Analysis of Breathing During Oral Reading by Young Children with and without Asthma using Non-Contact Respiratory Monitoring Methods. A Preliminary Study of Task and Reading Difficulty Effects

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Abstract

The aim of this research was to investigate the breathing patterns of children aged 5-9 years with asthma as they read aloud stories of increasingly difficulty. Participants were 11 children diagnosed with moderate to severe asthma recruited from an out-patient clinic and 11 gender- and age-matched controls recruited from local schools.

Non-contact respiratory monitoring methods were employed to yield acoustic recordings during three non-reading tasks and three reading aloud tasks which increased in difficulty. Measurements included breathing rate, pause time in speech, and time ratio between inspiration between inspiration and expiration (I/E ratio). Pauses that occurred during the reading tasks were classified as either occurring at grammatical junctions where pausing during oral reading would be expected, or at ungrammatical junctions, where pausing was associated with either needing to breath, a reading mistake and/or upon recognition of an unknown word. The acoustic measures were recorded using a free audio editor and recorder programme (Audacity version 2.0.3') on a Notebook laptop with an inbuilt microphone.

The main result indicated that 82% of children with asthma breathed more slowly when reading books that were difficult for them, and this was negatively associated with asthma severity ($p=0.046$). The findings demonstrated that children with asthma appear to cope when reading more difficult materials by breathing more slowly, pausing for longer ([$F(1, 16) = 5.454$, $p = 0.033$]) and increasing expiration time.

The current research is the first of its kind and provides a base for future studies to investigate the relationship between breathing and the reading of children with asthma. Questions remain whether this relationship is related to low achievement in reading. Future research to confirm, disconfirm or otherwise is necessary to add to the sparse literature on the breathing of children with asthma while reading aloud.

Chapter 1 Introduction

A number of children frequently experience chronic health conditions that have a profound effect on their everyday health and wellbeing. Chronic health conditions include a wide range of long-term medical illnesses. Common chronic health conditions in children include: heart conditions, tuberculosis, sickle cell anemia, hemophilia, rheumatic fever, diabetes and asthma. The triggers, symptoms, and treatments of these conditions reflect the pathophysiology of the main body systems (Thies, 1999). Children with chronic health conditions, such as asthma, are more likely to come from a lower social economic status (SES), and are more likely to have poorer academic achievement rates. Additionally these children have more negative health outcomes as adults, and are more likely to participate in unsafe behaviours compared to their ‘healthy’ peers (Besson, Blanc, Jones, Katz, & Yelin, 1993; Case, Fertig, & Paxson, 2005; Haas, 2007; Eide, Showalter, & Goldhaber, 2010).

In New Zealand, asthma is the most common, serious and chronic condition affecting children and accounts for many hospital admissions of children (Holt, Kljakovic, & Reid, 2003; Lai, Beasley, Crane, Foliaki, Shah, Weiland, 2008). Prevalence rates have steadily increased over the past 20 years and New Zealand is now amongst the highest in the world for both children and adults (Global Asthma Report, 2011). The New Zealand Asthma Foundation reported that one in four children suffers from asthma in this country (Asthma Foundation, 2012). Prevalence rates of severe asthma in New Zealand were reported by the International Study of Asthma and Allergies in Childhood (ISAAC), Phase 3 (Lai et al., 2008). Within the studied group of children aged 6-7 years identified as currently having asthma, the reported prevalence rates for severe asthma were 43.6% and 38.7% in the age group 13-14 years. The prevalence of current wheeze was reported as 22.2% in children 6-7 years and 26.7% in the older age group.

Factors Affecting the Outcomes of Children with Asthma

Socioeconomic status (SES).

