting a grip on other minds: mirror neurons, intention understanding, and cognitive empathy. *Soc. Neurosci.*, 2006, **1**: 175– 183.
Crossref | PubMed | Web of Science® | Google Scholar

Killgore, W. D. S., Balkin, T. J. and Wesensten, N. J. Impaired decision making following 49 h of sleep deprivation. *J. Sleep Res.*, 2006, **15**: 7– 13.
Wiley Online Library | PubMed | Web of Science® | Google Scholar

Killgore, W. D., Kahn-Greene, E. T., Lipizzi, E. L., Newman, R. A., Kamimori, G. H. and Balkin, T. J. Sleep deprivation reduces perceived emotional intelligence and constructive thinking skills. *Sleep Med.*, 2008, **9**: 517– 526.
Crossref | PubMed | Web of Science® | Google Scholar

Lang, P. and Bradley, M. M. The International Affective Picture System (IAPS) in the study of emotion and attention. *Handbook of Emotion Elicitation and Assessment*. Series in Affective Science. Oxford University Press, New York, NY, 2007: 29– 46.
Google Scholar

Lim, J. and Dinges, D. F. A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. *Psychol. Bull.*, 2010, **136**: 375.
Crossref | PubMed | Web of Science® | Google Scholar

McGlinchey, E. L., Talbot, L. S., Chang, K.-H., Kaplan, K. A., Dahl, R. E. and Harvey, A. G. The effect of sleep deprivation on vocal expression of emotion in adolescents and adults. *Sleep*, 2011, **34**: 1233.
Crossref | PubMed | Web of Science® | Google Scholar

Minkel, J., Htaik, O., Banks, S. and Dinges, D. Emotional expressiveness in sleep-deprived healthy adults. *Behav. Sleep Med.*, 2010, **9**: 5– 14.
Crossref | Web of Science® | Google Scholar

Moorcroft, W. H. Functions of sleep and NREMS. In: W. H. Moorcroft (Ed.) *Understanding Sleep and Dreaming*. Springer, New York, NY, 2013: 231– 259.
Crossref | Google Scholar

Ochsner, K. N. The role of control in emotion, emotion regulation, and empathy. In: D. Hermans, B. Rime and B. Mesquita (Eds) *Changing Emotions*. Psychology Press, New York, NY, 2013: 157– 165.
Google Scholar

Paula-Perez, I., Martos-Perez, J. and Llorente-Comi, M. [Alexithymia and Asperger syndrome]. *Rev. Neurol.*, 2010, **50**: S85.
PubMed | Google Scholar

Pilcher, J. J. and Huffcutt, A. J. Effects of sleep deprivation on performance: a meta-analysis. *Sleep*, 1996, **19**: 318– 326.
Crossref | CAS | PubMed | Web of Science® | Google Scholar

Rankin, K. P., Kramer, J. H. and Miller, B. L. Patterns of cognitive and emotional empathy in frontotemporal lobar degeneration. *Cogn. Behav. Neurol.*, 2005, **18**: 28– 36.
Crossref | PubMed | Web of Science® | Google Scholar

Rizzolatti, G. and Craighero, L. The mirror-neuron system. *Annu. Rev. Neurosci.*, 2004, **27**: 169– 192.
Crossref | CAS | PubMed | Web of Science® | Google Scholar

Shamay-Tsoory, S. G. The neural bases for empathy. *Neuroscientist*, 2011, **17**: 18– 24.
Crossref | PubMed | Web of Science® | Google Scholar

Shamay-Tsoory, S. G., Aharon-Peretz, J. and Perry, D. Two systems for empathy: a double dissociation between emotional and cognitive empathy in inferior frontal gyrus versus ventromedial prefrontal lesions. *Brain*, 2009, **132**: 617– 627.
Crossref | PubMed | Web of Science® | Google Scholar

Smith, A. Cognitive empathy and emotional empathy in human behavior and evolution. *Psychol. Rec.*, 2006, **56**: 3.
Crossref | Web of Science® | Google Scholar

Spiegel, K., Leproult, R. and Van Cauter, E. Impact of sleep debt on metabolic and endocrine function. *Lancet*, 1999, **354**: 1435– 1439.
Crossref | CAS | PubMed | Web of Science® | Google Scholar

