

Chronic Aircraft Noise Exposure Effects on Children's Learning and Development

JOSEPH MAHLAKANE SEABI

**A PhD Thesis Submitted to the Faculty of Humanities,
For the Degree of Doctor of Philosophy**

University of the Witwatersrand, Johannesburg,

2014

DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other university.

Joseph Mahlakane Seabi

Date

DEDICATION

To my late grandmother, Mrs. Hellen Lekganyane, 'Principal Map', for inculcating in me the value of education and for the continuous encouragement I received from her. How can I forget the trouble she took to wake me up every night to study, particularly in my Grade 12. The solid foundation she provided me with made it possible for me to be where I am today.

Ke re go lena Kgotuwe, le lena maina, Mahlakane Joseph Lekganyane, robalang ka kgotso le tsebe gore ke kgonne go fihlelela degree yeo le bego le ratile gore ke e humane. Degree ye keya rena ka moka, бага Lekganyane le бага Seabi, bao ba bego ba ratile go ka e humana.

ACKNOWLEDGEMENTS

- I would like to acknowledge Almighty God without whose help this endeavour would not have been possible. Glory be unto You, my Father, for You are my source of strength.

I would like to express my gratitude to all the people who made this research possible:

- In particular, I would like to acknowledge and thank my promoters, Prof. Kate Cockcroft and Dr. Paul Goldschagg, for their unwavering support, invaluable insights, encouragement and patience.
- Mike Greyling, for his time and support with the statistical analyses and interpretation.
- The RANCH-SA team, for their invaluable help with the data collection, capturing and scoring. To you, I say, Spikey Squares!
- Prof. Stephen Stansfeld and Dr. Charlotte Clark, for providing access to the assessment materials.
- The Carnegie Corporation of New York and the National Research Foundation (NRF), for their financial support.
- The learners in the three-year data collection process, without whose participation this study would have not been possible.
- Prof. Garth Stevens and Prof. Brett Bowman, for providing guidance during the conversion of this thesis into a PhD thesis by publication.
- My family, Gladys, Peter, Tebogo, Hellen and Barney, for their unstinting support, love and encouragement. I am fortunate to have them in my life.
- My wife, Rose, for her love and belief in me, which gave me the courage to take on seemingly formidable challenges, and for shouldering many of the responsibilities that I could not bear due to the demands of this degree.
- My beautiful princess, Bontle, for her love and support. Daddy will always love you.

ABSTRACT

The effects of exposure to environmental noise on individuals' functioning have been researched extensively in recent times. However, most of this research has focused on adults who, unlike children, have the cognitive capacity to anticipate and cope with noisy environments. This research was based largely on laboratory studies that lacked ecological validity thus avoiding the implications of long-term, real-life exposure to noise. The increasing exposure of people (currently over 80 million people) to unacceptable levels of aircraft noise worldwide gives rise to crucial questions such as the long-term effects of exposure to aircraft noise on children's reading comprehension, health and annoyance reactions and how children cope with exposure to noise. The objectives of this epidemiological study were to investigate the effects of chronic exposure to aircraft noise on primary school children's reading comprehension; to determine whether their learning was affected by noise; to uncover how these children coped with exposure to noise; to determine whether they were annoyed by exposure to noise; and to evaluate their subjective perceptions of whether exposure to noise impacted negatively on their health. The primary objective was to evaluate the children's reactions to the above factors after the relocation of an international airport to another area in order to determine whether the cessation of exposure to noise resulted in improved performance and functioning. This thesis is based on the publication of four scholarly articles that deal with the need for empirical research in an emerging field as well as the need for public education and the advocacy of a worthwhile form of environmental health. Children living in the vicinity of an international airport (noisy group) and those living in quieter areas, who matched the noisy group in terms of socio-economic status and language spoken at home, were recruited for the research. This yielded a cohort of 732 children with a mean age of 11.1 who participated in baseline measurements in 2009 as well as cohorts of 649 (mean age = 12.3) and 174 (mean age = 13.1) children. These children were reassessed after the closure and relocation of the airport for two subsequent years. The findings revealed that, unlike their peers from quieter backgrounds, the children exposed to aircraft noise reported that the noise significantly interfered with their learning and social activities at school, and they continued to report more interference than their counterparts despite the relocation of the airport. These findings were validated by the results of the objective measurement of reading comprehension, which showed that these children performed poorly in comparison to their peers. The children exposed to aircraft noise also reported higher levels of annoyance in all the waves of the study (from 2009 to 2011), and they continued to use more coping strategies following the relocation of the airport than the children from quieter environments. However, the findings revealed no significant impact of the noise on the children's health. Taken together, these findings suggest that chronic

exposure to aircraft noise may have a significant and detrimental impact on children's learning and level of annoyance but not on their subjective health ratings. This was one of the first longitudinal studies of this nature on the African continent.

Keywords: Aircraft Noise; Reading Comprehension; Annoyance; Coping; Health.

TABLE OF CONTENTS

Title Page	I
Declaration	II
Dedication	III
Acknowledgements	IV
Abstract	V
Table of Contents	VI
List of Publications	VII
List of Tables	XIII
List of Figures	IX
Appendices	X

CHAPTER ONE: INTRODUCTION	20
1.1. Background	20
1.2. Statement of the Problem	21
1.3. Motivation for the Study	22
1.4 Statement of Originality	24
1.5. Research Aims	25
1.6. Objectives of the Study	26
1.7 Conceptual Framework	27
1.8. Research Questions	28
1.9 Overview of Methods	29
<i>1.9.1. Design</i>	<i>29</i>
<i>1.9.2. Selection of Schools</i>	<i>29</i>
<i>1.9.3. Participants</i>	<i>29</i>
1.10. Outline of the Thesis	30
1.11 Roles and Responsibilities	32
 CHAPTER TWO: FUNDAMENTALS OF NOISE	 34
2.1. Sound and Noise	34
2.2. Noise Measurement	35
2.3. Noise Pollution by Aircraft	36
2.4. Aircraft Noise Policy	37
2.5. Effects of Noise on Children	41

CHAPTER THREE: CHILDREN’S HEALTH AND ANNOYANCE

REACTIONS TO EXPOSURE TO AIRCRAFT NOISE	48
3.1. Introduction	49
3.2. Noise Annoyance and Health	50
3.3. Research Questions	53
3.4. Methods	53
3.4.1. Context of the Study	53
3.4.2. Research Design	54
3.4.3. Participants	54
3.4.4. Procedure	57
3.4.5. Instruments	58
3.4.5.1. <i>Biographical Questionnaire</i>	58
3.4.5.2. <i>Noise Annoyance</i>	58
3.4.5.3. <i>Child General Health</i>	59
3.4.5.4. <i>Perceived Noise Exposure</i>	59
3.4.5.5. <i>Noise Measurements</i>	60
3.4.6. Statistical Analysis	61
3.5. Results	61
3.5.1. Perception of Noise at School	61
3.5.2. Perception of Noise at Home	63
3.5.3. Annoyance Reactions at School	64
3.5.4. Annoyance Reactions at Home	66
3.5.5. Child Self-Reported Health	66
3.6. Discussion	68

3.6.1.	Perception of Noise	68
3.6.2.	Aircraft Noise and Annoyance	69
3.6.3.	Aircraft Noise and Health	70
3.6.4.	Implications of the Findings	71
3.6.5.	Strengths and Limitations	71
3.7.	Conclusion	72
3.8.	Acknowledgments	72
3.9.	Conflict of Interest	73
3.10.	References	74

CHAPTER FOUR: EFFECTS OF NOISE ON CHILDREN'S LEARNING AND SOCIAL ACTIVITIES **79**

4.1.	Introduction	80
4.1.1.	Coping with Noise	81
4.1.2.	Research Questions	83
4.2.	Methods	83
4.2.1.	Participants	83
4.2.2.	Instruments	84
4.2.2.1.	<i>Biographical Questionnaire</i>	84
4.2.2.2.	<i>Disturbance at Activities</i>	85
4.2.2.3.	<i>Dealing with Noise</i>	85
4.2.2.4.	<i>Noise Measurements</i>	85
4.2.3.	Procedure	86
4.2.4.	Statistical Analysis	86

4.3.	Results	86
4.3.1.	Disturbance at School and Home Activities	86
4.3.2.	Coping with Noise at School and Home	89
4.4.	Discussion	92
4.4.1.	Disturbances to Activities and Coping Strategies	92
4.4.2.	Strengths and Limitations	94
4.5.	Conclusion	94
4.6.	Acknowledgments	94
4.7.	Conflict of Interest	95
4.8.	References	96

CHAPTER FIVE: THE MODERATING EFFECTS OF HOME LANGUAGE

100

5.1.	Introduction	101
5.1.1.	Sources of Noise in the Classroom	102
5.1.2.	Reading Comprehension	103
5.1.3.	Aircraft Noise in the Context of Reading Comprehension	104
5.1.4.	Aims	106
5.2.	Methods	107
5.2.1.	Context of the Study	107
5.2.2.	Participants	107
5.2.3.	Procedure	108
5.2.4.	Instruments	109
5.2.4.1.	<i>Biographical Questionnaire</i>	109

5.2.4.2.	<i>Reading Comprehension</i>	109
5.2.4.3.	<i>Intellectual Ability</i>	110
5.2.4.4.	<i>Noise Measurements</i>	110
5.2.5.	Ethical Considerations	110
5.3.	Results	111
5.3.1.	Effects of Aircraft Noise on Reading Comprehension	114
5.3.2.	Effects of Home Language on Reading Comprehension	114
5.3.3.	Effects of Aircraft Noise and Home Language on Reading Comprehension	115
5.4.	Discussion	116
5.4.1.	Effect of Language on Reading Comprehension	116
5.4.2.	Effect of Aircraft Noise on Reading Comprehension	118
5.4.3.	Limitations of the Study and Suggestions for Future Research	120
5.5.	Conclusion	121
5.6.	Acknowledgements	122
5.7.	References	123

CHAPTER SIX: LONGITUDINAL EFFECTS OF AIRCRAFT NOISE ON READING COMPREHENSION

6.1.	Introduction	128
6.2.	Materials and Methods	131
6.2.1.	Sampling and Design	131
6.2.2.	Instruments	132

6.2.2.1.	<i>Biographical Questionnaire</i>	133
6.2.2.2.	<i>Reading Comprehension</i>	133
6.2.2.3	<i>Noise Measurements</i>	134
6.2.3.	Analysis	135
6.3.	Results	135
6.3.1.	Effects of Removal of Aircraft Noise on Reading Comprehension	138
6.4.	Discussion	140
6.4.1.	Strengths and Limitations	142
6.5.	Acknowledgements	144
6.6.	Conflict of Interest	144
6.7.	References	145
CHAPTER SEVEN: COMBINING THE FINDINGS		149
7.1.	Introduction	149
7.1.2.	Aim of the Study	149
7.2.	Main Results	150
7.3.	Theoretical and Practical Contribution of the Research	157
7.4.	Limitations of the Study	158
7.5.	Suggestions for Future Research	159
7.6.	Conclusion	161
7.7.	References	162

APPENDICES	173
Appendix A: KwaZulu-Natal Department of Education Information Letter	174
Appendix B: Principal Information Letter	177
Appendix C: Parent Information Letter	180
Appendix D: Learner Information Letter	183
Appendix E: Sample of the Children's Questionnaire	184
Appendix F: Sample of the Suffolk Reading Scale 2	188

LIST OF TABLES

Chapter Three

Table 1.	Socio-Demographic Characteristics of the High Noise and Low noise groups	56
Table 2.	Perception of Noise at School and Home	62
Table 3.	Child Self-Reported Health	67

Chapter Four

Table 1.	Socio-Demographic Characteristics of the High Noise and Low Noise groups	84
Table 2.	Disturbance at School and Home Activities	88
Table 3.	Coping with Noise at School and Home	90

Chapter Five

Table 1.	Reading Comprehension Scores of Aircraft Noise Exposure and Language Groups	112
Table 2.	Interaction between Aircraft Noise and Language on Reading Comprehension	113
Table 3.	Summary of the Main Effects and Interaction Effects on Reading Comprehension	115

Chapter Six

Table 1.	Socio-Demographic Profile of the Low and High Noise Groups, 2010-2011: Frequencies and Odds Ratio	132
Table 2.	Comparison of Reading Comprehension Scores between the Low Noise and High Noise Groups in 2010 and 2011	136
Table 3.	Reading Comprehension Outcome Scores Adjusted for Gender, Language and Household Deprivation: 2010-2011	138
Table 4.	Interactions between Time, and Time and Group, in Relation to Reading Comprehension	140

LIST OF FIGURES

Chapter One

Figure 1.	Structure of the Thesis	32
-----------	-------------------------	----

Chapter Two

Figure 1.	Noise Annoyance Modelled as a Stress Response to the External Stimuli Sounds and Noise Management	44
Figure 2.	Four Routes (Primary Effects) that Contribute to Cognitive Impairment and Annoyance	45

Chapter Three

Figure 1.	Sound Level Meter	59
Figure 2.	Example of an Aircraft Flying Over a School	60
Figure 3.	Perception of Aircraft Noise at School	63
Figure 4.	Perception of Aircraft Noise at Home	64
Figure 5.	Annoyance Reactions to Aircraft Noise at School	65
Figure 6.	Annoyance Reactions to Aircraft Noise at Home	65

Chapter Four

Figure 1.	Disturbances Caused by Aircraft Noise at School	87
Figure 2.	Disturbances Caused by Aircraft Noise at Home	89
Figure 3.	Coping with Noise at School	91
Figure 4.	Coping with Noise at Home	91

Chapter Five

Figure 1.	Aircraft Noise and Language Interaction Plots for Reading Comprehension	116
-----------	---	-----

Chapter Six

Figure 1.	Line Chart Depicting Mean Scores of the Reading Comprehension Assessment in 2010 and 2011	139
-----------	---	-----

LIST OF PUBLICATIONS

- 1) **Seabi, J.** (2013). An epidemiological prospective study of children's health and annoyance reactions to aircraft noise exposure in South Africa. *International Journal of Environmental Research and Public Health*, 10, 2760-2777.
- 2) **Seabi, J.**, Cockcroft, K., Goldschagg, P. (2013). Longitudinal effects of exposure to chronic aircraft noise on children's activities. *International Journal of Scientific & Engineering Research*, 4(9), 1046-1054.
- 3) **Seabi, J.**, Cockcroft, K., Goldschagg, P., Greyling, M. (2012). The impact of aircraft noise exposure on learners' reading comprehension in South Africa: The moderating effect of home language. *Noise and Health*, 19, 29-37.
- 4) **Seabi, J.**, Cockcroft, K., Goldschagg, P., Greyling, M. (2013). A prospective follow-up study of the effects of chronic aircraft noise exposure on learners' reading comprehension in South Africa. *Journal of Exposure Science & Environmental Epidemiology*. 1-5.

CHAPTER ONE

1. Introduction

1.1. Background

The Wright brothers are credited as being the first people to have flown a plane successfully – in December, 1903 (*EyeWitness*, 2003). Since their invention, improvement and increasing speed and convenience, airplanes have become a popular form of mass transit largely because of the time saved by them compared to other means of transportation. Air transportation (i.e. commercial aircraft and helicopters) has numerous economic and social welfare benefits. Research on the effects of airports on local economies reveals that the proximity of airports to transport infrastructure far outweighs any adverse effects (Tomkins, Topham, Twomey, & Ward, 1998). The aircraft industry generates income for the economy and also provides many jobs. Mobility and accessibility are crucial factors in the competitiveness of national and international economies in a globalising world (Arndt, Braun, Eichinger, & Pansch, 2009; Braun, Klopheus, & Lueg-Arndt, 2010). Girvin (2009) reports that future air travel forecasts indicate demand that exceeds current airport capacity thus implying the need for the expansion of existing airports and/or the construction of new airports.

At the same time, however, the high noise levels of aircraft impact negatively on property values near airport flight paths – as the noise levels increase, the real estate values decrease (Zimmer, 2000). A recent survey on noise nuisance conducted in the vicinity of Amsterdam's Schipol Airport revealed that aircraft noise had the largest negative impact on house prices followed by rail and road traffic noise (Lijesen, van der Straaten, Dekkers, van Elk, & Blokdijk, 2010). According to the World Health Organization (2001), transportation (i.e. air, road and rail traffic) is the major source of noise pollution, more so than noise from industry and residential and construction activities. Berglund (1998) maintains that the growth in urban noise pollution is intolerable because of its direct and cumulative adverse effects as well as its effects on future

generations through its degradation of residential, social and learning environments. Millions of people worldwide are exposed to excessive noise in neighbourhoods near airports when aircraft take off, land or start their engines (*World Airnews*, 2001). Precautionary action in environmental planning is called for.

1.2. Statement of the Problem

As indicated above, aviation is a crucial factor in international commerce and national economies. However, aircraft landing and taking off generates substantial noise in long, low-altitude flight corridors (Berglund, Lindvall, & Schwela, 1999) thereby contributing to noise pollution, which has been increasing globally over the past decades and is now regarded as a major environmental problem (Goines & Hagler, 2007; Lavandier, Barbot, Terroir, & Schuette, 2011; Xie, Kang, Tompsett, 2011). It is estimated that world noise levels double every 10 years, and, in the United States alone, unacceptable noise (as perceived by people) has increased by nearly 40 percent since 1970 (Blomberg & Morris, 1999). It is further estimated that some 80 million people in Europe are exposed to unacceptable levels of continuous outdoor transport noise. In Amsterdam, 29 percent of the city's residents complain about noisy neighbours, 28 percent are routinely disturbed by the jarring sounds of traffic, and 26 percent are disturbed by the noise that comes from living under the airport flight paths. Even in American national parks, noise-free intervals rarely exceed a few minutes (Geary, 1996). In the same vein, Berglund et al. (1999) report that 30 percent of the European Union's population are exposed to levels of road traffic noise of more than 55 dB(A) and that 20 percent are subjected to unacceptable levels of noise. Noise from air traffic is reported to have declined largely as a result of the introduction of new and quieter airplanes, yet it is estimated that around 20 million people worldwide are still affected by noise levels exceeding the guide value of 55 dB(A) (IATA, 2004). Van Kempen, Staatsen and Van Kamp (2005) concur that in the past decade exposure to high levels of noise has decreased in some countries due to technological measures aimed at reducing noise but that this reduction is not significant due to the enormous growth in traffic and the 24-hour economy.

Other studies indicate significant global increases in the number of school learners exposed to noise levels sufficient to impair hearing, particularly in developing countries where compliance with noise guidelines is generally weak (Berglund et al., 1999; EEA, 2003; Pillay, Archary, & Panday, 2011). Ubouh, Akhiobare, Onifae and Ogbuji (2012) agree that environmental and occupational noises are increasing risk factors in hearing impairment in developing countries. South Africa, as a developing country, is no exception where urban development, economic growth and the accompanying expansion in transportation are major factors, together with ongoing road and building construction, in the increasing levels of noise. “Population growth, urbanisation and technological development are the main driving forces, and future enlargements of highway systems, international airports and railway systems will only increase the noise problem” (Berglund et al., 1999, p. 19). Aircraft noise is an under-researched yet growing social, economic and environmental problem in South Africa (Van der Merwe & Von Holdt, 2005).

1.3. Motivation for the Study

The effects of water, lead, chemical and air pollution on health are well known, but less attention has been paid to the effects of environmental noise on people, particularly children. This could possibly be as a result of the as yet unknown long-term effect of noise on individuals and also because noise pollution is often localised. For instance, when an aircraft passes overhead, the noise can temporarily interrupt a school lesson and disrupt concentration. However, in cases where aircraft fly overhead continuously, and where the regularity of interruptions reaches a certain level, the effects may not be temporary or transitory.

Environmental noise comprises sources of noise from transport activities (i.e. rail, road, air traffic); sources of noise from construction activities, industries, the community (i.e. neighbours, radio, television and bars); and social sources of noise such as fireworks, music concerts and portable music players (WHO, 1999). Noise is becoming a community concern internationally and

in South Africa. Aircraft operations generate substantial noise in areas close to commercial and military airports. The effects of environmental noise may be severe in children than in adult populations. Children may be more predisposed to environmental stressors than adults because of their reduced cognitive capacity to understand environmental issues and anticipate stressors, as well as their lack of well-developed coping repertoires (Ben-Shlomo & Kuh, 2002). Accordingly, in-depth research is needed on how aircraft noise exposure affects children. Children are also often unaware of the dangers of noise exposure and cannot choose where they live. It is therefore pertinent that a thorough investigation into how children perceive and are affected by an exposure to aircraft noise is conducted.

The auditory effects (i.e. impacts directly related to sound-induced damage to the auditory system) of noise have long been the focus of scientific investigation (Black, Black, Issarayangyun, & Samuels, 2007; Chen & Chen, 1993; Chen, Chen, Hsieh, & Chiang, 1997; Fields, 1992). However, the non-auditory effects (i.e. all effects on psychological, health and well-being that are caused by noise exposure with the exclusion of impacts on the ear as a hearing organ) of noise have been largely neglected, particularly on the African continent. The current study is consequently important for health promotion and the enhancement of children's learning in South Africa and other developing countries.

Extensive literature is available in Western and European countries on research on the effects of noise on reading comprehension (Clark, Martin, Kempen, Alfred, Head et al., 2006; Dockrell & Shield, 2006; Haines, Stansfeld, Job, Berglund, & Head, 2001; Hygge, Evans, & Bullinger, 2002), noise annoyance/or quality of life (Hygge, Evans, & Bullinger, 1998; Evans & Lepore, 1993; Stansfeld, Haines, & Brown, 2000), coping and stress (Haines et al., 2001; Hygge et al., 1998). However, little research had been conducted on the African continent on the effects of noise. To the best knowledge of the author, only three such studies have been done, and these focused on participants aged 12 years and older (Ana, Shendell, Brown, & Sridhar, 2009;

Nchemanyi, 2006; Pillay et al., 2011). Furthermore, these studies had cross-sectional research designs with all the accompanying limitations. For instance, it is well known that causality cannot be inferred in cross-sectional studies yet, given that the present study was interested in exposure-effects associations, identifying causal relationships was crucial in it. Since most of the studies in this area adopted cross-sectional research designs and were laboratory based, their ecological validity is questionable leaving crucial questions unanswered. Some of these are whether learners' reading comprehension, health and coping are affected by chronic exposure to aircraft noise and whether the effects of aircraft noise exposure are reversible after the cessation of the learners' exposure to the noise. Questions such as these can be answered fully only on the basis of longitudinal field study designs. In laboratory studies, ethical issues are raised when participants are intentionally exposed to noise, which may be harmful to them. Also, since such studies do not mirror the circumstances people are exposed to in real-life situations, they lack ecological validity. Naturalistic studies of real-life exposure to noise are more likely to reveal whether long-term noise exposure has any effect on learners' functioning.

The present study has links with several disciplines, namely psychology, geography, education, audiology, civil engineering, health and politics, and may accordingly be of interest and benefit to those working in these disciplines, urban planners, airport and government officials, and all those with an interest in the abatement or prevention of aircraft noise. Educational psychologists and educators may also find the research of interest, particularly as it relates to the learning and development of children within the context of school environments.

1.4. Statement of Originality

Given the call for scientific research that is “emancipated from hearing only the voices of Western Europe, from generation of silence, and from seeing the world in one colour” (Guba & Lincoln, 2005, p.212), the present study attempted to address this call by investigating the effects of exposure to aircraft noise on learners' reading comprehension, subjective health and annoyance reactions from

an African context. It is inconceivable that despite Africa being the world's second-largest and second most-populous continent, after Asia (Sayre, 2009), that there is limited epidemiological research in the area of the current study. Nuwayhid (2004) provides an alternative answer to this and states that environmental health psychological research is limited and remains neglected particularly in developing countries because of competing social, economic, and political challenges. Although the effects of chronic aircraft noise exposure on children's cognitive development and health have been intensively explored, most of these studies were based on cross-sectional design. One is limited with cross-sectional design as one is unable to determine causality, but can only state whether a condition and hypothetical cause are seen together (Swift, 2010). As a result, little is known about the long-term effects of chronic exposure to aircraft noise. The relocation of the Durban International Airport to La Mercy afforded the researcher with a rare opportunity to investigate the longitudinal effects of exposure to aircraft noise. It was during this investigation that four separate but interrelated studies were conducted and their results are discussed in light of existing literature. This thesis is also original because the researcher built a model, in which he initially investigated whether learners perceived aircraft noise, and if so, whether there were annoyed by exposure to aircraft noise. In addition, he investigated whether they perceived aircraft noise exposure to have an effect on their health. Given that their perception of noise and annoyance reactions were subjective, he added an instrument objectively assessed their reading comprehension. It was also important to explore how these learners coped with a stressor, such as aircraft noise. It is also worth noting that while a large body of literature explored annoyance due to aircraft noise exposure in adults, this thesis makes contribution to knowledge by exploring children's annoyance reactions

1.5. Research Aims

Against the background sketched above, the general aims of the study were to investigate the long-term effects of exposure to chronic aircraft noise on primary school learners in terms of their development and learning. As mentioned earlier, a need exists for longitudinal field studies on the

effects of chronic exposure to aircraft noise on learners' reading comprehension, learning activities, health and annoyance reactions, as well as on how they cope with such an environmental stressor.

It is argued that noise impedes learning and other cognitive processes in children. A significant impact of noise in the classroom is that it reduces speech intelligibility thus affecting the hearing and understanding of speech by the learners (Klatte, Lachmann, & Meis, 2010). Since learners spend a great deal of time listening in the classroom, the acoustic conditions should be such that they promote learners' listening. If learners are unable to hear the educator clearly, the crucial function of a classroom in providing an environment which enables the transfer of information and knowledge from the educator will be impaired. The learning process will be disturbed, and the learners may also find it difficult to interact with their peers. Because a child's understanding of speech in a noisy environment does not reach an adult level until the late teenage years (Nelson, 2003), the long-term effects of chronic aircraft noise exposure on learners require in-depth investigation.

1.6. Objectives of the Study

Objectives of the study were:

- 1) to investigate the effects of exposure to aircraft noise on the reading comprehension of the primary school learners in the study;
- 2) to determine whether the learning and social activities (i.e. listening to their educator, working quietly by themselves, working collaboratively and playing outdoors) of the learners exposed to aircraft noise were affected by the noise;
- 3) to detail how these learners coped with the exposure to the noise;
- 4) to determine whether they were annoyed by the exposure to the noise;
- 5) to evaluate their subjective perceptions of whether exposure to the noise impacted negatively on their physical health.

- 6) lastly, if the effects of exposure to aircraft noise were found, it was crucial to determine whether they were reversible on the aforementioned variables after the cessation.

The primary objective of the study was to evaluate the learners' reactions and performance on the aforementioned factors after the relocation of an international airport to another area, in order to determine whether cessation of exposure to noise led to improved performance and functioning. Learners with similar socio-economic status but located in a quieter area served as the control group in the study.

1.7. Conceptual Framework

Although a body of literature concerning non-acoustic factors has been steadily growing, previous research is characterised by crucial shortcomings. Although the effects of exposure to chronic aircraft noise on children's development and health have been investigated during the past decades, most of these studies were based on cross-sectional design and laboratory settings. Therefore, little is known about the long-term effects of chronic exposure to aircraft noise on children's reading comprehension, health, coping, and annoyance reactions. Given the relocation of the Durban International Airport, a rare opportunity presented itself, which allowed the researcher to investigate whether there were any significant differences between the noise-exposed (experimental) group and the control group before-and-after the relocation of the airport on the variables, perception of noise, annoyance reaction, coping strategy, health, and reading comprehension. Specifically, this thesis explored through the four studies whether children perceived aircraft noise; and if so, whether such exposure to aircraft noise impacted negatively on their learning and social activities (i.e. reading comprehension, listening to the teacher, working quietly, playing with friends, etc.); whether they were annoyed by disturbance arising from exposure to aircraft noise; whether they perceived aircraft noise to have an effect on their health; and how they coped with noise exposure. It was anticipated that by virtue of exposure to aircraft noise, they would not only perceive noise, but they would also find noise nuisance as it impact on their learning and social activities. Of most important

was if effects of noise were found on the aforementioned variables, whether such negative effects were reversible after the cessation of exposure to aircraft noise. Thus this design enabled the researcher to investigate the long-term effects of exposure to aircraft noise on children's learning and development.

1.8. Research Questions

The following broad research questions guided the study:

- 1.8.1. Were the learners in the study who were exposed to chronic aircraft noise significantly more annoyed than those from quieter areas, and, if so, did the cessation of noise exposure lead to any significant difference in terms of noise annoyance between these learners and the controls?
- 1.8.2. Were the learners' learning and social activities disturbed by exposure to aircraft noise, and how did these learners cope with exposure to noise in comparison to their peers from quieter areas, and whether there were any changes with their coping mechanisms after cessation of exposure to noise?
- 1.8.3. Did exposure to chronic aircraft noise impact negatively on the learners' reading comprehension, and, if so, were the effects reversible after cessation of exposure to such noise?
- 1.8.4. Were the subjective health ratings of the learners exposed to chronic aircraft noise significantly poorer than those of the control group, and, if so, whether these effects were maintained after relocation of the airport?

1.9. Overview of Methods

1.9.1. Design

Given that all published articles have detailed methodological sections, other relevant information that was not included in those articles due to space constraints is discussed here. The current study adopted a longitudinal pre-and-post-quasi-experimental design, which incorporated a control group of learners from relatively quiet school environments, who were matched in terms of socio-demographic variables with an experimental group of learners from noisy environments. Although it is argued in this study that longitudinal design of this nature has stronger ecological validity, it is equally acknowledged that this design is vulnerable to the threats of internal validity. For instance, it is susceptible to attrition (mortality) of participants during the post-test phases, and this was evident in the current study, but it occurred in both the control and experimental groups. Given the assumptions that all participants experienced identical experimental procedures except for the treatment condition, and that all participants were assessed at both baseline and outcomes, all of the main effect threats to internal validity such as maturation and testing were ruled out in line with the framework proposed by Shadish, Cook, and Campbell (2002).

1.9.2. Selection of schools

The children who participated in the study were from five co-education government schools that were selected according to the aircraft noise exposure of the school area. Two of the schools formed the experimental group as they were located directly under flight path (thus noise-exposed). The control group was composed of three schools (because of smaller classes), which were located in a relatively quieter area though within the same vicinity. The exclusion criteria for the schools comprised those that were not governmental schools, single sex schools and schools for children with special needs. Site inspections of schools revealed that all the selected schools were not sound insulated, which was important in order to be able to detect if any, the effect of noise. Once the

schools met the inclusion criteria, the principals were approached and request for permission to conduct the study was made.

1.9.3. *Participants*

Given the longitudinal nature of the study, the overall sample size differs between the three cohorts, owing this to attrition, late arrival and absence of participants because of the bad weather during the testing phases. The 2009 cohort comprised 732 participants while the 2010 and 2011 cohorts consisted of 649 and 174 participants. The experimental group (noise-exposed) comprised 333 participants in 2009, with 300 and 85 participants in 2010 and 2011, respectively. The control group had 399 in 2009, with 349 and 89 participants in 2010 and 2011, respectively. In terms of gender, there were 322 (43.9%) males in the 2009 cohort, while the 2010 and 2011 cohorts comprised 321 (49.4%) and 82 (47%) males, respectively. Female participants consisted of 331 (45.4%), 322 (49.6%) and 92 (53%), for the 2009, 2010 and 2011 cohorts, respectively. It is worth noting that due to missing questionnaires and/or uncompleted items in the questionnaires, that there are differences with the total numbers and this is evident with background variables such as speaking English as a first and second language.

1.10. **Outline of the Thesis**

Chapter Two of this thesis distinguishes between sound and noise, discusses current noise measurement and policy on aircraft noise, and reviews the current literature on the effects of aircraft noise on children.

Chapter Three covers the investigation of the learners' perceptions of aircraft noise, their annoyance reactions and whether they perceived noise to have an adverse effect on their health.

Chapter Four describes the longitudinal impact of aircraft noise exposure on the children's school activities and coping strategies. Specifically, this Chapter explores whether exposure to aircraft

noise has a negative impact on children's activities such as when working quietly, working in groups and when listening to the teacher. In addition, it also explores whether there are differences with how children cope with exposure to noise before and after the relocation of the noise.

Chapter Five discusses the cross-sectional effects of exposure to aircraft noise and the moderating effects of home language on reading comprehension. The overall aim of this Chapter is to examine the effects of exposure to aircraft noise, by comparing performance of learners in noisy and relatively quiet area on reading comprehension, and whether language spoken at home moderate the effects.

Chapter Six examines the longitudinal effects of aircraft noise exposure on the children's reading comprehension in order to determine whether the impact of noise on reading comprehension was reversible after cessation of the exposure to aircraft noise. Chapter Seven integrates the findings of the four studies and discusses their theoretical and practical implications. Limitations and recommendations for future research are made.

Figure 1 below illustrates the outline of the study. This thesis is based on the publication of four scholarly articles, and is an opportunity to produce empirical research in an emerging field through publication of the research, to provide public education and advocacy of a worthwhile aspect of environmental health. These articles that were written as autonomous contributions, and therefore the structure shown here is more explicit than may be apparent in the chapters that follow.

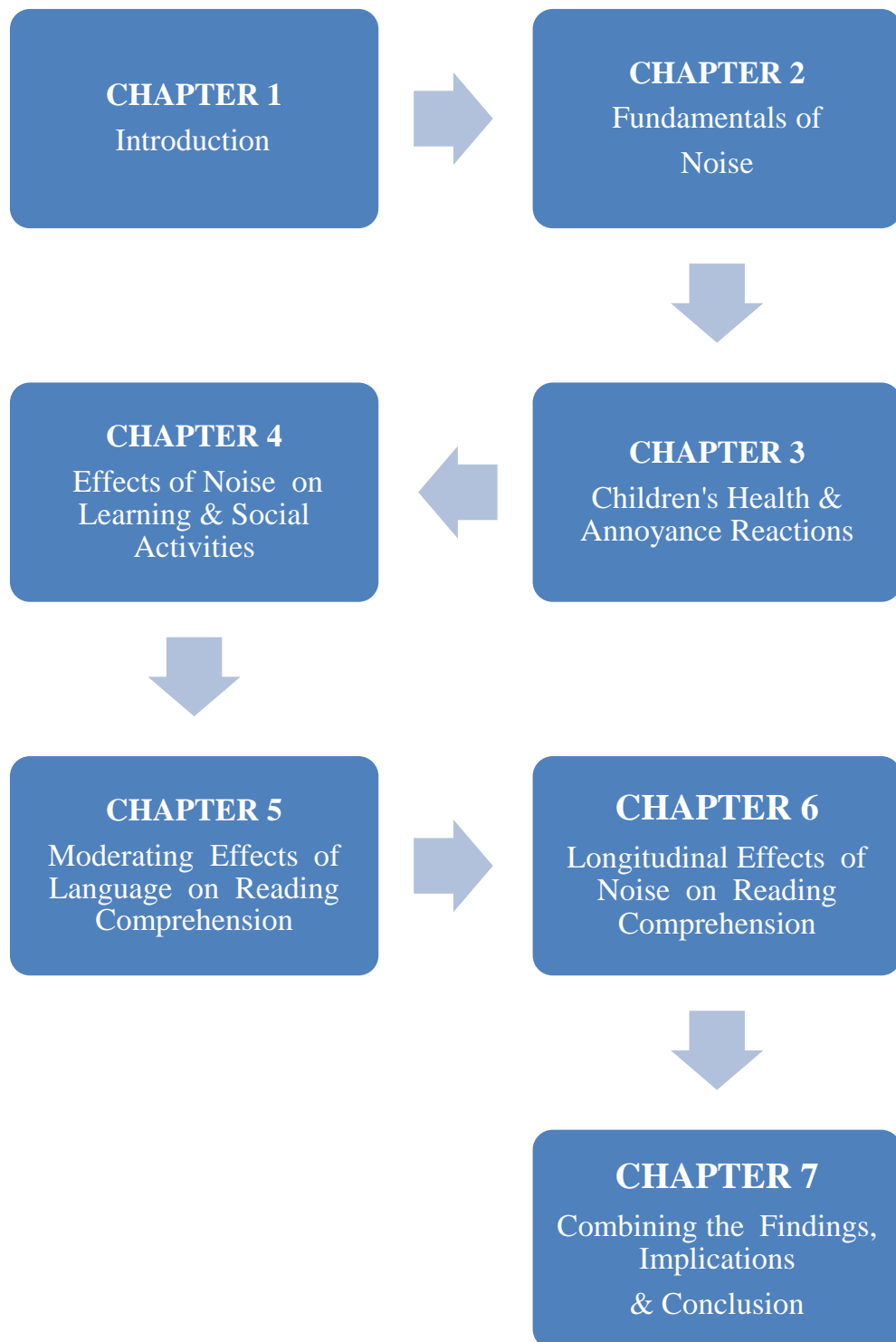


Figure 1. Structure of the thesis

1.11. Roles and Responsibilities

The candidate expressed interest in the project that was conceptualised by the promoters. The promoters provided administrative and logistic support. The candidate wrote a PhD proposal which

was accepted by the Faculty of Humanities Ethics Committee. The promoters sourced funding for the first year of the RANCH-SA project (Road Traffic and Aircraft Noise and Children's Cognition and Health in South Africa) and the candidate secured funding for data collection for the two successive years. Data collection was conducted with the support of 18 research assistants. Data were collected over a five-day period (annually) in Durban between 2009 and 2011.