Socioeconomic inequality is an unavoidable aspect of society. There are different socioeconomic strata that refer to a hierarchy of positions. This hierarchy can influence levels of wealth, health, access to resources and occupational prestige (Palloni, & Milesi, 2006). With each decreasing socioeconomic level, research has shown an association with an increasing prevalence of disease (Chen, Matthews, & Boyce, 2002). Case, Fertig, and Paxson, (2005) have shown that health in childhood is significantly associated with adult SES. For example, good health is positively associated with middle and high SES in adulthood. The reverse link has also been identified; having a lower SES in childhood was related to having reduced physical functioning in mid-adulthood (Guralnik, Butterworth, Wadsworth, & Kuh, 2006; as cited in Haas, 2008). Many studies have found a strong bidirectional relationship between SES and health and the subsequent outcomes on life (Case, Fertig, & Paxson, 2005; Chen, Matthews, & Boyce, 2002; Haas, 2008; Palloni, & Milesi, 2006; Palloni, Milesi, White, & Turner, 2009).

Lower economic status has also been found to be associated with asthma (Haas, 2008). Factors correlated with asthma prevalence rates among children aged 9 and younger include indicators that are representative of the family's SES, such as; type of housing, poverty status, and parent occupation (Italian Studies on Respiratory Disorders in Childhood and the Environment, 1997; as cited in Chen, Matthews, & Boyce, 2002). Asthma severity can also be somewhat influenced by SES; studies have shown a relationship between lower SES and an asthma condition during childhood and adolescence which is significantly more severe (Italian Studies on Respiratory Disorders in Childhood and the Environment, 1997; as cited in Chen, Matthews, & Boyce, 2002). Families from lower SES households have been associated with displaying behaviours such as poor management of asthma symptoms, and a decrease in use of asthma medications due to a lack of access to medical care (Holt & Beasley, 2001; Holt, Kljakovic, & Reid, 2003).

Poor health and mental health prospects.

Health status is an important factor as it can influence many developmental outcomes. Health contributes to a person's physical, mental, spiritual and social wellbeing, earning capacity, quality of life, education and learning capability. Haas (2007) reported that having poor health in childhood resulted in a higher likelihood of the presence of a persisting health condition or difficulty that impacted on an individual's workforce participation and productivity. Also, Haas (2007) found that there was three times the possibility that an adult would report their individual health as 'poor'.

Asthma is associated with poorer health and mental health and people with diagnosed -asthma have increased rates of hospital admissions and higher numbers of health care contacts (Asher, Keil, Anderson, Beasley, Crane, Martinez et al., 1995; Eisner, Yelin, Trupin, & Blanc, 2002; Holt & Beasley, 2001). Chronic asthma symptoms can interfere with sleep, exercise, growth, and achievement (Pattemore, Ellison-Loschmann, Asher, Barry, Clayton, Crane, D'Souza et al., 2004), all of which are crucial aspects of healthy development. A child from a lower SES household, and/or with asthma, can have poorer developmental outcomes. One important outcome is employment status as an adult.

Employment status.

Employment status is an indicator of having paid work. Participating in the labour market and earning income is viewed within society as an important adult outcome. Employment provides people with the means to live successfully and comfortably within society and to also contribute to society as a whole. Case, Fertig, and Paxson, (2005), reported that attainment of a vocation in adulthood was negatively related to the presence of a chronic illness in early development. Children who grew up in lower SES households, or had a chronic health condition such as asthma, had a higher likelihood of having a reduced earning potential in adulthood (Perrin, Bloom, & Gortmaker, 2007). Asthma is associated with major reductions in physical and mental health status and has been well established with limitations in work disability, productivity, increased absenteeism, and actual job loss in persons 18- 44 years old (Besson, Blanc, Jones, Katz, et al., 1993; Eisner, et al., 2002; Mancuso, Rincon, & Charlson, 2003; Stewart, Ricci, Chee, & Morganstein, 2003). A child who comes from a low SES background and/or has a chronic health condition such as asthma, can improve adult employment outcomes through good educational attainment.

Educational attainment.

