http://researchspace.auckland.ac.nz

ResearchSpace@Auckland

Copyright Statement

The digital copy of this thesis is protected by the Copyright Act 1994 (New Zealand).

This thesis may be consulted by you, provided you comply with the provisions of the Act and the following conditions of use:

- Any use you make of these documents or images must be for research or private study purposes only, and you may not make them available to any other person.
- Authors control the copyright of their thesis. You will recognise the author's right to be identified as the author of this thesis, and due acknowledgement will be made to the author where appropriate.
- You will obtain the author's permission before publishing any material from their thesis.

To request permissions please use the Feedback form on our webpage. http://researchspace.auckland.ac.nz/feedback

General copyright and disclaimer

In addition to the above conditions, authors give their consent for the digital copy of their work to be used subject to the conditions specified on the Library Thesis Consent Form.

Respiratory Sensation in Asthmatic Subjects and Matched Controls

by

Helen Gaeta

A thesis submitted for the degree of
Doctor of Philosophy in Physiology
University of Auckland
December 1994

ABSTRACT

Asthmatics most "at risk of death" from their asthma are those that have severe asthma with a history of severe life threatening attacks (SLTAs). Some asthmatics are poor perceivers of the severity of their asthma. It is not known whether these two groups form a homogeneous population. The aim of this thesis was to establish whether this was the case by comparing the sensitivity of asthmatics classified as severe with a history of severe life threatening attacks, asthmatics without a history of SLTAs, mild and moderate asthmatics, and matched controls to externally added resistive loads during inspiration. It also aimed to establish whether poor sensitivity to externally added resistive loads during inspiration was associated with diminished amplitude or increased latency of scalp potentials evoked by inspiratory occlusion.

Two studies were conducted to meet the first aim. The first study tested the applicability of the equal variance normal-normal model of signal detection theory as a descriptor of subjects' performance when discriminating between different levels of externally added resistive loads during inspiration. Twelve subjects rated their capacity to distinguish between pairs of resistive loads ranging from 2-33cmH2O/L/s presented during a single inspiration. Data were collected for 100, 200 and 300 single breath trials. The results showed that the model fitted the data well; that 200 trials provided performance indices that were sufficiently precise to distinguish between relatively low, average and high levels of sensitivity; and that, for the modality tested, respiratory sensation complied with Weber's Law. The second study applied the validated procedure to test the ability of 25 asthmatics classified either as severe, or mild or moderate, and 25 matched controls to distinguish between pairs of external resistive loads ranging from 2-33cmH2O/L/s presented during a single inspiration. Analysis of the data (ANOVA) showed that there were no significant differences in the ability of subjects to distinguish between resistive loads regardless of whether they were severe asthmatics with or without a history of SLTAs, mild or moderate asthmatics, or matched controls. It was concluded that asthmatics with poor sensitivity to the respiratory sensation tested

and asthmatics most "at risk of death" from their asthma were not a homogeneous group, but poor sensitivity coupled with severe asthma, and a history of SLTAs most likely increased the risk of death to that patient.

Four studies were conducted to meet the second aim. The first three studies were concerned with determining the reproducibilty of the scalp potential evoked by inspiratory occlusion (designated respiratory event related evoked potentials, RREP) and establishing a reliable recording protocol for the RREP that was relatively free of artefact. The results showed that the RREP was relatively stable over time and the best recording sites were cephalic electrode pairs C3-Cz and C4-Cz (10-20 International System). The fourth study examined the relationship between the ability of 25 asthmatic subjects and their matched controls to distinguish between levels of resistive loads added to inspiration and the latencies and amplitudes of the first positive and first negative components of the RREP. Correlation analysis showed that there was no relationship between sensitivity to added resistive loads during inspiration and RREP component parameters. It was concluded that diminution or absence of the early components of the RREP was not indicative of impaired perception of respiratory sensation though some issues regarding the appropriateness of the analysis still require resolution.

ACKNOWLEDGMENTS

Thank you to all the technical staff of the Department of Physiology who assisted in the development of equipment used in the studies reported in this thesis. In particular Si Yeo, John Quinn and Stewart Glasson.