Spielberger, C. D., Gorsuch, R. L. and Lushene, R. E. *Manual for the State-Trait Anxiety Inventory*. Consulting Psychologists Press Inc, Mountain View, CA, 1970.
Crossref | Google Scholar

Tempesta, D., Couyoumdjian, A., Curcio, G. *et al* . Lack of sleep affects the evaluation of emotional stimuli. *Brain Res. Bull.*, 2010, **82**: 104– 108.
Crossref | PubMed | Web of Science® | Google Scholar

Tu, Y. and Gilthorpe, M. S. *Statistical Thinking in Epidemiology*. CRC Press, Boca Raton, FL, 2011.
Google Scholar

Van Der Helm, E., Gujar, N. and Walker, M. P. Sleep deprivation impairs the accurate recognition of human emotions. *Sleep*, 2010, **33**: 335.
Crossref | PubMed | Web of Science® | Google Scholar

Yoo, S.-S., Gujar, N., Hu, P., Jolesz, F. A. and Walker, M. P. The human emotional brain without sleep, a prefrontal amygdala disconnect. *Curr. Biol.*, 2007, **17**: R877– R878.
Crossref | CAS | PubMed | Web of Science® | Google Scholar

Yuan, P. and Raz, N. Prefrontal cortex and executive functions in healthy adults: a meta-analysis of structural neuroimaging studies. *Neurosci. Biobehav. Rev.*, 2014, **42**: 180– 192.
Crossref | PubMed | Web of Science® | Google Scholar

Citing Literature

Joanna C. Yau, Branda T. Sun, Jason D. Moreno, Addicting Content, Blue Light, and Curtailed Sleep, The Psychology and Dynamics Behind Social Media Interactions, 10.4018/978-1-5225-9412-3.ch009, (211-240), (2020).
Crossref

Pierre Bérastégui, Mathieu Jaspar, Alexandre Ghuysen, Anne-Sophie Nyssen, Informal fatigue-related risk management in the emergency department: A trade-off between doing well and feeling well, Safety Science, 10.1016/j.ssci.2019.104508, **122**, (104508), (2020).
Crossref

Eti Ben Simon, Raphael Vallat, Christopher M. Barnes, Matthew P. Walker, Sleep Loss and the Socio-Emotional Brain, Trends in Cognitive Sciences, 10.1016/j.tics.2020.02.003, (2020).
Crossref

Eleonora Farina, Veronica Ornaghi, Alessandro Pepe, Caterina Fiorilli, Ilaria Grazzani, High School Student Burnout: Is Empathy a Protective or Risk Factor?, Frontiers in Psychology, 10.3389/fpsyg.2020.00897, **11**, (2020).
Crossref

Adam Gerace, Gabrielle Rigney, Considering the relationship between sleep and empathy and compassion in mental health nurses: It's time, International Journal of Mental Health Nursing, 10.1111/inm.12734, **0**, 0, (2020).
Wiley Online Library

Veronica Guadagni, Marco Sarà, Massimiliano Conson, Antonio Carolei, Simona Sacco, Silvia Vadini, Caterina Pistarini, Arcangelo Barbonetti, Giuseppe Iaria, Francesca Pistoia, Cognitive and Emotional Empathy in Individuals with Spinal Cord Injury, Behavioural Neurology, 10.1155/2019/1312934, **2019**, (1-9), (2019).
Crossref

Daniela Tempesta, Valentina Socci, Luigi De Gennaro, Michele Ferrara, The Role of Sleep in Emotional Processing, Sleep, Memory and Synaptic Plasticity, 10.1007/978-981-13-2814-5, (125-170), (2019).
Crossref

Jamie J. Coleman, Caitlin K. Robinson, Ben L. Zarzaur, Lava Timsina, Grace S. Rozycki, David V. Feliciano, To Sleep, Perchance to Dream: Acute and Chronic Sleep Deprivation in Acute Care Surgeons, Journal of the American College of Surgeons, 10.1016/j.jamcollsurg.2019.03.019, (2019).
Crossref

Jillian Dorrian, Stephanie Centofanti, Ashleigh Smith, Kathryn Demos McDermott, Self-regulation and social behavior during sleep deprivation, , 10.1016/bs.pbr.2019.03.010, (2019).
Crossref

Kimberly A. Cote, Kari A. Lustig, Kevin J. MacDonald, The Role of Sleep in Processing Emotional Information, Handbook of Sleep Research, 10.1016/B978-0-12-813743-7.00033-5, (505-518), (2019).
Crossref