Education is a crucial factor to being a successful and contributing member of society as well as enhancing future health and quality of life. Education can influence the type of job, income and lifestyle a person has, and contributes to their success within society (Crump, Rivera, London, Landau, Erlendson & Rodriguez, 2013). Therefore, children with chronic health conditions transition into adulthood under-achieving academically as well as having significantly poorer health. Having poor health has been reported as having a negative impact on academic achievement (Case, et al., 2005; Eide, Showalter, & Goldhaber, 2010). The impairments resulting from chronic health conditions develop over time and include detrimental consequences for intellectual skills such as maths, reading, planning and problem-solving tasks. Poor educational attainment of children with chronic health conditions, such as asthma, can be impacted on by factors such as; high absenteeism which can increase the likelihood of school dropout, therefore, leading to decreased school performance, (Blackwell, Hayward, & Crimmins, 2001; Parsons & Bynner, 2007; Thies, 1999). Children with asthma who are at risk of having greater difficulties with achievement could improve educational outcomes through becoming a competent reader.

Early reading development.

Reading and language are central to high educational attainment and subsequent employment. To be employable in current society, there is a demand on graduates to be proficient in reading and writing (Snow, Burns, and Griffin, 1998). Reading is also an important contributor to cognitive development, language skills, healthy brain growth, general knowledge, and vocabulary (Stanovich, 1986). Developing reading skills is important to achieving successful outcomes for children with chronic health conditions. Within the New Zealand education system, leaning to read is a valued and fundamental skill by which instruction in order to develop this skill is provided to all children. Children enter primary school ready to learn and to build on the knowledge that they may have already acquired. Each child's knowledge will have been shaped by their health status as well as differing experiences with reading and language, such as being read to at home (Schaub, 2013). Additional to prior knowledge, each child will have different ways of understanding and interpreting those experiences, depending on the environment, culture, and community they are a part of (Clay, 1998; 2005). Therefore, teachers have the difficult responsibility to be aware of these interconnected influences and factors and to understand how to be able to create appropriate instruction for each individual, whatever their starting point may be.

It is a common occurrence to devise strategies for each individual child who enters school; in particular for children who enter at risk for reading difficulties due to chronic health problems (Clay, 2005). Marie Clay, a New Zealander and international expert in working with children with reading difficulties, defined reading as "a message-getting, problem solving activity which increases in power and flexibility the more it is practiced (Clay, 2005, p 6)". When the reader reads for meaning, they are finding and using information from many sources. Readers need to find and make use of various types of information within print and then combine the material with what is stored in memory from previous experiences with language (Clay, 2005). This process is the same whether the reader is a 5-year-old beginner working on their first book or an established mature reader. Information to be processed includes, an understanding of how the world works, using special knowledge about books and literacy experiences, the alphabet and the words often used in the language, as well as the potential meaning of the text itself. Additionally, the reader has to have knowledge of the rules about the order of ideas, words, and letters, the sentence structure of the language, and the special features of sound, shape and layout of words. Children entering school face additional challenges when learning to read.

Research has shown that having a positive self- concept is linked to an increase in academic achievement. The attributions and thoughts an individual believes about themselves and their abilities are widely known as contributing to one's 'self-concept'. Self- concept is assumed to affect all aspects of an individual's life system as it feeds into thoughts, behaviours and feelings. The development of self-concept is continuous throughout life; with experiences early in infancy and childhood having some of the most significant impacts (Carr, 2006). Contributing to an individual's self-concept is the ability to modulate those thoughts, behaviours and feelings (known as self-regulation) within varying situations. Through self- regulation an individual is able to navigate new tasks and experiences.

The concept of a self-regulated learner (SRL) has been well documented in the literature (i.e. Zimmerman, 1989; Pintrich & De Groot, 1990; Schnuck, 1989) and is related to the concepts discussed above. A self-regulated learner uses strategies such as planning, monitoring and modifying which are directed towards the acquisition of information and/or new skills (Zimmerman, 1989). A SRL is aware when they know a piece of information, and more importantly know when there is something yet to learn. Moreover, they use initiative to seek out the necessary information in order to learn the missing information (Zimmerman, 1989).