As presented in the List of Publications section, the candidate was the primary (first) author of all the articles. He made substantial contribution in terms of the following scientific research activities, namely, design of the research for his PhD, which included three waves of data collection, analysis of data and writing of the manuscript. The candidate sought the assistance of a statistician in order to analyse and interpret the collected data. Specifically, he gained experience of the whole publication process, which included planning of the study, collection of data, analysis of data, interpretation of the research results, and writing of the manuscripts. He wrote all the manuscripts and submitted them to his promoters for supervision. On the basis of feedback he received from his promoters, he critically revised them for important intellectual content and once they were satisfied with the manuscripts, he submitted them for consideration for publication. The candidate was also responsible for seeking suitable journals and these were based on the subject area of the journal, prestige of the journal as well as publication time lag. Given the word limit often imposed by journals, the candidate also sought journals which were not restrictive in terms of page limits. He was also responsible for revising the manuscripts in line with the feedback from the anonymous reviewers. His promoters served in advisory role in the process.

CHAPTER TWO

2. Fundamentals of Noise

This chapter commences with an exploration of the concept of sound versus noise, followed by an explanation of how sound is measured. Discussion of how aircraft produce sound, as well as various national standards, legislation and practices on aircraft noise in South Africa and other countries is made. Lastly, research on the effects of environmental noise on children is reviewed.

2.1. Sound and Noise

The terms ‘sound’ and ‘noise’ are often used interchangeably, yet the terms have different connotations. Schafer (1994) classifies sound in two ways, firstly, according to its physical properties (i.e. acoustics) and, secondly, according to the way it is perceived (i.e. psychoacoustics). In terms of acoustics, sound consists of “(1) the intensity (loudness) of sound, which is the level of sound pressure relative to a reference sound pressure level which is measured in decibels (dB) using a logarithmic scale; (2) duration or time period, which is concerned with how long sound is heard for and how it is distributed over time (continuous, intermittent or impulsive); and (3) the frequency or pitch, which is the number of sound waves high or low pressure areas or cycles per second (cps) or Hertz (Hz) passing a given point per second” (enHealth, 2004, p. 1). Sound is thus the result of pressure changes in a medium (usually air) caused by vibration or turbulence (Mace, Bell, & Loomis, 1999; Suter, 1991). Sound that is unpleasant and that interferes with the reception of wanted sound becomes noise (Berglund & Lindvall, 1995). Sound therefore becomes noise as a result of a particular assessment or appraisal of it. Although sound can have a range of different physical properties, it appears to become noise only when it has undesirable psychological and physiological effects on people.

Noise is defined as a sound that has the quality of loudness and sharpness and that is composed of several discordant tones that are disturbing and unpleasant (Thorne, 2007). Noise is

also described as a source of great annoyance, interrupting sleep, interfering with conversation and depriving people of the full enjoyment of many recreational activities (Bronzaft, 2004). According to Clark and Stansfeld (2011), the concept of noise implies that the sound one is exposed to is unwanted (an environmental stressor). Common to all these definitions is the annoyance and irritation that noise produces, since it is not wanted and is uncontrolled. Two distinctions that can be drawn between sound and noise are that sound is always relevant, whereas noise is irrelevant, and that sound is desired whereas noise is undesired (Aron, 2011). Not all sounds can be described as noise since certain sounds of nature such as bird songs and water flowing are not only welcomed but are considered beneficial to physical and mental health in terms of reducing stress (Maynard, 2009; Pretty, Peacock, Sellens, & Griffin, 2005). For the purposes of this thesis, the term 'noise' is used throughout to refer to sound that is both undesired and unpleasant.

2.2. Noise Measurement

Set standards exist for the operation of sound-measuring instruments in order to ensure that accurate, objective readings are made. In line with the noise control regulations published under PN 24 of 1998 (p. 7) of South Africa, any person taking noise readings has to ensure that sound-measuring instruments comply with the requirements for Type 1 instruments in accordance with IEC 651, IEC 804 and IEC 942. These requirements include the following: that the acoustic sensitivity of sound level meters is checked before and after every series of measurements by using a sound calibrator and that the results will be rejected if the before and after calibration values differ by more than 1 dBA; that the microphones of sound-measuring instruments are at all times provided with a windshield; that the sound-measuring instruments are operated strictly in accordance with the manufacturer's instructions; and that sound-measuring instruments are verified annually by a calibration laboratory for compliance with the specifications for accuracy of national codes of practice for acoustics to ensure the instruments comply with the Measuring Units and National Measuring Standards Act (Act 76 of 1973).

Aircraft noise can be determined by measuring the “level of noise in terms of sound intensity, which is a logarithmic measure of the sound intensity in comparison to the reference level of 0 dB” (Wahab, 2008, p. 22). Therefore, in dB units, intensity refers to the amplitude of a sound. Goldschagg (2007) states that sound can range from 1dB, which is near silence, to 140dB, which could be made by a military jet aircraft. A sound reaching 95dB is classified as a dangerous level by the Occupational Safety and Health Agency (Nunez, 1998). Belojevic, Jakovljevic and Slepcevic (2003) concur that sound levels of 90 dB and higher should be avoided in learning and working environments to protect hearing.

2.3. Noise Pollution by Aircraft

Aircraft noise originates from an aircraft’s engines and the passage of the airframe. The engines are the most significant source of the noise, especially during take-off (Zimmer, 2000). Zimmer further reports that noise sources vary with engine design and operating procedure and that the exhaust usually produces the largest part of the noise. Different aircraft types have different noise levels. For instance, jet-powered aircraft create intense noise from aerodynamics while low-flying, high-speed military aircraft produce loud aerodynamic noise (Crocker & Ray, 1978).

Wahab (2008) defines aircraft noise as “sound produced by any aircraft or its components, during various phases of a flight...” Aircraft take-off and landing sounds are largely intermittent while the maintenance of engine operations is continuous noise. A periodic intermittent noise is more likely to disrupt performance than a steady-state continuous noise of the same level. People can become habituated to steady-state continuous noise and consequently find it less disruptive. Noise from aircraft flyovers is accordingly more likely to disrupt performance owing to its intermittent nature. Manufacturers are progressively incorporating quieter technology into aircraft as a result of increasingly strict noise certification standards (Girvin, 2009). However, because of the growing demand for more aircraft, aircraft noise will continue to be a problem as more runways are added and new airports constructed.

The next section explores the regulation of external noise internationally, and then the focus shifts to South Africa.

2.4. Aircraft Noise Policy

Aircraft noise started to become a nuisance approximately 60 years ago when the first jet engine passenger-carrying aircraft were taken into service by airlines (Lyle, 1990). In 1966, one of the first international conferences, the London Noise Conference, was held to debate the growing aircraft noise problem (South Africa Department of Transport, 1998). The Assembly of the International Civil Aviation Organization (ICAO), a United Nations Organisation, identified the urgency of the problem, and an international conference with the theme of aircraft noise in the vicinity of airports was held. Following the conference, aircraft certification noise standards drove the aviation industry to adopt quieter aircraft technology. The crucial policy implementation involved phasing out older and noisier aircraft (called Chapter 2) and replacing them with the next fleet of quieter aircraft (called Chapter 3). ICAO established “maximum aircraft noise limits in 1969 (also known as Chapter 2) for three conditions (namely, take-off, approach and lateral), which each measured a defined condition and location. In line with these conditions, take-off noise is measured at a location 6 500 m along the runway from the aircraft’s brake release point; while sideline noise is measured at a location 450 m perpendicular to the runway centreline; and approach is measured at a location 2000 m upstream from the aircraft touchdown point” (Girvin, 2009, p. 15). In 1978, Chapter 3 limits were adopted, followed by Chapter 4 limits in 2005, which apply to commercial aircraft seeking type certification after January 2006.

In 1971, ICAO, adopted noise limit rules for certifying commercial aircraft, and since then aircraft noise limits in developed countries have been regulated (ICAO, 1993). In the United States (US), the 1990 Airport Noise and Capacity Act significantly reduced airports’ authority to limit aircraft operations with the exception of those airports with pre-existing restrictions such as the

Orange County, Long Beach and Ronald Reagan Washington National airports (Girvin, 2009). The development of aircraft quieter than the ICAO limits indicates that some high traffic airports in noise sensitive communities, especially in Europe, are now driving the demand for quiet aircraft technology (Airbus, 2007; ICAO, 2007; Joselzon, 2007). According to the US Department of Transportation, there is a “shared responsibility for noise mitigation strategies, whereby Congress enacts laws related to aircraft operations and aircraft noise (e.g. the phase-out of Stage 2 aircraft in favour of quieter aircraft); the ICAO promulgates and enforces regulations related to safety, approves airport operator-proposed noise abatement flight paths, sets standards; airport operators monitor noise levels, and plan noise-abatement flight paths; air carriers set flight schedules, and meet noise standards by replacing aircraft, fitting aircraft with hushkits; local governments plan land use, develop master plans and zoning compatible with recommendations in ICAO regulations; and lastly, residents impacted by aircraft noise understand noise issues and the steps that can be taken to minimize the effects of noise” (Nchemanyi, 2006, p. 23). In many countries, aircraft that are not certified, that is, those that do not fulfil ICAO requirements, are not permitted.

Following the Fifth Environmental Action Programme in 1993, the European Commission (EU) published a green paper on future noise policy that states that no person should be exposed to noise levels that endanger health and quality of life (European Commission, 2002). Many EU countries have adopted recommendations that set emission limits for exposure to noise in sensitive areas, and these have been integrated into national abatement laws and applied in land use plans, particularly for new infrastructure developments (Adams, Moore, Cox, Croxford, Refaee, & Sharples, 2006). Other countries have also put such regulations in place. For instance, Japan has approved laws such as the Aircraft Noise Prevention Law and the Special Measures Against Aircraft Noise at Specific Airports to authorise aircraft operating restrictions as well as non-aircraft noise abatement measures (Yamada, 2002). Quite recently, Japan also opted for the construction of costly new airports on offshore islands, partly in response to noise concerns (Boeing, 2010). Australia amended regulations in 1991 in order to implement ICAO phase-out operations of aircraft that did not meet the noise standards as set out in Stage 3 stating that aircraft not meeting the

requirements had to be phased out of use by the 25th anniversary of their first certificate of airworthiness, or 31st March 2002 (enHealth, 2004). The American National Standards Institute (ANSI) established requirements and acoustical performance criteria for outdoor and indoor noise. The ANSI (2002) states that the building design of schools should be cognisant of, and responsive to, surrounding land uses and the need to shield outdoor noise from the indoor environment. The ANSI requires that one-hour average background noise levels should not exceed 40 dB (A) in classrooms. Such regulations do not as yet exist in most developing countries.

The former European Commissioner for the Environment (Ritt Bjerregaard) stressed the importance of noise policy and its relevance to the environment. He reported that the absence of a generally accepted noise index was a major restraint to reducing the level of environmental noise (Bjerregaard, 1998). The European Commission (2000) provides a basis of common noise indicators for use throughout Europe for the assessment of environmental noise:

The “UK government produced planning policy guidelines on noise which outlines that considerations be taken into account in determining planning applications both for noise-sensitive developments and for those activities which generate noise. It reports that noise-sensitive developments such as housing, schools and hospitals should be sited away from major sources of noise (i.e. road, rail, air transport and industries), and where it is not possible to achieve such a separation of land uses, local planning authorities should consider whether it is practicable to control or reduce noise levels (or to mitigate the impact of noise) through the conditions or planning obligations” (Adams et al., 2006, p. 2389).

More economically developed Western countries have policies in place that regulate noise emissions, but South Africa, like other developing countries, seem to be lagging behind, specifically in terms of policy implementation. Developing countries often lack noise regulations and appropriate statistical information to produce noise exposure estimates (Berglund et al., 1999).

Ensuring adherence to regulations is also often problematic. However, the absence of policies and comprehensive information should not prevent the investigation of the effects of noise on communities and the development of provisional noise exposure estimates.

The South African Bureau of Standards published a code of practice in 1974 for the determination and limitation of disturbance around airports from aircraft noise (SABS, 1974). Nchemanyi (2006) reports that a code of practice (0117-1974) and an updated South African National Standard (SANS 10117-2003) were developed to safeguard the general public and to decrease noise and vibration impacts to a level more acceptable for residential development and to control land use in affected areas in the vicinity of airports. Another significant development in South Africa was the development of a White Paper on National Policy on Airports and Airspace Management in 1998, which has not yet been adopted; its purpose will be to integrate airports into their environments (South Africa Department of Transport, 1998). South Africa has few environmental noise regulations regarding noise pollution.

Given the increasing awareness that chronic exposure to aircraft noise levels may impair children's learning, the World Health Organization (2000) and the North Atlantic Treaty Organization (2000) working group stated that childcare centres and schools should not be situated near major sources of noise (i.e. airports, highways and industrial sites). Kaltenbach, Maschke and Klinkke (2008) concur that learners may be particularly affected as daytime outdoor noise exposure levels above 50 dB(A) may result in learning difficulties. Where schools are situated in the vicinity of major noise sources, external environmental noise can penetrate the facades of buildings with little attenuation. In South Africa, many schools are in noisy locations possibly due to rapid development surrounding schools or because of limited space to build schools due to poor planning. Apartheid legislation such as the Group Areas Act of 1950, which was designed to restrict Indians and Africans from their own residential and trading areas and to force them to live in appalling conditions around Durban (KwaZulu-Natal), also played a role.

For many emerging cities in developing countries, the problems of external environmental noise in schools are growing due to the increasing density of the population, industrial development and expanding transportation infrastructure (Lee & Khew, 1992). Sound treatment or sound insulation of schools and homes is often suggested as a possible noise mitigation strategy, yet Zimmer (2000) states that the treatment of buildings to reduce intrusive noise offers only a partial solution because building treatment has no effect on exposure to outdoor noise – when windows are open, the open window sound transmission path dominates, and, if windows are kept closed, costly mechanical ventilation systems are required. Furthermore, even though many schools are built with sound insulation in developed countries, this is rarely the case in developing countries due to poor planning and financial constraints.

Dockrell and Shield (2012) offer an alternative strategy of using sound amplification systems to minimise the impact of poor classroom acoustics. They report that these systems project the educator's voice so that learners are able to clearly hear him/her. Positive results were achieved from numerous studies that investigated the effectiveness of sound field systems on learning (Massie & Dillon, 2006; Mulder, 2011; Purdy, Smart, Baily, & Sharma, 2009). Jonsdottir, Laukkanen and Siikki (2003) note that sound field systems have the added advantage of reducing the strain on educators' voices. Although the use of sound amplification systems ensures that the transmission of information from the educator to the learners is improved, these systems do not minimise noise from external sources outside the classroom and the effects it may have on the children's learning. Schools in developed countries may be able to purchase such systems, but the cost is often prohibitive in developing countries.

2.5. Effects of noise on children

Chronic exposure to noise can have auditory and non-auditory effects (Shendell, Barnett, & Boese, 2004; WHO, 2004). Auditory effects that can result from direct exposure to loud noise include

damage to the tympanic membrane, hearing loss, and masking of auditory information (i.e. communication difficulties), while non-auditory effects comprise the indirect impact of exposure to noise on a person's physiological (responses such as increased blood pressure and heart rate), cognitive and socio-psychological systems. Exposure to environmental noise can adversely affect an individual's health and functioning. For example, it can lead to disturbance in the performance of daily activities, mental health problems, sleep disturbance and annoyance. The effects of noise range from subjective and behavioural effects, such as annoyance (Guski, 1999; Kroesen, 2011; Miedema, 2007), to physical effects such as high blood pressure (Babisch, 2011). The general stress theory postulates that exposure to noise affects the autonomous nervous system and the endocrine system, which, in turn, adversely impact the homeostasis of the human organism (Henry, 1992; McEwen, 1998). A growing body of research indicates that exposure to noise affects a human being's sympathetic and endocrine systems thereby causing physiological responses such as increased blood pressure and heart rate and stress hormones. The present study was consequently interested in determining the subjective, behavioural (non-auditory) and cognitive effects of aircraft noise on children in their learning environment (Babisch, 2003; Klatte, Bergström, & Lachmann, 2013; Lusk, Gillespie, Hagerty, & Ziemba, 2004; Maschke, Harder, Ising, Hecht, & Thierfelder, 2002; Vera, Vila, & Godoy, 1994). A detailed review of the effects of noise on children is provided in each of the studies presented in Chapter Three through to Chapter Six.

Noise is an environmental hazard that poses risks to the health and well-being of all people. Although other studies (Fidell, 1992; Job, 1996; Pedersen, 2007; Taylor, 1984) have attempted to explain how exposure to environmental noise may affect people, the present study drew on the theories of Stallen (1999) and Miedema (2007). Stallen (1999) based his theory on the Transactional Model of Stress and Coping (Lazarus & Folkman, 1984), which provides a framework for assessing the processes of coping with stressful events in terms of which stressful experiences are understood as person-environment transactions. Coping comprises all the behavioural, cognitive and emotional efforts to manage the specific demands resulting from the process of appraisal of the sources of noise exposure (Lercher, 1996). Accordingly, people attempt

to achieve a sense of equilibrium or balance in their social and physical environments by engaging in two separate appraisal processes to determine if an event is stressful. Firstly, a primary appraisal occurs when a person assesses a situation to determine if there is a potential threat or whether an event is stressful, desirable, controllable or irrelevant (Cohen & Spacapan, 1984). The secondary appraisal occurs when an individual evaluates his/her coping resources and examines whether coping options will accomplish the goal (Lazarus & Folkman, 1984). In this study, the goal included the ability to learn or to play without interference from the sources of noise. Coping options are then selected on the basis of the appraisal process, and this process continues until an event is perceived to be tolerable or not stressful.

Stallen (1999) uses this transactional model to describe the relationship between exposure to noise, annoyance and coping. Stallen conceptualises annoyance as a result of noise as another type of psychological stress and asserts that noise disturbance creates difficulties (primary appraisal) in reaching a particular goal or action, which may impair sensory and mental processes (Figure 1).

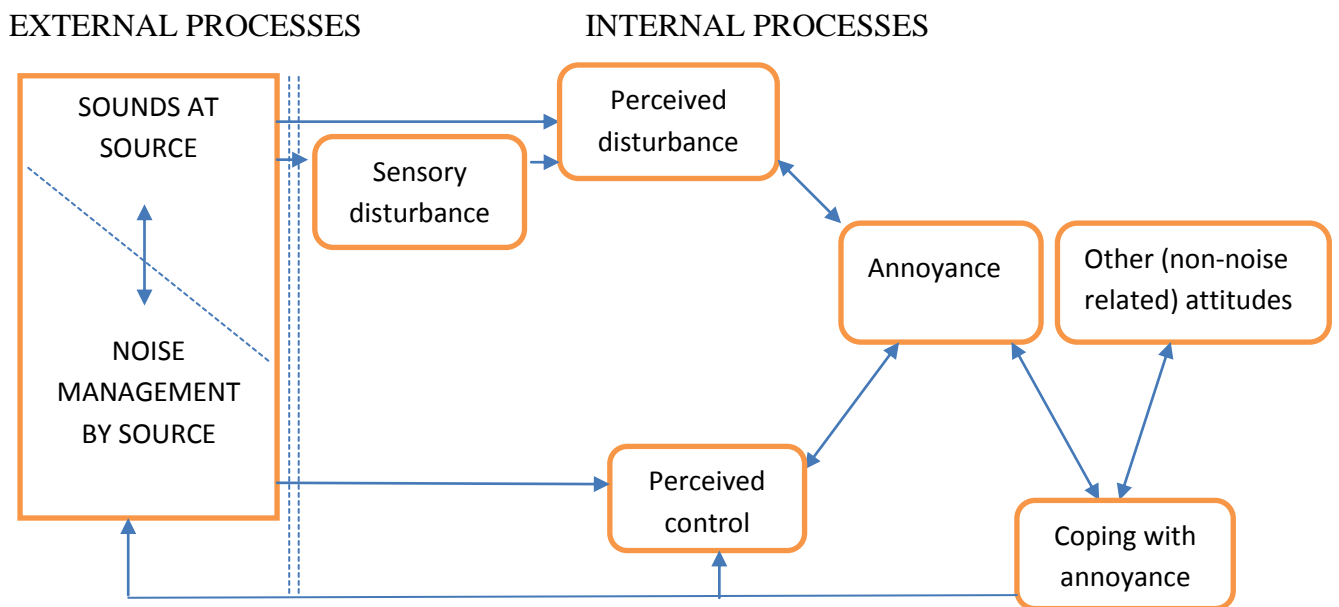


Figure 1. Graph showing noise annoyance modelled as a stress response to the external stimuli sounds and noise management. From “A theoretical framework for environmental noise annoyance” by P.J.M. Stallen, 1999, *Noise and Health*, 1(3), p. 73.

For example, in the present study, it was argued that learners exposed to chronic aircraft noise would perform poorly in reading comprehension tasks because the noise would interrupt teaching lessons, it would distract attention from the learning task, and the learners would struggle to hear the educator. In addition to perceived disturbance, non-acoustic factors such as perceived control determine annoyance. Perceived control is construed as the predictability of a noise situation, trust and recognition of concern where high disturbance and high control may be less annoying than moderate disturbance and no control (Suau-Sanchez, Pallares-Barbera, & Paul, 2011). Accordingly, perceived control is commonly regarded as an important mediator of responses to stress (Cambell, 1983). Long-term noise annoyance is considered a stressor (secondary appraisal) resulting from an evaluative process that includes the perceived disturbance and annoyance due to the sound (primary appraisal) and the perceived control over the noise situation (Schreckenberg, Meis, Kahl, Peschel, & Eikmann, 2010). Noise annoyance is thus generated by a dynamic process in which acoustic and non-acoustic factors are evaluated and re-evaluated by people based on their desires, needs and available resources. More specifically, annoyance caused by noise occurs when an environmental stressor such as aircraft noise is regarded as a stressor (primary appraisal) and when the ability to

cope with the stressor (secondary appraisal) is considered inadequate. This primary appraisal is similar to that in Miedema's (2007) model where he states that noise annoys people because it masks other sounds or signals. It thereby impairs performance in intellectual activities because it interrupts attention and concentration and leads to physiological arousal, which triggers unpleasant or distressing emotional reactions (Figure 2).

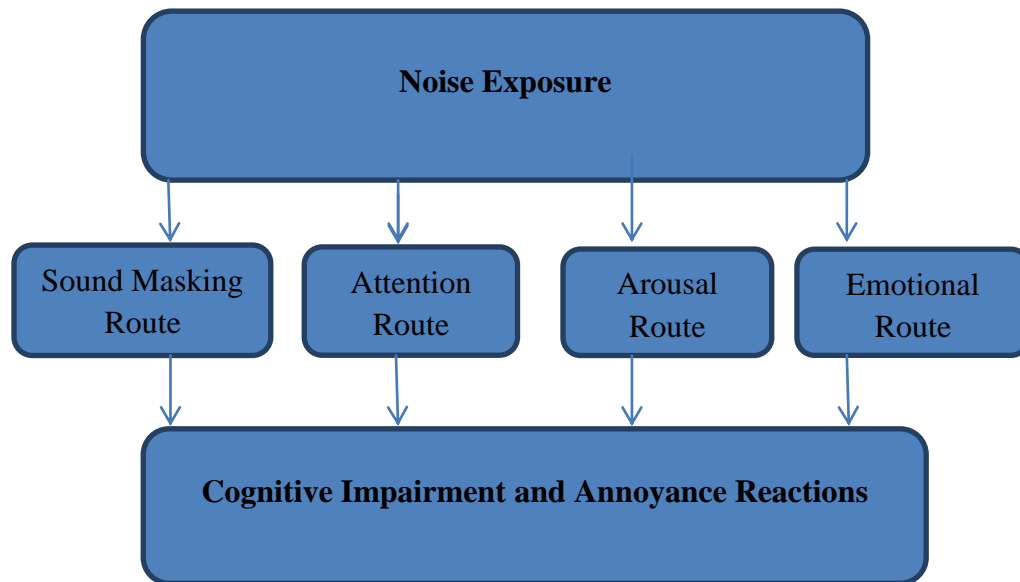


Figure 2. Graph showing four routes (primary effects) that contribute to cognitive impairment and annoyance. From "Annoyance Caused by Environmental Noise" by H.M.E. Miedema, 2007, *Journal of Social Issues*, 63(1), p. 43.

Miedema's model (2007) comprises four primary interferences caused by environmental noise, and these interferences may be accompanied by acute stress responses, such as irritation, while chronic stress may play a role in long-term effects such as cardiovascular disease (e.g. Babisch, 2005) and cognitive impairment (e.g. Stansfeld, Berglund, Clark, Lopez-Barrio, Fischer et al., 2005). These four primary interferences are (1) the sound masking route, (2) the attention route, (3) the arousal route and (4) the affective/emotional route. Although the effects of noise on a route may occur without the effects through the other routes (e.g. distraction of attention from a task by the noise of an airplane flying overhead), different types of routes may be interrelated, for instance anger may result because of aircraft noise interrupting conversation (Miedema, 2007). Miedema

reports that the sound-masking route or communication disturbance involves the masking of signals or sounds, which may force a speaker to try harder (speak louder) in order to be sufficiently audible during a conversation. Miedema adds that such masking of speech has an effect not only on an individual level but also on a societal level where, for example, people may temporarily stop talking in noisy environments.

The second interference involves disturbance to the concentration or attention route in respect of which Miedema reports that noise adversely affects attention by drawing on limited attention resources leaving little attention for other processes requiring attention. This disturbance is disruptive when the task requires the processing of information in the working memory. The third interference involves sleep disturbance, which occurs when there is over-activation of the arousal route (Miedema, 2007). As a result of higher arousal, the chances of a person falling asleep are reduced. Arousal can thus prevent an individual from falling asleep due to noise and result in poor sleep quality, which could have an impact on attention when awake. Finally, according to Miedema (2007), exposure to noise can disrupt the affective-emotional route by interrupting communication between people thereby leading to negative reactions such as irritation and anger. Over time, the impacts through these different routes may lead to further effects such as cognitive impairment (Stansfeld et al., 2005), cardiovascular disease (Babisch, 2005) and annoyance (Evans, Hygge, & Bullinger, 1998). In terms of this model, it is possible that, as a result of noise from aircraft flying over a school, the learners may be so annoyed that they may not be able to hear clearly what their educator is saying. Consistent with this assertion is research evidence that shows that exposure to noise causes negative reactions such as irritation, anxiety, depression, dissatisfaction and anger (Goines & Hagler, 2007; Thorne, 2008).

Unlike other models, in his model, Stallen (1999) identifies the secondary appraisal in terms of which he states that individuals may be behaviourally disturbed by sounds, but not annoyed by them, provided they have adequate coping resources. This would account for individual differences in annoyance. On the basis of Stallen's model (1999), it was hypothesised in the present study that the learners exposed to aircraft noise would be more annoyed than the learners from quieter areas

because the noise would interrupt their learning activities (primary appraisal). Furthermore, since they did not have control over where they resided, as that responsibility lay with their parents, and as they also did not have power over the airport management in terms of the location of the airport or the noise levels (secondary appraisal), they would perceive themselves to be less able to cope with exposure to the noise. These learners would be more annoyed also because of a possible sense that their parents, schools and airport managements had exposed them to chronic aircraft noise.

In summary, this chapter commenced by distinguishing between sound and noise, by reviewing the standard instruments used to measure sounds and by indicating how aircraft produce noise pollution. Other topics dealt with were the reduction of noise at the level of the source, the operational controls and land use planning. The chapter concluded with the delineation of auditory and non-auditory effects of chronic exposure to aircraft noise on children. In exploring the non-auditory effects of noise, the relevance of two models developed by Stallen (1999) and Miedema (2007) to the present study were discussed. The next four chapters present the results of the four studies conducted as part of this thesis.

CHAPTER THREE

An Epidemiological Prospective Study of Children's Health and Annoyance Reactions to Aircraft Noise Exposure in South Africa

Reprinted with permission from Seabi, J. (2013). An epidemiological prospective study of children's health and annoyance reactions to aircraft noise exposure in South Africa, *International Journal of Environmental Research and Public Health*, 10, 2760-2777.

Abstract: The purpose of this study was to investigate health and annoyance reactions to change in chronic exposure to aircraft noise in a sample of South African children. The study aimed to investigate if the effects of noise on health and annoyance could be demonstrated, and, if so, whether such effects persisted over time or whether they were reversible after the cessation of exposure to noise. A cohort of 732 children with a mean age of 11.1 (range = 8-14) participated in baseline measurements in Wave 1 (2009), and 649 (mean age = 12.3; range = 9-15) and 174 (mean age = 13.3; range = 10-16) children were reassessed in Wave 2 (2010) and Wave 3 (2011) after the relocation of the airport, respectively. The findings revealed that the children who had been exposed to chronic aircraft noise continued to experience significantly higher annoyance than their counterparts in all the waves at school and only in Wave 1 and Wave 2 at home. Aircraft noise exposure did not have adverse effects on the children's self-reported health outcomes. Taken together, these findings suggest that chronic exposure to aircraft noise may have a lasting impact on children's annoyance level but not on their subjective health rating. This was one of the first longitudinal studies of this nature on the African continent to make use of an opportunity resulting from the relocation of an airport.

Keywords: aircraft noise; annoyance; health; epidemiology; children; South Africa

3.1. Introduction

Aircraft noise emissions are annoying to many people, largely because of their intermittent nature. A meta-analysis study revealed that among all transport noise sources, aircraft noise is considered the most annoying (Miedema & Vos, 1998). As children are more susceptible to environmental stressors than adults because of reduced cognitive capacity to understand environmental issues and a lack of well-developed coping repertoires (Ben-Shlomo & Kuh, 2002), it is important to understand how they perceive and react to changes in aircraft noise exposure. This is particularly significant as a related study suggested that chronic exposure to aircraft noise could undermine children's reading comprehension performance (Seabi, Cockcroft, Goldschagg, & Greyling, 2012). An understanding of the way environmental noise affects children's development and functioning at home and school is key to optimising their learning potential and also has implications for teaching practice and health.

This study accordingly investigated the health and annoyance reactions of children to change in aircraft noise exposure. Unlike previous studies that have explored the association between aircraft noise exposure, annoyance and health, the strengths and uniqueness of the present study lie in its methodological design. Laboratory studies that evaluate the impact of noise are important as they enable greater control of confounding variables (related to environmental conditions) than is possible in field studies, yet the participants in such studies are generally exposed to only short bursts of noise during the experimental procedures thus making generalisation of the findings to chronically noise-exposed children problematic (Matheson, Stansfeld, & Haines, 2003). Furthermore, the effects of long-term exposure to aircraft noise on annoyance and health remain unknown due to most studies employing cross-sectional designs. Longitudinal studies that explore the association or link between exposure to noise, annoyance and health are required not only to provide understanding of causal pathways between these variables, but also to assist in the design of preventive interventions. In this study, the subjective annoyance and health reactions of children in the high noise (HN) and low noise (LN) groups were investigated through longitudinal analyses.

There is a growing body of literature in Euro-Western countries (Bronzaft & McCarthy, 1975; Evans, Hygge, & Bullinger, 1998; 1995; Haines, Stansfeld, Job, Berglund, & Head, 2001; Wu, Lai, Shen, Yu & Chang, 1995) on noise annoyance, yet not much research appears to have been done on the topic on the African continent. To the best knowledge of the author, only three such studies (Ana, Shendell, Brown, & Sridhar, 2009; Nchemayi, 2006; Pillay, Archary, & Panday, 2011) have been done in Africa and then only with participants aged 12 years and older. Furthermore, these studies had cross-sectional research designs, which have their own limitations. Noise pollution is a neglected environmental problem that is steadily growing in developing countries (Barboza, Carpenter, & Roche, 1995) where compliance with noise regulations is generally weak (Berglund, Lindvall, & Schwela, 1999). South Africa as a developing country is no exception. Urban development, economic growth and the related expansion in transportation are also the major factors increasing the levels of noise here. It is therefore important to determine how a developing country such as South Africa is faring in comparison with developed countries.

3.2. Noise Annoyance and Health

Noise annoyance encompasses broad psychological feelings that include irritation, discomfort, distress, frustration and offence when noise interrupts one's psychological state or ongoing activities (Guski, 1999) and interferes with one's quality of life. Noise annoyance as a result of chronic noise exposure can cause poor health in the form of prolonged activation of physiological responses such as increased blood pressure and heart rate and endocrine secretions (Clark & Stansfeld, 2007). A cross-sectional study conducted in Belgrade, Serbia among 328 preschool children revealed higher prevalence of hypertensive values of blood pressure and heart rate in children exposed to night time noise at home unlike those living in quieter homes (Belojevic, Jakovljevic, Stojanov, Paunovic, & Ilic, 2008). However, inconsistent findings emerged in respect of psychological health. Children attending school in the vicinity of Heathrow Airport revealed higher levels of psychological distress and hyperactivity (Haines, Stansfeld, Job, Berglund, & Head, 2001).

In the Munich Airport Study, which had a prospective longitudinal design, the effects of aircraft noise prior to and following the opening of the new airport, as well as the effects of chronic

noise and its reduction at the old airport (i.e. 6 and 18 month post relocation), were studied in 326 children aged 9 to 13 years (Bullinger, Hygge, Evans, Meis, & vos Mackensen, 1999). The children were investigated at the two airports in terms of three time points, and the findings indicated a significant decrease in total quality of life (i.e. psychological, physical, social and functional daily life) 18 months after aircraft noise exposure as well as motivational deficits in terms of fewer attempts to solve insoluble puzzles in the new airport area. Quality of life thus deteriorated in children exposed to noise 18 months after the opening of the airport.

Conversely, in the largest epidemiological RANCH study, no effect of aircraft or road traffic noise was found on psychological distress (Stansfeld, Berglund, Clark, Lopez-Barrio, Fisher, et al., 2005). Similar findings were found in 266 school children; thereby suggesting that exposure to chronic noise is not subjectively stressful (Ristovska, Georgiev, Gjorgiev, & Kocubovski, 2004). Clark and Stansfeld (2007) concluded that noise exposure may not be associated with serious psychological illness though it may impact on the well-being and quality of life of children. Given the lack of longitudinal research in this field, children's subjective health reactions to long-term exposure to aircraft noise are thus explored in this prospective study.

Extensive research on noise annoyance has been carried out on adults, yet few studies have been done on children's annoyance reactions to noise in school settings (Haines & Stansfeld, 2000). Consistent associations between exposure to aircraft noise and children's annoyance have been demonstrated in cross-sectional and laboratory studies conducted in the vicinity of international airports in developed countries (Babisch, Schulz, Seiwert, & Conrad, 2012; Evans et al., 1995; Haines, Brentnall, Stansfeld, & Klineberg, 2003; Haines, Stansfeld, Brentnall, Head, Berry et al., 2001; van Kempen, van Kamp, Stellato, Lopez-Barrio, Haines et al., 2009; Wu et al., 1995). A survey of over 2 000 primary school children aged 7 to 11 years in the UK exposed to different noise sources found that the children were not only aware of the noise but were also annoyed by it (Dockrell & Shield, 2004; Shield & Dockrell, 2004). These studies shed some light on the impact that exposure to noise may have, yet crucial questions remain unanswered regarding the long-term effects of noise exposure. Specifically, more research is needed on whether prolonged exposure to aircraft

noise results in high levels of annoyance and whether such effects remain constant or dissipate after the cessation of exposure to noise. If such effects do disappear, how long does it take them to disappear?

