SLEEP DEPRIVATION AS KEY FACTOR OF INFLUENCING COGNITIVE ABILITIES IN CONTEXT OF SECURITY ENVIRONMENT

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Abstract: In this study we examined in how far sleep deprivation leads to autism-like symptoms with regard to social cognition. The negative effects of sleep deprivation on physical and mental functioning are well documented and it is therefore surprising that relatively little research has been done into the effects of sleep deprivation on social behaviour and the ability to judge social interactions and emotional expressions appropriately. Our experiment, conducted amongst 25 male students at the Czech military academy in Brno, Czech Republic, showed no significant differences in performance on a standard autism test between pre- and post- sleep deprivation conditions. The purpose of the paper is describe impacts of sleep deprivation on men with high physical stress, what negatively influence relevant cognitions and emotions. Sleep deprivation strongly influence cognitive abilities, leading to military leadership development.

Keywords: sleep-deprivation, theory of mind, leadership, development of leader, social cognition, emotional expressions, security field.

1 Introduction

Security environment requires to have lot of high quality leaders, who can combine both requirements of subordinates and superiors. That combination need to apply model "be, know, do", which is developed from U.S. army rule (McNab, 2003). According to Jarošová, Pauknerová, Lorencová (2016) it is necessary to use relevant personal parameters to build leadership in organization. The group of personal parameters includes various elements, influencing level of leader. As one of the most influencing parameter is considered sleep deprivation.

It is widely recognized that sleep deprivation impairs a range of cognitive functions, including memory (Deliens et al., 2018; Menz et al., 2013; Kaida, Niki, Born, 2015; Chatburn et al., 2017), visual perception taking (Deliens et al., 2018), reaction time to visual cues (Dinges, Powell, 1985; Lim, Dinges, 2008), and emotional processing (Walker, 2009; Walker, van der Helm, 2009; Tempesta et al., 2018). With regard to the latter, especially our ability to correctly interpret emotional cues from others (i.e. facial expressions, changes in speech, etc.) is paramount in navigating the social environment properly and sleep deficiency can thus severely hinder social behavior and, in the long term, connectivity. Moreover, failure to either detect, or correctly interpret, emotional cues from others can, in critical contexts, have dire consequences, which reach far beyond the interests of the individual. It is therefore surprising that sleep deprivation is a common, and often accepted, part of many professional fields, such as health care and the military, in which it is critical to quickly and accurately assess crisis situations which include a human element.

1.1 Various interpretations of sleep deprivation effect

Sleep deprivation does, however, not seem to impair the recognition of different emotional ques equally (Killgore et al., 2017; Chen, Chen, 2019). In one study Killgore and colleagues (2017), on the basis of previous findings on the same data set (Huck et al., 2008), report that sleep deprived individuals, who were presented with photos of the facial expressions that go with the six main emotions (anger, happiness, surprise, sadness, disgust and fear (see e.g. Ekman, 2009; Cartella et al., 2019; Montes-Rodríguez, Rueda-Orozco, Prospéro-García, 2019), differed from well rested individuals in their interpretation of non-threatening emotions (happiness and sadness), whereas threatening emotions were usually interpreted correctly. These findings contradict Beatti's (2018) assertion that failure to correctly identify facial expressions of emotion may result from reduced visual perception rather than a cognitive impairment. After all, visual impairment should register equally across emotions whereas cognitive impairment can favor some emotional expressions over others (Herzog-Krzywoszanska, Krzywoszanski, 2019). These findings are supported by the observation that sleep deprivation leads to increased activity in the amygdala and decreased activity in the ventromedial prefrontal cortex (vmPFC) during the consolidation of fear memories (Feng et al., 2018). Moreover, Yoo and colleagues (2007) report a significant reduction in communication between the amygdala and the vmPFC in sleep deprived individuals. The increased activity in the amygdala may, in addition, go a long way in explaining the heightened sensitivity to anxiety (Pires et al., 2016) and the disproportional effects on the detection and interpretation of different emotions in sleep deprived individuals. It should however be noted that the study by Killgore and colleagues (2017) focused on the six primary emotions and it is unclear in how far these results hold up for larger sub-sets of emotions.