Self- regulated learning has been strongly linked to motivation. In order to utilize SRL strategies, a student has to have motive, interest and energy (i.e. motivation) to do so (Pintrich & De Groot, 1990). Motivation is the driver of stimulating, maintaining and directing behaviour. A student who is motivated towards attaining a learning task is likely to increase the possibility of a positive outcome (i.e. achieving the set goal/task). Meeting smaller learning goals will lead to achievement of larger objectives which will positively contribute to a child's developing self-concept. Low motivation is a factor that contributes to poor reading development in children.

Three well-documented obstacles have the potential to disrupt a child's journey to skilled reading (Snow et al., 1998). The first obstacle was identified as an issue of following and applying the alphabetic principle; encompassing the concept that the written spellings of words systematically represent spoken words. The second identified obstacle was a failure to translate and utilize the skills of spoken language across to reading, and failure to learn specific skills and strategies that are necessary for reading. The third obstacle was if a child never had, or lost an initial motivation to learn to read, and/ or failed to acknowledge and appreciate the rewards of reading. This third barrier, if a reality for a child, can magnify the effects of the first two, therefore, creating the probability of serious disruptions to a child's reading development, which occurs during the first three to four years of primary school. Alternatively, motivation may be present initially, but be lost if the child struggles due to other obstacles. These three obstacles are open to influence by the child's surrounding environment and early experiences with reading.

Breathing of children with Asthma.

In New Zealand, instruction in beginning reading involves reading aloud to a teacher (Clay, 1991). Reading aloud not only involves the processes of decoding letters and sounds into words; it also involves speaking those decoded symbols out loud. Fluent oral reading is a prerequisite to comprehension. A child who struggles to decode letters and sounds, or struggles to articulate sentences in a fluent sequence, will be focusing on the mechanics of reading rather than comprehending the meaning of what is being read. In order to achieve fluent oral reading, children must learn to coordinate their breathing, their speech, and their reading/decoding skills. In typical children, the development of the processes involved in speech-breathing occurs from about three through to ten years of age (Hoit, Hixon, Watson, and Morgan, 1990; Boliek, Hixon, Watson, and Jones, 2009). Children who have breathing difficulties associated with asthma might find coordinating breathing during reading aloud an obstacle to achieving oral reading fluency. This suggests that there is a possibility that there are children who are at risk of struggling to carry out the tasks involved in early reading due to difficulties associated with compromised breathing.

The breathing of children with asthma is compromised because the disease affects the lungs and causes the airway to narrow, swell and inflame, increasing mucus secretions. These symptoms can result in wheezing, having difficulty breathing, and feelings of tightness in the chest (Celano & Geller, 1993; Lai et al., 2008). Asthma symptoms can be chronic or intermittent; as there are many materials and situations that can trigger an episode of breathlessness or breathing difficulty. Asthma can also be induced by exercise (exercise-induced asthma) or can occur only at night (nocturnal asthma). Chronic manifestations of asthma may result in a child being out of breath (Celano & Geller, 1993). Therefore, the symptoms of asthma can be chronic and impacted on by several different factors.

The breathing problems associated with asthma can not be cured, but they can be effectively managed. Generally, it is managed by way of corticosteroid inhalers on their own or in combination with long-acting bronchodilators (Celano & Geller, 1993). The frequency of use of the inhalers and anti-inflammatory medicines is dependent on the severity and regularity of asthmatic episodes. Effective management is reliant on access to medical care and medications, compliance with or adherence to the medications' guidelines and/or GP instructions, awareness/education, and careful monitoring of symptoms. Communication and collaboration among the child, parent, physician and the child's teacher/school is crucial to the successful prevention and management of asthma and asthma attacks (Celano & Geller, 1993; Rosenfeld, Rudd, Emmons, Acevedo-Garcia, Martin, & Buka, 2011). However, there is the potential for adverse physical effects when using steroids. Some of these adverse effects can potentially impact on the child's voice and wider health status.