Michiko Mizobe, Hitomi Kataoka, Hiroshi Yamagami, Chikao Ito, Yasuaki Koyama, Erika Yawata, Takashi Shiga, A night on call or an overnight shift does not reduce residents' empathy: a randomized crossover multicenter survey, BMC Medical Education, 10.1186/s12909-019-1822-5, **19**, 1, (2019).
Crossref

Siobhan Banks, Lauren B. Landon, Jillian Dorrian, Lauren B. Waggoner, Stephanie A. Centofanti, Peter G. Roma, Hans.P.A. Van Dongen, Effects of Fatigue on Teams and Their Role in 24/7 Operations, Sleep Medicine Reviews, 10.1016/j.smrv.2019.101216, (101216), (2019).
Crossref

Mindy Engle-Friedman, Steven G. Young, Sleep's Role in Effortful Performance and Sociability, Sleep, Personality, and Social Behavior, 10.1007/978-3-030-30628-1, (63-81), (2019).
Crossref

Brieann C. Satterfield, Adam C. Raikes, William D. S. Killgore, Sleep in Social Cognition and Judgment, Sleep, Personality, and Social Behavior, 10.1007/978-3-030-30628-1, (43-61), (2019).
Crossref

Tina Sundelin, Benjamin C. Holding, Sleep and Social Impressions, Sleep, Personality, and Social Behavior, 10.1007/978-3-030-30628-1, (119-133), (2019).
Crossref

Dawn Querstret, Katie O'Brien, Debra J. Skene, Jill Maben, Improving fatigue risk management in healthcare: A systematic scoping review of sleep-related/fatigue-management interventions for nurses and midwives, International Journal of Nursing Studies, 10.1016/j.ijnurstu.2019.103513, (103513), (2019).
Crossref

Simone Karan, Grace Vincent, Sally Ferguson, Sarah Jay, The Impact of on-Call Work for Partners' Sleep, Relationship Quality and Daytime Functioning, Clocks & Sleep, 10.3390/clockssleep1010016, **1**, 1, (185-192), (2019).
Crossref

Eunjoo Jung, Bora Jin, Associations Between Sleep Problems, Cognitive, and Socioemotional Functioning from Preschool to Adolescence, Child & Youth Care Forum, 10.1007/s10566-019-09509-5,

(2019).
Crossref

Lauren A. Fowler, Shannon Ellis, The Effect of 12 Hour Shifts, Time of Day, and Sleepiness on Emotional Empathy and Burnout in Medical Students, Clocks & Sleep, 10.3390/clockssleep1040038, **1**, 4, (501-509), (2019).
Crossref

Sara Peretti, Daniela Tempesta, Valentina Socci, Maria C. Pino, Monica Mazza, Marco Valenti, Luigi De Gennaro, Cinzia Di Dio, Antonella Marchetti, Michele Ferrara, The role of sleep in aesthetic perception and empathy: A mediation analysis, Journal of Sleep Research, 10.1111/jsr.12664, **28**, 3, (2018).
Wiley Online Library

Veronica Guadagni, Ford Burles, Michele Ferrara, Giuseppe Iaria, Sleep quality and its association with the insular cortex in emotional empathy, European Journal of Neuroscience, 10.1111/ejn.14124, **48**, 6, (2288-2300), (2018).
Wiley Online Library

Daniela Tempesta, Valentina Socci, Luigi De Gennaro, Michele Ferrara, Sleep and emotional processing, Sleep Medicine Reviews, 10.1016/j.smrv.2017.12.005, **40**, (183-195), (2018).
Crossref

Veronica Guadagni, Elizabeth Cook, Chelsie Hart, Ford Burles, Giuseppe Iaria, Poor sleep quality affects empathic responses in experienced paramedics, Sleep and Biological Rhythms, 10.1007/s41105-018-0156-8, **16**, 3, (365-368), (2018).
Crossref

Gaétane Deliens, Henryk Bukowski, Hichem Slama, Andrew Surtees, Axel Cleeremans, Dana Samson, Philippe Peigneux, The impact of sleep deprivation on visual perspective taking, Journal of Sleep Research, 10.1111/jsr.12595, **27**, 2, (175-183), (2017).
Wiley Online Library