Few longitudinal studies have examined the effects of persistent exposure to noise throughout children's development. In their School Environment and Health Study, Haines and colleagues (2001) conducted a longitudinal study near Heathrow Airport with children aged 8 to 11. Amongst their findings, exposure to aircraft noise was related to high levels of noise annoyance, though the annoyance response remained constant over a year with no strong evidence of habituation. These findings contradicted the conclusions reached from the follow-up Los Angeles Study, whereby indications of habituation of physiological stress response were suggested (Cohen, Evans, Krantz, Stokols, & Kelly, 1981). It was therefore postulated that how children respond to coping with environmental stress influences reports of annoyance, more than physiological responses. In a retrospective longitudinal Munich Airport Study that took advantage of a naturally occurring experiment, which no other studies are yet to replicate, children's affective responses to noise were investigated among 135 learners with a mean age of 10.78 (Evans et al., 1998). Children living in noisier areas were significantly more annoyed by noise than those not exposed to noise. However, when the airport closed down, the annoyance diminished. Quite recently, Clark and her colleagues (2013) undertook a six-year follow-up of the UK RANCH cohort of children who were exposed to aircraft noise at primary and high schools around the Heathrow Airport. These children significantly reported higher noise annoyance six years later at aircraft noise-exposed secondary school. No significant effects of noise on health outcomes were found. Although these findings demonstrate the impact of noise exposure on annoyance, they would have been more relevant for the present study had children who were tracked not been exposed to aircraft noise at high school, so that the longitudinal effects can be clearly demarcated. It would therefore be of interest to determine whether annoyance persisted or dissipated after the relocation of the airport.

3.3. Research Questions

This study was undertaken to answer the following questions.

- (1) Was there a statistically significant difference between the children in the high noise (HN) and low noise (LN) groups in respect of aircraft noise heard at *school* and *home* before and after the relocation of the airport?
- (2) Was there a statistically significant difference between the HN and the LN groups in annoyance reaction in respect of aircraft noise exposure at *school* and *home* before and after relocation of the airport?
- (3) Was there a statistically significant difference between the HN and the LN groups in health scores before and after relocation of the airport?

3.4 Methods

3.4.1. Context of the Study

Durban International Airport was selected as a case study because it presented an opportunity to study the chronic effects of exposure to aircraft noise on learners' health and annoyance reactions before and after it relocated to La Mercy, which is approximately 35 kilometres north of the city centre of Durban. According to the statistics provided by the Airports Company South Africa, this airport is the third busiest airport in South Africa, following OR Tambo International Airport in Johannesburg and Cape Town International Airport, and it is the ninth busiest airport in Africa (ACSA, 2012).

The children in this study were from five co-education public schools that were selected according to the noise exposure of the school area. Two highly exposed schools (HN group) were selected as the study population for the aircraft noise exposure area. The windows, walls and façades of the schools were not sound insulated. The low noise group comprised schools in locations not

exposed to aircraft noise but that matched the socio-demographic characteristics (such as age, language spoken at home and social deprivation) of the high noise group. Schools located outside the flight paths were selected by visual inspection of the airport. This study was conducted under the auspices of the Road Traffic and Aircraft Noise and Children's Cognition and Health in South Africa (RANCH-SA). It had a cross-sectional, longitudinal design involving children in Grade 5 through to Grade 8 who were attending schools in areas exposed to high levels of aircraft noise. The aim of the project was to assess the effects of exposure to aircraft noise on the cognitive performance and health of primary school children. In the present paper, health and annoyance subjective reactions of children exposed to aircraft noise were investigated. This would ensure that when the chronic effects of aircraft noise exposure on cognitive performance were looked into, the factors that moderate or compound the associations could be controlled.

3.4.2. Research Design

The difficulty of conducting long-term laboratory studies on the effects of noise is that they pose ethical concerns about exposing participants to noise over period of time, which can be harmful to their health. To overcome this difficulty, the present study adopted an epidemiological prospective field study design, which is an "important method for identifying risk factors in epidemiological studies and it enables a stronger case for causation to be made because it is possible to demonstrate whether a proposed factor causes the development of the disease" (Swift, 2010, p. 7). This was the third longitudinal study to make use of a naturally occurring experiment resulting from the relocation of an airport, and it involved within-group comparisons in terms of which measurements over three time periods were made in respect of the same children.

3.4.3. Participants

The study involved a cohort of 732 children with a mean age of 11.1 years (range = 8–14) who participated in baseline measurements in Wave 1 (2009). A cohort of 649 (mean age = 12.3; range =

9–15) and 174 (mean age = 13.3; range = 10–16) children were reassessed after the relocation of the airport in Wave 2 (2010) and Wave 3 (2011), respectively.

Table 1

The socio-demographic characteristics of the high noise and low noise groups

Socio-demographic characteristic	Wave 1				Wave 2				Wave 3			
	Low	High	OR	(95% CI)	Low	High	OR	(95% CI)	Low	High	OR	(95% CI)
	Noise	Noise			Noise	Noise			Noise	Noise		
Boys	49%	51%	0.92	0.69-1.23	50%	50%	1	0.73-1.36	49%	54%	0.8	0.44-1.48
English	55%	59%	0.83	0.62-1.12	58%	62%	0.85	0.61-1.18	67%	53%	1.8	0.96-3.41
Deprived	30%	40%	0.62	0.46-0.85	31%	39%	0.70	0.50-0.99	43%	51%	0.73	0.39-1.35

KEY: OR = Odds ratio

A high attrition of participants occurred in Wave 3 because permission to do a follow-up study of the children in Grade 8 (i.e. in the new schools) was not granted by some of the school principals and also because of the bad weather on the assessment day, which resulted in many children not coming to school. Research indicates that although prospective longitudinal studies are one of the strongest research methodologies for studying aetiological mechanisms (Vandenbroucke, 2008), they are vulnerable to participant attrition (Wolke, Waylen, Samara, Steer, Goodman et al., 2009). Table 1 shows the socio-demographics of the sample.

3.4.4. Procedure

Written permission was obtained from the education authorities and from the parents to allow their children to participate in the study. The children were informed about the limits of confidentiality as well as the voluntary nature of their participation. Informed assent from the children was also obtained. On the day of testing, the assessment administrators introduced themselves according to the RANCH-SA script, which avoided the word ‘noise’ so as not to influence the participants’ perceptions of the study – the project was simply introduced as an environmental study. The administrators were trained in advance on standard assessment protocol and how to administer the actual tests. The assessments were conducted in groups in the classrooms in the morning between 8 a.m. and 10 a.m. The pre-test assessments took place in Wave 1 before the relocation of the airport, and the post-test assessments took place in Wave 2 and in Wave 3. The analyses presented here were therefore those of the 2009, 2010 and 2011 cohorts. Each testing procedure began with practice items to ensure that the participants understood what was required in the assessment. The completed tests were placed in a coded envelop immediately after completion of the assessment. The children were offered chips and juices for participating in the study.

3.4.5. Instruments

3.4.5.1. *Biographical Questionnaire*

Information on the participants' gender, age and languages spoken was obtained from biographical questionnaires completed by the participants and parents. The children's questionnaire was administered in print form and completed before the assessment. The parents' questionnaire was sent beforehand to the participants' parents and collected from each child on the day of the assessment. Socio-economic status was determined on the basis of the percentage of children eligible for free meals at school as research indicates a "significant correlation between the free school meal ratio and a range of census indicators representative of socio-economic status" (Stansfeld, Haines, Brentnall, Head, Roberts et al., p. 21). A criterion for a child's eligibility for a free school meal was that the child's caregiver should be in receipt of a government social grant.

3.4.5.2. *Noise Annoyance*

Annoyance assessment measures regarding community response to aircraft noise often involve a participant indicating his annoyance rating on a numerical category scale; in other studies, participants are asked about noise interference with their other activities (Berglund, Lindvall, & Nordin, 1990). In this study, annoyance in response to aircraft noise was assessed on the basis of seven adapted questions (Fields, de Jong, Brown, Flindell, Gjestland et al., 1997) that measured the level of annoyance on a four-point Likert scale (never, sometimes, often, always) as experienced by the children when they heard aircraft and road traffic noise. The higher the score, the higher the noise annoyance level (range 0-4). Reliability analysis was conducted to assess the internal consistency of the questionnaire. The results revealed Cronbach's alpha (α) of 0.94, which indicated that the questionnaire had high internal consistency.

3.4.5.3. *Child General Health*

This questionnaire was adapted from the Child General Health Questionnaire, which was based on the largest epidemiological study to date on aircraft and road traffic noise (Stansfeld et al., 2005). The children were asked to rate their health on a five-point rating scale (1 = very good to 5 = very bad). They also had to respond on a five-point rating scale (1 = never to 5 = every day) indicating whether they had felt like vomiting, had experienced headaches or stomach aches or had difficulty sleeping (including waking up at night and feeling sleepy during daytime) in the past month. Reliability analysis revealed Cronbach's alpha (α) of 0.66, which suggested a moderate internal consistency.

3.4.5.4. *Perceived Noise Exposure*

The children's self-reported exposure to noise at school and home was measured in terms of one source of environmental noise, namely aircraft. They were required to indicate if they had heard the noise and whether they had been annoyed by the noise. They responded on a four-point rating scale (1 = never to 4 = always).



Figure 1. Sound level meter

3.4.5.5. Noise Measurements

The instrument used to measure noise was a SVAN 955 Type 1 sound level meter (Figure 1). A Rion NC74 acoustic calibrator was used to check the instrument calibration before and after the measurements were performed. Noise measurements of the aircraft noise levels were taken during the testing period (8 a.m. to 10 a.m.) outside the classrooms. The baseline Leq noise measurements for the high noise groups at the noise-exposed schools near the flight path (Wave 1) ranged from 63.5 to 69.9 Leq. Maximum noise levels ranged from 89.8 to 96.5 dBA L_{max}. In the case of the low noise groups at schools in the quieter areas, the noise measurements during the Wave 1 testing yielded results of 54.4 to 55.3 Leq and 73.2 to 74.3 L_{max}. The noise measurements during Waves 2 and 3 after the aircraft noise had disappeared produced results at the formerly noise-exposed schools of 55.2 Leq and maximum noise levels of 60.8 to 71.2 L_{max}. Levels at the quieter schools averaged between 50.5 and 57.9 Leq and between 60.6 and 70.5 L_{max}. No measurements were done at the children's homes due to limited resources; however, the schools were within walking distance. An example of an aircraft flying over one of the noise-exposed schools in Wave 1 is shown in Figure 2.



Figure 2. Example of an aircraft flying over a school.

3.4.6. Statistical Analysis

Statistical Analysis System (SAS) version 9.2 was used in the statistical analyses. In line with the previous study (p. 470), “all F tests with repeated measures of wave were treated as multivariate analyses of variance, MANOVAs, rather than as univariate analyses of variance, ANOVAs. These MANOVAs yield higher p values and thus are more conservative than the corresponding univariate epsilon-corrected Greenhouse-Geisser ANOVAs”. Effect estimates were presented as odds ratios (ORs) with 95% confidence intervals (CIs) for socio-demographic characteristics.

3.5. Results

3.5.1. Perception of Noise at School

As shown in Table 2, the HN group yielded significantly higher mean scores in Wave 1 ($F_{1, 732} = 104.29, p = 0.00$) and Wave 2 ($F_{1, 649} = 13.82, p = 0.00$) on aircraft noise heard at school than the LN group. However, there was no significant difference ($F_{1, 174} = 0.67, p = 0.41$) between the two groups on aircraft noise in Wave 3. These results imply that the children in the HN group perceived more aircraft noise in their school environment before and after the relocation of the airport than those in the quieter environments (LN group).

Table 2

Perception of noise at school and home

	Wave 1				Wave 2				Wave 3			
	Low Noise Mean	High Noise Mean	Difference Score (95% CI)	DF, N, F, P- value	Low Noise Mean	High Noise Mean	Difference Score (95% CI)	DF, N, F, P-value	Low Noise Mean	High Noise Mean	Difference Score (95% CI)	DF, N, F, P- value
<u>At School</u>												
Item 1	1.93	2.72	-0.78	(1, 732)	1.93	2.20	-0.26	(1, 649)	1.71	1.63	-0.08	(1, 174)
			(-0.93-0.63)	F=104.29			(-0.40-0.12)	F=13.82			(-0.11-0.27)	F=0.67
				P=0.00*				P=0.00*				P=0.41
Item 2	1.83	2.88	-1.05	(1, 732)	1.94	2.21	-0.27	(1, 649)	1.42	1.63	-0.21	(1, 174)
			(-1.20-0.91)	F=213.96			(-0.42-0.12)	F=12.87			(-0.41-0.00)	F=4.06
				P=0.00*				P=0.00*				P=0.04*
<u>At Home</u>												
Item 1	2.43	2.38	0.05	(1, 732)	2.22	2.01	0.20	(1, 649)	1.95	1.74	0.20	(1, 174)
			(-0.09-0.19)	F=0.49			(0.07-0.34)	F=9.04			(-0.00-0.42)	F=3.62
				P=0.48				P=0.02*				P=0.05*
Item 2	2.08	2.38	-0.29	(1, 732)	1.96	2.37	-0.40	(1, 649)	1.71	1.63	0.08	(1, 174)
			(-0.44-0.15)	F=16.43			(-0.56-0.24)	F=24.18			(-0.16-0.32)	F=0.43
				P=0.00*				P=0.00*				P=0.50

KEY: Item 1=Hear aircraft noise; Item 2=Annoyance from aircraft noise;

*p< .05

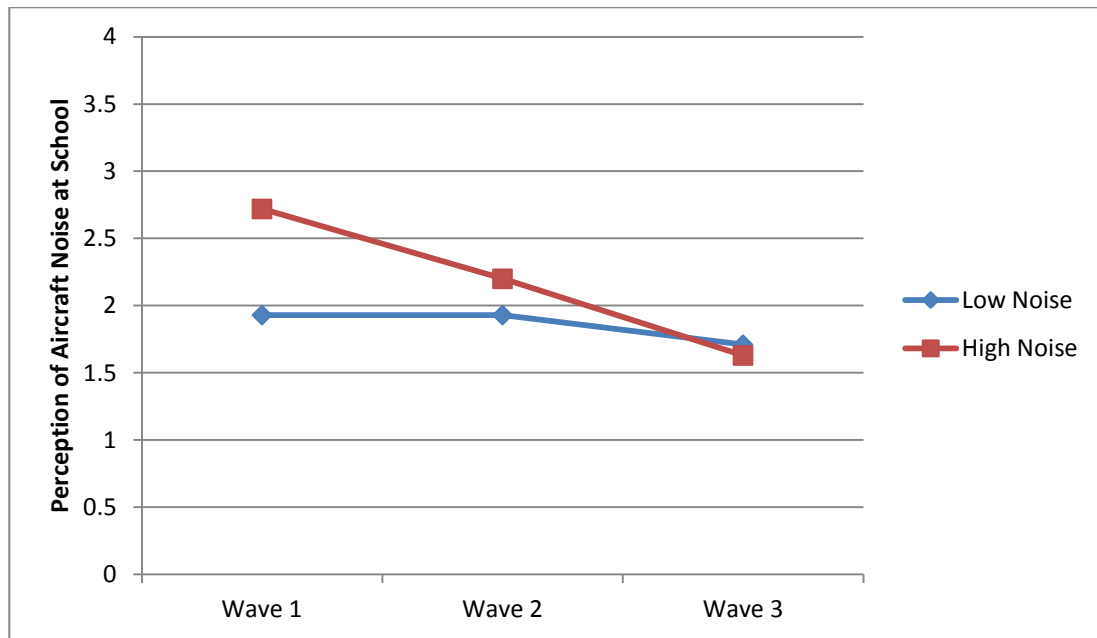


Figure 3. Perception of aircraft noise at school

The present study was also interested in the potential interaction between wave and group in respect of aircraft noise perceived at school. As illustrated in Figure 3, there were significant interactions ($F_{2, 174} = 3.93, p = 0.02$), similar to the trends in the main effects, where the mean scores of the HN group were substantially higher than those of the LN group in respect of aircraft traffic noise in Wave 1 and Wave 2 but not in Wave 3.

3.5.2. Perception of Noise at Home

Question 1 also investigated whether there was a significant difference between the HN and LN groups in respect of aircraft noise heard at home before and after relocation of the airport. As shown in Table 2, there was no significant difference between the groups in Wave 1 ($F_{1, 732} = 0.49, p = 0.48$). However, the mean scores of the children in the LN group were substantially higher than those of the HN group in Wave 2 ($F_{1, 649} = 9.04, p = 0.02$) and Wave 3 ($F_{1, 174} = 3.62, p = 0.05$). These findings were not expected, especially as that the LN group was not exposed to aircraft noise. Figure 4 illustrates these results.

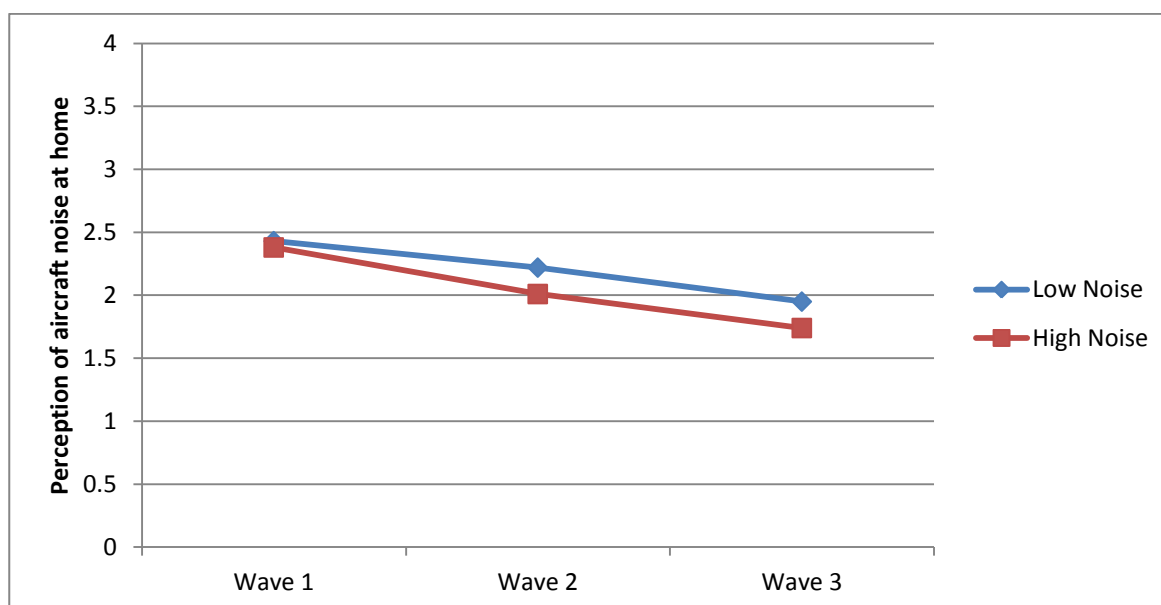


Figure 4. Perception of aircraft noise at home

3.5.3. Annoyance Reactions at School

In order to elucidate the impact of noise perceived at school, Question 2 examined whether there was a significant difference in the annoyance reaction between the HN and LN groups in all the waves as a function of aircraft noise exposure. The HN group demonstrated statistically significantly higher mean scores than the LN group in Wave 1 ($F_{1, 732} = 213.96, p = 0.00$), Wave 2 ($F_{1, 649} = 12.87, p = 0.00$) and Wave 3 ($F_{1, 174} = 4.06, p = 0.04$), as shown in Table 2. Figure 3.5 illustrates that while the children in the HN group were substantially annoyed by aircraft noise before the airport was decommissioned, the effects narrowed despite the significance effects remaining.

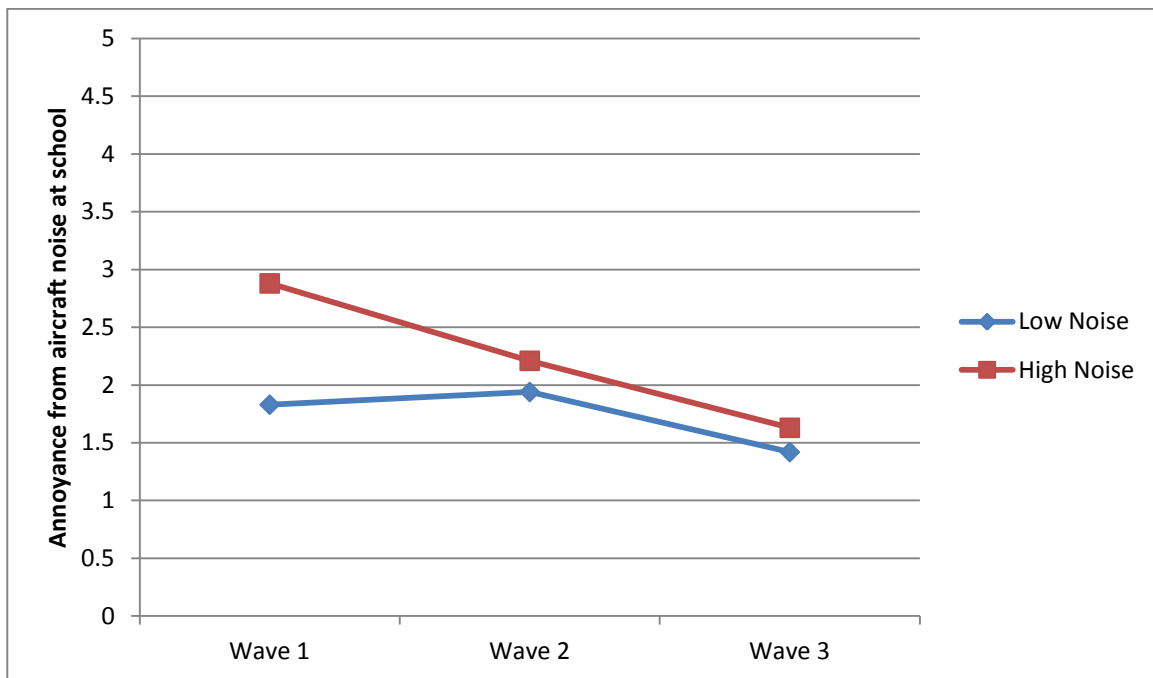


Figure 5. Annoyance reactions from aircraft noise at school

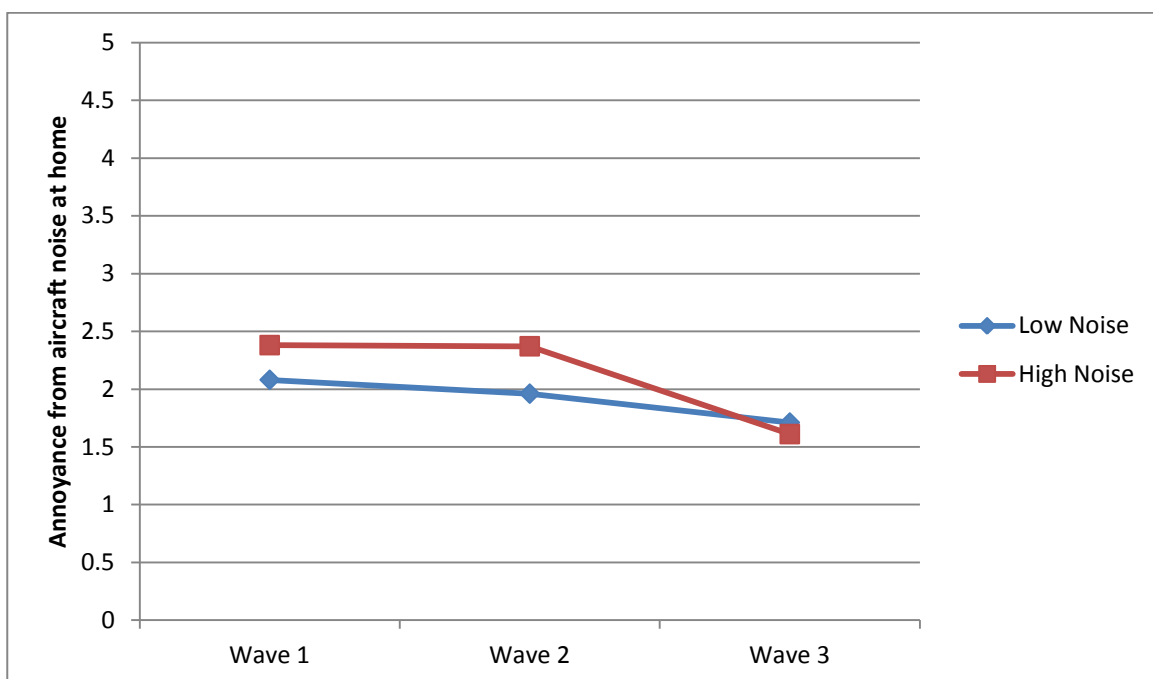


Figure 6. Annoyance reactions from aircraft noise at home

3.5.4. Annoyance Reactions at Home

Question 2 also investigated whether there was a significant difference between the HN and LN groups in the annoyance reactions resulting from aircraft noise exposure at home in all the waves. As shown in Table 2, the HN group demonstrated significantly higher scores than the LN group in respect of annoyance reactions resulting from aircraft noise in Wave 1 ($F_{1, 732} = 16.43, p = 0.00$) and in Wave 2 ($F_{1, 649} = 24.18, p = 0.00$). No significant effects were observed in Wave 3 ($F_{1, 174} = 0.43, p = 0.50$). The interaction effects are illustrated in Figure 6.

3.5.5. Child Self-Reported Health

Question 3 compared the children's self-reported health scores between the HN and the LN groups in all the waves. The LN group demonstrated a significantly poorer health score than the HN group in Wave 1 ($F_{1, 732} = 6.20, p = 0.01$), as shown in Table 3. However, there was no significant difference between the two groups in Wave 2 ($F_{1, 649} = 0.18, p = 0.66$) and Wave 3 ($F_{1, 174} = 0.17, p = 0.67$). There were also no statistically significant differences observed between the HN and the LN groups with regard to headaches, vomiting, stomach aches and difficulty sleeping in all the waves.

Table 3

Child Self-Reported Health

Health Items	Wave 1				Wave 2				Wave 3			
	Low Noise Mean	High Noise Mean	Difference Score (95% CI)	DF, N, F, P- value	Low Noise Mean	High Noise Mean	Difference Score (95% CI)	DF, N, F, P-value	Low Noise Mean	High Noise Mean	Difference Score (95% CI)	DF, N, F, P- value
Item 1	1.90	1.72	0.17	(1, 732)	1.77	1.74	0.02	(1, 649)	1.73	1.77	-0.04	(1, 174)
			(0.03-0.32)	F=6.20			(-0.09-0.14)	F=0.18			(-0.25-0.16)	F=0.17
				P=0.01*				P=0.66				P=0.67
Item 2	2.04	2.05	-0.01	(1, 732)	1.97	2.04	-0.66	(1, 649)	1.96	1.97	-0.01	(1, 174)
			(-0.15-0.13)	F=0.02			(-0.21-0.88)	F=0.76			(-0.28-0.25)	F=0.01
				P=0.88				P=0.38				P=0.91
Item 3	1.88	2.00	-0.11	(1, 732)	1.86	1.91	-0.05	(1, 649)	1.75	1.82	-0.07	(1, 174)
			(-0.27-0.03)	F=2.30			(-0.20-0.10)	F=0.42			(-0.35-0.20)	F=0.27
				P=0.12				P=0.51				P=0.60
Item 4	2.00	1.94	0.06	(1, 732)	1.74	1.89	-0.15	(1, 649)	1.86	1.75	0.11	(1, 174)
			(-0.09-0.22)	F=0.59			(-0.31-0.01)	F=3.27			(-0.19-0.41)	F=0.51
				P=0.44				P=0.07				P=0.47
Item 5	1.95	2.06	-0.11	(1, 732)	1.85	1.93	-0.07	(1, 649)	1.95	2.09	-0.14	(1, 174)
			(-0.24-0.01)	F=2.87			(-0.20-0.04)	F=1.50			(-0.42-0.13)	F=1.05
				P=0.09				P=0.22				P=0.30

KEY: 1= General health; 2=Headache; 3=Vomit; 4=Stomach ache; 5=Difficulty sleeping; * p < .05

3.6. Discussion

This prospective study explored the children's perceived health and annoyance reactions to change in exposure to aircraft noise in South Africa. This was the first and largest epidemiological prospective study on the African continent on the influence of chronic exposure to aircraft noise on children's health and annoyance reactions. The study had four main findings. First, the children in the HN group continued to perceive substantially more noise at school despite the relocation of the airport than those in the LN group. Second, although there was no significant difference in the perception of noise between the groups in Wave 1 at home, the learners in the LN group perceived greater noise levels than their counterparts in Wave 2 and Wave 3. Third, the learners in the HN group experienced high levels of annoyance in all the waves at school and home (Wave 1 and Wave 2). Fourth, despite the LN group reporting poor health scores in Wave 1, there was no significant difference between the groups on health outcomes in Wave 2 and Wave 3. Taken together, these findings suggest that chronic exposure to aircraft noise may have a lasting impact on children's annoyance but not on their subjective health rating.

3.6.1. Perception of Noise

The children exposed to high levels of aircraft noise (HN) perceived substantially higher levels of noise prior to and following the relocation of the airport than those in the LN group at school. These findings corroborate previous research that found that 42 percent of the children heard aircraft noise at home (Haines, Brentnall & Stansfeld, 2000). It was expected that the HN learners in the present study would experience high levels of aircraft noise as their schools were located under flight paths, yet, interestingly, they continued to perceive substantial levels of noise at their schools despite the relocation of the airport to another area. It seems that these children were accustomed to noise exposure. Indeed, Evans and Lepore (1993) report that children may adapt to distracting chronic noise by filtering or tuning out both unwanted auditory stimuli and relevant auditory stimuli. Although children may find this cognitive strategy helpful, the tendency of children to tune out noise may become over-generalised in such a way that they tune out stimuli indiscriminately (Stansfeld et al.,

2005). This tuning out cognitive strategy may lead children exposed to noise to have poorer ability to sustain attention in the classroom, which may affect their concentration and learning over time, even in the absence of noise exposure (Haines et al., 2001). The findings of the present study have implications for education, especially because children spend much of their time listening in the classroom. Successful communication does not depend only on the skill of the educator to impart knowledge, but also on whether the educator can be heard clearly by the children (Lee & Khew, 1992). It is therefore argued that poor listening environments have unfavourable effects on children's ability to attend to and process relevant aspects of the acoustic signals in classrooms and thereby compromise their learning and performance (Picard & Bradley, 2001).

The findings of the present study also revealed no significant difference between the HN and LN groups in respect of noise heard at home in Wave 1. However, the children in the LN group perceived higher noise levels at home than their counterparts in Wave 2 and Wave 3. This finding was unexpected, and it seems that other sources of noise may have been present given that this group was not located in the vicinity of the airport. By adopting a quantitative approach involving the administration of questionnaires, crucial information about other sources of noise may have been missed. Burns cautions that reliance on quantitative approaches alone can become an end in itself as participants are restricted to options predefined by the researcher (Burns, 2000).

3.6.2. Aircraft Noise and Annoyance

The findings of the present study revealed higher annoyance among the children in the HN group in all the waves at school and in Wave 1 and Wave 2 at home. These results are consistent with empirical research, which shows that children exposed to noise are annoyed by exposure to aircraft noise (Clark et al., 2013; Haines et al., 2001; Miedema & Oudshoorn, 2001; Wu et al., 1995). Contrary to the findings of other studies, though, is the finding that the children in the HN group in the present study remained annoyed by noise even after the relocation of the airport. These results are inconsistent with those of the longitudinal study conducted at Munich Airport, which found that the children living in

noisier areas were significantly more annoyed by noise, but that when the airport closed down, the annoyance diminished (Evans, 1998). The results of the present study suggest that chronic exposure to aircraft noise may have a lasting impact on children's development and that, therefore, children should be protected from such environmental hazards. However, since the HN group continued to perceive noise after the relocation of the airport, and they remained annoyed, could these findings be attributed to other sources of noise not measured? This warrants further investigation.

It is surprising that the children in the HN group were also highly annoyed by exposure to noise at home in Wave 1 and Wave 2, especially since they perceived less noise at home in comparison to their counterparts (see previous section). Given that the LN children perceived a substantial level of noise at home in Wave 2 and Wave 3, it would have been expected that they would be highly annoyed at home. These results may point to a stress-related effect. The children in the HN group were exposed to higher levels of stress at school, and this sympathetic overstimulation may have been transferred to the children's home even though the stress did not persist.

3.6.3. Aircraft Noise and Health

The results showed that the self-reported general health of the LN children was poor in Wave 1. This result is inexplicable, especially since trouble was taken during the conceptualisation and piloting phase to ensure that the children in the HN and LN groups were from similar socio-economic and health backgrounds. It is further surprising that their health was relatively poor only in Wave 1, and yet they were not exposed to aircraft noise. It seems that other factors (air pollution, noise pollution from road traffic, construction, and so on) beyond the scope of this study may have been responsible for these results.

No significant difference was found between the HN and LN children in respect of the other health-related outcomes (e.g. headache, vomit, stomach ache and difficulty sleeping) in all the waves. Consistent with these results are the findings of a large epidemiological RANCH study, which

established no effect of aircraft or road traffic noise on health (Stansfeld et al., 2005) even six years later (Clark et al., 2013). In a qualitative study, Haines and her colleagues (2003) reported that the children did not perceive noise pollution to have adverse effects on their health. It therefore seems that exposure to aircraft noise does not have an adverse effect on children's self-reported health outcomes. However, these findings contradict those found in the Munich Airport Study, which showed a significant decrease in total quality of life up to 18 months after relocation of the airport (Bullinger et al., 1999). It is therefore recommended that future studies should either use the same instrument that measured the total quality of life in the Munich Airport Study or objective measures of health to determine whether or not aircraft noise exposure impacts negatively on health.

3.6.4. Implications of the Findings

Numerous economic and social welfare benefits are derived from air transportation (i.e. commercial aircraft, jets, aviation aircraft and helicopters), yet they come at a cost. The results of the present study reveal that exposure to aircraft noise results in substantial levels of annoyance. Since the children who were exposed to aircraft noise continued to experience greater annoyance following the relocation of the airport, chronic aircraft noise exposure seems to have a lasting impact on children's functioning. These effects appear not to be reversible. Policy makers and airport officials should accordingly ensure that children's school environments are conducive to their learning and development and that environmental hazards such as noise pollution are avoided and/or eliminated. Aircraft noise exposure did not have adverse effects on the health-related outcomes of the children, which could be as a result of the subjective measures that were used to assess health in this study. Future studies should be based on more objective measurements.

3.6.5. Strengths and Limitations

To the best knowledge of the author, this longitudinal field study was the largest study to date on the African continent to examine the effects of aircraft noise exposure on children's health and annoyance

reactions. A major limitation of the study is that, while the analyses were based on longitudinal data (2009–2011), the 2011 cohort was very small because many participants were lost due to attrition. Noise measurements were carried out only in the schools and not in the children's homes due to limited resources. Another limitation relates to the exclusive focus on aircraft noise and not on other sources of noise (road traffic, construction, railway noise, and so on), which may have skewed the results. Future studies should use a mixed-methods design to avoid restricting or limiting the participants' responses.

3.7. Conclusion

The overall goal of the present study was to investigate the long-term effects of chronic exposure to aircraft noise on the health and annoyance reactions of a sample of South African children. The study aimed to examine if there were any effects of noise on health and annoyance, and, if there were, whether such effects persisted over time, or whether such effects were reversible after the cessation of exposure to aircraft noise. The findings revealed that, despite the relocation of the airport, the children who were exposed to chronic aircraft noise continued to be substantially more annoyed than the children from quieter environments. Aircraft noise exposure did not have adverse effects on the children's health.