Thank you to Suzanne Purdy for measuring the sound pressure level of the occlusion valve and her assistance with the cochlear implant subject.

Thank you to Thomas Bryant for the Spike2 data analysis programme he wrote for me.

Thank you to the Auckland Medical Research Foundation for funding this project.

Thank you to Karn Hinton for her invaluable assistance with all the studies reported in this thesis and for her exuberant sense of humour.

Thank you to both my supervisors, Paul Hill and John Irwin, for their support and advice. I am especially grateful to Paul Hill for giving me the opportunity to work in such a pleasant environment.

Thank you to all the volunteer subjects who participated in this project. I am indebted to you, not only for giving so generously of your time, but also for the insight you have given me into the problems of coping with a life-threatening disorder.

TABLE OF CONTENTS

	Page
ABSTRACT	ii
ACKNOWLEDGMENTS	iv
LIST OF FIGURES	viii
LIST OF TABLES	xi
1. GENERAL INTRODUCTION	1
2. INTRODUCTION TO SIGNAL DETECTION THEORY	7
3. VALIDATION OF DETECTION-THEORY PROCEDURE	13
3.a. Method	13
Subjects	13
Procedure (general)	13
Procedure (specific)	15
Detection-theory procedure	18
3.b. Results	19
Goodness of fit of the normal-normal model	19
Precision of estimates	22
Cumulative sensitivity and Weber's Law	22
3.c. Discussion	24
4. SENSITIVITY TO EXTERNALLY ADDED RESISTIVE LOADS BY ASTHMATICS AND NON-ASTHMATICS	28
4.a. Method	28
Subjects	28
Procedure	29
4.b. Results	31
Goodness of fit of the normal-normal model	31
Comparison of sensitivity measures	32
Cumulative sensitivity and Weber's Law	38
Sensitivity measures and respiratory airway resistance	38
Sensitivity measures and stimulus parameters	40
4.c. Discussion	43
Sensitivity and magnitude of resistive loads	50
Cumulative sensitivity and Weber's Law	50

Page

Perception of resistive loads and "at risk" asthmatics . . . 52

5. INTRODUCTION TO RESPIRATORY EVENT RELATED POTENTIALS . . 53

6. REPRODUCIBILITY OF RESPIRATORY EVENT RELATED POTENTIALS . . 58
6.a. Methods 58
Subjects 58
Procedure 58

6.b. Results 67

6.c. Discussion 61
Inconsistency between studies 67
Sources of artefact 68

7. AUDITORY CONTAMINATION OF RESPIRATORY EVENT RELATED POTENTIALS . . 70
7.a. Method 70
Subjects 70
Procedure 70

7.b. Results 73
Normal hearing subjects 73
Cochlear implant subject 87

7.c. Discussion 92

8. CARDIAC ARTEFACT 95
8.a. Method 95
Subjects 95
Procedure 95

8.b. Results 96

8.c. Discussion 103

9. THE RELATIONSHIP BETWEEN SENSITIVITY AND THE RESPIRATORY EVENT RELATED POTENTIAL . . 105

9.a. Method 105
Subjects 105
Procedure 105

Page

9.b. Results 107

9.c. Discussion 110

10. SUMMARY OF CONCLUSIONS 117

Appendix 1 120
Appendix 2 122

REFERENCES 135

LIST OF FIGURES

		Page
2.1	Theoretical distribution of noise and signal plus noise for three levels of signal strength	9
2.2	Theoretical distribution of noise and signal plus noise showing effect of criterion location on performance	9
2.3	An ROC with five experimental points	10
3.1	Valve port system	16
3.2	Six examples of ROCs	20
3.3	Six examples of normalised ROCs	21
3.4	Cumulative sensitivity curves for four subjects	24
4.1	Mean sensitivity values for asthmatics and controls	34
4.2	Mean sensitivity values for severe asthmatics, mild or moderate asthmatics, and controls	34
4.3	Mean sensitivity values according to incidents of SLTAs . . .	36
4.4	Mean sensitivity values according to time elapsed since SLTA	36
4.5	Cumulative sensitivity curves for four asthmatics and matched controls	39
4.6	Plot of mean sensitivity values and airway resistance	41
4.7	Plot of mean sensitivity values and stimulus duration	42
6.1	Example of trigger pulse, mouth pressure and Fz-joined earlobe signals	60
6.2a	Signal averages recorded on four occasions for three subjects	62
6.2b	Signal averages recorded on four occasions for three subjects	63
6.3	Grand average signals based on records for six subjects . .	65
7.1	Signal averages for 3 subjects recorded from frontal cephalic sites referenced to joined earlobes	74
7.2	Signal averages for 3 subjects recorded from central	