1.2 Brief introduction of the Theory of Mind

Interestingly, the vmPFC has also been implicated as one of the key brain regions for Theory of Mind (ToM) (Amodio, Frith, 2006); the ability project states of mind on other actors in the environment (Premack, Woodruff, 1978). It must be noted however that it is widely recognized that ToM arises from the interaction between more brain regions (Gallagher, Frith, 2003; Saxe, 2006; Abu-Akel, Shamay-Tsoory, 2011) and other regions, such as the Para cingulate cortex Gallagher, Frith, 2003) and the orbitofrontal cortex (Stone, 2000) have been suggested as the key area for ToM. These differences may arise from the application of different tests for ToM and it must be taken in to consideration that, what is commonly referred to as ToM, may in fact be a conglomerate of trades which have their origins in different regions of the brain.

ToM is instrumental in (human) social behavior as it provides the individual with a rapid, relatively accurate means of predicting the behavior of others within different social settings and in reaction to the individual's actions or those of third parties (i.e. Ben will be angry with John, if John kicks him: 3rd degree ToM). In humans ToM has been demonstrated to be oversensitive and too often include the attribution of human like behaviors and motivations to non-human agents (anthropomorphism) such as animals (Butterfield, Hill, Lord, 2012; Urquiza-Haas, Kotrschal, 2015), inanimate objects (Waytz, Heafner, Epley, 2014; Gjersoe, Hall, Hood, 2015; Riva, Sacchi, Brambilla, 2015), and abstract concepts such as nature (Tam, Lee, Chao, 2013) and Gods (Barrett, Keil, 1996; MacGillavry, 2018). Deficiencies in ToM have been extensively studied with relation to a range of psychological disorders, such as autism (Baron-Cohen et al., 2011), Schizophrenia (Harrington, Siegert, McClure, 2005), and epilepsy (Giovagnoli, 2014), as well as diseases which are associated with brain deterioration such as Huntington's (Snowden et al., 2003) and Parkinson's (Bora, Walterfang, Velakoulis, 2015) disease. The aim of the following study is to determine in how far the effects of acute sleep deprivation resemble diminished ToM as observed in the above-mentioned afflictions, specifically autism.

1.3 Leadership in security environment on development of managers

Leadership is described as basic tool how is possible to manage and lead people and human systems. There are specific approaches, when commanders must motive and get people to be more engaged in reaching defined goals. In context of army organization, Goffee and Jones (2008) mention potential

problems where is usually rigid hierarchy as barrier of developing leader's potential. They found out that the best army organization know necessity of the quality leadership in all levels.

Good leader must change mind setup, which help to improve thinking and behavior of potential leader. To become a good leader, Robbins, Coulter (2004) recommend three abilities:

- technical skills includes relevant knowledge of adequate technics and technologies;
- human skills are focused on interpersonal communication, motivation, leading or mentoring of people;
- conceptual skills target on conceptual, complex and critical thinking, connected to strategic areas.

On the way of preparing good commanders, there is relevant to use meta-competence model (Schwartzman, 2003). Meta-competence is human ability to obtain new competencies as personal development. This model focuses on adjustment of commanders in process of developing and cultivating leader's strategic skills. It includes six specific areas, which help to commander's improvement:

1. *identity* is process of feedback collection, that helps to self-awareness of personal skills in present form;
2. *mental agility* defines recognition ability in specific environment to reach effective performance. Base for this effectiveness is observing of specific areas (with high level of ambiguity and uncertainty), bringing relevant cognitive processes and improvisation;
3. *cross-cultural savvy* represents need of orientation in inter-culture affairs to understand different cultures from various point of views (e.g. religion, history, geographic, social or economy);
4. *interpersonal maturity* leads to application of teaching, couching, mentoring of all participating persons. Results of these activities must be shared with relevant entities;
5. *world-class warrior* is usually rated as the simplest area, divided from technical and tactical competencies during army duties and based on various army texts such e.g. army history, army arts, or simulations of army activities;
6. *professional astuteness* reflects army as kind of mission, where is applied liability and diplomatic as key factors on the way of well-advised realization activities.