3.8. Acknowledgments

The author gratefully acknowledges the assistance and inputs of Kate Cockcroft, Paul Goldschagg, Mike Greyling and the reviewers. He also thanks Stephen Stansfeld and Charlotte Clark for allowing him access to the RANCH test materials. Thanks are also extended to the children for participating in the study, which was supported financially by the National Research Foundation (NRF). The opinions, findings, conclusions and recommendations expressed in this publication are solely those of the author and not necessarily those of the NRF. This publication was also made possible (in part) by a grant from the Carnegie Corporation of New York.

3.9. Conflict of Interest

There are no conflicts of interest to declare.

3.10. References

- Airports Company South Africa. ACSA–Statistics. Available online: <http://www.acsa.co.za/home.asp?pid=100> (accessed on 16 December 2012).
- Ana, G., Shendell, D., Brown, G., Sridhar, M. (2009). Assessment of noise and associated health impacts at selected secondary schools in Ibadan, Nigeria. *Journal of Environmental and Public Health*. doi: 10.1115/2009/739502.
- Babisch, W., Schulz, C., Seiwert, M., Conrad, A. (2012). Noise annoyance as reported by 8- to 14-year old children. *Environment and Behavior*, 1, 68-86.
- Barboza, M.J., Carpenter, S.P., Roche, L.E. (1995). Prediction of traffic noise: A screening technique. *Journal of the Air and Waste Management Association*, 45, 703-708.
- Belojevic, G., Jakovljevic, B., Stojanov, V., Paunovic, K., Ilic, J. (2008). Urban road traffic noise and blood pressure and heart rate in preschool children. *Environment International*, 34, 226-231.
- Ben-Shlomo, Y., Kuh, D. (2002). A life course approach to chronic disease epidemiology: Conceptual models, empirical challenges, and interdisciplinary perspectives. *International Journal of Epidemiology*, 31, 285-293.
- Berglund, B., Lindvall, T., Nordin, S. (1990). Adverse effects of aircraft noise. *Environment International*, 16, 315-338.
- Berglund, B., Lindvall, T., Schwela, D. (Eds.). 1999. *Guidelines for Community Noise*. World Health Organization: Geneva, Switzerland.
- Bronzaft, A.L., McCarthy, D.P. (1975). The effects of elevated train noise on reading ability. *Environment and Behavior*, 7, 517-527.
- Bullinger, M., Hygge, S., Evans, G.W., Meis, M., von Mackensen, S. (1999). The psychological cost of aircraft noise for children. *Zentralblatt für Hygiene und Umweltmedizin*, 202, 127-138.
- Burns, R. (2000). *Introduction to Research Methods*. Sage: London, UK.
- Clark, C., Head, J., Stansfeld, S. (2013). Longitudinal effects of aircraft noise exposure on children's health and cognition: A six-year follow-up of the UK RANCH cohort. *Journal of Environmental Psychology*, 35, 1-9.

- Clark, C., Stansfeld, S. (2007). The effect of transportation noise on health and cognitive development: A review of recent evidence. *International Journal of Comparative Psychology*, 20, 145-158.
- Cohen, S., Evans, G.W., Krantz, D.S., Stokols, D., Kelly, S. (1981). Aircraft noise and children: Longitudinal and cross-sectional evidence on adaptation to noise and the effectiveness of noise abatement. *Journal of Personality and Social Psychology*, 40, 331-345.
- Dockrell, J.E., Shield, B. (2004). Children's perceptions of their acoustic environment at school and at home. *Journal of the Acoustical Society of America*, 115, 2964-2973.
- Evans, G.W., Hygge, S., Bullinger, M. (1998). Chronic noise exposure and physiological response: A prospective study of children living under environmental stress. *Am. Psychol. Soc.*, 9, 75-77.
- Evans, G.W., Hygge, S., Bullinger, M. (1995). Chronic noise and psychological stress. *Psychological Science*, 6, 333-338.
- Evans, G.W., Lepore, S.J. (1993). Nonauditory effects of noise on children: A critical review. *Child. Environ.*, 10, 31-51.
- Evans, G.W., Maxwell, L. (1997). Chronic noise exposure and reading deficits: The mediating effects of language acquisition. *Environment and Behavior*, 29, 638-656.
- Fields, J.M., de Jong, R.G., Brown, A.L., Flindell, I.H., Gjestland, T., Job, R.F.S., Kurra, S., Lercher, P., Schuemer-Kohrs, A., Vallet, M., Yano, T. (1997). Guidelines for reporting core information from community noise reaction surveys. *Journal of Sound Vibration*, 206, 685-695.
- Haines, M., Brentall, S., Stansfeld, S. (2000). Noise and Children Workshop. In M.L. Bistrup (Ed.). *Health Effects of Noise on Children*. National Institute of Public Health: Copenhagen, Denmark, 2000.
- Haines, M., Brentnall, S.L., Stansfeld, S.A., Klineberg, E. (2003). Qualitative responses of children to environmental noise. *Noise & Health*, 5, 19-30.
- Haines, M.M., Stansfeld, S.A. (2000). Measuring Annoyance and Health in Child Social Surveys. In D. Cassereau (Ed.), *Proceedings of Inter-Noise*. Societe Francais d' Acoustique: Nice, France, Volume 3, pp. 1609-1614.

- Haines, M., Stansfeld, S., Job, R., Berglund, B., Head, J. (2001). Chronic aircraft noise exposure, stress responses, mental health and cognitive performance in school children. *Psychological Medicine*, 31, 265-277.
- Haines, M.M., Stansfeld, S.A., Job, R.F.S., Berglund, B., Head, J. (2001). A follow-up study of effects of chronic aircraft noise exposure on child stress responses and cognition. *International Journal of Epidemiology*, 30, 839-845.
- Haines, M., Stansfeld, S.A., Brentnall, S.L., Head, J.A., Berry, B., Jiggins, M., Hygge, S. (2001). The West London Schools Study: The effects of chronic aircraft noise exposure on child health. *Psychological Medicine*, 31, 1385-1396.
- Hygge, S., Evans, G.W., Bullinger, M. (2002). A prospective study of some effects of aircraft noise on cognitive performance in school children. *Psychological Science*, 15, 469-474.
- Guski, R. (1999). Personal and social variables as co-determinants of noise annoyance. *Noise & Health*, 1, 45-56.
- Lee, S.E., Khew, S.K. (1992). Impact of road traffic and other sources of noise on the school environment. *Indoor Environment*, 1, 162-169.
- Matheson, M., Stansfeld, S., Haines, M. (2003). The effects of chronic aircraft noise exposure on children's cognition and health: 3 Field studies. *Noise & Health*, 5, 31-40.
- Miedema, H.M.E., Vos, H. (1998). Exposure-response relationships for transportation noise. *Journal of the Acoustical Society of America*, 104, 3432-3445.
- Miedema, H.M.E., Oudshoorn, C.G.M. (2001). Annoyance from transportation noise: Relationships with exposure metrics DNL and DENL and their confidence intervals. *Environmental Health Perspectives*, 109, 409-416.
- Nchemanyi, J.N. (2006). Community Perceptions on Noise Pollution Generated by Aircraft in Cape Town. Available online: http://dk.cput.ac.za/td_cput/255 (accessed on 23 January 2012).
- Picard, M., Bradley, J.S. (2001). Revisiting speech interference in classrooms. *Audiology*, 40, 221-244.
- Pillay, D., Archary, K., Panday, S. (2011). A preliminary study of the effects of aircraft noise on families who reside in close proximity to an airport. *South African Family Practice*, 53, 361-365.

- Ristovska, G., Georgiev, V., Gjorgjev, D., Kocubovski, M. (2004). Risk assessment of noise pollution in urban centre Skopje with digital modelling. *Journal of Environmental Protection and Ecology*, 5, 547-554.
- Seabi, J., Cockcroft, K., Goldschagg, P., Greyling, M. (2012). The impact of aircraft noise exposure on learners' reading comprehension in South Africa: The moderating effect of home language. *Noise & Health*, 19, 29-37.
- Stansfeld, S., Berglund, B., Clark, C., Lopez-Barrio, I., Fisher, P., Christrom, E., Haines, M., Head, J., Hygge, S., Kamp, I., Berry, B. (2005). Aircraft and road traffic noise and children's cognition and health: A cross-national study. *Lancet*, 365, 1942-1949.
- Stansfeld, S., Haines, M., Brentnall, S., Head, J., Roberts, R., Berry, B., Jiggins, M. (2001) *West London Schools Study: Aircraft Noise at School and Children's Cognitive Performance and Stress Responses*. Department of Health, Final Report, 2001. Available online: http://www.aerohabitat.eu/uploads/media/05-09-2006__Aerei_e_studenti__West_London_schools_study.pdf (accessed on 16 January 2013).
- van Kempen, E., van Kamp, I., Fischer, P., Davies, H., Houthuijs, R., Stellato, R., Clark, C., Stansfeld, S. (2006). Noise exposure and children's blood pressure and heart rate: The RANCH Project. *Occupational and Environmental Medicine*, 63, 632-639.
- van Kempen, E., van Kamp, I., Stellato, R.K., Lopez-Barrio, I., Haines, M.M., Nilsson, M.E., Clark, C., Houthuijs, D., Brunekreef, B., Berglund, B., Stansfeld, S.A. (2009). Children's annoyance reactions to aircraft and road traffic noise. *Journal of the Acoustical Society of America*, 125, 895-904.
- Shield, B.M., Dockrell, J.E. (2004). External and internal noise surveys of London Primary Schools. *Journal of the Acoustical Society of America*, 115, 730-738.
- Swift, H. (2010). *A Review of the Literature Related to Potential Health Effects of Aircraft Noise*. PARTNER Project 19 Final Report. Available online: <http://web.mit.edu/aeroastro/partner/reports/proj19/proj19-healtheffectnoise.pdf> (accessed on 16 January 2013).
- Vandenbroucke, J.P. (2008). Observational research, randomised trials, and two views of Medical Science. *PLoS Medicine*, 5. doi: 10.1371/journal.pmed.0050067.

- Wolke, D., Waylen, A., Samara, M., Steer, C., Goodman, R., Ford, T., Lamberts, K. (2009). Does selective drop out lead to biased prediction of behaviour disorders. *British Journal of Psychiatry*, 195, 249-256.
- Wu, T.N, Lai, J.S., Shen, C.Y., Yu, T.S., Chang, P.Y. (1995). Aircraft noise, hearing ability, and annoyance. *Archives of Environmental Health*, 50, 452-456.

CHAPTER FOUR

Longitudinal Effects of Exposure to Chronic Aircraft Noise on School Children's Activities

Reprinted with permission from Seabi, J., Cockcroft, K., Goldschagg, P. (2013), Longitudinal effects of exposure to chronic aircraft noise on children's activities. *International Journal of Scientific & Engineering Research*, 4(9), 1046-1054.

Abstract. The aim of this study was to determine whether chronic exposure to aircraft noise impacts negatively on school children's activities and to explore how such children cope with the noise exposure. Given the lack of longitudinal studies on the long-term effects of exposure to aircraft noise on children's activities and coping, this study sought to rectify this hiatus. A cohort of 732 children in South Africa with a mean age of 11.1 (range = 8-14) participated in baseline measurements in Wave 1 (2009), and 649 (mean age = 12.3; range = 9-15) and 174 (mean age = 13.3; range = 10-16) children were reassessed after the relocation of the airport in Wave 2 (2010) and Wave 3 (2011), respectively. The results revealed that the children who were exposed to aircraft noise were significantly more disturbed by the noise in all the waves (2009-2011) than those who attended schools in quieter environments. It was also found that the children who were exposed to aircraft noise continued to use more coping strategies (e.g. covering of ears, tuning out, waiting for the noise to end) than their counterparts even after the relocation of the airport thereby suggesting that aircraft noise exposure has long-term effects on children's performance.

Keywords: aircraft noise; coping strategies; epidemiology; children; South Africa

4.1. Introduction

A sound that interferes with people's normal activities, such as conversing, is commonly regarded as noise. Noise, defined as unwanted sounds, is a major problem in schools nowadays as it undermines the conditions required for learning and teaching (Boman & Enmarker, 2004). A growing body of research in developed countries reveals a negative association between aircraft and/or road traffic noise and *children's reading comprehension* (Berglund & Lindvall, 1995; Berglund, Lindvall, & Schwela, 1999; Clark, Martin, van Kempen, Alfred, Head et al., 2006; Dockrell & Shield, 2006; Haines, Stansfeld, Job, Berglund, & Head, 2001; Haines, Stansfeld, Brentnall, Head, Berry et al., 2001; Hygge, Evans, & Bullinger, 1996; 1998, 2002; Stansfeld, Haines, & Brown, 2000; Stansfeld, Berglund, Clark, Lopez-Barrio, Fischer et al., 2005); *children's memory* (Clark et al., 2006; Haines et al., 2001; Hygge et al., 1998; 2002; Stansfeld et al., 2000; 2005; Lercher, Evans, & Meis, 2003); *children's attention* (Haines et al., 2001; Hygge et al., 1998; Meis, Hygge, Evans, & Bullinger, 1998); *children's motivation* (Hygge et al., 1998; Stansfeld et al., 2005), *children's blood pressure* (Hygge et al., 1998; Cohen, Evans, Stokols, & Krantz, 1986); *children's annoyance/quality of life* (Hygge et al., 1998; Stansfeld et al., 2000; Evans & Lepore, 1993); and *children's stress* (Haines et al., 2001; Hygge et al., 1998).

Despite this body of research, little is known about the association of aircraft noise exposure with children's performance in developing countries, particularly in African contexts. Furthermore, most of the studies in this area have been based on cross-sectional and laboratory studies with the exception of the Los Angeles Airport Study and the Munich Airport Study (Cohen, Evans, Krantz, & Stokols, 1980, 1981; Haines, Stansfeld, Job, Berglund, & Head, 2001; Hygge et al., 2002). Laboratory studies lack ecological validity whereas studies of real-life exposure to noise are more likely to reveal whether long-term noise exposure has any effect on learning activities and how children cope with noise exposure. Less economical, large-scale prospective studies can provide a much higher degree of control over the type and quality of the data collected and consequently better statistical control over potential confounders (Swift, 2010).

The relocation of the Durban International Airport in South Africa to La Mercy, which is approximately 35 kilometres north of the city centre of Durban, provided the authors with an unprecedented opportunity to conduct a prospective longitudinal study of the effects of exposure to aircraft noise on children's activities. To the best knowledge of the authors, this was the first large longitudinal study of non-auditory effects of aircraft noise on children to be undertaken on the African continent. Lazarus (2000) argues that long-term research of this kind is needed in the study of coping and stress as factors in health generally take some time to emerge. The relocation of the airport provided a rare opportunity to determine not only whether aircraft noise exposure interfered with the children's activities, but also, if such interferences were found, whether they persisted despite the relocation of the airport, became worse, or whether the children in the loud noise group were able to adapt and catch up with their quieter counterparts group.

4.1.1. Coping with noise

In order to be able to develop interventions that address exposure to noise, it is important to understand how children cope with noise exposure so that its impact on them can be reduced. People implement various coping strategies to cope with the high levels of noise, the failure of which may result in psychological distress. Direct coping strategies include turning off the noise sources and negotiating with the people generating the noise, as well as indirect strategies that entail cognitive control (Lazarus, 1991). Direct coping strategies are difficult to carry out in most situations as they are often beyond an individual's control, consequently leaving the individual with indirect coping strategies to reduce his/her annoyance with the noise (Guski, 1999; Haines, Brentall, Stansfeld, & Klineberg, 2003). Miedema (2007) developed a model that identified four main interferences (sound masking, attention route, arousal route and affective/emotional route) caused by environmental noise, which may or may not be followed by acute or chronic stress responses. This model illustrates how an environmental noise disturbance as a stressor can interfere with behaviour (concentration, communication) and desired state (relaxation and sleep). It is the ability to cope with the stressor that is the key to an individual's health and well-being. According to WHO

Guidelines (2000), young children, elderly people and sick people may be less able to cope with the effects of exposure to noise due to their vulnerability and, as a result, they are likely to experience harmful effects.

A recent qualitative study explored children's perceptions of noise and how they coped with noise (Haines et al., 2001). In a sample of 36 children, the children in the high noise group reported that their daily activities (homework, school work, playing) were affected by high levels of aircraft noise to a greater extent than were the daily activities of those from quieter environments. Depending on the degree of control the children had over the noise sources, they implemented different coping strategies. Although they felt that they could close the windows or tell their neighbours to be quiet, they were not in control of the noise generated outside their homes such as that made by aircraft and busy roads. In order to cope with the sources of noise, the majority of these children covered their ears, wore headphones or played music, and these methods were followed by thinking about something else. It was also found that different sources of noise were associated with different emotions. For example, negative emotions (e.g. annoyance, sadness) tended to be linked to traffic and industrial noise while positive emotions (e.g. happiness) tended to be linked to natural sounds such as the wind and household noises (e.g. fans, television). Two-thirds of the children wanted their environments to be quieter, and a third thought noise was acceptable as it was. Given these findings, longitudinal analyses are needed to determine whether exposure to noise interferes with children's activities, and, if so, whether such interferences persist despite the cessation of environmental stressors and whether there are significant differences in coping strategies among children in the noise-exposed and quieter groups in the South African context.

4.1.2. Research Questions

This study aimed to investigate the longitudinal effects of aircraft noise exposure by tracking children who were exposed to chronic aircraft noise over three time periods. The study was guided by the following questions.

- 1) Was there a statistically significant difference between the children in the noise and quiet groups in terms of disturbances to activities at school and home before and after relocation of the airport?
- 2) Was there a statistically significant difference between the children in the noise and quiet groups on how they coped with noise exposure before and after relocation of the airport?

4.2 Methods

4.2.1. Participants

This study was based on a cohort of 732 children with a mean age of 11.1 (range = 8-14) who participated in baseline measurements in Wave 1 (2009). A cohort of 649 (mean age = 12.3; range = 9-15) and 174 (mean age = 13.3; range = 10-16) children were reassessed after the relocation of the airport in Wave 2 (2010) and Wave 3 (2011), respectively. A high attrition of the participants in Wave 3 occurred because permission to follow up learners in Grade 8 (i.e. in new schools) was not granted by some school principals and also because of bad weather on the assessment day, which resulted in many learners not coming to school. Research indicates that although prospective longitudinal studies are one of the best research methodologies for studying aetiological mechanisms (Vandenbroucke, 2008), they are vulnerable to participant attrition (Wolke, Waylen, Samara, Steer, Goodman et al., 2009). Table 1 shows the socio-demographics of the sample.

Table 1

The Socio-Demographic Characteristics of the High Noise and Low Noise Groups

Socio-demographic Characteristic	Low Noise	High Noise	OR	95% CI
Wave 1				
Boys	49%	51%	0.92	0.69-1.23
English	55%	59%	0.83	0.62-1.12
Deprived	30%	40%	0.62	0.46-0.85
Wave 2				
Boys	50%	50%	1	0.73-1.36
English	58%	62%	0.85	0.61-1.18
Deprived	31%	39%	0.70	0.50-0.99
Wave 3				
Boys	49%	54%	0.8	0.44-1.48
English	67%	53%	1.8	0.96-3.41
Deprived	43%	51%	0.73	0.39-1.35

OR: Odds Ratio; CI: Confidence Intervals

4.2.2. Instruments

4.2.2.1. Biographical Questionnaire

Information on the participants' gender, age and languages was obtained from biographical questionnaires completed by the participants. The children's questionnaire was administered in print form and completed before the assessment. Socio-economic status was determined by the percentage of children eligible for free meals at school as research indicates a "significant correlation between the free school meal ratio and a range of census indicators representative of socio-economic status (Stansfeld, Haines, Brentnall, Head, Roberts et al., 2001, p. 21). A criterion for the eligibility of a child for a free school meal was that the child's caregiver should be in receipt of a government social grant.

4.2.2.2.Disturbance at activities

The children were asked to rate on a four-point scale (1=never to 4= always) whether they found that aircraft noise interfered with their playing outdoors, listening to the teacher and working quietly by themselves or in a group.

4.2.2.3.Dealing with noise

The children responded on a four-point rating scale (1=never to 4=always) on how they coped with noise at home and at school. The items included dealing with noise by covering one's ears, carrying on with one's work, switching off (tuning out) and waiting for the noise to end.

4.2.2.4.Noise Measurements

The instrument used to measure noise was a SVAN 955 Type 1 sound level meter. A Rion NC74 acoustic calibrator was used to check the instrument calibration before and after the measurements were done. Noise measurements were taken during the testing period (8 a.m. to 10 a.m.) outside the classrooms in order measure aircraft noise levels. The baseline Leq noise measurements for the high noise groups at the noise-exposed schools near the flight path (Wave 1) ranged from 63.5 to 69.9 Leq. Maximum noise levels ranged from 89.8 to 96.5 dBA L_{max}. In the case of the low noise groups at schools in quieter areas, noise measurements in Wave 1 yielded results of 54.4 to 55.3 Leq and 73.2-74.3 L_{max}. Noise measurements in Waves 2 and 3 after the aircraft had left produced results at the formerly noise-exposed schools of 55.2 Leq and maximum noise levels of 60.8 to 71.2 L_{max}. Levels at the quieter schools averaged between 50.5 and 57.9 Leq and 60.6 and 70.5. No measurements were conducted at the children's homes as the schools were within walking distance.

4.2.3. Procedure

Written permission was obtained from the education authorities and from the parents to allow their children to participate in the study. The children were informed about the limits of confidentiality and the voluntary nature of their participation. Informed consent from the children was also obtained. The assessments took place in groups in the classrooms in the morning between 8 a.m. and 10 a.m. The pre-test measurements took place in Wave 1 (2009) before the relocation of the airport, and the post-test measurements took place in Wave 2 (2010) and in Wave 3 (2011). A detailed explanation of the procedure is provided elsewhere (Seabi, Cockcroft, Goldschagg, & Greyling, 2012).

4.2.4. Statistical Analysis

Statistical Analysis System (SAS) version 9.2 was used to conduct the statistical analyses. In line with the previous study, “all F tests with repeated measures of wave were treated as multivariate analyses of variance, MANOVAs, rather than univariate analyses of variance, ANOVAs (Hygge et al., 2002, p.470). These MANOVAs yield higher p values and thus are more conservative, than the corresponding univariate epsilon-corrected Greenhouse-Geisser ANOVAs”. Effect estimates were presented as odds ratios (ORs) with 95% confidence intervals (CIs) for socio-demographic characteristics.

4.3. Results

4.3.1. Disturbance at school and home activities

Table 2 indicates that the noise-exposed children were significantly more disturbed by aircraft noise at school than those in the quiet group in Wave 1 ($F_{1, 732} = 139.28, P=0.00$), Wave 2 ($F_{1, 649} = 17.21, P=0.00$) and Wave 3 ($F_{1, 174} = 5.69, P=0.01$). In terms of disturbances at home, a statistically significant difference was found between the groups only in Wave 1 ($F_{1, 732} = 25.56, P=0.00$). As

illustrated in Figure 1, there were significant interactions ($F_{2, 174} = 3.54, P=0.03$), similar to the trends in the main effects, where the mean scores of the high noise group were substantially higher than those of the quieter group in Wave 1, Wave 2 and Wave 3 in terms of disturbances in activities at school. Figure 2 illustrates significant interaction effects of the Group X Wave ($F_{2, 174} = 2.94, P=0.05$) in terms of disturbances in activities at home. The children in the high noise group were substantially disturbed by aircraft noise at home before the relocation of the airport (Wave 1), yet these effects diminished in Wave 2 and Wave 3.

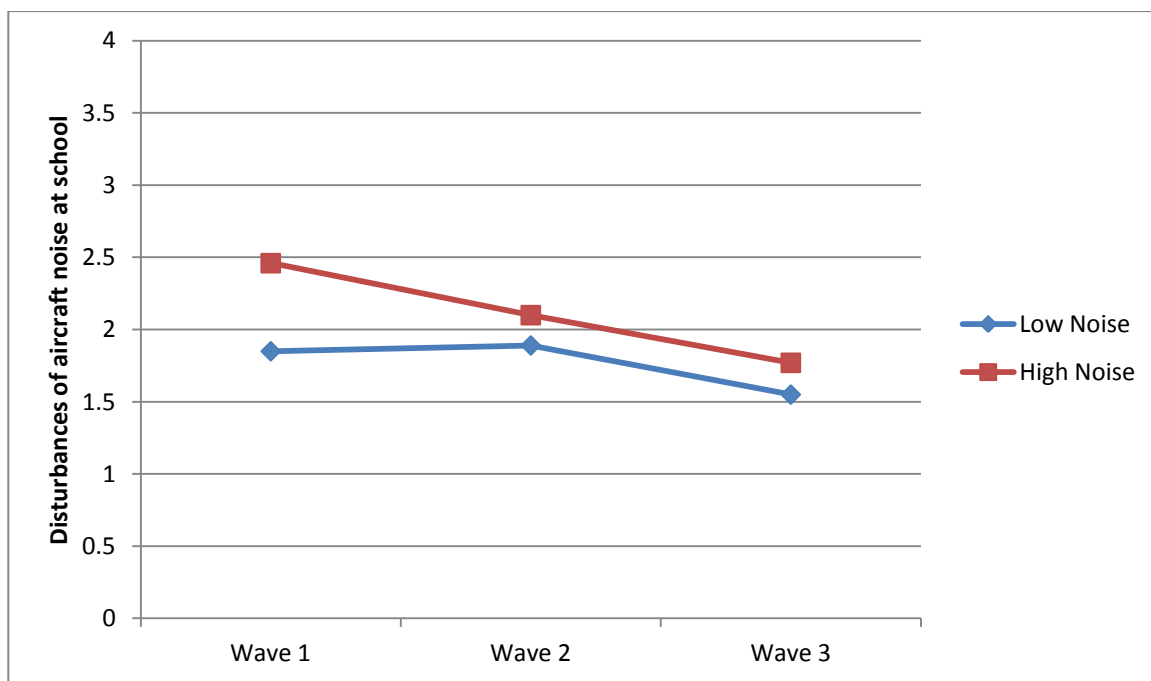


Figure 1. Disturbances caused by aircraft noise at school

Table 2

Disturbances in school and home activities

	Wave 1				Wave 2				Wave 3			
	Low Noise Mean	High Noise Mean	Difference Score (95% CI)	DF, N, F, P- value	Low Noise Mean	High Noise Mean	Difference Score (95% CI)	DF, N, F, P-value	Low Noise Mean	High Noise Mean	Difference Score (95% CI)	DF, N, F, P-value
<u>At School</u>												
Item 1	1.85	2.46	-0.60	(1, 732)	1.89	2.10	-0.21	(1, 649)	1.55	1.77	-0.21	(1, 174)
			(-0.70-0.50) F=139.28				(-0.31-0.11) F=17.21				(-0.39-0.03) F=5.69	
			P=0.00*				P=0.00*				P=0.01*	
<u>At Home</u>												
Item 1	1.93	2.19	-0.26	(1, 732)	1.88	1.97	-0.08	(1, 649)	1.57	1.66	-0.08	(1, 174)
			(-0.36-0.16)F=25.56				(-0.19-0.01) F=2.62				(-0.27-0.09) F=0.88	
			P=0.00*				P=0.10				P=0.34	

KEY: Item 1= Disturbed by aircraft noise; * p < .05

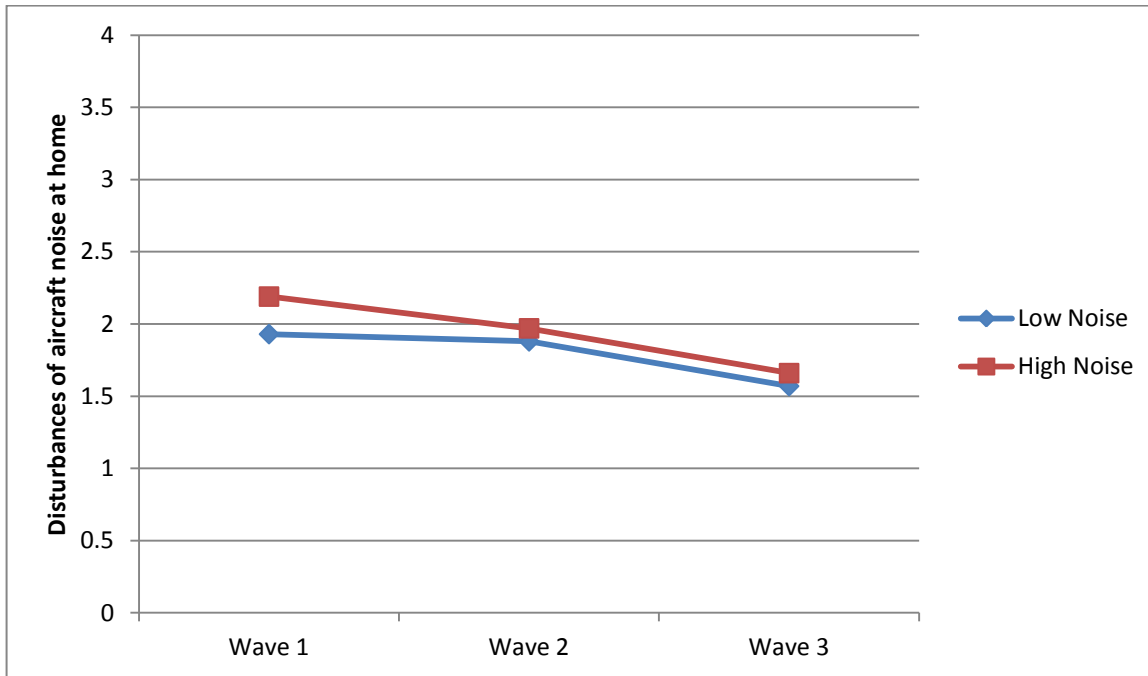


Figure 2. Disturbance of aircraft noise at home

4.3.2. Coping with noise at school and home

Table 3 indicates that the noise-exposed children implemented significantly more coping strategies (e.g. covering of ears, tuning out and waiting for noise to end) at school than those in the quieter group in Wave 1 ($F_{1, 732} = 43.07, P=0.00$) and Wave 2 ($F_{1, 649} = 5.63, P=0.01$). There was, however, no significant difference between the groups in Wave 3 ($F_{1, 174} = 0.87, P=0.35$). In terms of exposure to noise at home, the children in the high noise group also implemented more coping strategies than their counterparts in Wave 1 ($F_{1, 732} = 6.96, P=0.00$). There was no significant difference between the groups regarding their coping strategies in Wave 2 ($F_{1, 649} = 0.13, P=0.71$) and Wave 3 ($F_{1, 174} = 0.37, P=0.54$). Figures 3 and 4 illustrate the results.

Table 3

Coping with Noise at School and Home

	Wave 1				Wave 2				Wave 3			
	Low Noise Mean	High Noise Mean	Difference Score (95% CI)	DF, N, F, P- value	Low Noise Mean	High Noise Mean	Difference Score (95% CI)	DF, N, F P-value	Low Noise Mean	High Noise Mean	Difference Score (95% CI)	DF, N, F, P- value
<u>At School</u>												
Item 1	1.89	2.19	-0.29 (-0.38-0.20)	(1, 732) F=43.07 P=0.00*	1.90	2.01	-0.10 (-0.19-0.01)	(1, 649) F=5.63 P=0.01*	1.75	1.83	-0.08 (-0.25-0.09)	(1, 174) F=0.87 P=0.35
Item 2	2.65	2.77	-0.11 (-0.24-0.01)	(1, 732) F=3.10 P=0.07	2.59	2.49	-0.09 (-0.03-0.23)	(1, 649) F=2.08 P=0.14	2.41	2.64	-0.23 (-0.51-0.04)	(1, 174) F=2.65 P=0.10
<u>At Home</u>												
Item 1	1.89	2.02	-0.12 (-0.21-0.03)	(1, 732) F=6.96 P=0.00*	1.87	1.85	0.01 (-0.07-0.11)	(1, 649) F=0.13 P=0.71	1.76	1.81	0.05 (-0.24-0.12)	(1, 174) F=0.37 P=0.54
Item 2	2.39	2.44	-0.05 (-0.18-0.07)	(1, 732) F=0.43 P=2.29	2.29	2.16	0.13 (-0.00-0.27)	(1, 649) F=3.56 P=0.05*	2.14	2.37	-0.22 (-0.50-0.05)	(1, 174) F=2.52 P=0.11

KEY: Item 1= Coping strategies used (covering ears, tuning out, and waiting for noise to end); 2=Wish for quietness; * p < .05

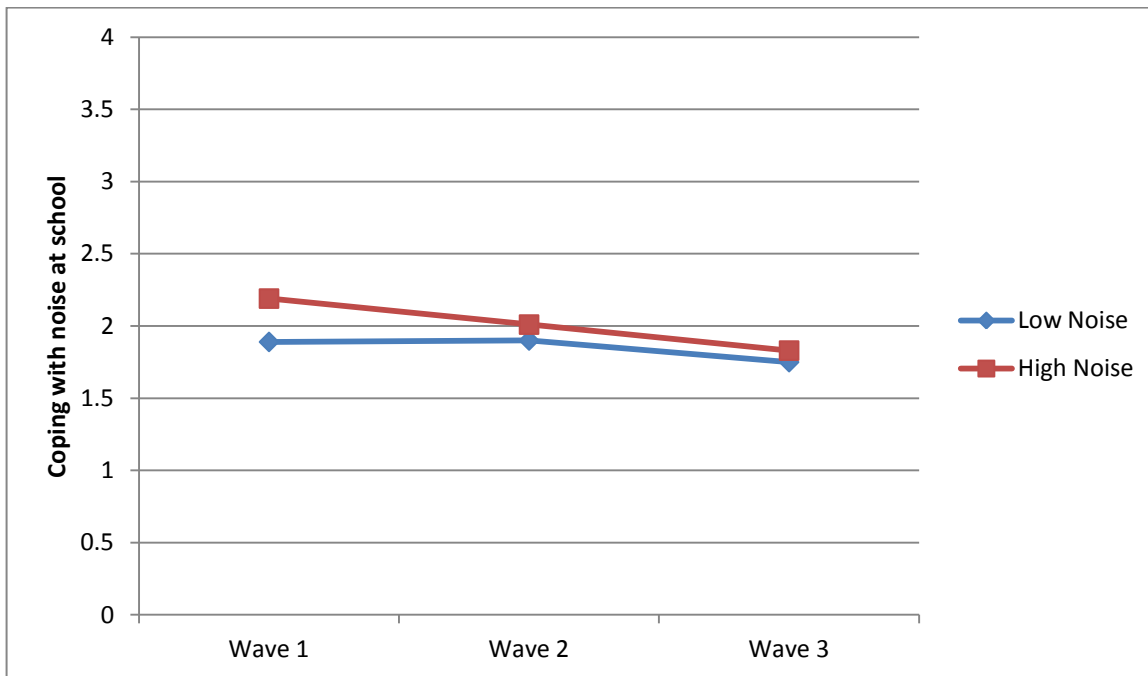


Figure 3. Coping with noise at school

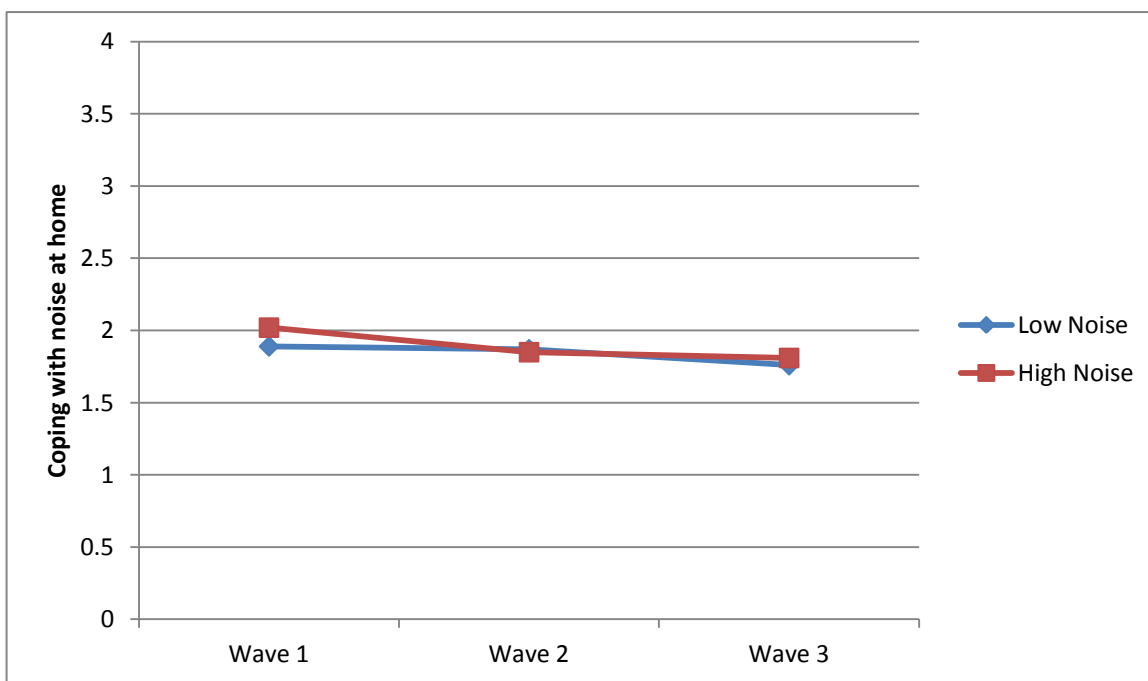


Figure 4. Coping with noise at home

4.4. Discussion

Two main findings emerged from the study. First, the children's activities were substantially more disturbed at school in all the waves in the noise-exposed group than were the activities of the children in the quieter area. Second, the children who had been exposed to aircraft noise continued to use more coping strategies (e.g. covering ears, tuning out, waiting for the noise to end) than their counterparts despite the relocation of the airport. Taken together, these findings suggest that aircraft noise exposure adversely affects children's school activities and that these effects can have a lasting impact on children's functioning.

