Effects of heart rate variability and blood pressure on cognition in healthy and clinical cohorts

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BMedSc(Hons)

2016

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Submitted in partial fulfilment of the requirements for the degree of Doctorate of Philosophy (Science) at the University of Technology Sydney.
Declaration

Certificate of original authorship

I certify that the work in this thesis has not been previously submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature:

Date: 22/05/2016

Louisa Giblin
Acknowledgments

Firstly, I would like to thank my principal supervisor, Associate Professor Sara Lal. I am enormously grateful for the opportunity to have undertaken a PhD as your student. Your insight, guidance, feedback, and support has been invaluable throughout my candidature. Thank you for your energy and enthusiasm for human research; our meetings always inspired and motivated me. I hope we collaborate again in the future.

I would also like to thank my co-supervisors, Associate Professor Roderick Clifton-Bligh and Associate Professor Christopher Zaslawski, for your feedback and intellectual input, and for allowing me to work autonomously. And thank you Professor David Sibbritt, for your expert advice on the statistical analysis.

I would like to express my sincere gratitude to my partner, Josh Chalkley, who has not only supported me with positive encouragement, kept me company during late nights, and made me many cups of tea, but also spent countless hours proof-reading and editing this thesis. Thank you for your kindesses.

Thank you also to my friends and colleagues in the Neuroscience Research Unit at UTS, in particular, Taryn Chalmers, Ty Lees, Jaymen Elliott, and Leon Rothberg. Thank you for being there to discuss ideas, troubleshoot problems, and for your words of encouragement.

My sincere thanks go to all the generous participants who volunteered their time to be part of this research. Thank you to Diabetes NSW and Alzheimer’s Australia, who advertised this study to help with recruitment.

Thank you also to Alzheimer’s Australia Dementia Research Foundation for providing a top-up scholarship.

Thank you to Budi Jap, who designed the software and analysis for the heart rate variability data used in this study. Thank you for providing the data quickly and accurately.
My warmest thanks go to my family and friends for their endless support and understanding throughout this year. Thank you also for being both participants in this research and helping to recruit others.

Finally, I would like to thank the markers, for reading, reviewing, and accepting this thesis.
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<tbody>
<tr>
<td>AD</td>
<td>Alzheimer’s disease</td>
</tr>
<tr>
<td>ANCOVA</td>
<td>Analysis of covariance</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
</tr>
<tr>
<td>ANS</td>
<td>Autonomic nervous system</td>
</tr>
<tr>
<td>APOEε4 allele</td>
<td>Epsilon 4 allele of apolipoprotein E</td>
</tr>
<tr>
<td>BMI</td>
<td>Body mass index</td>
</tr>
<tr>
<td>BP</td>
<td>Blood pressure</td>
</tr>
<tr>
<td>bpm</td>
<td>Beats per minute</td>
</tr>
<tr>
<td>CR</td>
<td>Cardiac reactivity</td>
</tr>
<tr>
<td>DBP</td>
<td>Diastolic blood pressure</td>
</tr>
<tr>
<td>df</td>
<td>Degrees of freedom</td>
</tr>
<tr>
<td>DM</td>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td>ECG</td>
<td>Electrocardiogram</td>
</tr>
<tr>
<td>F</td>
<td>F statistic</td>
</tr>
<tr>
<td>HF</td>
<td>High frequency</td>
</tr>
<tr>
<td>HPA</td>
<td>Hypothalamic-pituitary-adrenal</td>
</tr>
<tr>
<td>HR</td>
<td>Heart rate</td>
</tr>
<tr>
<td>HREC</td>
<td>Human Research Ethics Committee</td>
</tr>
<tr>
<td>HRT</td>
<td>Hormone replacement therapy</td>
</tr>
<tr>
<td>HRV</td>
<td>Heart rate variability</td>
</tr>
<tr>
<td>IQ</td>
<td>Intelligence quotient</td>
</tr>
<tr>
<td>IQR</td>
<td>Interquartile range</td>
</tr>
<tr>
<td>LAQ</td>
<td>Lifestyle Appraisal Questionnaire</td>
</tr>
<tr>
<td>LF</td>
<td>Low frequency</td>
</tr>
<tr>
<td>LF/HF</td>
<td>Low frequency to high frequency ratio (sympathovagal balance)</td>
</tr>
<tr>
<td>LSD</td>
<td>Least significant difference</td>
</tr>
<tr>
<td>MANCOVA</td>
<td>Multiple analysis of covariance</td>
</tr>
<tr>
<td>MCI</td>
<td>Mild cognitive impairment</td>
</tr>
<tr>
<td>mm</td>
<td>Millimetres</td>
</tr>
<tr>
<td>mmHg</td>
<td>Millimetres of mercury</td>
</tr>
<tr>
<td>MMSE</td>
<td>Mini-Mental State Examination</td>
</tr>
<tr>
<td>ms</td>
<td>Milliseconds</td>
</tr>
<tr>
<td>ms²</td>
<td>Milliseconds squared</td>
</tr>
<tr>
<td>mV</td>
<td>Millivolts</td>
</tr>
<tr>
<td>n</td>
<td>Sample size</td>
</tr>
<tr>
<td>NSAIDs</td>
<td>Non-steroidal anti-inflammatory drugs</td>
</tr>
<tr>
<td>p</td>
<td>p value</td>
</tr>
<tr>
<td>PFC</td>
<td>Prefrontal cortex</td>
</tr>
<tr>
<td>pNN50</td>
<td>Percentage of NN intervals &gt;50ms apart</td>
</tr>
<tr>
<td>PNS</td>
<td>Parasympathetic nervous system</td>
</tr>
<tr>
<td>RMSSD</td>
<td>Root mean square of successive differences</td>
</tr>
<tr>
<td>RSA</td>
<td>Respiratory sinus arrhythmia</td>
</tr>
<tr>
<td>SBP</td>
<td>Systolic blood pressure</td>
</tr>
<tr>
<td>SD</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>SDNN</td>
<td>Standard deviation of NN interval</td>
</tr>
<tr>
<td>sec</td>
<td>Second</td>
</tr>
<tr>
<td>SNS</td>
<td>Sympathetic nervous system</td>
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<tr>
<td>t</td>
<td>t statistic</td>
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<tr>
<td>U</td>
<td>U statistic</td>
</tr>
<tr>
<td>ULS</td>
<td>Ultra low frequency</td>
</tr>
<tr>
<td>UTS</td>
<td>University of Technology</td>
</tr>
</tbody>
</table>
Sydney

