Centre for Lifespan Development Research

Brock University

Featured Research

Centre for Lifespan Development Research

Dr. Kimberly Cote

The connections between sleep, mental processing & behaviour

What's the bottom line?

Today, many people intentionally cut down on sleep in order to make more time for work or social demands — research has shown that a lack of sleep can be problematic for various aspects of people's behaviour, particularly emotional processing. In her work, Dr. Cote investigates the relationship between sleep and waking function using various methods to gain an understanding of how sleepiness may impact individuals' mental processing and behaviours.

Dr. Cote ...
is a Neuroscientist and Professor at Brock University, where she examines the impact that sleep has on daily functioning. Dr. Cote obtained her Master's degree from the University of Toronto and Ph.D. from the University of Ottawa.

Are you getting enough sleep — What is this research about?

Sleep is a very important part of daily life, however, many people in today's society are not getting enough sleep — sometimes due to lifestyle choices, sleep disorders, or even the type of work that they do (e.g., shift work). Insufficient sleep or *sleep deprivation (SD)* can be problematic, with sleepy individuals experiencing issues with mental, physical, and emotional functioning. SD leads to reduced alertness, slowed response times, poor mood, and difficulty paying attention and remembering information.

Recognizing the important role that sleep plays in individuals' lives, Dr. Kimberly Cote and colleagues work to understand how SD may impact various aspects of behaviour, using objective experimental designs, measures of brain activity, and analyses of individual differences.

Sleep & Aggression

Aggression refers to behaviours where an individual directly attempts to harm or inflict unpleasantness upon someone else. There is a great deal of anecdotal evidence to support a role for sleep in aggression. For example, sleepy children have more conduct disorders, and sleepy adults have more mood disruptions. As well, researchers have found that SD participants experience greater activation of the amygdala (a brain area important for reward and emotion processing) when shown emotionally salient images, and less connectivity between the amygdala and the medial prefrontal cortex than well-rested control individuals. SD participants may therefore be more prone to react aggressively. However, no experimental studies of the effects of SD on aggression had been carried out until Dr. Cote and colleagues conducted an experimental examination on

SD and reactive aggression — finding that SD may lead to a dulling of emotions and reduced reactive aggression, particularly among males. Specifically, using the Point Subtraction Aggressive Paradigm (a measure of reactive aggression that utilizes provocation to elicit aggressive reactions), Dr. Cote found that after 24-hours of SD, sleepy males tend to show less reactive aggression as compared to males who were not SD. Considering all of the research, Dr. Cote and colleagues have suggested that SD may induce "a state of emotional imbalance or instability, where it is possible to have both tonic levels of blunting (because of diminished vigilance and attention overall), with situational or context-driven reactivity" (e.g., reactive aggression).

Sleep & Hormones

Given the above research, there is clear evidence for a relationship between sleep and aggression, but the question remains as to what mechanisms may underlie this relationship. There is some evidence to suggest that SD may alter endocrine function (e.g., hormone levels such as estrogen and testosterone). Hormones are produced in the body and act as 'messengers' telling organs and glands how they should be functioning to keep an individual in proper health (e.g., metabolism, sex drives, reproduction, mood, etc.). If SD has an impact on regular endocrine functioning, this may in turn influence aggressive behaviours, as hormones play important roles in an individual's mood and behaviour.

Dr. Cote and colleagues have worked to systematically investigate how SD may affect the endocrine-aggression relationship, looking specifically at testosterone, estrogen, and cortisol levels in the saliva of participants. Interestingly it was found that testosterone may be strongly affected by SD, with one study showing that 24 hours of SD was related to a 27% decrease in testosterone levels among SD males, as compared to a 3% increase in testosterone among the well-rested Control group males. This finding denotes a drastic change in testosterone levels considering that male levels of testosterone typically decrease only 1-2% per year with age. This decrease in testosterone may relate to the blunting of emotions reported among SD individuals, particularly the lower levels of reactive aggression sleepy males described above.

Sleep & Emotional Information

Given that SD may lead to an emotional imbalance then SD may also impact individuals' processing of emotional information, an important factor in healthy social functioning. Using methods that look at brain activity, such as examining Event-Related Potentials (ERPs — a measurement of the brain's response to stimuli) through electroencephalography (EEG — a technique that measures electrical activity in the brain), Dr. Cote and colleagues have been able to examine the connection between SD and emotional processing, finding that SD may impact neural responses to specific pieces emotional information.

Specifically, Dr. Cote and colleagues have investigated the impact that SD may have on individuals' neural processing of emotionally expressive faces (e.g., sad faces), a very important part of daily social interactions. In terms of ERPs and faces, previous work has demonstrated that, visual stimuli tend to induce two specific ERP waveforms, the P1 and N170, with P1 waveforms reflecting early sensory processing, while N170 waveforms are associated with late sensory processing and individuals' perceptions of faces (along with other types of stimuli). The N170 is maximal at occipito-temporal sites and can be influenced by manipulation of (e.g., rotation) and variation in individual face characters. In contrast, the P1 is maximal at lateral occipital sites and tends to be influenced by low-level

stimulus characteristics, rather than face perception alone.