Tina Sundelin, Mats Lekander, Kimmo Sorjonen, John Axelsson, Negative effects of restricted sleep on facial appearance and social appeal, Royal Society Open Science, 10.1098/rsos.160918, **4**, 5, (160918), (2017).
Crossref

Cara A. Palmer, Candice A. Alfano, Sleep and emotion regulation: An organizing, integrative review, Sleep Medicine Reviews, 10.1016/j.smrv.2015.12.006, **31**, (6-16), (2017).
Crossref

Sandra Tamm, Gustav Nilsonne, Johanna Schwarz, Claus Lamm, Göran Kecklund, Predrag Petrovic, Håkan Fischer, Torbjörn Åkerstedt, Mats Lekander, The effect of sleep restriction on empathy for

pain: An fMRI study in younger and older adults, Scientific Reports, 10.1038/s41598-017-12098-9, **7**, 1, (2017).
Crossref

Rafael Ahlskog, Moral Enhancement Should Target Self-Interest and Cognitive Capacity, Neuroethics, 10.1007/s12152-017-9331-x, **10**, 3, (363-373), (2017).
Crossref

M. Farquhar, For nature cannot be fooled. Why we need to talk about fatigue, Anaesthesia, 10.1111/anae.13982, **72**, 9, (1055-1058), (2017).
Wiley Online Library

Veronica Guadagni, Ford Burles, Silvana Valera, Emeleigh Hardwicke-Brown, Michele Ferrara, Tavis Campbell, Giuseppe Iaria, The Relationship Between Quality of Sleep and Emotional Empathy, Journal of Psychophysiology, 10.1027/0269-8803/a000177, **31**, 4, (158-166), (2017).
Crossref

Paul Kelley, Steven W. Lockley, Jonathan Kelley, Mariah D. R. Evans, Is 8:30 a.m. Still Too Early to Start School? A 10:00 a.m. School Start Time Improves Health and Performance of Students Aged 13–16, Frontiers in Human Neuroscience, 10.3389/fnhum.2017.00588, **11**, (2017).
Crossref

Adam J. Krause, Eti Ben Simon, Bryce A. Mander, Stephanie M. Greer, Jared M. Saletin, Andrea N. Goldstein-Piekarski, Matthew P. Walker, The sleep-deprived human brain, Nature Reviews Neuroscience, 10.1038/nrn.2017.55, **18**, 7, (404-418), (2017).
Crossref

Olav Kjellevold Olsen, Ståle Pallesen, Torbjørn Torsheim, Roar Espevik, The effect of sleep deprivation on leadership behaviour in military officers: an experimental study, Journal of Sleep Research, 10.1111/jsr.12431, **25**, 6, (683-689), (2016).
Wiley Online Library

Felice Iasevoli, Livia Avvisati, Valentina Gilardi, Gianmarco Latte, Emiliano Prinzivalli, Domenico de Berardis, Alessandro Valchera, Michele Fornaro, Carmine Tomasetti, Andrea de Bartolomeis, Chronobiology of Mood Disorders, Melatonin, Neuroprotective Agents and Antidepressant Therapy, 10.1007/978-81-322-2803-5, (273-295), (2016).
Crossref

Alan C Logan, Martin A Katzman, Vicent Balanzá-Martínez, Natural environments, ancestral diets, and microbial ecology: is there a modern “paleo-deficit disorder”? Part I, Journal of Physiological Anthropology, 10.1186/s40101-015-0041-y, **34**, 1, (2015).
Crossref

Monica Mazza, Daniela Tempesta, Maria Chiara Pino, Anna Nigri, Alessia Catalucci, Veronica Guadagni, Massimo Gallucci, Giuseppe Iaria, Michele Ferrara, Neural activity related to cognitive and emotional empathy in post-traumatic stress disorder, Behavioural Brain Research, 10.1016/j.bbr.2014.12.049, **282**, (37-45), (2015).
Crossref

Michele Ferrara, Anna Bottasso, Daniela Tempesta, Marika Carrieri, Luigi De Gennaro, Giovanni Ponti, Gender Differences in Sleep Deprivation Effects on Risk and Inequality Aversion: Evidence from an Economic Experiment, PLOS ONE, 10.1371/journal.pone.0120029, **10**, 3, (e0120029), (2015).
Crossref

Derk-Jan Dijk, Daily variations in sleep: associated genes and effects on affect, Journal of Sleep Research, 10.1111/jsr.12268, **23**, 6, (607-608), (2014).
Wiley Online Library