There are a number of factors that can be considered as additional to low SES, school absenteeism, steroid use, low motivation, and poorer overall health as obstacles to learning to read and subsequent educational attainment by children with asthma. These include; lower intelligence, more severe asthma, poor medication adherence, medication effects on voice, breath control, and difficulty with breathing while reading aloud. These factors are investigated in Chapter 2 through a review of previous research.

Chapter 2 Literature Review

Children with asthma are more likely to experience 'health' related risks and common risk factors of today's society relative to children this chronic condition; for example, lower socioeconomic status, higher school absence, and lower academic achievement. Additionally, they may be in danger of decreased school functioning from factors associated with having a chronic illness such as asthma (i.e. severity, breath control, medication, anxiety, and difficulties with breathing and reading aloud simultaneously). These factors have the potential to even further impact and impede a student's learning and achievement in school.

Educational Attainment of Children with Asthma

Gutstadt, Gillete, Mrazek, Fukuhara, Labrecque, and Strunk (1989) aimed to measure the academic performance of children with asthma using scores from standardised tests of reading and mathematics. Participants were 99 children between the ages of 9 and 17 years who had been diagnosed with "moderately severe to severe asthma" (Gutstadt et al., 1989, p 471). Reading performance was measured by the WJ-III Reading Mastery Tests (Woodcock, 1973), and maths by the Key Math Diagnostic Arithmetic test in the children aged 9-12 years (Connolly, Nachtman, and Pritchett, 1971). The WJ-III PsychoEducational Battery tests of achievement (Woodcock, 1978) were administered to the children aged 13-17 years. These tests were administered individually during the first two weeks of the study in two 1-hour sessions. The results indicated that children with asthma performed 'average to slightly above average' with mean scores of 52.4 and 52.4 for reading and mathematics respectively when compared to the standardised norms of the same aged peers. The authors concluded that their higher achievement findings in children with asthma were unlike others reported previously in the literature which showed children with asthma as achieving lower than their 'control' peers.

In 1993, Celano and Geller reviewed six published studies on the academic achievement of children with asthma (Hinckley, 1979; Freudenberg, Feldman, Clark, Millman, Valle, & Wasilewski, 1980; Mcloughlin, Nall, Isaacs, Petrosko, Karibo, & Lindsey, 1983; Fowler, Johnson, & Atkinson, 1985; Silva, Sears, Jones, Holdaway, Hewitt, Flannery et al., 1987; Gutstadt, Gillette, Mrazek, Fukuhara, LaBrecque, & Strunk, 1989; as cited in Celano & Geller, 1993). They concluded that academic results from children with severe asthma did not show lower achievement rates than children without asthma. In 1993, McNaughton and colleagues reported on the school achievement of 381 New Zealand children with asthma. Their conclusions were consistent with Celano & Geller's (1993) review of the literature as they found that the children with asthma in their study did not show lower achievement than the children without asthma.

Austin, Huberty, Huster, and Dunn (1998) used children with asthma's data from school administered standardised achievement tests to investigate school performance. Participants were 108 children with asthma ages between 8-12 years and who had been being treated with medication for at least the previous year. Participants were screened to ensure that they did not have any other chronic physical condition, intellectual deficits or developmental delay. Performance was measured primarily through two tests; the Iowa Test of Basic Skills (Riverside Publishing Co. 1986) and the California Achievement Tests (CTB/McGraw Hill, 1985). Vocabulary, language, mathematics, reading, and a composite score were used in the analysis. Participants were categorised as either high severity (n=58) or low severity (n=50). The mean reading and maths achievement scores children with severe asthma was significantly lower than for children with low severity (i.e. m= 51.5, SD =7.5, m= 55.3, SD=5.9; maths m=50.9, SD=8.0, and m= 55.9, SD=5.9. There were significant differences in the achievement rates of both reading and mathematics between the two severity groups. The authors concluded that children who had more severe asthma were at a greater risk of having lower achievement scores.

