Stress, Anxiety, and Depression: Prevalence and Associations to Electroencephalography and Cognitive Performance in Healthcare Professionals

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I. Declaration

I declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy (Science) in the School of Life Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This document has not been submitted for qualifications at any other academic institution.

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Signature of candidate: Production Note: Signature removed prior to publication. Date: 31.08.20

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III. Publications and Presentations

Publications

1. Maharaj, S., Lees, T., & Lal, S. (2018). Negative mental states and their association to the cognitive function of nurses. *Journal of Psychophysiology, 33*(3), 207–218. https://doi.org/10.1027/0269-8803/a000223

2. Maharaj, S., Lees, T., & Lal, S. (2019). Prevalence and Risk Factors of Depression, Anxiety, and Stress in a Cohort of Australian Nurses. *International Journal of Environmental Research and Public Health*, *16*(1), 61. https://doi.org/10.3390/ijerph16010061

3. Chalmers, T., Maharaj, S., Lees, T., Lin, C. T., Newton, P., Clifton-Bligh, R., McLachlan, C. S., Gustin, S. M., & Lal, S. (2020). Impact of acute stress on cortical electrical activity and cardiac autonomic coupling. *Journal of Integrative Neuroscience*, 19(2), 239–248. https://doi.org/10.31083/j.jin.2020.02.74

4. Ferreira, B., Maharaj, S., Simpson, A., Nassif, N., & Lal, S., (2020), The metabolic role of depression and burnout in nurses. *Translational Metabolic Syndrome Research,* 3, 9-11. https://doi.org/10.1016/j.tmsr.2020.03.002

5. Beehan-Quirk, C., Jarman, L., Maharaj, S., Simpson, A., Nassif, N., & Lal, S., (2020), Investigating the effects of fatigue on blood glucose levels – Implications for diabetes. *Translational Metabolic Syndrome Research,* 3, 17-20. https://doi.org/10.1016/j.tmsr.2020.03.001

6. Lees. T., Maharaj, S., Kalatzis, G., Nassif, N., Newton, P., & Lal, S. (2020) Electroencephalographic prediction of global and domain specific cognitive performance of clinically active Australian Nurses (*Accepted for publication, Journal: Physiological Measurement*)

Published abstracts

1. Lees, T, Maharaj, S and Lal, S. (2015). Electroencephalographic markers of subjective cognitive performance: implications towards electrophysiological prediction of early cognitive decline. Frontiers in Human Neuroscience Conference Abstract: ASP2015 - 25th Annual Conference of the Australasian Society for Psychophysiology

2. Maharaj, S, T, Lees, C, Zaslawski, K, Fatima-Shad, Lal, S. (2017), 'Assessing the link between negative mental states and cognitive performance in health professionals.' Conference Abstract: The 4th Annual Conference of the Australasian Cognitive Neuroscience Society

Conference proceedings

1. Maharaj, S, Lees, T, Lal, S. (2015), 'Cognitive function associations to mental states in nurses', The combined health science conference - New Horizons 2015 [poster], Sydney, 23-25 November

2. Lees, T, Maharaj, S, Lal, S. (2015), 'Electroencephalographic markers of subjective cognitive performance: implications towards electrophysiological prediction of early cognitive decline' ASP2015 - 25th Annual Conference of the Australasian Society for Psychophysiology, University of Newcastle, Sydney, December, 2-4

7. Maharaj, S, Lees, T, Lal, S. (2016), 'Electroencephalographic changes in beta & gamma reactivity associated with cognitive performance' [poster], The Inter-University Neuroscience and Mental Health Conference, Sydney, September, 20-21

8. Maharaj, S, Lees, T, Lal, S. (2016), 'Negative mental states and their association to cognition & brain function in nurses.' [poster], The Society for Mental Health Research Conference, Sydney, December 07-09

9. Maharaj, S, T, Lees, C, Zaslawski, K, Fatima-Shad, Lal, S. (2017), 'The Prevalence of depression in a cohort of Australian Nurses.' [poster], The Inter-University Neuroscience and Mental Health Conference, Sydney, September 14-15

10. Maharaj, S, T, Lees, C, Zaslawski, K, Fatima-Shad, Lal, S. (2017), 'Assessing the link between negative mental states and cognitive performance in health professionals.' [poster], The 4th Annual Conference of the Australasian Cognitive Neuroscience Society, Adelaide, November 23-26

11. Lees, T, Maharaj, S, Kalatzis, G, Nassif, N, Newton P, Lal, S., (2018), The neurocognitive relationship between stress and anxiety, and memory and decision-making performance of Australian Nurses. 58th Annual Meeting of the Society for Psychophysiological Research (SPR), Quebec, October 3-7

12. Ferreira B, Maharaj, S, Simpson, A, Nassif, N, Lal, S., (2019), Investigating the metabolic effects of depression and burnout in nurses. The 36th Combined Health Science Conference - New Horizons 2019, Sydney, November 14-15

13. Beehan-Quirk, C, Jarman, L, Maharaj, S, Simpson, A, Nassif, N, Lal, S., (2019), The effects of fatigue on blood glucose levels – implications for diabetes. The 36th Combined Health Science Conference - New Horizons 2019, Sydney, November 14-15

Other (manuscripts currently submitted for publication)

1. Maharaj S, Lees T, Lin CT, Newton P, Clifton-Bligh R, McLachlan C, Gustin S, Lal S., The relationship between neurocognitive performance, psychometrics, demographics, and HRV parameters in nurses and non-healthcare participants