4.4.1. Disturbances at activities and coping strategies

This study revealed that the school activities of the noise-exposed children were significantly more disturbed than those of the children in the quieter environment in all the waves. These findings are consistent with the literature, which indicates that children who live in the vicinity of an airport feel that their performance in different activities is affected by exposure to noise (Haines et al., 2001). Haines and Stansfeld (2000) found that the children exposed to aircraft noise reported interferences with their classroom activities such as working and thinking. Another study found that the children attending school in a noisy area reported that the train noise bothered them and influenced their ongoing activities (Bronzaft & McCarthy, 1975). The World Health Organization (2000) accordingly recommends that the level of noise in school environments should not exceed 35 dB. However, many children do not have access to ideal or calm learning environments, particularly in less developed countries (Haines & Stansfeld, 2000) like South Africa where some children in remote rural areas attend schools under trees. For children to perform at their optimal level and to succeed scholastically, they should be at an environment that is conducive to teaching and learning.

Of significant interest in this study is that the children in the noise-exposed group reported high levels of disturbances in their activities in all the waves despite the relocation of the airport after Wave 1. These children also used more coping strategies at school in Wave 1 and Wave 2 than those in the quieter group. It therefore seems that the effects of chronic exposure to aircraft noise are long term – these results are corroborated by other studies. An earlier study found that reducing the noise inside a school by 16 dB(A) had little effect on the children's performance (Cohen et al., 1986). It also revealed that even when the sources of noise were removed, as in the closure of the airport, it took several years for the adverse effects of exposure to noise to abate (Hygge et al., 1996).

Although statistically significant differences were found between the groups before and after the relocation of the airport, there was a declining trend, particularly in the noise-exposed group as illustrated in Figures 1 to 4. These findings can be explained by the partial retention of behavioural coping strategies (Raw & Griffiths, 1990), which suggests that when people experience a change in noise exposure, they alter some of their coping strategies, such as closing windows, but they partially retain such strategies after the change resulting in excess effect (Brown & van Kamp, 2009).

The implications of these findings are that chronic aircraft noise exposure has a lasting impact on children's learning and development. These effects appear irreversible. Policy makers and airport officials should therefore ensure that children's school environments are conducive to their learning and development and that environmental hazards such as noise pollution are avoided and/or eliminated.

4.4.2 Strengths and limitations

To best knowledge of the authors, this longitudinal field study was the first large study to examine the effects of aircraft noise exposure on children's activities and how children cope with noise exposure. A limitation of the study is that, while the analyses were based on 2009-2011 longitudinal data, the 2011 cohort was very small because significant numbers of the participants were lost due to attrition. Another limitation was the exclusive focus on aircraft noise impacts to the exclusion of other sources of noise (road traffic, construction, railway noise, etc.), which may have skewed the results.

4.5. Conclusion

This longitudinal study provides stronger evidence than previous studies that aircraft noise exposure impacts negatively on the school activities of children. The fact that the noise-exposed children's activities remained disturbed and that these children continued to use more coping strategies to counter noise than their counterparts, despite the relocation of the airport, suggests that chronic exposure to aircraft noise has a lasting impact on children's learning activities. Steps should therefore be taken to protect children from such environmental hazards.

4.6. Acknowledgments

The authors thank Stephen Stansfeld and Charlotte Clark for allowing them access to the RANCH test materials. Thanks are also extended to the children for participating in the study.

This study was supported financially by the National Research Foundation (NRF). The opinions, findings, conclusions and recommendations expressed in it are solely those of the

authors and not necessarily those of the NRF. The study was also made possible (in part) by a grant from the Carnegie Corporation of New York.

4.7. Conflict of Interest

There are no conflicts of interest to declare.

4.8. References

- Ana, G., Shendell, D., Brown, G., Sridhar, M. (2009). Assessment of Noise and Associated Health Impacts at Selected Secondary Schools in Ibadan, Nigeria. *Journal of Environmental and Public Health* (6 pages).
- Berglund, B., Lindvall, T. (1995). *Community Noise*. Archives of the Center for Sensory Research. Stockholm, 2(1), 1-195.
- Berglund, B., Lindvall, T., Schwela, D.H. (Eds.). (1999). HWO. *Guidelines for community noise*. World Health Organization, Geneva.
- Boman, E., Enmarker, I. (2004). Factors affecting pupils' noise annoyance in schools: The building and testing of models. *Environment and Behavior*, 36(2), 207-228.
- Bronzaft, A.L., McCarthy, D.P. (1975). The effects of elevated train noise on reading ability. *Environment and Behavior*, 7, 517-527.
- Brown, A.L, van Kamp I. (2009). Response to a change in transport noise exposure: A review of evidence of a change effect. *Journal of the Acoustical Society of America*, 125, 3018-3029.
- Clark, C., Martin, R., Kempen, E. v., Alfred, T., Head, J., Davies, H. et al. (2006). Exposure-Effect Relations between Aircraft and Road Traffic Noise Exposure at School and Reading Comprehension. *American Journal of Epidemiology*, 27-37.
- Cohen, S., Evans, G.W., Stokols, D., Krantz, D.S. (1986). *Behavior, Health, and Environmental Stress*. New York: Plenum.
- Cohen, S., Evans, G.W., Krantz, D.S., Stokols, D. (1980). Physiological, motivational, and cognitive effects of aircraft noise on children. Moving from the laboratory to the field. *American Psychologist*, 35(3), 231-243.
- Cohen, S., Evans, G.W., Krantz, D.S., Stokols, D., Kelly, S. (1981). Aircraft noise and children: longitudinal and cross-sectional evidence on adaptation to noise and the

- effectiveness of noise abatement. *Journal of Personality and Social Psychology*, 40(2), 331-345.
- Dockrell, J.E., Shield, B.M. (2006). Acoustical Barriers in Classrooms: The Impact of Noise on Performance in the Classroom. *British Educational Research Journal*, 32(3), 509-525.
- Evans, G.W., Hygge, S., Bullinger, M. (1998). Chronic noise exposure and physiological response: A prospective study of children living under environmental stress. *American Psychological Society*, 9, 75-77.
- Evans, G.W., Hygge, S., Bullinger, M. (1995). Chronic noise and psychological stress. *Psychological Science*, 6, 333-338.
- Evans, G.W., Lepore, S.J., (1993). Nonauditory effects of noise on children: A critical review. *Children's Environments*, 10(1), 31-51.
- Guski, R. (1999). Personal and social variables as co-determinants of noise annoyance. *Noise & Health*, 3, 45-65.
- Haines, M., Brentnall, S., Stansfeld, S., Klineberg, E. (2003). Qualitative responses of children to environmental noise. *Noise & Health*, 5(19), 19-30.
- Haines, M.M., Stansfeld, S.A. (2000). Measuring annoyance and health in child social surveys. In D. Cassereau (Ed.), *Proceedings of Inter-Noise*, Vol. 3 (pp. 1609-1614). Nice, France: Societe Francais d'Acoustique.
- Haines, M.M., Stansfeld, S.A., Job, R.F.S., Berglund, B., Head, J. (2001). Chronic aircraft noise exposure, stress responses, mental health and cognitive performance in school children. *Psychological Medicine*, 31, 265-277.
- Haines, M., Stansfeld, S., Job, R.S., Berglund, B., Head, J. (2001). A follow-up study of effects of chronic aircraft noise exposure on child stress responses and cognition. *International Journal of Epidemiology*, 30(4), 839-845.

- Haines, M.M., Stansfeld, S.A., Brentall, S., Head, J., Berry, B., Jiggins, M., Hygge, S. (2001). The West London schools study: The effects of chronic aircraft noise exposure on child health. *Psychological Medicine*, 31, 1385-1396.
- Hygge S., Evans, G.W., Bullinger, M. (1996). The Munich Airport noise study: cognitive effects on children from before to after the change over the airports. In *Inter-Noise 96* (pp. 2189-2194). Liverpool.
- Hygge, S., Evans, G.W., Bullinger, M.A. (1998). *The Munich Airport Noise Study—Effects of chronic aircraft noise on children's cognition and health*. 7th International Congress on Noise as a Public Health Problem, Sydney, Australia, 268-274, November.
- Hygge, S., Evans, G.W., Bullinger, M.A. (2002). Prospective study of some effects of aircraft noise on cognitive performance in school children. *Psychological Science*, 15(5), 469-474.
- Lazarus, R.S. (2000). Toward better research on stress and coping. *American Psychologist*, 55, 665-673.
- Lazarus, R.S. (1991). *Emotion and adaptation*. London: Oxford University Press.
- Lercher, P., Evans, G.W., Meis, M. (2003). Ambient noise and cognitive processes among primary schoolchildren. *Environment and Behaviour*, 35, 725-735.
- Meis, M., Hygge, S., Evans, G.W., Bullinger, M. (1998). Dissociative effects of traffic noise on implicit and explicit memory: Results from field and laboratory studies. In N.L. Carter & R.F.S. Job (Eds.), *Noise as a public health problem*. Noise Effects, Conference, 1 (pp. 389-394). Sydney, Australia: Noise Effects '98 Pty Ltd.
- Miedema, H.M.E. (2007). Annoyance caused by environmental noise: Element for evidence-based noise policies. *Journal for Social Issues*, 63(1), 41-57.
- Raw, G.J., Griffiths, I.D. (1990). Subjective response to changes in road traffic noise: A model. *Journal of Sound Vibration*, 141, 43-54.

- Seabi, J., Cockcroft, K., Goldschagg, P., Greyling, M. (2012). The impact of aircraft noise exposure on learners' reading comprehension in South Africa: The moderating effect of home language. *Noise & Health*, 19, 29-37.
- Stansfeld S.A., Berglund, B., Clark, C., Lopez-Barrio, I., Fischer, P., Öhrström, E., Haines, M.M., Head, J., Hygge, S., van Kamp, I., Berry, B.F. (2005). Aircraft and road traffic noise and children's cognition and health: a cross-national study. *Lancet*, 365(9475), 1942-1949.
- Stansfeld, S., Haines, M., Brentnall, S., Head, J., Roberts, R., Berry, B., Jiggins, M. (2001). *West London Schools Study: aircraft noise at school and children's cognitive performance and stress responses*. Department of Health.
- Stansfeld, S.A., Haines, M.M., Brown, B. (2000). Noise and Health in the Urban Environment. *Reviews on Environmental Health*, 15(1-2), 43-82.
- Swift, H. (2010). A review of the literature related to potential health effects of aircraft noise. PARTNER Project 19 Final Report. Retrieved on 16 January 2013 from <http://web.mit.edu/aeroastro/partner/reports/proj19/proj19-healtheffectnoise.pdf>
- Vandenbroucke, J.P. (2008). Observational Research, Randomised Trials, and Two Views of Medical Science. *PLoS Med.*, 5(3): e67. doi:10.1371/journal.pmed.0050067
- Wolke, D., Waylen, A., Samara, M., Steer, C., Goodman, R., Ford, T., Lamberts K. (2009). Does selective drop out lead to biased prediction of behaviour disorders. *British Journal of Psychiatry*, 195, 249-256.
- World Health Organization. (2000). *Guidelines for Community Noise*.

CHAPTER FIVE

The Impact of Aircraft Noise Exposure on South African Children's Reading Comprehension: The Moderating Effect of Home Language

Reprinted with permission from Seabi, J., Cockcroft, K., Goldschagg, P., Greyling, M. (2012). The impact of aircraft noise exposure on learners' reading comprehension in South Africa: The moderating effect of home language. *Noise and Health*, 19, 29-37.

Abstract: Given the limited studies conducted within the African continent, the purpose of this study was to investigate the impact of chronic aircraft noise exposure and the moderating effect of home language on the learners' reading comprehension. The sample comprised of 333 (45.5%) senior primary learners exposed to high levels of aircraft noise (Experimental group) and 399 (54.5%) learners residing in a quieter area (Control group). Of these, 151 learners in the Experimental group spoke English as a first language (EFL) and 162 spoke English as a second language (ESL). In the Control group, the numbers were similarly divided (EFL $n = 191$; ESL $n = 156$). A univariate General Linear Model was used to investigate the effects of aircraft noise exposure and language on reading comprehension, while observing for the possible impact of intellectual ability, gender, and socioeconomic status on the results. A significant difference was observed between ESL and EFL learners in favour of the latter ($F_{1,419} = 21.95$, $p = .000$). In addition a substantial and significant interaction effect was found between the experimental and control groups for the two language groups. For the EFL speakers there was a strong reduction in reading comprehension in the aircraft noise group. By contrast this difference was not significant for the ESL speakers. Implications of the findings and suggestions for further research are made in the article.

Keywords: Aircraft noise, home language, reading comprehension, South Africa

5.1. Introduction

A major challenge facing the South African education system is to address the needs of all learners, regardless of their geographical and linguistic backgrounds. Education is one of South Africa's most significant areas of concern. An Annual National Assessment conducted recently indicates that 65% of Grade 3's and 72% of Grade 6's are not at the grade appropriate language level (Department of Basic Education, 2011). Given such statistics, it is evident that the country's schooling system performs well below its potential, and that improving the basic education outcome is a prerequisite for the national long-term development goal. A part of improving the educational system lies in identifying the areas of concern that may impede the optimal transference of knowledge and learning. This includes factors that are often overlooked and thought to only affect a few, such as environmental noise.

It has been established that aircrafts produce a considerable amount of noise (Stansfeld, Berglund, Clark, Lopez-Barrero, Fischer, et al., 2005). Given this, it seems logical for airports to be situated reasonably far from areas such as residences and schools, where noise can be a significant source of distraction and annoyance (Goldschagg, 2007; Rivlin, 1984). However, this is not the case in South Africa, as there are several airports situated close to learning environments. Schools are learning environments that should stimulate cognitive development, facilitate transfer of knowledge, and enable children to learn about the society they live in (Clark & Stansfeld, 2005). Having loud noise sources (such as airports) close to schools may compromise the learning process. Although there is research from Western countries regarding exposure to aircraft noise and its impact on reading comprehension (Evans & Maxwell, 1997; Haines, Stansfeld, Job, Berglund, & Head, 2001), to the best of the authors' knowledge, there is no research in this area within developing countries, such as South Africa.

The impact of unwanted noise on learning is confounded by the fact that South Africa has eleven official languages. This multilingual characteristic presents interesting dynamics to the investigation of reading comprehension and aircraft noise. Learning in South Africa is predominantly facilitated in English followed by Afrikaans, although statistics indicate that a majority of the population (74%) speak an indigenous (African) language as their first language. Therefore, for many learners, English is their second and sometimes even their third language, which they may not be proficient in (Pretorius & Naude, 2002). Thus, English second language (ESL) learners may be at a double disadvantage, having to read and comprehend in their second language and simultaneously having to contend with background air traffic noise.

5.1.1. Sources of noise in the classroom

In South Africa, learning is predominantly facilitated by a teacher giving instructions orally, while learners listen and absorb the information. Classrooms, therefore, need to support communicative behaviour to facilitate learning. Noise in the classroom consists of a combination of external noise, which permeates into the building, together with internally generated noise (Shield & Dockrell, 2003). Internal noise mainly consists of noise generated by the learners themselves, as they participate in classroom activities and converse among themselves. External noise, on the other hand, as highlighted, includes noise from transportation sources, such as road traffic, aircraft noise (for some schools), and to a lesser degree, railway noise. A survey conducted in London indicates that sources of external environmental noise include cars, which account for 86%, aircraft 54%, lorries 35%, and buses 24% of the noise, respectively (Shield & Dockrell, 2000). Research in South Africa indicates similar trends of environmental noise experienced by learners in the classroom (Seabi, Goldschagg, & Cockcroft, 2010). Children are thus exposed to noise from several sources when they are learning. Although it is acknowledged that internal noise can interfere with the learning process, external noise is envisaged to pose an even greater distraction to

learning activities. The logic being that, unlike internal noise, aircraft noise, for example, is louder and intermittent, and consequently educators and learners have less (if any) control over such a noise (Shield & Dockrell, 2008). Thus, learners situated near high levels of environmental noise may be at a higher risk of academic delays than learners who are not exposed to noise levels that infringe on the optimal acoustic levels in a classroom. Academic delays experienced by these learners may be in the form of impaired reading ability and comprehension, which the current study tries to investigate.

5.1.2. Reading Comprehension

The ability to read is one of the leading factors for the learners' successful transitioning to higher grades of learning; with different levels requiring a higher order of thinking and understanding of texts. It is widely recognised that language and reading proficiency are pivotal to educational success primarily because education is still largely a language-based activity (Webb, 1996). Effective reading requires readers to engage actively with the text in an attempt to comprehend the thoughts and feelings of another mind via the text' (Pumfrey, 1977).

A reader's understanding of a text can be limited by various barriers, language being the most obvious one (Orasanu, 1986). If a reader does not possess a good command of the language that the text is in, there is a high chance of a limited understanding of that text (Pretorius & Naude, 2002); thus, introducing a language bias. Issues around language bias are pertinent in multilingual countries such as South Africa. Sternberg's (1996) linguistic relativity hypothesis is of interest, given the predicament of language bias. In the context of this hypothesis, a learner's understanding of classroom assessment is potentially a function of language. Essentially the hypothesis suggests that a learner's comprehension of a text is dependent on and limited to the learner's level of competency of the language in which the text is written. The hypothesis further proposes that people develop certain cognitive styles

and interpretations based on the language they communicate in. A criticism of this hypothesis is that it underestimates people's capabilities to comprehend texts that are not in their dominant language. What the linguistic hypothesis argument does highlight is that language can play a role in creating discrepancies in learning that may place ESL speakers at a reading disadvantage compared to EFL speakers, if they are all being educated in English (Ramaahlo, 2010).

Cummin's (1991) language theory holds that language proficiency has two facets: basic interpersonal communication skills (BICS) and cognitive academic language proficiency (CALP). BICS are primary skills pertaining to listening and speaking such as being able to hold a fluent conversation in English on a day-to-day basis. CALP, on the other hand, is the ability to cope with the academic demands of a language such as the ability to comprehend texts. The theory suggests that even if one can converse fluently in English, for example, this does not automatically translate into the academic skill of being able to comprehend a text in English (de Klerk, 2002). The application of this theory in South Africa, where the medium of teaching is predominantly English, raises questions as to whether learners from different linguistic backgrounds have acquired both BICS and CALP in English. A South African study found that ESL speakers performed significantly less well than EFL speakers in an assessment that measured reading ability (Ireland-Lathy, 2006). This suggests that the ESL learners might not have acquired the levels of CALP needed to comprehend the text effectively. The linguistic character of South Africa is such that many South African learners are likely to have acquired BICS, but their CALP may not be adequately developed, which puts them at a greater risk of underachieving in an English medium school in comparison with their EFL counterparts.

5.1.3. Aircraft Noise in the context of Reading Comprehension

The impact of aircraft noise on cognitive tasks, such as reading comprehension, has been researched over the past 30 years. Given that reading comprehension involves higher cognitive processes such as attention and memory, and these processes appear to be sensitive to exposure to chronic noise (Goldman & Bisanz, 2002), it is logical to assume that deficits in

reading performance may be found as a result of noise exposure. Indeed, research has found reading comprehension to be more sensitive to noise than other cognitive tasks (Jones, 1990), and this is possibly because of its extensive dependence on memory. Hockey (1979) found that participants exposed to loud noise conditions had better recall of names from a passage, but poorer overall comprehension, than those in quieter environments. A significant drop in children's school performance, especially in learning to read, was found when the background noise level interfered with speech (Hetu, Truchon-Gagnon, & Bilodeau, 1990). Evans and Maxwell (1997) also found deficits in language skills among six- and eight-year old children exposed to chronic aircraft noise. Shield and Dockrell (2002) found a negative association between children exposed to noise and reading comprehension.

Quite recently, impairments in reading comprehension performance were demonstrated among children aged nine to ten years, exposed to three airports in the UK (Stansfeld, Berglund, Clark, Lopez-Barrero, Fischer et al., 2005). In another study, exposure to chronic aircraft noise was associated with a six-month delay in the reading ability of eight- to eleven-year-old children and the differences remained even after adjusting the analyses for age, language spoken, and level of economic standing (Haines et al., 2001). This was particularly important because it suggested that language might not necessarily facilitate differences in reading comprehension skills. However, it was imperative to infer results obtained from any study with caution. It could be that such results in the Heathrow study might have been context-specific. The study was conducted in London, where learners from different cultural backgrounds were arguably more similarly exposed to English, in comparison to South Africa, where English may be an official language, but is not spoken equally by all people.

Although these studies (Evans & Maxwell, 1997; Hetu et al., 1990; Hockey, 1979; Stansfeld et al., 2005) reveal a consistent association between reading comprehension and

exposure to chronic aircraft noise, no significant effect of noise on reading comprehension was found (Haines et al., 2001; Hygge, Evans & Bullinger, 2002). However, when Hygge et al. (2002) conducted a separate analyses of the 15 most difficult items in the reading comprehension test, a significant difference between the two groups was demonstrated, and this remained even after adjustment for age, socioeconomic deprivation, and home language, [$F(1, 417) = 4.75, p = 0.032$]. This finding suggests that chronic exposure to aircraft noise impairs learners' performance only on difficult items of the reading comprehension test. Simple cognitive tasks that require less attention for processing appear not to be affected by noise. Investigating whether similar findings would be observed in a multilingual context, such as in South Africa, is useful, as this may indicate whether it is significantly more difficult for ESL learners to comprehend texts that demand greater CALP skills.

The present article focuses on a cross-sectional cohort, and examines whether effects of exposure to aircraft noise can be found on reading comprehension, and if so, whether the language spoken at home moderates the effects.

5.1.4. Aims

The general aim of the study was to examine the effects of exposure to chronic environmental noise, by comparing the reading comprehension performance of learners exposed to aircraft noise with those not exposed to aircraft noise. As language is inextricably tied to reading and comprehension, the further aim was to examine the influence of language on reading comprehension. In order to gain insight into the possible factors that affect reading comprehension, the following questions guided the study:

1. Does exposure to chronic aircraft noise impact negatively on primary school learners' reading comprehension?

2. Is there a significant difference between English First Language (EFL) learners' and English Second language (ESL) learners' reading comprehension abilities?
3. Does language spoken at home play a moderating role in the impact of aircraft noise on reading comprehension?

5.2. Methods

5.2.1. Context of the study

The current study was conducted under the auspices of a longitudinal South African based study namely, the Road and Aircraft Noise Exposure on Children's Cognition and Health (RANCH-SA). RANCH-SA investigated the impact of environmental noise, specifically aircraft noise, on primary school learners' memory, attention, and reading comprehension abilities in the province of KwaZulu Natal. Durban International Airport (prior to relocation to the new King Shaka International Airport site) was selected as a case study. Two schools exposed to a high level of aircraft noise (experimental group) were selected as the study population for the aircraft noise exposure area. The control group comprised three schools in locations not exposed to aircraft noise but matched the socio-demographic characteristics (such as language spoken at home, parental education and occupation) of the noise-exposed areas. Schools located outside aircraft flight paths were selected by visual inspection of maps of the areas surrounding Durban International Airport.

5.2.2. Participants

The sample comprised 732 participants from five schools, located either in a high aircraft noise urban area (16 hours outdoor $Leq > 69$ dBA) around the Durban International Airport as well as a quieter area (16 hours outdoor $Leq < 40$ dBA). The participants were all from similar socio-economic backgrounds, and the schools were selected on the basis of their

proximity to and distance from the airport. The two schools situated under the aircraft flight path constituted the experimental group and consisted of 333 (45.5%) participants, and the three schools situated far from the airport constituted the control group and comprised 399 participants (54.5%). The participants' ages ranged from 9 to 14 years with a mean age of 11.9 years. There were 322 (43.9%) boys and 331 (45.4%) girls – 79 (10.7%) participants did not respond to the gender category question. Of the 732 participants, 390 (53.2%) spoke English as a first language, and 342 (46.8%) spoke English as a second language (IsiZulu, IsiXhosa, Southern Sotho). Three hundred and seventy-one participants (50%) reported that they received free meals at school, 236 (32.3%) did not receive meals, and 125 (17.7%) indicated that they were unsure about this question. A non-probability purposive sampling technique was used in the study. Criteria for participating in the study were a minimum of two years of residence in the study area, normal hearing (as perceived by parents and teachers) and being in Grade 5 or 6 at the time of the study. Those with known learning difficulties, auditory processing disorders and/or attentional problems were allowed to participate but were excluded from the analyses.

5.2.3. Procedure

Written permission was obtained from the education authorities and from the parents/guardians to allow their children to participate in the study. Informed assent from the learners was also obtained. The cognitive performance tests were group-administered in the classrooms, between 8 a.m. and 10 a.m. in the morning. They were informed of the limits of confidentiality, as well as the voluntary nature of their participation. RANCH-SA assessment administrators were trained in advance on the standard assessment protocol and how to administer the tests. All the assessments were conducted under normal air traffic (i.e. mid-week) movement conditions. On the day of testing, the assessment administrators introduced themselves according to the RANCH-SA script, which avoided the word 'noise' so as not to influence the participants' perceptions of the study. The study was introduced as an

environmental health study with the noise questions embedded in the environment and health sections. The Suffolk Reading Scale Level 2 (SRS2) was one of the instruments administered according to the RANCH-SA protocol. Each testing procedure began with practice items, to ensure that the participants understood what was required in the assessment. The completed tests were placed in a coded envelope immediately after completion of the assessment. The participants (learners) were offered crisps and fruit juice for participating in the study.

5.2.4. Instruments

Although the RANCH-SA study incorporated a number of instruments, this study focused on the Suffolk Reading Scale Level 2 Biographical Questionnaire, the noise measurement instrument and intellectual ability.

5.2.4.1. Biographical Questionnaire

Information on the participants' gender, age, race and language was obtained from the biographical questionnaire, which was completed by the participants and the parents. The children's questionnaire was administered in print form and completed before the assessment. The parents' questionnaire was sent in advance to the participants' parents and collected from each learner on the day of the assessment.

5.2.4.2. Reading Comprehension

Reading Comprehension was measured with the Suffolk Reading Scale Level 2 (SRS2) (Hagley, 1987), which measures the reading comprehension of children ranging in age from 6 years 4 months to 13 years 11 months. It was standardised for children in the United Kingdom. The test comprises 86 multiple-choice sentence completion questions, each having five potential answers. The SRS2 had a test-retest coefficient of 0.88 in the standardisation

sample (Hagley, 2002). Although the SRS2 has not been standardised for South African conditions, it had a Cronbach's alpha of 0.93 when used with a sample of South African primary school learners (Ramaahlo, 2010).

5.2.4.3. Intellectual Ability

Intelligence was measured with the Figure Analogies Subtest of the Quantitative Battery for Cognitive Abilities Test (Lohman & Hagen, 2002). The Figure Analogies Test (also known as Matching Mate) presents figural analogies of the type 'A→B: C→___'. This test measures inductive reasoning and visualisation and has a reported Kuder–Richardson reliability coefficient of 0.91 (Lohman & Hagen, 2002). It was administered to a sample of South African learners and found to be valid and reliable (Seabi et al., 2010). It was included in order to determine whether the comparison groups were equivalent in terms of intellectual ability.

5.2.4.4. Noise Measurements

The instrument used to measure noise was a SVAN 955 Type 1 sound level meter. A Rion NC74 acoustic calibrator was used to check the instrument calibration before and after measurements were performed. Noise measurements were taken during the testing period (8 a.m. to 10 a.m.). The average sound level (LAeq) measured was 69, with a maximum of 95 dBA in the experimental group, and 40, with a maximum of 54 dBA in the control group.

5.2.5. Ethical considerations

The RANCH-SA study adhered to the following ethical procedures: to gain their informed consent, an information letter was sent to the education authorities and the parents of the potential participants. It outlined the nature of the study and what participation would entail.

It also informed the parents who would have access to the data, including other researchers affiliated with RANCH-SA. The right to withdraw from the study at any stage, as well as how to obtain feedback from the study, was explained. The potential participants were informed about the lack of any direct benefit in participating in the study. The signing of a consent form by a parent was considered informed consent. Consent was also obtained from the children themselves. Only after consent from the education authorities and the parents had been obtained, were the children grafted into the study. Given the public nature of the assessments conducted in a group setting, anonymity could not be guaranteed, but all the data were kept confidential.

5.3. Results

Out of a total of 732 participants, 39 (5%) did not complete the reading comprehension assessment (due to lateness); consequently, in total, only 693 (95%) of the scores were available for analysis. The reading comprehension mean for the South African sample was significantly lower (mean = 35.27; SD: 11.2) than that reported in a similar study (mean = 98.2) conducted in the UK (Haines et al., 2001). The latter study also used the SRS2 and obtained a mean score of 99.29 after adjusting for ethnicity, main language and age. The large difference in the means highlighted the lower level of reading comprehension performance of the South African learners compared to the UK learners.

Table 1 below shows the mean scores in the SRS2 for both the control and experimental groups as well as for the EFL and ESL learners. As anticipated, the learners who were not exposed to aircraft noise (the control group) demonstrated a higher reading comprehension performance ($M = 32.44$, $SD = 16.71$) compared to the experimental group that was exposed to aircraft noise ($M = 29.81$, $SD = 14.23$).

Table 1

Reading Comprehension Scores of Aircraft Noise Exposure and Language Groups

Groups	N	Mean	SD
Experimental	333	29.81	14.23
Control	399	32.44	16.71
EFL	342	36.19	14.91
ESL	318	28.60	13.51

A comparison of the language groups revealed that the EFL learners performed significantly better ($M = 36.19$, $SD = 14.91$) in reading comprehension than their ESL counterparts ($M = 28.60$, $SD = 13.51$; $t[658] = -6.83$, $p < 0.000$), as shown in Table 1. This was anticipated given that the SRS2 is an English assessment. The mean score of the EFL learners was also slightly above the study's overall average in the SRS2 ($M = 35.27$). This highlighted the fact that the overall reading comprehension performance of the EFL learners generally surpassed that of the study's sample as a whole. Meanwhile, the ESL learners not only performed significantly less well than their EFL counterparts, but, as a group, they performed below the sample's (overall) reading comprehension average.

The study was also interested in investigating the interaction between aircraft noise and home language in reading comprehension. The interaction means shown in Table 2 reveal similar trends to the main effects where the EFL learners not exposed to aircraft noise demonstrated superior reading comprehension ($M = 40.9$, $SD = 14.06$) in comparison to all the other groups in the study. As can be observed from the table, the largest difference in mean scores was between the EFL learners in the control group ($M = 40.9$) and the EFL learners in the experimental group ($M = 30.16$). This suggests an association between aircraft noise and language, which is elaborated later on. For the ESL groups, on the other hand, whether they were exposed to chronic aircraft noise or not, their mean scores for reading

comprehension were lower. This suggests that the effect of noise on the ESL learners' reading comprehension performance was generally negligible.

Table 2

Interaction between Aircraft Noise and Language on Reading Comprehension

Groups	Language	N	Mean	SD
Experimental	EFL	151	30.16	13.76
	ESL	162	29.48	14.69
Control	EFL	191	40.95	14.06
	ESL	156	27.69	12.14

A univariate general linear model was used to test the effect of aircraft noise and language on reading comprehension. The model also controlled for the possible impact of intellectual ability, gender and socio-economic status on the results. Intellectual ability was controlled as a covariate in the model, and, although no statistically significant differences were observed in the gender groups ($F_{1,419} = 2.47$, $p = .1168$) or in the level of socio-economic status ($F_{3,419} = 1.40$, $p = .2430$) in respect of reading comprehension ($\alpha = 0.05$), they were also included to control for the small extraneous effects and to improve the power of the test.

In addition, the effect sizes were calculated. The effect sizes gave an indication of the extent to which variance in reading comprehension was influenced by aircraft noise and/or language. Furthermore, the effect sizes enabled the researchers to establish the main effect that had the greatest influence on the reading comprehension performance of the different groups in the study. Although the SPSS software (used to analyse data in the study) supplied the partial Eta-squared effect sizes output, Cohen's d effect sizes were calculated instead. This was because Cohen's d is resistant to sample size influences, unlike the partial Eta-squared, which can be affected by a large sample size such as that in this study (Rosenthal & Rosnow, 1996). Moreover, in the study, the partial Eta-squared values did not sum to one, making interpretation of the effect size problematic.

5.3.1. The effects of aircraft noise on reading comprehension

The first question sought to examine what, if any, impact, aircraft noise had on reading comprehension. The results indicated statistically significant differences between the experimental and control groups on reading comprehension in favour of the control group ($F_{1,419} = 11.75$, $p = 0007$). This implied that the learners exposed to chronic aircraft noise had significantly lower scores for reading comprehension than the learners not exposed to the same intensity of noise. However, a small effect size ($d = 0.35$) was determined, indicating that although exposure to aircraft noise negatively impacted reading comprehension, the impact was minimal.

5.3.2. The effects of home language on reading comprehension

The second question sought to examine whether there was a statistically significant difference between the EFL learners and ESL the learners in reading comprehension. It was postulated that the EFL learners would perform significantly better than the ESL learners as the test of reading comprehension, the SRS2, was an English-based assessment. As shown in Table 3, a statistically significant difference was observed in favour of the EFL learners ($F_{1,419} = 19.79$, $p \leq .0001$) thus suggesting that the learners' primary language influenced their reading comprehension performance, particularly if the assessment was not in their home language. A moderate effect size ($d = 0.46$) for language in reading comprehension was determined. This was a larger effect than that of aircraft noise and served to highlight the relatively larger influence language had on reading comprehension performance.

Table 3

Summary of the main effects and interaction effects on reading comprehension

Variable	DF	F	p
Aircraft Noise	1,419	11.75	0.007*
Language	1,419	19.79	< 0.0001*
Aircraft Noise and Language	1,419	19.46	< 0.0001*

*Indicates significance at the 0.05 level ($p \leq 0.0001$)

5.3.3. The effects of aircraft noise and home language on reading comprehension

The study also investigated whether aircraft noise and language interacted to influence the learners' performance in reading comprehension. As can be seen in Table 3, the results showed a statistically significant interaction ($F_{1,419} = 19.46$, $p \leq .0001$). The effect of this interaction was substantial ($d = 0.87$), implying a large, practical difference in the effect of aircraft noise on the performance of the two language groups.