A longitudinal study of 92 children with asthma compared standardised achievement test scores with those of children without asthma. Children were matched on gender and age at the start of formal schooling at age 6 years (Silverstein, Mair, Katusic, Wollan, O'Connell, & Yunginger, 2001). Children with asthma scored in the 70.33 percentile (SD= 24.17) as compared to children without asthma who scored in the 69.11 percentile (SD= 23.23) in a measure of reading. Both groups of children scored beyond the national average on all measures after a mean of 6.6 years of schooling. No significant differences were found between the two groups.

A study by Annett, Bender, and Gordon (2007) used the results of a Continuous Performance Test (CPT) and various standardised measures of behavioural and intellectual functioning in order to measure achievement in children with asthma. Participants were children aged 6-12 years (N=939), who had been identified as having mild or moderate asthma and who had no psychological difficulties. The mean score for children in letter-word identification in the Woodcock-Johnson-Revised Tests of Achievement (1990) was m= 106.2, SD= 15.5. As the child's age increased, so did the number of correct responses. Therefore, due to this positive relationship between age and number of correct responses, the authors concluded that children performed as was expected for their developmental age.

A number of studies who sought to explore the academic achievement of children with asthma reviewed in this paper used a single measure of their school performance. One of these studies, by McNelis, Dunn, Johnson, Austin, and Perkins (2007) reported three measures of school performance over a 24 month period. Participants were 54 children aged 4-14 years whose asthma had increased in severity in the 6 weeks preceding the first measure.

Increasing asthma severity was identified by (a) an increased prescription for medication, to be taken on a daily basis, (b) an initial referral to an asthma specialist, and/or (c) an initial emergency department or hospital admission. School records of achievement were available for about half of the children. On a scale with 50 being ‘average’, at the start of the study, the childrens mean reading achievement was m=54.79, after 12 months m=52.40, and after 24 months m=53.70, thus remaining at an ‘average’ level throughout the studied period. There were no significant changes over time on reading or other achievement measures for this group of children with asthma.

A cross-sectional study of 8- 17 year olds (N= 3812), 397 of whom had asthma, used data from a state- wide program’s standardised test to explore the association between academic achievement, school absence, and asthma status (Moonie, Sterling, Figgs, & Castro, 2008). Scores were categorized into five different clusters of performance. Of the children with asthma, 18% were identified as being in the lowest group as opposed to 26% of children without asthma (N= 3415). Children identified in the lowest achieving group had the highest mean days absent from school. In both children with and without asthma, results showed a pattern of achievement decreasing as days absent from school increased. In addition, children with higher asthma severity were more likely to be falling behind their peers, as compared to children with milder asthma. Overall, however, the authors reported no significant differences in the distribution of achievement between children with asthma and children without asthma.

Kohen (2010) used cross-sectional data of children with asthma from standardised reading and maths tests as well as parent-reported school performance to measure the relationship between asthma, asthma severity and academic achievement. Participants were 8,914 children aged between 7 and 15 years identified as having asthma, no asthma, and ‘other’ chronic conditions besides asthma. Data was taken from the 1998/1999 cycle of the

National Longitudinal Survey of Children and Youth (NLSCY). Asthma was characterised into three distinct degrees of severity: ‘low’, ‘moderate’, and ‘severe’. One part of the analysis involved adjusting for socio-demographics, school absences and chronic conditions. After these adjustments the researchers reported that children who had moderate or severe asthma were 84% and 59% respectively, more likely to have low achievement scores on standardised maths tests as compared to children without chronic conditions. In regards to reading, children with moderate and severe asthma were 83% and 36% respectively, more likely to have low achievement scores as compared to children without chronic conditions.