2. Lees T, Maharaj S, Kalatzis G, Nassif N, Newton P, Lal S., Anxiety and its relationship to the neurocognitive performance of Australian Nurses

3. Leong D, Akella A, Kumar Singh A, Lal S, Newton P, Clifton-Bligh R, McLachlan C, Gustin S, Maharaj S, Lees T, Cao J, Lin CT., Classifying the Level of Lab-induced Stress in a combined sample of nurses and non-health professionals using Auto-Encoder

4. Chalmers T, Maharaj S, Lal S., Assessing associations between workplace factors and Depression and Anxiety in Australian heavy vehicle truck drivers

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VII. Abbreviations

ABS = Australian Bureau of Statistics

ACTH = Adrenocorticotropic Hormone

AIHW = Australian Institute of Health and Welfare

AIN = Assistant in Nursing

ANOVA = Analysis of Variance

ANS = Autonomic Nervous System

β = Beta

B = Regression Coefficient

BMI = Body Mass Index

BP = Blood Pressure

Bpm **=** beats per minute

CANTAB **=** Cambridge Neuropsychological Test Automated Battery

CBT **=** Cognitive Behavioural Therapy

CRH = Corticotropin Releasing Hormone

°C = Degrees Celsius

DASS = Depression Anxiety Stress Scale

DC = Direct Current Value

EEG = Electroencephalography

ELISA = Enzyme-linked Immunosorbent Assay

EOG = Electro-oculogram

ESS = Epworth Sleepiness Scale

fMRI = Functional Magnetic Resonance Imaging

g('s) = Relative Centrifugal Force (RCF)

GHQ = General Health Questionnaire

GP = General Practitioner

HPA axis = Hypothalamic Pituitary Adrenal Axis

HR = Heart Rate

HREC = Human Research Ethics Committee

Hz = Hertz

IQ = Intelligence Quotient

LC-MS/MS = Liquid Chromatography Tandem Mass Spectrometry

MANCOVA = Multiple Analysis of Covariance

MCI = Mild Cognitive Impairment

MEG = Magnetoencephalography

mmHg = Millimetres Mercury

MMSE = Mini Mental State Examination

MRI = Magnetic Resonance Imaging

NC = No Change

NHC = Non-Healthcare comparative group

NS = Non-Significant

NSW = New South Wales

OMS = Ohms

PET = Positron Emission Tomography

qEEG = Quantitative Electroencephalography

R = Correlation Coefficient

r = Rho value

R^2 = Coefficient of determination

RN = Registered Nurse

SD = Standard Deviation

SE = Standard Error

µV = Microvolts

ug/dL = Micrograms per Decilitre

USA = United States of America

UTS = University of Technology Sydney

WAIS = Wechsler Adult Intelligence Scale

$\mu V/s^2$ = Microvolts per second squared

VIII. Abstract

Healthcare remains one of the most demanding careers available. Psychological distress is widespread among healthcare professionals. However, few studies have investigated the prevalence of stress and common mental health issues such as anxiety, and depression in Australian healthcare professionals, and their associations with electroencephalography (EEG) and cognitive performance. The present study assessed the prevalence of stress, anxiety and depression, and the relationships between these mental states and cognitive performance in healthcare professionals. It also investigated associations between cortisol and mental health/cognitive performance measures.

Data was obtained from 154 participants divided into four groups: nurses (n=81), allied health professionals (n=31), doctors (n=20), and non-healthcare professionals (n=22). The experimental protocol involved pre-study and post-study blood pressure measurements and the collection of salivary cortisol. A questionnaire battery obtained lifestyle, demographic, and work-related data. Mental health data was obtained using the Depression, Anxiety, Stress Scale, and the General Health Questionnaire. A 32-lead monopolar EEG was recorded over two five-minute phases (a resting baseline phase followed by an active phase involving the Stroop task). Finally, cognitive performance was assessed using the Mini-Mental State Examination and the Cognistat.

Prevalence rates in healthcare providers ranged between 26-60% for depression, 26-44% for anxiety, and 29-60% for stress. Stress was associated with decreases in repetition ($r=-0.46$, $p=0.039$), memory ($r=-0.49$, $p=0.029$), and attention ($r=-0.51$, $p=0.021$) in doctors, while anxiety was linked to decreased memory ($r=-0.23$, $p=0.047$) in nurses and global cognition ($r=-0.36$, $p=0.049$) in allied health professionals. Depression was also related to declines in memory ($r=-0.27$, $p=0.019$) in nurses. Conversely, stress was associated with better judgement ($r=0.61$, $p=0.004$) in doctors. Stress, anxiety, and depression were also associated with mixed findings in both high and low-frequency brain activities (decreased theta, increased delta, decreased alpha, increased beta, decreased gamma). No associations were found between cortisol and mental health/cognitive performance measures.

These findings provide insight into the prevalence of mental health symptomology in Australian health professionals and suggest that negative mental states are associated with both improvements and impairments in cognitive performance. Unique variations in electroencephalographic changes were also linked to stress, anxiety, and depression; giving insight into what brain rhythms may underlie stress, anxiety, and depression, and how they may relate to various cognitive processes. Further research exploring the effects of negative mental states on personal wellbeing and cognition could enable the development of industry-specific management, monitoring, and/or intervention strategies aimed at preserving the health and performance of health professionals.