The nature of the interaction between noise and primary language spoken is illustrated in Figure 1. The EFL speakers performed substantially better in the control condition ($p \leq 0.0001$, $d = 0.78$) while the ESL learners performed slightly worse in the control condition. This effect was, however, not statistically significant ($p = 0.5366$, $d = -0.09$).

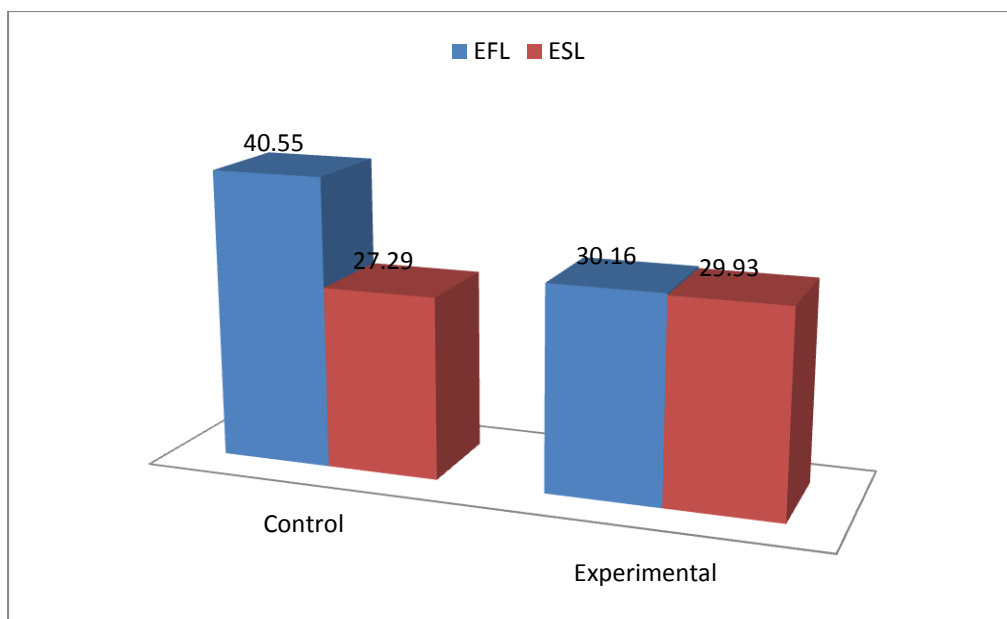


Figure 1. Aircraft noise and language interaction plots for reading comprehension

5.4. Discussion

5.4.1. The effects of language on reading comprehension

It was postulated that the EFL learners would perform significantly better than their ESL peers in an English reading comprehension assessment. This prediction was based on Stenberg's theory (1996) that low proficiency in the language of a text was likely to result in limited understanding of that text. The results of this study corroborated this prediction and supported the findings of a previous study, which revealed that ESL learners were at a disadvantage to EFL learners with regard to English literacy assessments such as the SRS2 (Ireland-Lathy, 2006).

The ESL learners also performed consistently less well than their EFL counterparts, irrespective of the environmental noise conditions. Home language thus seemed to be a pertinent factor in determining successful reading comprehension for the EFL learners. These results were in accordance with the premises put forward by Cummins (1991). The ESL learners had possibly acquired basic communication (BICS) fluency in English but might not

have had the academic proficiency (CALP) needed to fully comprehend the reading assessment. The ESL learners, unlike their EFL counterparts, probably also had the additional burden of translating the text from English into their primary language and back to English again. Furthermore, they probably had a lower vocabulary range, which placed them at a disadvantage in identifying words and extracting meaning from texts (Cornoldi & Oakhill, 1996). In addition, learning in what could be considered a 'new or foreign language' was probably frustrating and stressful thereby detrimentally affecting the performance of the ESL learners (Kamwendo, 2006). All these factors could be considered language barriers that interfered with the performance of the ESL learners in English language-based tasks. The ESL learners might have achieved higher scores if the reading comprehension had been in a language they were more proficient in.

The issue of language bias in assessment and education is not new in South Africa and often results in what some authors call a misdiagnosis of language barriers as learning disorders (Foxcroft & Roodt, 2001; Pretorius & Naude, 2002). As indicated by linguists such as Alexander (2005), English remains the dominant language in today's world, even in multilingual countries like South Africa. The dominance of the English language also extends to social institutions such as schools. The issue of language thus creates an unequal playing field in education in South Africa and possibly other countries with similar linguistic characteristics.

The conundrum that South Africa faces is that despite the evidence of language biases in the learning areas, limited resources in the form of teachers and capital, to educate learners in all 11 official languages, restricts the transformative objectives of the Language in the Educational Policy (Department of Education, 1997). Language remains a contentious issue in South Africa, and the findings of this and earlier studies show that language plays a significant role in reading comprehension.

5.4.2. The effect of aircraft noise on reading comprehension

The findings of the study demonstrated a statistically significant difference between the learners exposed to aircraft noise and those in quieter areas. However, this difference was evident only in the case of the EFL speakers, who showed a substantial decrease in performance in the noisy environment. Thus, in respect of the EFL learners, these results were in line with those of earlier empirical studies, which revealed delayed reading ability for such learners exposed to chronic aircraft noise (Haines et al., 2001; Hygge et al., 2002). The findings pointed to the vulnerability of the ESL children in reading comprehension in a noisy environment. Unlike previous studies that also found significant noise effects in reading comprehension, the present study indicated the extent to which noise impacts reading comprehension performance. In this study, substantial differences ($d = 0.76$) were found in the EFL group under noisy conditions.

The largest significant difference in reading comprehension performance, when the effect of noise and language were analysed together, was observed in the EFL group. The EFL learners who were not exposed to aircraft noise performed the best in the English reading comprehension assessment. Such findings were expected as there was a better chance of processing and understanding a text or assessment when it was in one's primary language (Cain & Oakhill, 2006; Sternberg, 1996). Furthermore, given that the EFL learners in the control group were not exposed to aircraft noise, they were less likely to be distracted by noise.

However, the EFL learners in the vicinity of the airport still performed significantly better than both the ESL sample groups (control and experimental) but had significantly poorer reading comprehension in comparison to their EFL counterparts in the quieter area. These findings suggest that environmental stressors, such as aircraft noise, can compromise the performance of tasks such as reading for learners who would not be expected to struggle

with a language assessment in their primary language. In the study, the physical environment of those already proficient in English was crucial for optimal performance in classroom activities that involved the comprehension of texts. In view of the fact that the study controlled for gender, socio-economic status and intellectual ability, aircraft noise evidently hindered the reading comprehension performance of these learners. Research supports the notion that environmental noise can undermine the processes of learning and teaching (Berglund, Lindvall, & Schwela, 1999).

Conversely, the ESL group exposed to chronic aircraft noise showed little difference from the ESL group not exposed to noise in the reading comprehension assessment. This finding was not anticipated as one would expect that having to grapple with unfavourable conditions would further impair reading comprehension performance in the context of processing ‘another language’. Some research has suggested that noise can improve concentration as it raises one’s attention level (Berglund, 1995), however this research focused on noise in the test situation and would therefore not be able to account for the differences between the two groups in this study. The findings of this study call for rethinking of what is necessary for achievement in certain learning areas for different learners. An alternative explanation for the different pattern of results for the language may be found in the history of racial segregation in South Africa as race correlates strongly with home language, and different race groups typically live in different socio-economic areas. The ESL speakers in the study may well live in noisy environments unrelated to aircraft noise. There is some evidence for this in the collected data as the learners were asked about the level of noise experienced both at home and in the school environment. The noise experienced at school was greater in the group exposed to aircraft noise ($F_{1,723} = 49.23$, $p < 0.001$, $d = 0.52$), and this effect was not significantly different for the two language groups. Conversely, there was a substantial difference in the impact of the experimental condition on the two language groups when the noise at home was considered. The noise experienced at home was moderately higher for the EFL learners exposed to aircraft noise than that for the EFL

speakers not exposed to aircraft noise ($p < 0.001$, $d = 0.44$). In contrast, there was little difference in the mean scores of the ESL groups under the two experimental conditions ($p = 0.9796$, $d = -0.04$). Interestingly, both ESL groups experienced similar noise levels at home, which were not statistically significantly different from those of the aircraft-exposed noise group of the EFL learners ($d = 0.12$ experimental, $d = 0.07$ control).

5.4.3. Limitations of the study and suggestions for future research

The results of this study should be read in the context of the following limitations. Like most studies on aircraft noise, a cross-sectional analysis was done. A problem with such studies is that conclusions are correlational, and causal inferences cannot easily be made (Rosenthal & Rosnow, 1996). Consequently, it cannot summarily be said that chronic exposure to aircraft noise, for instance, causes impaired reading comprehension. True experiments that allow for the testing of causal inferences are not always practical and may compromise ecological validity as they tend to be less naturalistic (Whitley, 2002). However, although causal inferences cannot be drawn, information gained from correlational research can still contribute valuable knowledge to a field of study (Bryman, 1993).

Language is central to aspects of learning such as reading comprehension, yet it cannot be said that it is the only factor in the differences between English first language learners and English second language learners. Other variables such as learner motivation and access to learning resources in the school may be confounding with the language variable in the study and contributing to the differences observed. Factors such as learner motivation and educators' teaching style were beyond the scope of this study, but they are important areas for future research.

5.5. Conclusion

The study examined the impact of aircraft noise and language on reading comprehension in a sample of learners in Durban. The findings provide some insight into the effects that environmental noise and socio-cultural factors such as language can have on reading comprehension as part of cognitive functioning. They suggest that marginalisation can take on various dimensions, socially, culturally and even geographically. It is not suggested that because one is exposed to chronic aircraft noise, or one speaks English as a second or third language, that this necessarily means lower reading comprehension skills. Rather, the findings suggest that those who are exposed to chronic aircraft noise or who are not primary English learners are more likely to exhibit lower reading comprehension skills than those who are not in a similar situation. The findings also support the view that learners cannot be fitted into one mould; different learners have different priority needs in respect of optimal educational development. For the EFL groups, noisy environments had the greatest negative impact on reading comprehension performance while for the ESL groups, home language was a more likely predictor of reading comprehension performance.

The ability to read and comprehend a text is crucial for progression in the educational sphere and in today's world. Exposure to environmental aircraft noise and issues of language are not the only factors that affect reading comprehension. The importance of fostering the most favourable educational experience for all learners in South Africa is self-evident:

“Education is the great engine of personal development. It is through education that the daughter of a peasant can become a doctor, that a son of a mineworker can become the head of the mine, that a child of farm workers can become the president of a great nation.”
(Nelson Mandela)

5.6. Acknowledgements

The researchers would like to thank the learners who participated in the study. Without their generous participation this research would not have been possible. This material is based upon work supported financially by the National Research Foundation (NRF). Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and therefore the NRF does not accept any liability in regard thereto. This publication was also made possible (in part) by a grant from the Carnegie Corporation of New York. The statements made and views expressed are, however, solely the responsibility of the authors.

5.7. References

- Alexander, N. (2005). *Mother tongue-based bilingual education in South Africa: The dynamics of implementation*. Cape Town: Salty Print.
- Berglund, B. (1995). *Health effects of community noise*. In M. Newman (Ed.), *Proceedings of the 15th International Congress of Acoustics*. Trondheim: Acoustical Society of Norway; p. 11-5.
- Berglund, B., Lindvall T., Schwela D.H. (Eds.). (1999). *Guidelines for Community Noise*. London: World Health Organization.
- Bryman, A. (1993). *Quantity and Quality in Social Research*. London: Routledge.
- Cain, K., Oakhill, J. (2006). Assessment matters: Issues in the measurement of reading comprehension. *British Journal of Educational Psychology*, 76, 697-708.
- Clark, C., Stansfeld, S.A. (2005). The effect of aircraft noise and road traffic noise on children's reading. *Literacy Today*, 44, 9, 24-6.
- Cornoldi, C., Oakhill J. (1996). *Reading Comprehension Difficulties: Processing and Intervention*. Lawrence Erlbaum: New Jersey.
- Cummins J. (1991). Language development and academic learning. In L.M. Malavé, G. Duquette (Eds.), *Language, culture and cognition: A collection of studies in first and second language acquisition*. Clevedon: Multilingual Matters, pp. 161-75.
- de Klerk, V. (2002). Language Issues in our schools: Whose voice counts? Part 1: The parents speak. *Perspectives in Education*, 201, 1-14.
- Department of Basic Education. (2011). *Macro-Indicator Trends in the Schooling System*. Pretoria: DBE.
- Department of Education. (1997). Language in Education Policy. *Government Gazette*, 17997 (383). Pretoria: Government Printer.
- Evans, G.W., Maxwell, L. (1997). Chronic noise exposure and reading deficits: the mediating effects of language acquisition. *Environment and Behavior*, 29, 638-656.
- Foxcroft, C., Roodt, G. (2001). *An introduction to psychological assessment in the South African context*. Oxford: Oxford University Press.

- Goldman, S.R., Bisanz, G.L. (2002). Toward a functional analysis of scientific genres: Implications for understanding and learning processes. In J. Otero, J.A. León, A.C. Graesser (Eds.), *The psychology of science text comprehension*. NJ: Erlbaum, Mahwah, pp. 19-50.
- Goldschagg, P. (2007). *Airport noise in South Africa – Prediction models and their effect on land use planning*. Unpublished doctoral dissertation. University of Stellenbosch.
- Hagley, F. (1987). *Suffolk Reading Scale*. Windsor: NFER-NELSON.
- Hagley, F. (2002). *Suffolk Reading Scale II: Teacher's Guide*. London: GL Assessment.
- Haines, M.M., Stansfeld, S.A, Brenthall, J., Head, J., Berry, M., Jiggins, S. et al. (2001). The West London Schools Study: The effects of chronic aircraft noise exposure on child health. *Psychological Medicine*, 31, 1385-1396.
- Haines, M.M., Stansfeld, S.A., Job, R.F., Berglund, B., Head, J. (2001). Chronic aircraft noise exposure, stress responses mental health and cognitive performance in school children. *Psychological Medicine*, 31, 265-277.
- Hetu, R., Truchon-Gagnon, C., Bilodeau, S.A. (1990). Problems of noise in school settings. *Journal of Speech Language, Pathology and Audiology*, 14, 31-39.
- Hockey, R. (1979). Stress and the cognitive components of skilled performance. In V. Hamilton, D.M. Warburton (Eds.), *Human Stress and Cognition*. New York, NY: Wiley, p.p. 141-77.
- Hygge, S. (2003). Classroom experiments on the effects of difference noise sources and sound levels on long-term recall and recognition in children. *Applied Cognitive Psychology*, 17, 895-914.
- Hygge, S., Evans, G.W., Bullinger, M. (2002). A prospective study of some effects of aircraft noise on cognitive performance in school children. *Psychological Science*, 13, 469-474.
- Ireland-Lathy, H.L. (2006). *An assessment of reading in First Language and Second Language learners who experience barriers to learning*. Unpublished Master's Dissertation. University of the Witwatersrand.

- Jones, D. (1990). Recent advances in the study of human performance in noise. *Environment International*, 16, 447-458.
- Kamwendo, G.H. (2006). No easy walk to linguistic freedom: A critique of language planning during South Africa's first decade of democracy. *Nordic Journal of African Studies*, 15, 53-70.
- Lohman, D.F., Hagen, E.P. (2002). *Cognitive Abilities Test (Form 6): Research handbook*. Itasca, IL: Riverside.
- Orasanu, J. (1986). *Reading comprehension: From research to practice*. New Jersey: Laurence Erlbaum Associates.
- Pretorius, E., Naudé, H. (2002). A culture transition: Poor reading and writing ability among children in South African townships. *Early Child Development and Care*, 172, 439-449.
- Pumfrey, P.D. (1977). *Measuring reading abilities: Concepts, sources and applications*. Manchester: Department of Education.
- Ramaahlo, M. (2010). *The Application of the Suffolk Reading Scale (2) on South African Learners*. Unpublished M.A. dissertation. University of the Witwatersrand.
- Rivlin, L.G., Weinstein, C.S. (1984). Educational issues, school settings and Environmental Psychology. *Environment Psychology*, 4, 347-364.
- Rosenthal, R., Rosnow, R.L. (1996). *Essentials of behavioral research: Methods and data analysis*. 2nd ed. New York: McGraw Hill.
- Seabi, J., Goldschagg, P., Cockcroft, K. (2010). Does aircraft noise impair learners' reading comprehension, attention and working memory? A pilot study. *Journal of Psychology in Africa*, 20, 109-112.
- Shield, B.M., Dockrell, J.E. (2003). The effects of noise on children and schools: A review. *Building Acoustics*, 10, 97-106.
- Shield, B.M., Dockrell, J.E. (2002). *The effects of noise on the attainments and cognitive performance of primary school children*. Department of Health, United Kingdom.

- Shield, B.M., Dockrell, J.E. (2000). The Prevalence of Injuries among Pianists in Music Schools in Ireland. *Medical Problems of Performing Artists*, 15, 155-160.
- Shield, B.M., Dockrell, J.E. (2008). The effects of environmental and classroom noise on the academic attainments of primary school children. *Journal of the Acoustics Society of America*, 123, 133-144.
- Stansfeld, S.A., Berglund, B., Clark, C., Lopez-Barrero, I., Fischer, P., Ohrstrom, E. et al. (2005). Aircraft noise and road traffic noise and children's cognition and health: a cross-sectional study. *LANCET*, 365, 1942-1949.
- Sternberg, R.J. (1996). *Successful intelligence: How practical and creative intelligence determine success in life*. New York: Simon and Schuster.
- Webb, V. (1996). Language planning and politics in South Africa. *International Journal of the Sociology of Language*, 118, 139-162.
- Whitley, B.E. (2002). *Principals of research in behavioral science*. New York: McGraw Hill.

CHAPTER SIX

A Prospective Follow-Up Study of the Effects of Chronic Aircraft Noise Exposure on Learners' Reading Comprehension in South Africa

Reprinted with permission from Seabi, J., Cockcroft, K., Goldschagg, P., Greyling, M. (*In Press*). A prospective follow-up study of the effects of chronic aircraft noise exposure on learners' reading comprehension in South Africa. *Journal of Exposure Science & Environmental Epidemiology*.

Abstract: The purpose of this epidemiological study was to investigate the long-term effects of exposure to aircraft noise on the reading comprehension of a sample of South African children. In view of the impaired reading comprehension found in the noised-exposed group before the relocation of the airport, the study aimed to determine whether the effects of aircraft noise on reading comprehension remained after the relocation of the airport or whether they disappeared. A cohort of 732 learners with a mean age of 11.1 participated in baseline measurements in 2009, and 649 (mean age = 12.3) and 174 (mean age = 13.1) learners were reassessed after the relocation of the airport in 2010 and 2011, respectively. The results revealed no significant effect of the groups on reading comprehension across the testing periods, but significant effects of home language were demonstrated on reading comprehension. These findings suggest that exposure to chronic aircraft noise may have a lasting impact on children's reading comprehension.

Keywords: Epidemiology, Reading Comprehension, Aircraft Noise, Children,

6.1. Introduction

Among the rights that children have is the right to education, and it is important to ensure that these rights are not compromised in any way. In line with the democratic constitution of the Republic of South Africa (RSA), this implies that the education environment should be conducive to learning (RSA, 1996). Like the workplace and home environments, the school is also a significant micro-environment since it facilitates the psychological, physical and socio-emotional development of learners. As learners spend a good deal of time listening in the classroom, the acoustic conditions should promote clear listening. Noise interference when listening can cause problems with concentration, fatigue, irritation, misunderstandings, decreased working capacity and stress reactions (Lazarus, 1998). Research indicates that noise can lead to misunderstanding of verbal information (Klatte, Wegner, & Hellbrück, 2005). The World Health Organization (WHO, 2000) therefore recommends that the permissible level of noise in school environments should not exceed 35 dB. However, many learners do not have access to ideal or calm learning environments, particularly in less developed countries (Ana, Shendell, Brown, & Sridhar, 2009) such as South Africa. It is accordingly important to investigate and identify factors that may have an adverse effect on learning.

Extensive research has been conducted in first world countries (e.g. the United Kingdom, Germany, the Netherlands) on the effects of aircraft noise exposure on children's cognitive performance and psychological and physiological well-being. However, limited research has been done on the subject in developing countries. Reading comprehension involves higher cognitive processes such as attention and memory, which are often sensitive to exposure to chronic noise. It can therefore be argued that deficits in reading performance may be the result of noise exposure. Exposure to chronic aircraft noise was found to be associated with a six-month delay in the reading ability of 8 to 11-year-old children (Haines, Stansfeld, Job, Berglund, & Head, 2001). A recent epidemiological study in the United Kingdom, Spain and the Netherlands revealed that exposure to aircraft noise at school was associated with poorer reading comprehension and that this association was maintained even after adjustments for socio-economic variables, episodic memory (conceptual recall and

information recall), working memory and sustained attention (Clark, Martin, van Kempen, Alfred, Head, et al., 2006). Several studies (Evans & Maxwell, 1997; Hetu, Truchon-Gagnon, & Bilodeau, 1990; Hockey, 1979; Stansfeld, Berglund, Clark, Lopez-Barrio Fischer, et al., 2005) indicate a consistent pattern of association between reading comprehension and exposure to chronic noise, yet other studies (Haines, Stansfeld, Brentnall, Head, Berry et al., 2001; Hygge, Evans, & Bullinger, 2002) reveal no significant effect of noise on reading comprehension. However, when separate analyses of the 15 most difficult items in the reading comprehension test were done, a significant difference between the Low Noise and High Noise groups emerged, and this remained even after adjustment for age, socio-economic deprivation and home language (Hygge et al., 2002). This suggests that chronic exposure to aircraft noise impairs learners' performance only in respect of difficult items in reading comprehension tests. This result supports the postulation that simple cognitive tasks that require less attentional processing are not affected by noise, which may explain the non-significant results obtained in some studies (Haines et al., 2001; Hygge et al., 2002).

Of interest in the present study was whether the effects of exposure to chronic noise were reversible, and, if they were, how long it took for cognitive performance to improve. This interest was motivated by studies that suggest that the effects of chronic noise exposure are reversible. For instance, worse reading comprehension scores were found for children in classrooms on the noisy side of a school building facing a railway line than for children on the less noisy side (Bronzaft & McCarthy, 1975). The differences in reading ability between the groups disappeared in a follow-up study (Bronzaft, 1981) after a noise abatement programme, which balanced the noise levels on the front and back sides of the building. Similarly, Hygge et al. (2002) compared two experimental groups (old airport and new airport, known as the Munich Airport Study) exposed to aircraft noise and two control groups that had little exposure to aircraft noise on reading, memory and attention in a prospective study. A sample of 326 children with ages ranging between 8 and 12 years participated in

three waves of data collection: one wave began six months prior to the switch-over of the airports, and the other two waves took place after the switch-over of the airports, that is, the second was a year later and the third was two years later. Although the results revealed impairment in long-term memory and reading in the noise-exposed group at the new airport after the switch-over, improved scores were found in the formerly noise-exposed group. Short-term memory also improved in the latter group after the old airport had been closed. These results suggest that exposure to noise has an adverse effect on reading and memory, and that these effects occur prospectively, yet it is not clear whether these effects are reversible. An earlier study (Cohen & Weinstein, 1981) found that reducing the noise inside a school by 16dB had little effect on the children's school performance.

This study is a follow-up of a cross-sectional study (Seabi, Cockcroft, Goldschagg, & Greyling, 2012) conducted in South Africa in 2009 nine months before the Durban International Airport was decommissioned. The authors compared the performance of 333 (45.5%) learners who were exposed to chronic aircraft noise with 399 (54.5%) learners in quieter environments on reading comprehension. The results revealed significant differences in favour of the learners in quieter areas. Following the relocation of the Durban International Airport, post-test assessments were conducted on the same cohort of learners in 2010 and 2011, which are reported in this paper. The intention of this study was therefore to determine whether the effects of the aircraft noise on reading comprehension remained after the relocation of the airport or whether they disappeared.

6.2. Materials and Methods

6.2.1. Sampling and design

The present study adopted a longitudinal epidemiological field study design whereby repeated observations of the same variables over a three-year period (2009-2011) were made in respect of learners in the vicinity of a noisy flight path and those in quieter areas. Longitudinal studies that explore the associations between exposure to noise and reading comprehension are required not only to provide understanding of causal pathways between these variables but also to assist in the design of preventive interventions. The present analyses are based on the follow-up of the 2009 cross-sectional study with the focus on the 2010 and 2011 cohorts. The instruments obtained from the original RANCH project (Stansfeld et al., 2005) in London were piloted and based on the results, changes were made to the instruments. Data were collected over three time periods (i.e. 2009-2011). Pre-test assessments of the attention, working memory, annoyance, health and reading comprehension of the learners were done prior to the relocation of the airport in July 2009. The same learners were tracked and assessed on the above areas of functioning in August of 2010 and 2011 after the Durban International Airport had been relocated on 1 May 2010 to the new site where it is currently known as the King Shaka International Airport.

A cohort of 732 learners with a mean age of 11.1 participated in baseline measurements in 2009. A sample of 649 learners between the ages of 9 and 15 (mean age = 12.3) with 49.6 % (n=322) girls and 49.4% boys (n=321) were reassessed in 2010. Of the 649 learners, six (.92%) did not indicate their gender. In 2011, the sample comprised 174 learners of whom 53% (n=92) were girls and 47% (n=82) were boys with ages ranging from 10 to 16 years (mean age = 13.1). Participants were lost because permission to follow up on some learners in Grade 8 (i.e. in the new schools) was not granted by their school principals. Other reasons were relocation and the bad weather on the assessment day, which resulted in the

absence of many learners from school. Research indicates that although longitudinal studies are one of the strongest research methodologies for studying aetiological mechanisms (Vandenbroucke, 2008), they are vulnerable to participant attrition (Wolke, Waylen, Samara, Steer, Goodman et al., 2009). A detailed breakdown of the socio-demographic characteristics of the sample is given in Table 1.

Table 1

Socio-demographic profile of the low and high noise groups, 2010-2011: frequencies and odds ratio

	2010			2011		
	Low	Noise	High Noise	Low Noise	High Noise	
	N.	N.	N.	N.	N.	
			OR (95% CI)			OR (95% CI)
Boys	174	147		40	42	
Girls	172	150		52	40	
EFL	194	166		37	34	
ESL	120	121		26	23	
Deprived	209	209		30	36	
Not deprived	43	108		54	44	
Mean age	12.2	12.4		13.0	13.2	
Deprived	31%	39%	0.70(0.50-0.99)	43%	51%	0.73(0.39-1.35)
English	58%	62%	0.85(0.61-1.18)	67%	53%	1.8 (0.96-3.41)
Boys	50%	50%	1 (0.73-1.36)	49%	54%	0.8 (0.44-1.48)

Key: EFL= English first language; ESL= English second language; OR= Odds ratio

6.2.2. Instruments

The variables attention, working memory, annoyance, health and reading comprehension were assessed, but this study focused on reading comprehension. Detailed information on the procedure that was followed in assessing the above areas of functioning is provided elsewhere (Seabi et al., 2012). A biographical questionnaire was used to obtain biographical

data relevant to the study; the Suffolk Reading Scale (2) was used to obtain reading comprehension levels; and noise was measured with a SVAN 955 Type 1 sound level meter.

6.2.2.1. Biographical Questionnaire

The biographical questionnaire was administered to all the participants in print form and was completed prior to the assessment. It collected information on the participants' home language, age, gender, health, socio-economic deprivation, support at home and school work. Socio-economic deprivation was determined by the percentage of children eligible for free meals at school – research indicates a “significant correlation between the free school meal ratio and a range of census indicators representative of socio-economic status (Stansfeld, Haines, Brentnall, Head, Roberts et al., 2001, p. 21). A criterion for a child's eligibility for a free school meal was that the child's caregiver should be in receipt of a government social grant.

6.2.2.2. Reading Comprehension (SRS2)

Reading comprehension was measured with the Suffolk Reading Scale Level 2 (Hagley, 2002). The test comprises 86 multiple-choice sentence completion questions, each containing five potential answers. The SRS2 has a test-retest coefficient of 0.88 (Hagley, 1987). This scale measures the reading comprehension of children ranging in age from 6 years 4 months to 13 years 11 months in the United Kingdom. Although the ages of some of the participants in this study fell outside the above age category, it is important to remain cognizant of the South African context.

Inspection of international studies that used the SRS2 as a reading comprehension assessment instrument revealed that their average scores were significantly higher than those

found among the South African learners (which ranged from 35.42 to 58.78 in the High Noise and Low Noise groups, as shown in Table 2). For instance, in the West London Schools Study, a mean reading comprehension score of 96.8 with a minimum of 69 and a maximum of 128 was found after adjusting for ethnicity, primary language and age (Matsui, Stansfeld, Haines & Head, 2004). Further studies conducted around Heathrow Airport also reported participants obtaining a mean reading comprehension score of 98.48 in high noise conditions and between 100.01 and 102.66 in low noise conditions after adjusting for the same socio-demographic characteristics mentioned above (Haines et al., 2001).

The school-going age for the majority of children in England and Wales is four years (Sharp, 1998) so that they can be admitted into the reception class at the beginning of the year in which they turn five. Therefore, although the SRS2 is normed for children between the ages of 6 years 4 months and 13 years 11 months, the English standard is significantly higher than that of South African learners due to increased schooling exposure as a result of starting school earlier. A South African study found that although the SRS2 has not been standardised for South African conditions, it had a Cronbach's alpha of 0.93 when used with a sample of primary school learners (Ramaahlo, 2010). A test-retest co-efficient of 0.88 was also found in the South African context (Seabi et al., 2012).

6.2.2.3. Noise Measurements

A SVAN 955 Type 1 sound level meter was used to measure the external noise in the vicinity of the five schools in the study, and a Rion NC74 acoustic calibrator was used to test the instrument's calibration prior to and after the measurements were taken. The measurement of the noise was taken between 08:00 a.m. and 10:30 a.m., which was the period when testing took place. The baseline Leq noise measurements for the High Noise group at the noise-exposed schools near the aircraft flight path in 2009 ranged from 63.5 to 69.9 Leq. Maximum

noise levels ranged from 89.8 to 96.5dBA L_{max}. In the case of the Low Noise group at schools in quieter areas, noise measurements in 2009 yielded results of 54.4 to 55.3 Leq and 73.2 to 74.3 L_{max}. Noise measurements in 2010 and 2011, after the aircraft had gone, yielded results at the formerly noise exposed schools of 55.2 Leq and maximum noise levels of 60.8 to 71.2 L_{max}. Levels at the quieter schools averaged 50.5 to 57.9 Leq and 60.6 to 70.5 L_{max}.

6.2.3. Analysis

Statistical Analysis Software (SAS) version 9.4 was used to compute the analyses, and a univariate analysis was performed to test whether the conditions of homogeneity had been met. The reading comprehension scores were normally distributed with skewness of -0.03 and -0.05 and kurtosis of -0.14 and -0.47 for the 2010 and 2011 cohorts respectively. Repeated multiple analyses of covariance (MANCOVAs) were done in order to observe, simultaneously, reading comprehension as well as the level of noise, gender and language at the different times of testing to establish whether interactions were taking place. All the statistical tests were two-tailed, and the alpha value was set at 0.05.

6.3. Results

Given the significant difference ($F_{1,419} = 11.75, p = 0007$) found in reading comprehension between the Low Noise ($M=32.44, SD=16.7$) and High Noise ($M=29.81, SD=14.2$) groups based on the 2009 cross-sectional analyses, the present study wanted to ascertain whether statistically significant differences between these groups would be found in reading comprehension in the 2010 and 2011 cohorts.

Table 2 shows the unadjusted means, standard deviations and p-values obtained in 2010 and 2011, which did not take into account the effects of other potentially confounding variables. The reading comprehension mean score of the Low Noise group (M=43.52, SD=12.4) did not differ significantly ($p>0.1611$, .05) from that of the High Noise group (M=35.41, SD=15.7) in 2010. There was also no statistically significant difference ($p>0.0625$, .05) between the Low Noise group (M=58.78, SD=17.2) and the High Noise group (M=46.29, SD=16.8) in reading comprehension in 2011. Unlike in 2009, when a statistically significant difference was observed, no significant effects were found between the groups in reading comprehension in both 2010 and 2011 (after the removal of the noise). Although there was no statistically significant difference between the High and Low Noise groups in reading comprehension in 2010 and 2011, the reading comprehension mean scores of the Low Noise group were higher than those of the High Noise group. The absence of statistically significant differences may therefore be explained by the reduction in the sample size.

Table 2

Comparison of reading comprehension scores between the low noise and high noise groups in 2010 and 2011

Group	2010				2011			
	N.	Mean	SD	p.	N.	Mean	SD.	p.
Low Noise Group	300	43.52	12.4		85	58.78	17.2	
				0.161				0.063
High Noise Group	349	35.42	15.7		89	46.29	16.8	

* Significant at 0.05

Table 3 shows the adjusted results based on multi-variable analyses of gender, deprivation, language spoken at home and groups in reading comprehension in 2010 and 2011. As can be seen in the table, no significant effects of the groups, $F(1, 649) = 1.98, p = 0.16$, gender, $F(1, 649) = 0.46, p = 0.49$ and deprivation, $F(1, 649) = 0.73, p = 0.39$ were found in reading comprehension in 2010. Similarly, no significant effects of the groups, $F(1, 177) = 3.51, p = 0.06$, gender, $F(1, 177) = 0.19, p = 0.66$. and deprivation, $F(1, 177) = 0.09, p = 0.76$ were found in reading comprehension in 2011. However, significant effects of home language were found in reading comprehension in 2010, $F(1, 649) = 8.97, p = 0.00$ and 2011, $F(1, 177) = 10.19, p = 0.00$ thereby highlighting the impact of home language on reading comprehension. A small variance of 11% was accounted for by in 2010 and 2011.

Table 3

Reading comprehension outcome scores adjusted for gender, language and household deprivation: 2010-2011

2010					
Variables	df.	Mean Square	F.	p.	
Groups	1	398.30	1.98	0.161	
Gender	1	92.13	0.46	0.499	0.114496
Language	1	1804.26	8.97	0.003	
Deprivation	1	147.41	0.73	0.393	
2011					
Groups	1	945.86	3.51	0.062	
Gender	1	50.99	0.19	0.664	0.110473
Language	1	2743.72	10.19	0.002	
Deprivation	1	24.10	0.09	0.765	

6.3.1. The effect of removal of aircraft noise on reading comprehension

The second aim of this study was to determine whether the removal of aircraft noise leads to increased performance in reading comprehension. In order to determine whether reading comprehension scores improved after the relocation of the airport, the means for the Low Noise and High Noise groups were computed across both testing periods (Figure 1). It was

noted that the reading comprehension scores increased over time for the High Noise as well as the Low Noise groups and that the gap between the groups widened in favour of the latter group. A repeated measure of analysis of variance was conducted to ascertain whether the increase in means was statistically significant. Table 4 shows no statistically significant difference ($p>0.05$) regarding the interaction between the time (2010 and 2011) and the reading comprehension scores. Furthermore, no statistically significant effect ($p>0.05$) was found with regard to the interaction between time and group in reading comprehension. This suggests that while reading comprehension scores improved over time, the magnitude of the difference in the interaction between time and the High Noise and Low Noise groups was not strong enough to render it significant with the implication that the removal of aircraft noise did not lead to improved reading comprehension. The absence of statistical difference may be explained by the reduction in the sample size.