		Page
	cephalic sites referenced to joined earlobes	75
7.3	Signal averages for 3 subjects recorded from parietal cephalic sites referenced to joined earlobes	76
7.4	Signal averages for 3 subjects recorded from frontal cephalic sites referenced to Cz	80
7.5	Signal averages for 3 subjects recorded from central cephalic sites referenced to Cz	81
7.6	Signal averages for 3 subjects recorded from parietal cephalic sites referenced to Cz	82
7.7	Signal averages for cochlear implant subject recorded with joined earlobe referencing	89
7.8	Signal averages for cochlear implant subject recorded on two separate occasions	90
7.9	Signal averages for cochlear implant subject recorded with Cz referencing	91
8.1	Signal averages for one subject recorded with cephalic and non-cephalic referencing	99
8.2	Selected traces for five subjects recorded with cephalic and non-cephalic referencing	100
8.3	Selected signal averages for 5 subjects with and without cardiac electrical activity	101
8.4	Signal averages for 4 subjects triggered from the QRS complex of the ECG	102
9.1	Mean peak component latencies and peak component amplitudes for signal averages recorded from C3-Cz and C4-Cz electrode pairs	108
9.2	Signal averages for 1 asthmatic subject and matched control recorded from C3-Cz electrode pair	109
9.3	Mean sensitivity and P1 amplitude	111
9.4	Mean sensitivity and P1 latency	112

Page

9.5 Mean sensitivity and N1 amplitude 113

9.6 Mean sensitivity and N1 latency 114

LIST OF TABLES

		Page
3.1	Details of subjects participating in study	14
3.2	Six-point rating scale	18
3.3	95% confidence limits for estimates of d' based on 100, 200 and 300 trials	23
4.1	Subject characteristics and measures of lung function	30
4.2	ANOVA results for differences in sensitivity between asthmatics and controls	33
4.3	ANOVA results for differences in sensitivity between severe asthmatics, mild or moderate asthmatics, and controls	35
4.4	ANOVA results for differences in sensitivity between asthmatics who had experienced SLTAs and those that had not experienced SLTAs	35
4.5	ANOVA results for differences in sensitivity between asthmatics experiencing SLTAs within 12 months of testing and those experiencing SLTAs more than 12 months preceding testing	37
4.6	Scheffé post hoc test results for differences in sensitivity between pairs of resistive loads	37
4.7	Weber fractions for asthmatics and matched controls	40
5.1	Summary of protocols used in different studies to record RREPs	57
6.1	Individual peak component latencies and amplitudes for six subjects	64
6.2	Peak latencies and amplitudes for grand average data	66
7.1	Electrode montages used for recording data from normal hearing subjects	72
7.2	Electrode montages used for recording data from cochlear implant subject	72

Page

7.3a Individual peak component latencies and amplitudes from records for three subjects for frontal electrode sites (joined earlobe referencing) 78

7.3b Individual peak component latencies and amplitudes from records for three subjects for central electrode sites (joined earlobe referencing) 79

7.4a Individual peak component latencies and amplitudes from records for three subjects for frontal electrode sites (Cz referencing) 84

7.4b Individual peak component latencies and amplitudes from records for three subjects for central electrode sites (Cz referencing) 85

7.4c Individual peak component latencies and amplitudes from records for three subjects for parietal electrode sites (Cz referencing) 86

8.1 Individual peak component latencies and amplitudes for records from electrode pairs C3-Cz and C4-Cz for five subjects 97