2 Materials and methods

To test in how far sleep deprivation leads to diminished ToM functioning akin to the symptoms of autism, 25 male students from the Czech military academy in Brno, Czech Republic, were recruited. Participation was voluntary, and participants had a possibility to opt out at any stage during the experiment. Before the start of the experiment participants signed a form of consent and were informed of what would happen to them. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Brno University of Defence, Faculty of Military Leadership.

For purpose of the research, there is defined hypothesis that "sleep deprivation does not lead to impairment of ToM". To verify it, there was applied ANOVA and T-test. All 25 participants finished the experiment although it must be noted that several individuals who signed up for the experiment opted out before the experiment had begun. We tested also for physical markers of fatigue using a Medicore Max pulse and a blood pressure monitor (separate measures for the Eyes test and the questionnaire described. Statistical analysis was done using IBM SPSS 24.

3 Results

Participants (N=25) were tested before and after a night of acute sleep deprivation (21:00 and 04:00) for both ToM and physical markers of fatigue. To test participants' ToM, we distributed a Czech translation of the "The Eyes Test" (MacGillavry, 2018), which was designed to be sensitive enough to detect deficiencies in ToM amongst high-functioning individuals with autism and Asperger's syndrome. The test consists of 36 photos of eyes (taken from different individuals), which express a certain emotion. Each photo comes with four emotions of which the participant has to select the correct one. In addition, we administered a short questionnaire which presented participants with a series of profession specific cases for which they had to decide, on a five-point Likert scale, in how far the outcome of the actions of one of the main actors can be viewed as his/her personal responsibility.

This questionnaire was designed to specifically addresses inabilities in metalizing with relation to hindsight bias. The correlation between hindsight bias (the inability to adopt the point of view of someone else, or the self, during past events due to current knowledge of the outcome of events; I knew it all along!) and ToM deficiencies has previously been reported (Bernstein et al., 2007; Birch, Bernstein, 2007). We therefore assumed that ToM deficiencies should register on a profession specific test which related to decision making in crisis situations.

The test consists of 10 cases (4 of which were decoy cases) which were split into two parts, part A and part B (5 cases (2 decoy-cases) each). Half of the group (N=13) were provided with part A in the evening and part B in the morning. The other half of the group got part B first and part A second. Both tests were administered before and after a night of acute sleep deprivation. We reverse scored answers to cases with negative outcomes in order to keep the measure constant.

We tested the data from the Eyes Test for normality using the K-S test for:

- evening condition: $D(25)=0.12$, $p>0.05$
- morning condition, $D(25)=0.17$, $p>0.05$

Both gained value indicate, that the data from both conditions approximate normality.

Subsequently we compared the two conditions:

- Evening: Mean=25,60; Standard error=0,592
- Morning: Mean=25,84; Standard error=0,754

On these values there was applied a Paired Samples T-Test:

$$t(24) = -0{,}327$$

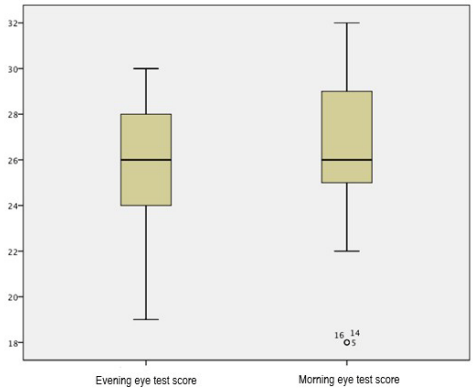
$$p > 0{,}05$$

$$r = 0{,}033$$

On this basis we conclude that, in our sample, there is no significant effect of one night of acute sleep deprivation on participants' ability to successfully fill out the Eyes Test.