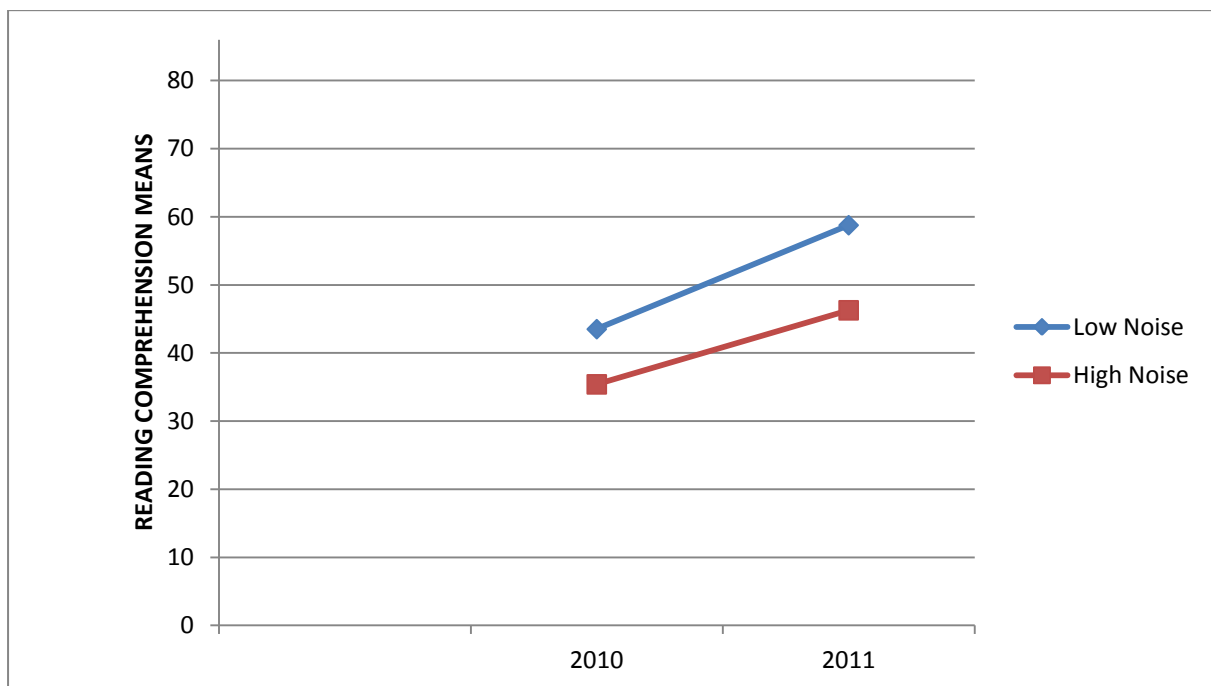


Figure 1. Line chart depicting mean scores of reading comprehension in 2010 and 2011

Table 4

Interactions between time, and time and group, in reading comprehension

	DF	F	P
Time	2	0.89	0.41
Time*Groups	4	0.39	0.68

6.4. Discussion

The purpose of this study was to determine whether the effects of aircraft noise on reading comprehension remained after the relocation of the airport or whether they disappeared. The performance of the previously noised-exposed (High Noise) learners was therefore compared to that of the learners in quieter environments (Low Noise) in reading comprehension in 2010 and 2011. There were three main findings.

First, chronic exposure to high levels of aircraft noise was not associated with reading comprehension in 2010 and 2011 despite evidence of significant effects of exposure to chronic aircraft noise that was found prior to the relocation of the airport in 2009. These results are inconsistent with previous studies, which established an exposure-effect relation between aircraft noise and reading comprehension (Evans & Maxwell, 1997; Haines et al., 2001). Although the mean scores of the reading comprehension in 2010 and 2011 were not statistically significant between the Low Noise and High Noise groups, the mean scores of the Low Noise group were higher than those of their counterparts thus replicating previous studies (Hockey, 1979; Stansfeld et al., 2005) that showed that reading comprehension scores of learners exposed to noise were lower. The lack of statistically significant differences could be attributed to the reduction in the sample size during the follow-ups.

Second, of significant interest is that in the adjusted results, while no significant effects of the groups were found in reading comprehension across all the testing periods, significant effects of language spoken at home were found in reading comprehension. This finding is consistent with previous research, which revealed that learners scored higher if they spoke the main (dominant) language of the country (Clark et al., 2006). Similarly, it was found that learners for whom the language spoken at school was an additional language were further disadvantaged by noise in the classroom (Evans & Hygge, 2007). These findings corroborate the performance of the 2009 cohort in South Africa whose reading comprehension was influenced by the language spoken at home (Seabi et al., 2012). Home language thus continues to be an important factor, especially in the assessment of cognitive performance and particularly reading comprehension.

Third, in attempting to determine whether the relocation of the airport led to improved reading comprehension scores, the results revealed increasing trends in respect of the means for both the groups, especially for the Low Noise group, although the increments were not statistically significant. The absence of a significant difference between the groups suggests that the removal of aircraft noise did not lead to improved reading comprehension. The increase in reading comprehension scores may be explained by the learners becoming 'test wise' as the same Suffolk Reading Scale 2 was administered to them each year. The increase in their scores could therefore be due to familiarity with the test. From a developmental perspective, these increments can also be explained by maturation processes. This finding is inconsistent with that of the Munich Airport Study (Evans et al., 1995; 1998; Hygge et al., 2002), which revealed that the reduction in aircraft noise exposure led to significantly improved reading comprehension scores. Given the fact that the post-measurements were carried out a year and two years following the decommissioning of the airport in the Munich Study, while in the present study they were conducted three months and 15 months after the relocation of the Durban Airport, it seems that more time may be required for the effects of

aircraft noise exposure to be reversed. On the basis of the results of this study, exposure to chronic aircraft noise seemingly impacts children's reading comprehension for at least 15 months after the removal of the noise.

In accordance with the recommendation of Matheson and his colleagues (2003, p. 39) that "research should investigate whether the effects which have been observed in the existing research persist over time, whether they become more severe, or whether children adapt to noise and catch-up with their non-noise exposed counterparts", this study attempted to follow up on the participants over a three-year period.

6.4.1. Strengths and limitations

The results of this study provide avenues for future studies, yet some limitations should be noted. To our best knowledge, this was one of the first and one of the largest studies on the African continent to explore the impact of exposure to chronic aircraft noise on children's reading comprehension. A review of the literature also indicates that few studies (Evans et al., 1998; Stansfeld et al., 2005) in this area have adopted a longitudinal field study design, partly because of the relatively high cost of and the time needed to carry out studies of this nature, as well as the potential loss of participants due to attrition. This was true in this study where the cohorts in 2009 and 2010 included samples of 732 and 650 respectively whereas in 2011 the sample was only 178. In order to obviate such problems, many studies use cross-sectional and laboratory designs that are relatively cost-effective and provide a 'snap shot' of a sample of a population at a single point in time. Major limitations of laboratory studies are, however, that the results are unlikely to have external validity regarding the impact of, for example, noise in everyday living situations (Boes, Nüesch, & Stillman, 2012), and it is difficult to shield the participants from the hypotheses of the study, which may affect their responses (Halonen, Vahtera, Stansfeld, Yli-Tuomi, Salo et al., 2012). Laboratory studies

accordingly suffer from limited generalisability to real-world settings (Basner, Muller, & Elmenhorst, 2011). Another limitation concerns the noise measurements, which should have been done in the homes as well as the classrooms. Lastly, although the Suffolk Reading Scale for measuring reading comprehension was not standardised for the South African population, this instrument was nevertheless used in the study (Ramaahlo, 2010; Seabi, Goldschagg, & Cockcroft, 2010).

In conclusion, this epidemiological field study provides compelling evidence that exposure to aircraft noise impacts negatively on learners' reading comprehension and that the effects are sustained over time even after cessation of exposure to the noise (environmental stressor). The findings have implications for education and land use planning as they indicate that schools located near airports are deleterious for optimal learning. Schools should therefore not be built near existing airports where exposure to noise exceeds the WHO (2000) recommended levels for school playgrounds.

In order to counter the loss of participants due to attrition in longitudinal studies, future studies should explore ways of retaining participants through incentives such as book vouchers. It would have been interesting to determine whether reading comprehension impairments occurred at the new airport, but this was not possible as the airport is located in an area that was previously farm land, and there are currently no residents in the vicinity. The learners in the present study should be followed up to explore the long-term developmental consequences of exposure to see whether they persist throughout their education.

6.5. Acknowledgments

The authors gratefully acknowledge assistance of the reviewers, as well as the children who participated in the study. They would also like to thank Stephen Stansfeld and Charlotte Clark for allowing them access to the RANCH test materials.

This material is based upon work supported financially by the National Research Foundation (NRF). Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and not necessarily the NRF. This publication was also made possible (in part) by a grant from the Carnegie Corporation of New York.

6.6. Conflict of interest

There are no conflicts of interest to declare.

6.7. References

- Ana, G., Shendell, D., Brown, G., Sridhar, M. (2009). Assessment of Noise and Associated Health Impacts at Selected Secondary Schools in Ibadan, Nigeria. *Journal of Environmental and Public Health* (6 pages). doi:10.1155/2009/739502. Retrieved 16 December 2012. <http://www.hindawi.com/journals/jep/2009/739502/>
- Basner, M., Muller, U., Elmenhorst, E.M. (2011). Single and combined effects of air, road, and rail traffic noise on sleep and recuperation. *Sleep*, 34(1), 11-23.
- Boes, S., Nüesch, S., Stillman, S. (2012). *Aircraft noise, health and residential sorting: Evidence from two quasi-experiments*. Health, Econometrics and Data Group. The University of York. Retrieved 16 February 2013, http://www.york.ac.uk/media/economics/documents/herc/wp/12_21.pdf
- Bronzaft, A.L., McCarthy, D.P. (1975). The effects of elevated train noise on reading ability. *Environment and Behavior*, 7, 517-527.
- Bronzaft, A.L (1981). The effect of a noise abatement program on reading ability. *Journal of Environmental Psychology*, 1, 215-222.
- Clark, C., Martin, R., van Kempen, E., Alfred, T., Head, J., Davies, H.W. et al. (2006). Exposure-effect relations between aircraft and road traffic noise exposure at school and reading comprehension: the RANCH project. *American Journal of Epidemiology*, 163(1), 27-37.
- Cohen, S. & Weinstein, N. (1981). Nonauditory effects of noise on behavior and health. *Journal of Social Issues*, 37, 36.
- Evans, G.W., Hygge, S. & Bullinger, M. (1995). Chronic noise and psychological stress. *Psychological Science*, 6, 333-338.

- Evans, G.W., Hygge, S., Bullinger, M. (1998). Chronic noise exposure and physiological response: A prospective study of children living under environmental stress. *American Psychological Society*, 9, 75-77.
- Evans, G.W. & Hygge, S. (2007). Noise and performance in children and adults. In L. Luxon, D. Prasher (Eds.), *Noise and its Effects*. London: Whurr.
- Evans, G.W., Maxwell, L. (1997). Chronic noise exposure and reading deficits: the mediating effect of language acquisition. *Environment and Behavior*, 29, 638-656.
- Hagley, F. (2002). *Suffolk reading scale 2*. Windsor, United Kingdom: NFER-NELSON.
- Hagley, F. (1987). *Suffolk Reading Scale*. Windsor, United Kingdom: NFER-NELSON.
- Haines, M.M., Stansfeld, S.A., Brentnall, S., Head, J., Berry, B., Jiggins, M., Hygge, S. (2001). The West London schools study: The effects of chronic aircraft noise exposure on child health. *Psychological Medicine*, 31, 1385-1396.
- Haines, M.M., Stansfeld, S.A., Job, R.F.S., Berglund, B., Head, J. (2001). Chronic aircraft noise exposure, stress responses, mental health and cognitive performance in school children. *Psychological Medicine*, 31, 265-277.
- Halonen, J.I., Vahtera, J., Stansfeld, S., Yli-Tuomi, T., Salo, P., Pentti, J., Kivimaki, M., Lanki, T. (2012). Associations between Nocturnal Traffic Noise and Sleep: the Finnish Public Sector Study. *Environmental Health Perspectives*, 120(10), 1391-1396.
- Hetu, R., Truchon-Gagnon C., Bilodeau, S.A. (1990). Problems of noise in school settings: A review of literature and the results of an exploratory study. *Journal of Speech Language, Pathology and Audiology*, 14, 31-39.

- Hockey, R. (1979). Stress and the cognitive components of skilled performance. In V. Hamilton, D.M. Warburton (Eds.), *Human Stress and Cognition*. New York: Wiley, pp. 141-177.
- Hygge, S., Evans, G.W., Bullinger, M. (2002). A prospective study of some effects of aircraft noise on cognitive performance in school children. *Psychological Science*, 15(5), 469-474.
- Klatte, M., Wegner, M. Hellbrück, J. (2005). *Noise in the school environment and cognitive performance in elementary school children*. Part B – Cognitive psychological studies. Forum Acusticum, Budapest.
- Lazarus, H. (1998). Noise and Communication: The present state. In N.L. Carter, R.F.S. Job (Eds.), *Noise as a Public Health Problem*, 1,157-162. Noise Effects '98 PTY Ltd. Sidney, Australia
- Matheson, M.P., Stansfeld, S.A., Haines, M.M. (2003). The Effects of Chronic Aircraft Noise Exposure on Children's Cognition and Health: 3 Field Studies. *Noise & Health*, 5(19), 31-40.
- Matsui, T., Stansfeld, S., Haines, M., Head, J. (2004). Children's Cognition and Aircraft Noise Exposure at Home – The West London Schools Study. *Noise & Health*, 7(25), 49-58.
- Ramaahlo, M. (2010). *The Application of the Suffolk Reading Scale (2) on South African Learners*. Unpublished Master's thesis. University of the Witwatersrand, South Africa.
- Republic of South Africa (RSA). (1996). *Constitution, The Bill of Rights*. Pretoria: Government Printers.

- Seabi, J., Goldschagg, P., Cockcroft, K. (2010). Does aircraft noise impair learners' reading comprehension, attention and working memory? A pilot study. *Journal of Psychology in Africa*, 20(1), 101-104.
- Seabi, J., Cockcroft, K., Goldschagg, P., Greyling, M. (2012). The impact of aircraft noise exposure on learners' reading comprehension in South Africa: The moderating effect of home language. *Noise and Health*, 19, 29-37.
- Sharp, C. (1998). *Age of starting school and the early years curriculum*. Paper presented at the NFER'S annual conference. October. London, United Kingdom.
- Shield, B., Dockrell, J. (2008). The effects of environmental and classroom noise on the academic attainments of primary school children. *Journal of the Acoustical Society of America*, 123, 133-144.
- Stansfeld, S.A., Berglund, B., Clark, C., Lopez-Barrio, I., Fischer, P., Öhrström, E., Haines, M.M., Head, J., Hygge, S., van Kamp, I., Berry, B.F. (2005). Aircraft and road traffic noise and children's cognition and health: a cross-national study. *LANCET*, 365 (9475), 1942-1949.
- Stansfeld, S., Haines, M., Brentnall, S., Head, J., Roberts, R., Berry, B., Jiggins, M. (2001). *West London Schools Study: aircraft noise at school and children's cognitive performance and stress responses*. Department of Health.
- Vandenbroucke, J.P. (2008). Observational Research, Randomised Trials, and Two Views of Medical Science. *PLoS Med.* 5(3), e67. doi:10.1371/journal.pmed.0050067
- Wolke, D., Waylen, A., Samara, M., Steer, C., Goodman, R., Ford, T., Lamberts, K. (2009). Does selective drop out lead to biased prediction of behaviour disorders. *British Journal of Psychiatry*, 195, 249-256.
- World Health Organisation. (2000). *Guidelines for Community Noise*.

CHAPTER SEVEN

Combining the Findings

7.1. Introduction

This chapter covers the results presented in Chapters Three to Six. The main aims of the overall study are reviewed, followed by a discussion on the integration of the findings of the four studies dealt with in this thesis. The implications of the results are considered as are the contributions of the research to the body of knowledge on environmental health, specifically in relation to chronic aircraft noise exposure among children. The extent to which generalisations from the results can be made are discussed together with recommendations for future studies.

7.1.2. Aim of the study

Zusman (2007) notes that aircraft noise in a school environment can change following the sound insulation of classrooms, the opening or closing of airport runways, the opening or closing of an entire airport, and so on. The present study focused on the relocation of the Durban International Airport from Durban Central to another area, La Mercy. Given this rare opportunity to investigate the consequences of the relocation of an airport, the fundamental aims of the study were to investigate whether learners who were exposed to chronic aircraft noise experienced interference with their learning and social activities, performed poorly in a reading comprehension test and/or experienced higher levels of annoyance than their peers in schools in quieter areas. The synthesis of the data on three types of transport noise sources, namely roads, airways and railways, indicated that aircraft noise produced a stronger annoyance response than the other sources (Miedema & Vos, 1998). This study consequently set out to investigate the effects of chronic exposure to aircraft noise. Aircraft noise was considered a stressor in the study because people exposed to unwanted noise tend to react to it in a similar fashion to any other stressor.

Unlike previous empirical studies (Haines et al., 2001a), with the exception of the Munich Airport Study, this study was able to make use of the opportunity resulting from the relocation of the Durban Airport to investigate the long-term effects of exposure to aircraft noise on children's learning and their development. Chapters Three to Six discuss the results of studies conducted and in this chapter, the results of the four studies undertaken for the purposes of this thesis are discussed and integrated in relation to the fundamental aims of the thesis.

7.2. Main Results

The main question posed in the study was whether exposure to chronic aircraft noise interfered with the learners' learning and social activities. Specifically, the learners were asked whether they found that the aircraft noise interfered with their outdoor recreation, their ability to listen to the educator and their ability to work quietly and collaboratively in groups in the classroom. In comparison to their peers from quieter school backgrounds, these learners reported that air traffic noise interfered significantly with the above activities throughout all the waves of the study (i.e. 2009 to 2011). These findings corroborate those of previous studies where the children reported interference from aircraft noise with their classroom activities such as thinking and working (Haines & Stansfeld, 2000). The results are also consistent with Miedema's (2007) model, which lists four types of interference that can result from exposure to environmental noise. Against the background of Miedema's model, it is evident that the learners in this study experienced communication disturbance (sound masking) as they could not clearly hear the educator, nor could they hear one another when working or playing in groups. Environmental noise thus reduces speech comprehension through masking and consequently affects the mental processing of information. Because the schools of these learners in the study group were located adjacent to flight paths and close to runways, it was probably almost impossible to maintain an uninterrupted conversation.

A crucial question that remains is why the children continued to experience interference even after the relocation of the airport and the accompanying removal of the noise. A possible answer is that these learners may have adapted to noise interference during activities by filtering out sound stimuli, including unwanted noise, and that this tuning-out strategy may have been generalised to all situations, whether or not noise was present, thus affecting their concentration and learning over time even in the absence of noise exposure (Cohen et al., 1986; Haines et al., 2001). These learners may thus have developed poorer ability to maintain attention in the classroom.

These learners continued to report not only disturbance or interference but also higher annoyance – a stress response – than their counterparts in the control group despite the relocation of the airport as discussed in the first study presented in Chapter Three. It was anticipated that, after the relocation of the airport, the annoyance experienced by these learners from aircraft noise would abate. In view of the fact that only aircraft noise measurements were conducted, other sources of noise, such as road or railway traffic, may have confounded or skewed the findings. A significant limitation of the study in this regard concerns the questionnaires, which were closed-ended and offered no option for the learners to provide detailed qualitative responses. Exposure to aircraft noise may, however, also have long-term effects that are not immediately reversible after the cessation of the noise exposure. The learners therefore continued to report interference and annoyance, possibly due to the residuals of exposure to aircraft noise. Indeed, an earlier study revealed that reducing the noise inside a school by 16 dB(A) had little effect on improving the learners' performance (Cohen, Evans, Krantz, Stokols, & Kelly, 1981). It was also found, in another study, that despite the removal of aircraft noise resulting from the closure of an airport, it took several years before the adverse effects of exposure to noise ceased (Hygge, Evans, & Bullinger, 1996).

As the measurement of interference was based on the learners' subjective reports, an objective measurement was also used to verify whether chronic exposure to aircraft noise impaired the learners' reading comprehension performance. The Suffolk Reading Comprehension Scale was administered, and the cross-sectional results revealed that the learners from noisy environments performed significantly less well than their peers in quieter environments ($p = 0007$). These findings corroborate a growing consensus that exposure to noise impacts adversely on reading comprehension (Clark et al., 2006; Evans, 1998; Haines et al., 2001; Hygge et al., 1996; Stansfeld et al., 2005). Auditory language processing, which is an integral part of reading comprehension, is therefore understandably sensitive to exposure to environmental noise. Auditory language processing consists of central auditory processing and language processing, where central auditory processing encompasses the processing and interpretation of auditory signals as they travel along the auditory pathway to the brain (Phillips, 2007), and where language processing is described as the ability to attach meaning to auditory signals using linguistic knowledge (Richard, 2001). Of the vast amount of information detected by the sensory organs during a cognitive task, some parts are identified, selected and organised through perceptual and attentional processes. In further processing, relevant data may be 'filed' and compared with what is already kept in the long-term memory. In tasks with the highest mental load, that is, those that require considerable cognitive resources, central processing is needed to select and execute an appropriate response. In all stages, there are individually determined capacity limitations that may be disturbed by intrusive or intervening factor(s) in information processing (Gamberale, Kjellberg, Akerstedt, & Johansson, 1990). This was confirmed by a separate aspect of this study that compared the auditory language processing performance of noise-exposed children to that of those children from quieter backgrounds (Hollander & de Andrade, 2013). The results revealed significantly below average scores in all the auditory language processing subtests among the children from schools exposed to noise ($p = 001$). These results suggest that chronic exposure to aircraft noise may impair children's auditory language processing.

In addition to the cross-sectional analyses, it was the intention of this study to explore the developmental or longitudinal impact of chronic exposure to aircraft noise on reading comprehension. Post-test assessments were therefore conducted in 2010 and 2011 after the relocation of the airport. In contrast to the cross-sectional effects of aircraft noise that were demonstrated in reading comprehension, the longitudinal post-test results revealed no effects of group (i.e. the Low Noise and High Noise groups) or demographic variables (i.e. gender and socio-economic status) on reading comprehension. The present findings failed to corroborate the findings of the Munich Airport Study, which indicated significantly increased reading comprehension following the decommissioning of the airport (Evans et al., 1998; Hygge et al., 2002). As the post-test assessments were conducted just under a two-year period in the present study, more time may have been required before the reversal of the reading comprehension impairment could be demonstrated. The lack of significant results may also have been due to the high attrition rate of the participants in the follow-up study. It can therefore be argued that chronic exposure to aircraft noise may have negative effects on learners' reading comprehension that remain for at least 15 months after the removal of the noise (the relocation of the airport in the case of the present study). This body of literature indicates that exposure to aircraft noise impacts negatively on children's reading comprehension, yet factors such as language spoken at home, socio-economic deprivation and gender, which may confound and/or interact with the effects of noise, are often not reported. Unlike many of the countries reporting research in this field, South Africa is a culturally, linguistically and socio-economically diverse country. Consequently, these demographic factors were taken into account during the analyses, and the variable 'language spoken at home' was found to have a significant effect on reading comprehension. The results indicated that the learners who were exposed to chronic aircraft noise and who did not speak English as a first language performed significantly worse in reading comprehension tests than their counterparts. This is important in the South African context as it suggests that these learners experienced a double disadvantage: exposure to noise and the fact that they spoke English as an additional language. These findings provide additional evidence that

cognitive tasks relying on the central processing of language are susceptible to the effects of exposure to noise and that these effects seem to persist over time.

The best-researched subjective response to noise appears to be annoyance, but this has been investigated generally only in adult populations (Banerjee, 2013; Lekaviciute & Argalasova-Sobotova, 2013; Shepherd, Welch, Dirks, & Mathews, 2010). Research is also needed on how children perceive and react to changes in aircraft noise exposure. This is important, especially since children are more vulnerable to environmental stressors than adults, and also because they generally cannot choose where they want to live or be educated (Bistrup, Hygge, Keiding, & Passchier-Vermeer, 2001). The long-term effects of chronic exposure to aircraft noise on children remain unknown. The learners who were exposed to aircraft noise (High Noise group) in the present study reported higher levels of annoyance both prior to and 18 months after the relocation of the airport than those from quieter environments. These findings are consistent with those of previous studies, which indicated that children attending schools exposed to chronic aircraft noise were significantly more annoyed by noise than their counterparts (Evans, Hygge, & Bullinger, 1995; Haines, Stansfeld, Job, Berglund, & Head, 2001). Recently, children who were exposed to aircraft noise at primary school were followed up six years later at high school, where they were still exposed to aircraft noise, and they were found still to have high noise annoyance responses (Clark, Head, & Stansfeld, 2013). A unique finding in the present study was that the learners continued to demonstrate high annoyance levels to noise despite the relocation of the airport and thus the removal of the noisy conditions. These results support Miedema's (2007) contention that exposure to environmental noise may lead to impairment of cognitive performance, such as poor or reduced reading comprehension, and long-term unwanted emotional reactions, such as annoyance, when noise interferes with their behaviour (e.g. communication, concentration) or a desired state (e.g. relaxation, sleep). These findings are consistent with those of empirical studies in the past that indicated that chronic exposure to

noise created annoyance in the research participants (Stansfeld & Matheson, 2003). The present findings also corroborate those found in South Africa with an older sample where the participants reported experiencing annoyance due to aircraft noise exposure as it interfered with their sleeping, studying, watching television and maintaining conversations (Pillay, Archary, & Panday, 2011).

Given the increasing demands for air transportation due to convenience and cost effectiveness, as well as studies based on exposure-effect associations of different sources of noise on annoyance, which reveal that aircraft noise produces greater annoyance responses than other noise sources at the same level of exposure (Miedema & Odshoorn, 2001; Miedema & Vos, 1998), it is imperative that strategies for ensuring that the school environments are conducive to learning are implemented. These strategies could include double-glazing of windows and building sound insulation barriers. Because of the poor quality of most schools in the Durban area and the high cost of soundproofing, sound amplification systems could be used to improve the audibility of educators by amplifying their voice so that they can be easily heard against the background noise.

The present study also revealed that the learners who were exposed to noise used more coping strategies than their peers both prior to and following the relocation of the airport. It was expected that these learners would cease using these strategies after the relocation of the airport as they would consider them no longer necessary. However, this could be explained by the notion that when participants experience a change in noise exposure, they change some of their coping strategies, specifically those more overt noise-mitigating behaviours such as covering one's ears and closing windows, while more subtle cognitive strategies such as tuning out information may be retained, at least for a while following the cessation of the noise (Raw & Griffiths, 1990).

In terms of psychological stress theory, the present study does indeed contribute to the body of knowledge on noise-induced annoyance. Exposure to aircraft noise leads not only to greater perceived disturbance but also directly impacts learners' reading comprehension performance resulting in high annoyance levels and the need to protect themselves from such an environmental stressor. This study supports Stallen's (1999) theory that an external stimulus, such as exposure to aircraft noise, prevents the attainment of goals such as hearing an educator, learning a lesson or reading and understanding a written text. Learners therefore engage in secondary appraisal in an attempt to assess whether they have the resources and whether they can apply them in order to cope with environmental noise. Some of the strategies they implement may be detrimental such as filtering or tuning out all noise. As soon as they realise that their cognitive and behavioural coping strategies are ineffective, annoyance may develop.

In terms of health, the learners in the present study were asked whether they thought the air traffic noise had a significant effect on their general health and whether they experienced headaches and stomach pains, and/or had difficulty sleeping. The findings revealed no significant impact of noise on the subjective reporting of health. While some limited studies have explored the exposure-effect associations between sleep disturbance and noise exposure among children, a previous study found a significant exposure-effect association between road traffic noise and sleep quality and perceived interference (Öhrström, Hadzibajramovic, Holmes, & Svensson, 2006). Health (measured in terms of blood pressure) was found to be associated with exposure to environmental noise in a recent study conducted with an adult sample (Babisch & van Kamp, 2009). Future studies should use both subjective perceptions and objective measurements to ascertain the impact of noise exposure on children's health.

7.3. Theoretical and Practical Contribution of the Research

This thesis makes a substantial theoretical contribution to research in this field because of its support for, and relevance to, Stallen's (1999) and Miedema's (2007) models in an African context. The thesis also makes a methodological contribution by illustrating the value of longitudinal, naturalistic research with a prospective design in environmental health studies as cause and effect relationships are more easily investigated, and the results can be generalised towards a larger population. Longitudinal designs also provide stronger internal validity and permit examination of changes in behaviours over time (Evans & Lepore, 1993). Of significant interest is the finding that, while aircraft noise exposure impacts on learners' activities and performance, these effects appear not to be reversible within at least 18 months after the removal of the noise.

The thesis also makes a practical contribution as it demonstrates that learners living in aircraft noise-exposed areas are not only disturbed by the noise, but their reading comprehension is also negatively affected, resulting in higher annoyance and the use of more coping strategies than learners from quieter environments. The findings from the four studies that formed the basis of the thesis add to the growing research evidence on international airports and provide scientific proof that exposure to chronic aircraft noise has a negative impact on learners' learning, social activities and reading comprehension, and that these learners experience high levels of annoyance that continue even after the noise has abated. The results also provide new evidence, contrary to the results of the Munich Airport Study, (which demonstrated improved performance on reading comprehension after the relocation of the airport (Hygge et al., 2002), as the observed effects of noise on reading comprehension in the present study appeared not to be reversible. These effects may have long-term implications, particularly for English second-language learners. These findings should be considered when developing policy on noise exposure limits, the location of school buildings and the construction of airports.

By tightening the regulations on aircraft noise, the annoyance responses of learners residing in the vicinity of an airport may be reduced and their reading comprehension performance improved. Effective reading comprehension underpins all scholastic success as evidenced by the Standardised Assessment Tests [SATs] results (Shield & Dockrell, 2003). Cause for concern is that the 1998 White Paper on National Policy on Airports and Airspace Management, which aims to integrate airports into their environments in South Africa, has still not been adopted.

Because of the large number of children in South Africa who are exposed to high levels of environmental noise, radical action is needed to ensure that school environments are conducive to the learning and social development of children. None of the high academic achievers interviewed by Bronzaft (1996) later in their lives (see her book *Top of the Class*) reported growing up in noisy and unfavourable home and school environments. It should thus be everyone's responsibility to ensure that noise does not deprive children of the nurturing and favourable conditions necessary for effective learning and development. Pillay et al. (2011) also report that families living in the vicinity of airports in South Africa have complained about excessive exposure to aircraft noise and have expressed concern that it can undermine their auditory and psychological well-being.

7.4. Limitations of the study

Like any other research, this study had certain limitations, which were discussed in each of the chapters (i.e. Chapters Three to Six), but the major limitations are dealt with in this section. A longitudinal developmental research design can answer cause-effect questions that are not easily answered by other research designs, but it has the limitation that participants may be lost in the course of observing them recurrently over a period of time. This was evident in Wave 3 of this study, which focused solely on aircraft noise to the exclusion of

noise sources such as railway and road traffic noise. This may have skewed the research results. In addition, while longitudinal studies have a stronger ecological validity, they also lack internal validity. Although the instruments used in the study were found to have moderate to high internal validity, some of the instruments such as those that measured noise annoyance were psychometrically weak as they involved Likert scale with forced choice. The focus of the study was on whether statistically significant differences existed between the experimental and control groups at each interception (wave), not necessarily within the groups. As a result, within-group analyses will be conducted for a separate manuscript (that is not form part of the thesis). Given that a non-probability purposive sampling technique was used in the selections of schools and participants, generalisation of the results is limited due to lack of representative of the population. Noise measurements were not conducted in the home environments but only in the school environments and, even then, not inside the classrooms.

7.5. Suggestions for Future Research

Chapters Three to Six in this thesis concluded with recommendations for future studies. As a result, these recommendations are not reiterated in this section; instead, further suggestions for future research are made.

- 1) Given the scarcity of longitudinal studies on the long-term effects of exposure to aircraft noise on children, it is planned that the learners who participated in this study will be traced and assessed after five years to determine their performance in the various assessments relative to their peers from quieter areas.
- 2) Future studies should employ longitudinal designs so that cause-effect relations can be clearly established. Because of the potential loss of participants over time

(Paunovic, Stansfeld, Clark, & Belojevic, 2011), as was the case in Wave 3 of this study, short questionnaires should be used and incentives given in the form of book vouchers, for instance, to encourage continued participation.

- 3) Noise measurements in this study were done only in the schools due to limited resources. Future research should explore the effect of exposure to aircraft noise both at home and school.
- 4) This study focused on exposure to aircraft noise to the exclusion of other sources of noise such as railways and roads. Comparative research should therefore be conducted on the effect of alternative noise sources on children's learning and development. Because road traffic noise is also high in the urban areas of South Africa, future studies should also explore the effects of this noise.
- 5) In this study, the learners were asked whether they believed that exposure to aircraft noise had an impact on their health, and the responses revealed no significant relation between these variables. Future studies should therefore employ both subjective and objective measurements of health.
- 6) Given the high costs of installing sound insulation systems in school buildings, it is recommended that schools should be located far away from noise sources; that stricter laws regarding noise pollution should be promulgated and that awareness should be raised about the potentially harmful effects of noise.
- 7) A review of the literature revealed that policy on aircraft noise is not well developed in developing countries, such as South Africa, compared to that in first world countries. It is therefore suggested that the drafting of noise policy in developing countries should receive urgent attention.

- 8) South Africa is a developing country with high rates of unemployment, poverty and illiteracy, as well as a lack of awareness of the non-auditory effects resulting from exposure to noise on children's learning, health and psychological development. The government may consequently be paying insufficient attention to the impact of exposure to environmental noise on children. The scholarly community should therefore draw attention to the learning and health risks of chronic exposure to environmental noise through the publication of articles in scholarly journals as well as in local newspapers.

7.6. Conclusion

This study was undertaken in response to calls for research on whether children's performance and health were affected by exposure to aircraft noise and whether such impairments (if found) were reversible (Mathews, 2009; van Kempen, 2008). The findings of the study revealed that exposure to chronic aircraft noise in learning environments had considerably worse adverse effects on these children's learning and social activities, such as school work, playing and reading comprehension, than was the case with the children in quieter learning environments. It was also found that the noise-exposed learners were substantially more annoyed by noise and that they used more coping strategies than did the children in quieter environments. It is evident that children are vulnerable to the adverse effects of exposure to aircraft noise. The government and education stakeholders involved in policy formulation and implementation should therefore strive to ensure that children's learning environments are conducive to learning and are free from excessive environmental noise.

7.7. References

- Adams, M., Moore, G., Cox, T., Croxford, B., Refaee, M., Sharples, S. (2006) Sustainable Sounds capes: Noise Policy and the Urban Experience. *Urban Studies* 43(13), 2385-98.
- Airbus (2007). *Global Market Forecast 2007-2026*. Airbus, Blagnac Cedex.
- American National Standards Institute. (2002). *American National Standard acoustical performance criteria. Design requirements and guidelines for schools* (ANSI S12. 60-2002). New York, NY: Author.
- Ana, G., Shendell, D., Brown, G., Sridhar, M. (2009). [Assessment of Noise and Associated Health Impacts at Selected Secondary Schools in Ibadan, Nigeria](#). *Journal of Environmental and Public Health*, 6 pages.
- Arndt, A., Braun, T., Eichinger, A., Pansch, H. (2009). *Economic catalytic impacts of air transport in Germany – The influence of connectivity by air on regional economic development*. Paper presented at the 13th Air Transport Research Society Conference, Abu Dhabi, June 2009.
- Babisch, W. (2011). Cardiovascular effects of noise. *Noise & Health*, 13, 201-204.
- Babisch W. (2003). Stress hormones in the research on cardiovascular effects of noise. *Noise & Health*, 5(18), 1-11.
- Babisch, W. (2005). Noise and health. *Environmental Health Perspectives*, 113(1), A14-A15.
- Babisch, W., van Kamp, I. (2009). Exposure-response relationship of the association between aircraft noise and the risk of hypertension. *Noise & Health*, 11(44), 161-168.
- Banerjee, D. (2013). Road traffic noise and self-reported sleep disturbance: Results from a cross-sectional study in western India. *Noise and Vibration Worldwide*, 44(2), 10-17.
- Belojevic, G., Jakovljevic, B., Slepcevic, V. (2003). Noise and mental performance: Personality attributes and noise sensitivity. *Noise & Health*, 6(21), 77-89.
- Berglund, B. (1998). *Community noise in a public health perspective*. In V.C. Goodwin, D.C. Stevenson (Eds.), *Inter-Noise 98*, vol. 1, pp. 19-24, New Zealand Acoustical Society, Auckland.
- Ben-Shlomo, Y., Kuh, D. (2002). A life course approach to chronic disease epidemiology: Conceptual models, empirical challenges, and interdisciplinary perspectives. *International Journal of Epidemiology*, 31, 285-293.