Dr. Cote's research has indicated that SD may lead to impairment in categorizing and processing sad facial expressions and to a greater amount of neural reactivity (as indicated by greater amplitude in the N170 waveform) when processing subtle angry or fearful facial expressions. This greater N170 amplitude may indicate that additional cortical resources are being utilized when SD individuals are tasked with interpreting the more salient angry or fearful faces. Overall, Dr. Cote's research has shown that SD may uniquely impair individuals' perception of emotional facial expressions, with specific neural and behavioural implications.

Dr. Cote and colleagues have also investigated how SD impacts the processing of emotional scenes (e.g., pictures), finding again that SD led to deficits in neural processing. Specifically, through analyzing an ERP waveform named the Late Positive Potential (LPP), which reflects late processing stages such as sustained attention towards emotionally salient stimuli, Dr. Cote has found that SD individuals allocate a greater amount of attention towards emotional pictures than well-rested individuals, particularly when these images depict negative scenes, as indicated by larger LPPs being uniquely observed among SD individuals. When excessive attention is placed on emotional information, it may limit the amount of cognitive resources available for other processing needs, in turn impacting decision-making and behaviour. Additionally, there appear to be individual differences in vulnerability to SD, as Dr. Cote's research has shown that individuals with lower reappraisal strategies in emotional regulation (i.e., being less able to change the way one thinks about or interprets a situation or stimulus) tend to be more susceptible to SD-related deficits around emotional information and the resulting drain on cognitive resources.

Overall, Dr. Cote's research has demonstrated that SD may lead to unique impairments in individuals' mental processing of emotional information. These SD-related impairments tend to manifest as emotional imbalances and may relate to changes in social behaviours and diminish the amount of cognitive resources available for effective processing of other important information when in an SD state.

So what — Where is this research being used?

Social Behaviour & Decision-making — Given the above research and the fact that a large portion of today's society is SD, sleepy individuals may have a diminished ability to accurately recognize and respond to the emotional cues around them, affecting their social behaviour (i.e., SD individuals may appear to have a lack of empathy or may develop mood disorders in the long-term). Additionally, SD individuals may pay more attention to emotional information, reducing the cognitive recourses available for efficient processing of other information — in turn impacting their decision-making abilities and behaviour. Anyone who interacts with sleepy individuals or groups, particularly those in hospital settings who often experience shift work, may want to take Dr. Cote's research into consideration when designing interventions or interpreting behaviours.

Emotion Regulation — In terms of chronic SD, the excessive attention that sleepy individuals may place on emotional information may lead to long-term consequences, such as the development of mood disorders. As such, Dr. Cote's findings around emotional dysregulation may be particularly relevant for any clinician or practitioner who works with psychiatric conditions that include an SD component, as there may be strong rational for sleep therapies to control emotional and behavioural symptoms in these conditions.

Men's Health — Not getting enough sleep may be harming individuals more than they know, especially university-age men. As previously outlined, SD may lead to reductions in testosterone levels in men, in turn impacting males' sexual behaviour, reproduction, and general health. Dr. Cote has suggested that the connection between sleep, hormones, and overall health should be explored further with experimental research in both men and women, as it has strong implications for the health of people in today's society.

How do they do it?

Dr. Cote employs interesting methods:

- Strong experimental designs and objective examinations of behaviour
- The use of EEG and ERPs technologies to examine brain function
- Sophisticated sleep laboratory facilities
- Multiple behavioural and physiological measures

What's next?

Dr. Cote is continuing to investigate SD as related to neural functioning and outcome behaviours – furthering the previously described studies and investigating new topics. Specifically, Dr. Cote is interested in examining the impact of more commonly experienced levels of SD, such as continuous sleep restriction (e.g., sleeping less than one needs over many nights, perhaps only 5-6 hrs) on the brain's processing of emotional information in pictures and facial expressions. She is also continuing with her novel work investigating the impact of sleep loss and the role of hormones in aggression behaviour. Specifically, current studies are examining this relationship in women, by measuring estrogen at different phases of the menstrual cycle while controlling for hormonal contraceptive use. Lastly, Dr. Cote is particularly interested in understanding the basis of individual differences in vulnerability and resiliency to sleep loss, especially in the context of emotion processing and behaviour.

Referred Works

Cote, K.A., Jancsar, C., & Hunt. B. (*in progress*). Event—related neural response to emotional picture stimuli following sleep deprivation.

Cote, K. A., McCormick, C. M., Geniole, S. N., Renn, R. P., & MacAulay, S. D. (2013). Sleep deprivation lowers reactive aggression and testosterone in men. *Biological psychology, 92*(2), 249—256. doi: 10.1016/j.biopsycho.2012.09.011

Cote, K. A., Mondloch, C. J., Sergeeva, V., Taylor, M., & Semplonius, T. (2014). Impact of total sleep deprivation on behavioural neural processing of emotionally expressive faces. *Experimental brain research, 232*(5), 1429—1442. doi: 10.1007/s00221—013—3780—1

Want More Information?

Are you a student, researcher or organization who would like to be involved in Dr. Cote's work?

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