VaD = Vascular dementia
VLF = Very low frequency
\( \chi^2 \) = Chi square statistic
Z = Z score
\( \downarrow \) = Decrease
> = Greater than

\( \geq \) = Greater than or equal to
\( \uparrow \) = Increase
\( < \) = Less than
\( \leq \) = Less than or equal to
% = Percentage
\( \pm \) = Plus or minus
* = Regression analyses performed
List of publications and presentations

List of publications


List of presentations

National conferences


International conferences


Abstract

Australia’s aging population has heightened demand for earlier detection and prevention methods for dementia. Studies have shown that autonomic dysfunction precedes mild cognitive impairment, a precursor to dementia (Collins et al., 2012). The present study explores the links between heart rate variability (HRV) (reflecting autonomic activity), blood pressure (BP), and cognitive function in non-clinical and clinical cohorts (depression, diabetes (type 1 and 2), and hypertension).

Participants were added to an existing database (De Leon, 2009, Smith, 2010) (n=100) to produce a cumulative sample of n=297. The experimental protocol commenced with three baseline BP measurements, the Lifestyle Appraisal Questionnaire (Craig et al., 1996) and the Disease State Questionnaire (Giblin, 2013). The participant underwent two electrocardiogram recordings for HRV analysis (10 minutes of baseline and 10 minutes of a cognitive task). Two psychometric tests were then administered: the Mini-Mental State Examination (Folstein et al., 1975) and the Cognistat (Kiernan et al., 1987). Finally, three additional BP measurements completed the study protocol.

Higher baseline parasympathetic activity was significantly correlated (p=<0.05) to better cognitive performance (e.g. memory) in females 18-50 years and males 51-65 years however this was also correlated to poorer cognitive scores (e.g. judgment) in females 36-65 years and males 36-50 years. HRV reactivity (cognitive task minus baseline) was mostly positively correlated to cognition (e.g. comprehension) in females 18-35 and 51-65 years.

Higher vagal activity was linked to higher cognitive scores (e.g. attention) in all clinical groups yet also linked to poorer cognitive scores (e.g. orientation) in the type 1 diabetes and hypertension groups. HRV reactivity was mostly positively correlated to cognition (e.g. naming) in the hypertension sample yet inversely linked to cognition in the other clinical groups.

Both clinical and non-clinical groups had positive correlations between BP reactivity and cognitive performance (e.g. attention), suggesting low BP reactivity may be a predictor for cognitive decline.
These initial findings contribute new knowledge to the field of HRV and cognition, particularly in clinical groups and the less-studied HRV and BP reactivity in clinical and non-clinical groups. By gaining a better understanding of early autonomic risk factors for cognitive impairment, preventative countermeasures (e.g. anti-hypertensive use and autonomic biofeedback) may be considered to slow or cease dementia progression. Delaying or stopping the development of dementia has the potential to reduce expected rises in government expenditure, lower the burden on carers and nursing homes, lengthen lifespans, and ultimately improve the quality of life in elderly populations.