- Berglund, B., Lindvall, T. (1995). *Community Noise*. Archives of the Center for Sensory Research. Stockholm, 2(1), 1-195.
- Berglund, B., Lindvall, T., Schwela, D. (1999). *Guidelines for Community Noise*. World Health Organization. Geneva, Switzerland.
- Bistrup, M.L., Hygge, S., Keiding, L., Passchier-Vermeer, W. (2001). *Health Effects of Noise on Children and Perception of Risk of Noise*. Copenhagen: National Institute of Public Health.
- Bjerregaard, R. (1998). Europe 4th Environment Ministers' Conference. Aarhus, Denmark, 23 June 1998. European Commission. SPEECH/98/135 23/06/1998.
- Black, D., Black, J., Issarayangun, T., Samuels, S. (2007). Aircraft noise exposure and resident's stress and hypertension: A public health perspective for airport environmental management. *Journal of Air Transport Management*, 13(5), 264-276.
- Blomberg, L., Morris, D. (1999). *Sound decisions*. The New Rules, Winter, 1999, pp. 16-20.
- Boeing (2010). *Current market outlook*. <http://www.boeing.com/commercial/cmo>
- Braun, T., Klophaus, R., Lueg-Arndt, A. (2010). *Wider economic benefits of air transport: estimating consumer surplus for Germany*. Proceedings of 12th World Conference of Transport Research, Lisbon, July 2010.
- Bronzaft, A.L. (2004). Noise pollution. In R.M.Stapleton (Ed.), *Pollution A to Z* [online] =22&docNum=CX340810018 New York: Macmillan Reference USA. Available: <http://galenet.galegroup.com/servlet/eBooks?ste0>> (Retrieved 27 May 2009)
- Bronzaft, A.L. (1996). *Top of the class*. Greenwich, CT: Ablex Publishing Corporation.
- Campbell, J.M. (1983). Ambient stressors. *Environment and Behavior*, 15, 355-380.
- Chen, T.J., Chen, S.S. (1993). Effects of aircraft noise on hearing and auditory pathway function of school-age-children. *International Archives of Occupational and Environmental Health*, 65 107-111.
- Chen, T.S., Chen, P., Hsieh, H., Chiang, H. (1997). Auditory effects of aircraft noise on people living near an airport. *Archives of Environmental Health*, 52, 45-50.
- Clark, C., Head, J., Stansfeld, S. (2013). Longitudinal effects of aircraft noise exposure on children's health and cognition: A six-year follow-up of the UK RANCH cohort. *Journal of Environmental Psychology*, 35, 1-9.
- Clark, C., Stansfeld, S.A. (2007). The effect of transportation noise on health and cognitive development: A review of recent evidence. *International Journal of Comparative Psychology*, 20, 145-158.

- Clark, C., Martin, R., van Kempen. E., Alfred, T., Head, J., Davies, H.W. et al. (2006). Exposure-effect relations between aircraft and road traffic noise exposure at school and reading comprehension: the RANCH project. *American Journal of Epidemiology*, 163(1), 27-37.
- Cohen, S., Evans, G.W., Stokols, D., Krantz, D.S. (1986). *Behavior, Health, and Environmental Stress*. New York: Plenum.
- Cohen, S., Evans, G.W., Krantz, D.S., Stokols, D., Kelly, S. (1981). Aircraft noise and children: Longitudinal and cross-sectional evidence on adaptation to noise and the effectiveness of noise abatement. *Journal of Personality and Social Psychology*, 40, 331-345.
- Cohen, S., Spacapan, S. (1984). The social psychology of noise. In D.M. Jones, A.J. Chapman (Eds.), *Noise and Society*. Chichester: John Wiley & Sons, Chapter 9, pp. 221-245.
- Crocker, M.J., Ray, W. (1978). Noise of air transportation to nontravelers. In D.N. May (Ed.), *Handbook of Noise Assessment*. USA: Van Nostrand Reinhold Company.
- Dockrell, J., Shield, B. (2012). The impact of sound field systems on learning and attention in elementary school classrooms. *Journal of Speech, Language, and Hearing Research*, 55, 1163-1176.
- Dockrell, J. E., Shield, B.M. (2006). Acoustical barriers in classrooms: the impact of noise on performance in the classroom. *British Educational Research Journal*, 32(3), 509-525.
- enHealth Council Australia (2004). *The Health Effects of Environmental Noise – Other Than Hearing Loss*. May 2004.
- European Commission (2002). Directive 2002/49/EC, 25 June 2002 relating to the assessment and management of environmental noise.
- European Environment Agency (2003). *Europe's environment: the third Assessment*. EEA Summary Report. Copenhagen.
- Evans, G.W., Hygge, S., Bullinger, M. (1998). Chronic noise exposure and physiological response: A prospective study of children living under environmental stress. *American Psychological Society*, 9, 75-77.
- Evans, G.W., Hygge, S., Bullinger, M. (1995). Chronic noise and psychological stress. *Psychological Science*, 6, 333-338.
- Evans, G.W., Lepore, S.J. (1993). Nonauditory effects of noise on children: A critical review. *Children Environments*, 10, 31-51.

- Evans, G.W. (1998). “The motivational consequences of exposure to noise”. In Proceedings of the Seventh International Congress on Noise as a Public Health Problem, edited by N. Carter and R.F.S. Job ~Noise Effects of Ltd., Sydney, Australia!, Vol. 1, pp. 311–320.
- EyeWitness. (2003). *The Wright Brothers – First Flight, 1903*. Available from: <http://www.eyewitnesstohistory.com/wright.htm> (Retrieved February 16 2013)
- Fidell, S. (1992). Interpreting findings about community response to environmental noise exposure: what do the data say? *Proc. I.O.A.*, 14(4) (Euro-Noise)
- Fields, J.M. (1992). *Effect of Personal and Situational Variables on Noise Annoyance with Special Reference to Implications for en Route Noise*. Federal Aviation Administration Office of Environment and Energy, Washington, D.C. and Nasa Langley Research Center, FAA-AEE-92-03: Hampton.
- Fields, J.M., De Jong, R.G., Gjestland, T., Flindell, I. H., Job, R.F.S., Kurra, S., Lercher, P., Vallet, M., Yano, T., Guski, R., Felscher-Suhr, U., & Schumer, R. (2001). “Standardized general-purpose noise reaction questions for community noise surveys: Research and a recommendation” *Journal of Sound and Vibration*, 242, 641–679.
- Gamberale, F., Kjellberg, A., Akerstedt, T., Johansson, G. (1990). Behavioural and psychophysiological effects of the physical work environment. *Scandinavian Journal of Work Environment & Health*, 16 (suppl 1) 5-16.
- Geary, J. (1996). Saving the sounds of silence. *New Scientist*, 13 April 1996, p. 45.
- Girvin, R. (2009). Aircraft noise-abatement and mitigation strategies. *Journal of Air Transport Management*, 15, 14-22.
- Guski, R. (1999). Personal and social variables as co-determinants of noise annoyance. *Noise & Health*, 3, 45-65.
- Goines, L. & Hagler, L. (2007) Noise Pollution: A Modern Plague. *Southern Medical Journal*, 100 (3), 287-293
- Goldschagg, P. (2007). *Airport noise in South Africa – Prediction models and their effect on land use planning*. Unpublished doctoral dissertation. University of Stellenbosch.
- Group Areas Act of 1950, Apartheid South Africa. Retrieved 12 October 2013 from: http://www.rebirth.co.za/apartheid_group_areas.htm
- Haines, M.M., Stansfeld, S.A. (2000). Measuring annoyance and health in child social surveys. In D. Cassereau (Ed.), *Proceedings of Inter-Noise*, vol. 3 (pp. 1609-1614). Nice, France: Societe Francais d’ Acoustique.

- Haines, M., Stansfeld, S., Job, R., Berglund, B., Head, J. (2001a). Chronic aircraft noise exposure, stress responses, mental health and cognitive performance in school children. *Psychological Medicine*, 31, 265-277.
- Haines, M.M., Stansfeld, S.A., Job, R.F.S., Berglund, B., Head, J. (2001). A follow-up study of effects of chronic aircraft noise exposure on child stress responses and cognition. *International Journal of Epidemiology*, 30, 839-845.
- Henry J.P. (1992). Biological basis of the stress response. *Integrative Physiological and Behavioral Science*, 27, 66-83.
- Hollander, C., de Andrade, V.M. (2013). The effects of aircraft noise on the auditory language processing abilities of English first language primary school learners in Durban, South Africa, *Urban Education*, 20(10), 1-23.
- Hygge, S., Evans, G.W., Bullinger, M. (2002). A prospective study of some effects of aircraft noise on cognitive performance in school children. *Psychological Science*, 15(5), 469-474.
- Hygge, S., Evans, G.W., Bullinger, M. (1996). The Munich Airport noise study: cognitive effects on children from before to after the change over the airports. In *Inter-Noise 96* (pp. 2189-2194). Liverpool.
- Hygge, S., Evans, G.W., Bullinger, M.A, (1998). *The Munich Airport Noise Study – Effects of chronic aircraft noise on children’s cognition and health*. 7th International Congress on Noise as a Public Health Problem. Sydney, Australia, 268-274, November.
- International Civil Aviation Organization (2007). *Environmental Report 2007*. International Civil Aviation Organization (ICAO). Montreal.
- International Civil Aviation Organization (1993). *International Standards and Recommended Practices*. Environmental Protection Annex 16 to the Convention on International Civil Aviation: 1. Geneva.
- International Air Transport Association. (2004). *Environmental review 2004*. Accessed from: <http://www.iata.org/ps/publications/9486.htm>. (Retrieved February 16 2013).
- Job, R.F.S. (1996). The influence of subjective reactions to noise on health effects of the noise. *Environment International*, 22, 93-104.
- Jonsdottir, V., Laukkanen, A-M, Siikki, I. (2003). Changes in teachers’ voice quality during a working day with and without electric sound amplification. *Folia Phoniatr. Logop*, 55(5), 267-280.

- Joselzon, A. (2007). *Fuel Conservation – A manufacturer's perspective*. ICAO Colloquium on Aviation Emissions with Exhibition, May 2007.
- Kaltenbach, M., Maschke, C., Klinker, R. (2008). Health consequences of aircraft noise. *Deutsches Arzteblatt International*, 105(31-32), 548-556.
- Klatte, M., Bergström, K., Lachmann, T. (2013). Does noise affect learning? A short review on noise effects on cognitive performance in children. *Frontiers in Psychology*, 4, 1-6.
- Klatte, M., Lachmann, T., Meis, M. (2010). Effects of noise and reverberation on speech perception and listening comprehension of children and adults in a classroom-like setting. *Noise & Health*, 12(49), 270-282.
- Kroesen, M. (2011). *Human response to aircraft noise*. TRAIL Thesis Series. T2011/7, June 2011, the Netherlands. Accessed from: <http://repository.tudelft.nl/view/ir/uuid%3Af59b8feb-167b-4f51-ad31-81c2c7be6193/> (Retrieved May 27 2013).
- Lavandier, C., Barbot, B., Terroir, J., Schuette, M. (2011). Impact of aircraft quality combined with the repetition of aircraft flyovers on annoyance as perceived activity disturbance in a laboratory context. *Applied Acoustics*, 72(4), 169-176.
- Lazarus, R.S., Folkman, S. (1984). *Stress, Appraisal, and Coping*. New York: Springer.
- Lee, S.E., Khew, S.K. (1992). Impact of road traffic and other sources of noise on the school environment. *Indoor Environment*, 1, 162-169.
- Lekaviciute J., Argalasova-Sobotova, L. (2013). Environmental noise and annoyance in adults: research in Central, Eastern and South-Eastern Europe and Newly Independent States. *Noise & Health*, 15(62), 42-54. doi: 10.4103/1463-1741.107153.
- Lercher, P. (1996). Environmental noise and health: An integrated research perspective. *Environment International*, 22, 117-128.
- Lijesen, M., Van der Straaten, J.W., Dekkers, J.E.C., Van Elk, R., Blokdijs J. (2010). How much noise reduction at airports? Transportation Research Part D. *Transport and Environment*, 15(1), 51-59.
- Lusk, S.L., Gillespie, B., Hagerty, B.M., Ziemba, R.A. (2004). Acute effects of noise on blood pressure and heart rate. *Archives of Environmental Health*, 59 (8), 392-399.
- Lyle, C. (1990). The Noise Issue: The Need for Accountability, Planning and Leadership. *ICAO Journal for Airport Policy in the United States*, 45, 7-14.
- Kaltenbach, M., Maschke, C., Klinker, R. (2008). Health consequences of aircraft noise. *Deutsches Arzteblatt International*, 105(31-32), 548-556.

- Mace, B.L., Bell, P.A., Loomis, R.J. (1999). Aesthetic, affective, and cognitive effects of noise on natural landscape assessment. *Society & Natural Resources*, 12, 225-242.
- Maschke, C., Harder, J., Ising, H., Hecht, K., Thierfelder, W. (2002). Stress hormone changes in persons exposed to simulated night noise, *Noise & Health*, 5(17), 35-45.
- Massie, R., Dillon, H. (2006). The impact of sound-field amplification in mainstream cross-cultural classrooms: Part 2 – Teacher and child opinions. *Australian Journal of Education*, 50(1), 78-94.
- Mathews, R. (2009). *The Effect of Community Noise on Health and Well-being*. Unpublished Master's dissertation. Auckland University of Technology.
- Maynard, R. (2009). Environmental Noise and Health in the UK: A report published by the Health Protection Agency on behalf of an ad hoc Expert Group on the Effects of Environmental Noise on Health. http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1246433634856
- McEwen, B.S. (1998). Protective and damaging effects of stress mediators. *New England Journal of Medicine*, 338, 171-179.
- Miedema, H.M.E. (2007). Annoyance caused by environmental noise: Element for evidence-based noise policies. *Journal for Social Issues*, 63(1), 41-57.
- Miedema, H.M.E., Oudshoorn, C.G.M. (2001). Annoyance from transportation noise: Relationships with exposure metrics DNL and DENL and their confidence intervals. *Environmental Health Perspectives*, 109, 409-416.
- Miedema, H.M.E., Vos, H. (1998). Exposure-response relationships for transportation noise. *Journal of the Acoustical Society of America*, 104, 3432-3445.
- Mulder, H. (2011). Dynamic sound field: teachers' ratings. Accessed from: http://www.phonakpro.com/content/dam/phonak/b2b/C_M_tools/Library/Field_Study_News/en/FSN_DynamicSoundField-Teacher_Ratings-2011_04.pdf (Retrieved 24 May 2012).
- Nchemanyi, J.N. (2006). *Community Perceptions on Noise Pollution Generated by Aircraft in Cape Town*. Available online: http://dk.cput.ac.za/td_cput/255 (Retrieved 23 January 2012).
- Nelson, J.P. (2003). Meta-analysis of airport noise and hedonic property values: Problems and prospects. *Journal of Transport Economics and Policy*, 38 (Part 1), 1-22.
- North Atlantic Treaty Organization. (2000). *The Effects of Noise from Weapons and Sonic Booms, and the Impact on Humans, Wildlife, Domestic Animals and Structures*. Final

- Report of the Working Group Study Follow-up Program to the Pilot Study on Aircraft Noise. Report No. 241. June.
- Nunez, D.G. (1998). *Cause and Effects of Noise Pollution. Interdisciplinary Minor in Global Sustainability*. University of California, Irvine.
- Ohrstrom, E., Hadzibajramovic, E., Holmes, M., Svensson, H. (2006). Effects of road traffic noise on sleep: studies on children and adults. *Journal of Environmental Psychology*, 26(2), 116-126.
- Pedersen, E. (2007). Wind turbine noise, annoyance and self-reported health and wellbeing in different living environments. *Occupational and Environmental Medicine*, 64(7), 480-486.
- Phillips, D.P. (2007). An introduction to central auditory neuroscience. In F. Musiek, G. Chermak (Eds.), *Handbook of (Central) Auditory Processing Disorder, Auditory Neuroscience and Diagnosis* (pp. 53-87). San Diego, CA: Plural Publishing.
- Pillay, D., Archary, K., Panday, S. (2011). A preliminary study of the effects of aircraft noise on families who reside in close proximity to an airport. *South African Family Practice*, 53, 361-365.
- Pretty, J., Peacock, J., Sellens, M., Griffin, M. (2005). The mental and physical health outcomes of green exercise. *International Journal of Environmental Health Research*, 15(5), 319-337.
- Purdy, S.C., Smart, J.L., Baily, M., Sharma, M. (2009). Do children with reading delay benefit from the use of personal FM systems in the classroom? *International Journal of Audiology*, 48(12), 843-52.
- Raw, G.J., Griffiths, I.D. (1990). Subjective response to changes in road traffic noise: A model. *Journal of Sound Vibration*, 141, 43-54.
- Richard, G.J. (2001). *The source for processing disorders*. East Moline, IL: Lingui Systems.
- Sandberg, U. (1999). *Tyre/road noise—myths and realities*. In Proceedings of the 2001 International Congress and Exhibition on Noise Control Engineering, Inter Noise 2001, 27-30 August 2001, The Hague, The Netherlands.
- Schafer, R.M. (1994). *The Soundscape: Our Sonic Environment and the Tuning of the World*. Rochester, VT: Destiny Books.
- Schreckenber D., Meis M., Kahl C., Peschel C., Eikmann T. (2010). Aircraft noise and quality of life around Frankfurt Airport. *International Journal of Environmental Research and Public Health*, 7, 3382-3405. doi: 10.3390/ijerph7093382.

- Shendell, D., Barnett, C., Boese, S. (2004). *Science-based recommendations to prevent or reduce potential exposures to biological, chemical, and physical agents in schools*. Healthy Schools Network, Inc. [Available: <http://www.healthyschools.org/documents/HPSchlsWhtPpr.pdf>] (Retrieved 16 February 2010).
- Shepherd, D., Welch, D., Dirks, K.N., Mathews, R. (2010) Exploring the relationship between noise sensitivity, annoyance and health-related quality of life in a sample of adults exposed to environmental noise. *International Journal of Environmental Research and Public Health*, 7, 3579-3594
- Shield B.M., Dockrell J.E. (2003). The effects of noise on children and schools: A review. *Building Acoustics*, 10, 97-106.
- South African Bureau of Standards. (1974). *Code of Practice for the Determination and Limitation of Disturbance Around an Aerodrome due to Noise from Aeroplanes*. Pretoria.
- South Africa Department of Transport. (1998). National Policy on Aircraft Noise and Engine Emissions. *Government Gazette*, 7-9. Pretoria.
- South Africa Department of Transport. (1998). *White Paper on National Policy on Airports and Air Space Management*, 37- 46. Pretoria.
- Standards South Africa (2003). *SANS 10117: 2003 South African national standard: calculation and prediction of aircraft noise around airports for land use purposes*. Pretoria: Standards South Africa.
- Stallen, P.J.M. (1999). A theoretical framework for environmental noise annoyance. *Noise & Health*, 1, 69-80.
- Stansfeld, S.A., Matheson, M.P. (2003). Noise pollution: non-auditory effects on health. *British Medical Bulletin*, 68(1), 243-257.
- Stansfeld, S., Berglund, B., Clark, C., Lopez-Bario, I., Fisher, P., Christrom, E., Haines, M., Head, J., Hygge, S., Kamp, I., Berry, B. (2005). Aircraft and road traffic noise and children's cognition and health: A cross-national study. *LANCET*, 365, 1942-1949.
- Stansfeld, S.A., Haines, M.M., Brown, B. (2000). Noise and Health in the Urban Environment. *Reviews on Environmental Health*, 15(1-2), 43-82.
- Suau-Sanchez, P., Pallares-Barbera, M., Paul, V. (2011). Incorporating annoyance in airport environmental policy: noise, societal response and community participation. *Journal of Transport Geography*, 19(2), 275-284.

- Suter, A. (1991). *Noise and its effects*. Administrative Conference of the United States, November.
- Sayre, A.P. (2009) Africa; Twenty-First Century Books.
- Taylor, C.W. (1984). Promoting health strengthening and wellness through environmental variables. In J.D. Matarrazzo, S.M. Weiss, J.A. Herd, N.E. Miller (Eds.). *Behavioural health: A handbook for health enhancement and disease prevention* (s.130-149). New York: Wileys and Sons.
- Thorne, R. (2007). *Assessing intrusive noise and low amplitude sound*. Doctoral thesis. Massey University, Palmerston North, New Zealand.
- Tomkins, J., Topham, N., Twomey, J., Ward, R. (1998). Noise versus access: The impact of an airport in an urban property market. *Urban Studies*, 35(2), 243-258.
- Ubouh, E.A., Akhiobare, S.M.O., Onifae, O.A., Ogbuji, S.I. (2012). Perception of Health-Impacts of Environmental Noise in an Ambient Noise Context in Owerri-Urban, Imo State, Nigeria. *International Journal of Advances in Applied Sciences*, 1(3), 101-107.
- Van der Merwe J.H., Von Holdt, D. (2005). Aircraft noise management through controlled area demarcation in South Africa: Applications at Cape Town. *International South African Journal of Science*, 101, 400-408.
- Van Kempen, E. (2008). *Transportation noise exposure and children's health and cognition*. Unpublished doctoral thesis. Utrecht, the Netherlands: University of Utrecht.
- Van Kempen, E., Kruize, H., Boshuizen, H.C., Ameling, C.B., Staatsen, B.A.M., de Hollander, A.E.M. (2002). The association between noise exposure and blood pressure and ischemic heart disease: A meta-analysis. *Environmental Health Perspectives*, 110(3), 307-317.
- Van Kempen, E., Staatsen, B., van Kamp. I. (2005). *Selection and evaluation of exposure-effect relationships for health impact assessment in the field of noise and health*. RIVM report 630400001/2005. <http://rivm.openrepository.com/rivm/bitstream/10029/7412/1/630400001.pdf>
- Vera, M.N., Vila, J., Godoy, J.F. (1994). Cardiovascular effects of traffic noise: The role of negative self-statements. *Psychological Medicine*, 24, 817-827.
- Wahab, A.N.B.A. (2008). *Aircraft noise level study at the Sultan Ismail International Airport*. Unpublished Master's thesis. Universiti Teknologi, Malaysia.
- Wells, A.T., Young, S.B. (2004). *Airport planning & Management* (5th ed.). New York: McGraw-Hill.

- WHO Regional Office for Europe 2004. *Noise and Health Home*. Bonn, Germany: WHO European Centre for Environment and Health. Available: <http://www.euro.who.int/Noise> [Retrieved 28 January 2011].
- World Health Organisation. (2000). *Guidelines for Community Noise*. Geneva, Switzerland.
- World Health Organization (1999). *Guidelines for Community Noise*. Geneva, Switzerland.
- Xie, H., Kang, J., Tompsett, R. (2011). The impact of environmental noise on the academic achievements of secondary school students in Greater London. *Applied Acoustics*, 72, 551-555.
- World Air News (2001). African airlines directory. *World Air news*. August 18-50.
- Yamada, I. (2002). *Effectiveness of soundproofing of private houses as part of environmental measures in the vicinity of airports in Japan*. The 2002 International Congress and Exposition on Noise Control Engineering, Dearborn, MI, USA. August 19-21, 2002.
- Zimmer, I.B. (2000). *Assessing the economic impact of aircraft noise on communities*. Unpublished doctoral dissertation. New Jersey Institute of Technology.
- Zusman, A.F. (2007). *Findings of the FICAN pilot study on the relationship between aircraft noise reduction and changes in standardized test scores*. FICAN. July 2007. Retrieved on 16 February 2013 from: http://www.fican.org/pdf/FICAN_Findings_on_school_study.pdf

APPENDICES

APPENDIX A

KWAZULU-NATAL DEPARTMENT OF EDUCATION



Psychology

School of Human & Community Development
University of the Witwatersrand
Private Bag 3, WITS, 2050
Tel: (011) 717 4500 Fax: (011) 717 4559



INFORMATION LETTER

Dear Madam/ Sir

My name is Joseph Seabi, and I am conducting research for the purpose of obtaining a PhD degree at the University of the Witwatersrand. The focus of this research is on investigating the effects of exposure to aircraft noise on learners' reading comprehension, perceived health and annoyance reactions. The proposed study aims to compare performance of learners exposed to chronic aircraft noise and those from relatively quieter areas before-and-after decommissioning of the airport.

It should take the learners approximately two hours to complete the questionnaires. Participation of learners in this research include filling out questionnaire asking information such as their age, gender, health, school work, and how they deal with noise at home and school. In addition, they will be required to complete a reading comprehension task.

Participation is voluntary, and no person will be disadvantaged in any way for choosing to participate or to withdraw at any time. Confidentiality will be ensured, and only my supervisor and I will have access to the data. No identifying information will be included in the research report. On completion of my research report the data will be destroyed. The learners will also be asked to complete a form showing that they are willing to participate in the study.

Should you allow the study to take place, would you be so kind as to sign the consent letter granting me permission.

Should you have any questions please do not hesitate to contact me on the number below during working hours. You may also contact my supervisors, Prof. Kate Cockcroft on (011) 717-4511 or e-mail her at kate.cockcroft@wits.ac.za; and Dr. Paul Goldschagg on (011) 717-3172 or email him at paul.goldschagg@wits.ac.za.

Thank you for your kindness.

Mr. Joseph Seabi

(011) 717-8331; E-mail: joseph.seabi@wits.ac.za

CONSENT LETTER



I -----, the representative of KwaZulu-Natal Department of Education, do hereby grant Joseph Seabi permission to conduct his research in our district.

(Please Print)----- at ----- on-----

Signature-----

APPENDIX B



Psychology

School of Human & Community Development
University of the Witwatersrand
Private Bag 3, WITS, 2050
Tel: (011) 717 4500 Fax: (011) 717 4559



PRINCIPAL INFORMATION LETTER

Dear Sir/Madam

My name is Joseph Seabi, and I am conducting research for the purpose of obtaining a PhD degree at the University of the Witwatersrand. The focus of this research is on investigating the effects of exposure to aircraft noise on learners' reading comprehension, perceived health and annoyance reactions. The proposed study aims to compare performance of learners exposed to chronic aircraft noise with those from relatively quieter areas before-and-after the relocation of the airport.

I therefore wish to request your permission to conduct my research in your school. It should take the learners approximately two hours to complete the questionnaires. I understand that this is a substantial investment of time. However their response is valuable as it will contribute towards a South African understanding of whether chronic exposure to aircraft noise impact on reading comprehension, health and annoyance.

Participation of learners in this research include filling out questionnaire asking information such as their age, gender, health, school work, and how they deal with noise at home and school. In addition, they will be required to complete a reading comprehension task.

Participation is voluntary, and no person will be disadvantaged in any way for choosing to participate or to withdraw at any time. Confidentiality will be ensured, and only my supervisors and I will have access to the data. No identifying information will be included in

the research report. On completion of my research report the data will be destroyed. The learners will also be asked to complete a form showing that they are willing to participate in the study.

Should you allow the study to take place in your school, would you be so kind as to sign the consent letter granting me permission.

Should you have any questions please do not hesitate to contact me on the number below during working hours. You may also contact my supervisors, Prof. Kate Cockcroft on (011) 717-4511 or e-mail her at kate.cockcroft@wits.ac.za; and Dr. Paul Goldschagg on (011) 717-3172 or email him at paul.goldschagg@wits.ac.za.

Thank you for your kindness.

Mr. Joseph Seabi

(011) 717-8331; E-mail: joseph.seabi@wits.ac.za

PRINCIPAL CONSENT LETTER



I -----, the principal of -----, do hereby grant Joseph Seabi permission to conduct his research in my school.

(Please Print)----- at ----- on-----

Signature-----

APPENDIX C



Psychology

School of Human & Community Development
University of the Witwatersrand
Private Bag 3, WITS, 2050
Tel: (011) 717 4500 Fax: (011) 717 4559



PARENT INFORMATION LETTER

Dear Parent/Caregiver

My name is Joseph Seabi, and I am conducting research for the purpose of obtaining a PhD degree at the University of the Witwatersrand. The focus of this research is on investigating the effects of exposure to aircraft noise on learners' reading comprehension, perceived health and annoyance reactions.

I wish to invite you to grant permission for your child to participate in the study. The entire process should not take more than two hours for learners to complete the tasks, and will be conducted with the permission of the school in a time that will be specified by the school.

Participation of learners in this research include filling out a questionnaire asking information such as their age, gender, health, school work, and how they deal with noise at home and school. In addition, they will be required to complete a reading comprehension task.

Participation in this study is voluntary. Should you choose not to provide your consent your child will not be disadvantaged. He/she will thus not participate in the research and you will not have to respond to this letter. Should you grant consent, I ask you to please complete and return the form below. In addition, your child has the right to choose not to participate or to withdraw from the study at any time.

Once more, I assure you that all responses are confidential. All questionnaires will be destroyed after I have analyzed them. Should you have any questions please do not hesitate to contact me on the number below during working hours. You may also contact my supervisors, Prof. Kate Cockcroft on (011) 717-4511 or e-mail her at kate.cockcroft@wits.ac.za; and Dr. Paul Goldschagg on (011) 717-3172 or email him at paul.goldschagg@wits.ac.za.

Thank you for your kindness.

Mr. Joseph Seabi

(011) 717-8331; E-mail: joseph.seabi@wits.ac.za

PARENT CONSENT FORM



I ----- parent of ----- in Grade -----
have read and understood the information provided in this consent form. I grant permission
for my child to participate in the study conducted by Joseph Seabi.

I understand that:

- Participation in this study is voluntary
- I may withdraw my child from the study at any time without our child suffering any prejudice
- No information that may identify my child or his/her family will be included in the research report, and his/her responses will remain confidential.

(Please Print)----- at ----- on-----

Signature-----

APPENDIX D



Psychology
School of Human & Community Development
University of the Witwatersrand
Private Bag 3, WITS, 2050
Tel: (011) 717 4500 Fax: (011) 717 4559



LEARNER INFORMATION SHEET

Dear Learner

My name is Joseph Seabi, and I am conducting research for the purpose of obtaining a degree at the University of the Witwatersrand. A reading comprehension passage will be read to you and you will be asked questions based on that text. Should you choose to participate in the study, you will be required to answer questions with a pencil.

Participation in this study is voluntary, and you will not be disadvantaged in any way for not choosing to participate in the study. You may refuse to answer any questions you would prefer not to, and may choose to withdraw from the study at any point.

If you may want any further information, please do not hesitate to contact me telephonically on (011) 717-8331 during working hours or via e-mail at joseph.seabi@wits.ac.za. You may also contact my supervisors, Prof. Kate Cockcroft on (011) 717-4511 or e-mail her at kate.cockcroft@wits.ac.za; and Dr. Paul Goldschagg on (011) 717-3172 or email him at paul.goldschagg@wits.ac.za.

Thank you for your kindness.

Mr. Joseph Seabi

LEARNER ASSENT FORM



I -----, in Grade----- assent to participate in the study conducted by Joseph Seabi. I understand the following conditions:

- My participation in the study is completely voluntary.
- I will not in any way be disadvantaged by agreeing to fill out the questionnaires.
- The questionnaires are confidential.
- My responses may be used but no information that could identify me will be included in the researcher's report.
- I have the right to withdraw from the study at any stage.
- I may refuse to answer any questions in the questionnaire which I would rather not answer.

Signature

Date

APPENDIX E

SAMPLE OF CHILDREN'S QUESTIONNAIRE

Code _____

Date _____

Level A _____

Questionnaire for children



Your answers are **CONFIDENTIAL**.
They will **NOT** be seen by your parents, carers or teachers.

Everyone's views are very important to us so please try to complete this questionnaire **without talking**.

If you need someone to help you **put your hand up** and a monitor will come over to you.

Who are you?




1. Are you a **boy** or a **girl**?

θ_1 Boy θ_2 Girl


2. What **languages** are **spoken** in your **home**?

*tick **ALL** languages that apply*

θ_1 English θ_2 IsiZulu θ_3 IsiXhosa θ_4 Sepedi (Northern Sotho)
 θ_5 Sesotho θ_6 Setswana θ_7 Xitsonga θ_8 Tshivenda
 θ_9 IsiNdebele θ_{10} Afrikaans θ_{11} SiSwati
 θ_{12} Other(s) _____ 
 please specify

3. What is the **main language** spoken in your **home**?

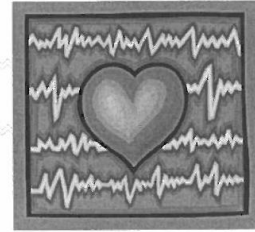
*tick **ONE** language*

θ_1 English θ_2 IsiZulu θ_3 IsiXhosa θ_4 Sepedi (Northern Sotho)
 θ_5 Sesotho θ_6 Setswana θ_7 Xitsonga θ_8 Tshivenda
 θ_9 IsiNdebele θ_{10} Afrikaans θ_{11} SiSwati
 θ_{12} Other(s) _____ 
 please specify

4. Has the school **offered** to give you **free school meals**?

θ_1 Yes θ_2 No θ_3 Don't know

Your health



5. In general, would you say **your health** is...

θ_1 Very good θ_2 Good θ_3 Fair θ_4 Bad θ_5 Very bad

6. In the last **month** how often have **you** had a **headache**?

θ_1 Never θ_2 A few times θ_3 Once a week θ_4 A few times a week θ_5 Every day

7. In the last **month** how often have **you** felt like you were going to be **sick, throw up or vomit**?

θ_1 Never θ_2 A few times θ_3 Once a week θ_4 A few times a week θ_5 Every day

8. In the last **month** how often have **you** had a **tummy-ache**?

θ_1 Never θ_2 A few times θ_3 Once a week θ_4 A few times a week θ_5 Every day

9. In the last **month** how often have **you** found it **difficult** to get to **sleep**?

θ_1 Never θ_2 A few times θ_3 Once a week θ_4 A few times a week θ_5 Every night

10. In the last **month** how often have **you** **woken up** during the **night**?

θ_1 Never θ_2 A few times θ_3 Once a week θ_4 A few times a week θ_5 Every night

11. People sometimes **feel sleepy** during the **daytime**...

In the last **month**, during **your daytime activities**, how often have **you** had a **problem** with **sleepiness** (feeling sleepy, struggling to stay awake)?

θ_1 Never θ_2 A few times θ_3 Once a week θ_4 A few times a week θ_5 Every day

APPENDIX F

SAMPLE OF SUFFOLK READING SCALE 2

Suffolk Reading Scale 2

First name	<input type="text"/>																				
Surname	<input type="text"/>																				
Boy	<input type="checkbox"/>	Girl	<input type="checkbox"/>																		
Date of birth	<input type="text"/>	<input type="text"/>	<input type="text"/>	/	<input type="text"/>	<input type="text"/>	<input type="text"/>	/	<input type="text"/>	<input type="text"/>	<input type="text"/>	Date of test	<input type="text"/>	<input type="text"/>	<input type="text"/>	/	<input type="text"/>	<input type="text"/>	<input type="text"/>		
Pupil ID	<input type="text"/>																				
School name	<input type="text"/>																				
Class	<input type="text"/>										Year	<input type="text"/>									
For teacher's use only																					
AGE at date of testing		RAW SCORE total number correct		STANDARDISED SCORE with 90% confidence band				PERCENTILE RANK		AGE EQUIVALENT with 90% confidence band											
years	completed months			lower limit				upper limit		lower limit			years	months	upper limit						

Mark boxes like this ☒ .

Practice Items									
P1. The sky was _____.									
girl <input type="checkbox"/>	leg <input type="checkbox"/>	blue <input checked="" type="checkbox"/>	grass <input type="checkbox"/>	smile <input type="checkbox"/>					
P2. You _____ water to make tea.									
boil <input type="checkbox"/>	milk <input type="checkbox"/>	fill <input type="checkbox"/>	paint <input type="checkbox"/>	match <input type="checkbox"/>					
P3. A monkey is an _____.									
envelope <input type="checkbox"/>	octopus <input type="checkbox"/>	excuse <input type="checkbox"/>	apron <input type="checkbox"/>	animal <input type="checkbox"/>					
P4. The complicated problem was _____ to solve.									
divided <input type="checkbox"/>	definite <input type="checkbox"/>	difficult <input type="checkbox"/>	squared <input type="checkbox"/>	physical <input type="checkbox"/>					