Eide, Showalter, and Goldhaber (2010) found contrasting results to the above studies when exploring the link between asthma and school performance. The national sample consisted of individuals and their families pooled from the Child Development Supplement (CDS) of a Panel Study of Income Dynamics (PSID). Data was from 2,908 children between the ages of 5 and 18 years, 32% (N= 930) of which had diagnosed asthma. Maths and reading performance was measured by the Woodcock Johnson Revised Tests of Achievement (Woodcock, 1973) particularly the “Applied Problems” (maths) and the “Passage Comprehension” (reading) subtests. The results on the reading measure showed that boys and girls with asthma scored more than one standard deviation higher on performance when compared to children without asthma (boys= 1.27 SD’s; girls= 1.88 SD’s). The authors concluded that the positive relationship between the presence of asthma and higher achievement scores was contradictory to their hypotheses, and could possibly be explained by a third unknown variable.

A recent study by Krenitsky-Korn (2011) used the final grades in Maths and English of 57 students (i.e. with asthma N=28 and without asthma N=29) to assess academic achievement. Participants were 33 females and 24 males between the ages of 14 and 18 years. Achievement was measured by the final grade a student received (numeric grade) from the previous academic year. For maths, the results showed that students with asthma had a mean rate of achievement of 84.2 (SD= 8.7) whereas students without asthma had a mean achievement rate of 88.6 (SD= 7.2). For English, students with asthma had a mean achievement rate of 89.3 (SD=7.2) and students without asthma, a mean rate of 90.3 (SD= 5.2). The authors concluded that there was a significant difference in the achievement rates of students with and without asthma for mathematics but not for English.

Liberty, Pattemore, Reid, & Tarren-Sweeney (2010) compared four measures of achievement at two time points over a 12 month period that spanned the participants' first year of formal schooling. Participants were 298 children, 55 of which had been identified with current asthma. The cohort of children with and without asthma were equal on three factors: (1) time in school, (2) 'readiness' (i.e. skills learned prior to schooling), and (3) age. Of the children who were experiencing current asthma, 39.2% were found to be very low achieving in word reading after one year of school, as compared to 22.5% of children without asthma. More so, analyses of measurements taken at Time 2 showed that 47% of children with current asthma were low achieving in both word and text reading measures compared to 25.6% of children without asthma. There were significant differences between the two groups of children on the measures of reading but not maths. The authors conclude these differences were not related to SES, absenteeism, or intelligence.

Studies of the educational attainment of children with asthma have reported conflicting results. There are a number of possible explanations for this difference. Potential explanations include methodological differences and differences in the inclusion of factors related to achievement and asthma.

Limitations of Studies of Educational Attainment of Children with Asthma.

A methodological factor affecting studies on the academic achievement of children with asthma was the use of participant samples encompassing a wide range of ages (e.g. Celano & Geller, 1993; Silverstein et al., 2001; McNelis et al., 2007; Moonie et al., 2008). This confounds the study findings of school achievement as it does not account for the effects of age or time in school. Learning is cumulative; typically as a child's age increases and the more years they spend in school increases, their knowledge of the world and specific school subjects grow (Buckingham, Wheldall, and Beaman-Wheldall, 2013; Annett, Bender, & Gordon, 2007; Papalia, Duskin-Feldman, & Wendkos Olds, 2007). Therefore, the results and conclusions of studies who did not control for age and time in school could have reduced the reliability and validity of the results due to the impact that these factors have on learning.

A second limitation of prior studies of the academic achievement of children with asthma has been the use of teacher or parent reports of achievement (e.g. Celano, & Geller, 1993; McNelis et al., 2007). Self-reports are not as robust a measure when compared to standardised measures of individual achievement. This is due to the potential of biases, for example, reporting achievement to be particularly bad to ensure help of services or alternatively reporting above actual in order to increase status or esteem. This ultimately leads to biased results and limits the reliability and validity of the information (Funder, 2007; Shaughness & Zechmeister, 2012).