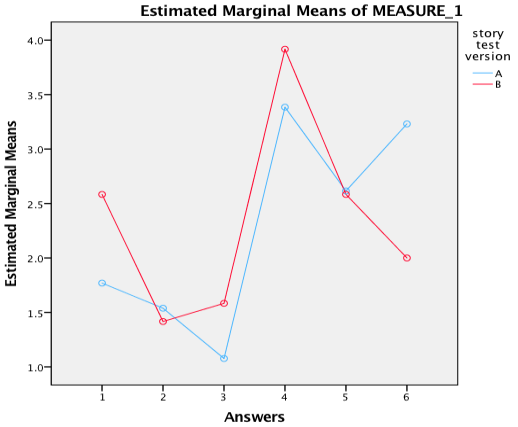
Answers to the questionnaire were analyzed using a mixed ANOVA design which indicates that there is no significant effect of sleep deprivation within our test group on performance on a short hindsight-bias questionnaire.

Figure 1. Boxplots of the Eyes Test show a slight, yet not significant, improvement amongst most participants.



Source: own work by authors

Figure 2. The estimated marginal means of the questionnaire shows large similarities between both groups.



Source: own work by authors

In our sample, there is no significant effect of one night of acute sleep deprivation on participants' ability to successfully fill out the Eyes Test despite the fact that Boxplots of the Eyes Test show a slight, yet not significant, improvement amongst most participants. One night of acute sleep deprivation was either not strong enough or the physical effects of sleep deprivation do not involve the markers we tested for. The 0-hypothesis (sleep deprivation does not lead to impairment of ToM) can, at least on the basis of our data, not be discarded. However, it must be noted that the experiment was run on a limited sample (25 participants), which was drawn from a population (Czech military personnel) which receives regular training in counterbalancing the effects of sleep deprivation.

In the modern world sleep deprivation is both common and can have significant negative effects on work efficiency and overall success. It is therefore paramount to understand both the physical and the mental effects of sleep deprivation. In this paper, we tested in how far sleep deprivation leads to symptoms which resemble problems in Theory of Mind as observed in a range of mental and neuro-degenerative disorders such as autism, Asperger's syndrome, Parkinson's disease and Huntington's disease. We hypothesized that, given that our participants were all healthy young males without a history of neuro-degenerative illness, deficiencies in ToM would resemble those observed in mental disorders most and therefore administered a standardized autism-spectrum test which was supplemented with a profession-specific hindsight test and a range of tests for physical markers of fatigue. Our experiment showed no significant differences between pre- and post- sleep deprivation conditions in neither the ToM tests nor the tests for physical markers.

It is however interesting to note that both the ToM and physical post tests showed more, although not significantly more, overall variability. Moreover, due to scheduling, the post-test was taken around 4:00 a.m. rather than the more common 7:00 a.m. (Killgore et al., 2017), which resulted in 3 hours less wakefulness. This may be why there was no notable difference in the physical markers we tested for. However, there is reason to believe that sleep deprivation affects mental processing prior to physical function and we should therefore expect that mental effects of sleep deprivation can be observed without changes in physical states. As such more research must be done into the interaction between sleep deprivation and social cognition. We recommend that further research builds on at least 48 hours of wakefulness as our experiment clearly showed that ± 20 hours is clearly not sufficient to illicit any notable effects.

4 Conclusions

Sleep deprivation is considered as important factor, which influence leadership development and it requires cognition (Chen, Chen, 2019). According to description of sleep deprivation phenomenon, it is possible to decide, that there is negative effect of sleep deprivation on working memory,

cognitive skills and appropriate decision making process (Zhang et al., 2019; De Havas et al., 2012).

Sleep deprivation has specific influence in military population, where is necessary to interact personal stressors, internal motivation, self-care or leadership development. To support leadership development in army there is important to provide adequate condition for sleeping, sustain health which are connected to long-time military sustainability (Capaldi, Balkin, Mysliwiec, 2019; Yang et al., 2019). Therefore, persons in military must minimize sleep deprivation, what leads to improve relevant psychomotor abilities and psychophysical performance (Ritland et al., 2019; Tyyskä et al., 2010; Kahn-Greene et al., 2006; Deliens et al., 2013; Killgore, 2007; Meunier, 2017).

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Primary Paper Section: A

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