The instrument employed and how it is used to measure the academic achievement is a factor affecting studies of achievement outlined above. Standardised tests measure close to the 'actual' performance of the child and are administered in a consistent manner with reliable ways of scoring and interpreting scores. Standardised measures also have norms which can be referenced against study findings to gauge typicality in children of a certain age or developmental stage. This ensures a more valid and accurate representation of a child's ‘true’ level of achievement. However, to only use this as the measure of achievement could give a skewed representation of a child’s performance (Gudstadt et al., 1989; Annett et al., 2007; Eide et al., 2010; and Fowler et al. 1992). This is due to the stringent administration protocols not accurately reflecting the ‘busy’ everyday environment that a child works and performs within when attending school. With the inclusion of school administered group tests as well as teachers ratings of class performance and adaptive functioning skills (Austin et al., 1998) this allows for a more holistic indication of a child’s overall performance. Looking at a child’s wider school experience in regards to their achievement and standardised tests results gives more information and allows for identifying and targeting specific areas of need as well as building on areas of strength.

The focus and presentation of results is a limitation in previous research studies on the academic achievement of children with asthma. Various studies have presented the average achievement scores (e.g. Celano, & Geller, 1993; Silverstein et al., 2001; McNelis et al., 2007; Moonie et al., 2008) as opposed to reporting the proportion of children who fall within a low achieving category (i.e. Liberty et al., 2010). Presenting an average score instead of scores that represent levels of academic progress has the potential to conceal an individual child’s true level of performance. Additionally, this form of presentation by putting children into one category takes away the uniqueness and spread of the data; data which could have some very interesting and useful information. Therefore, low achievement may go unseen and the future impact that this may have on a child’s learning and development may be substantial (Milton, Whitehead, Holland, & Hamilton, 2004; Liberty et al., 2010).

Another limitation concerns methods of screening and the inclusion of participants with difficulties that impact on achievement rates (Gudstadt et al., 1989; Annett et al., 2007; Silverstein et al., 2001; and Fowler et al., 1992; Moonie et al., 2008; Kohen, 2010; Krenitsky-Korn, 2011). For example, having a lower IQ, an intellectual delay, or a learning disability has been proven to have an impact on the achievement scores of children (Batshaw, Carr, 2005, Papalia et al., 2006). Furthermore, including a child who is suffering from one of these conditions could go potentially skew interpretations of the results as the difficulty with achievement could be wrongly attributed to the asthma condition. This could have ramifications for the validity of a study's results and conclusions, as it could be that these underlying conditions contributed to low achievement but this is confounded with asthma status. There is substantial evidence throughout the developmental and education literature on the link between learning disabilities and reading difficulties (Carr, 2006; Batshaw, Pellegrino, & Roizen, 2002; Miller & Schwanenflugel, 2008). Inclusion and exclusion criteria are important to consider, especially when looking at the impact on achievement and drawing conclusions from research findings. Therefore, significant consideration should be given to exclusion criteria in studies of the impact of asthma on achievement.

Another limitation has been the use of a 'control' group (or lack of) (i.e. Gudstadt et al., 1989; Annett et al., 2007; Moonie et al. 2008, Kohen, 2010). The use of a control group is crucial in psychological research (Goodwin, 2009). The control group provides a baseline measure of performance against which the 'experimental' group can be compared. Ideally the two groups have no significant differences apart from the one factor (condition) (Goodwin, 2009). Having a control group allows researchers to have some reference point to where children should typically be achieving (i.e. 'healthy' controls) (Shaughnessy, Zechmeister & Zechmeister, 2012) and from this they can estimate whether the group of children (with asthma) are achieving below, similarly, or above that reference group. In addition, a control group allows researchers to identify and discuss the impacts of a chronic condition on children's performance. For a particular factor being researched, this impacts on the ability to draw conclusions and derive possible explanations for the results.

However, in some instances, it may be more favourable to use an appropriate 'contrast' sample. For example, research has identified a number of 'general effects' attributable to chronic conditions as well as specific effects related to and attributable to a condition (i.e. asthma) (Eide et al., 2010; Austin et al., 1998). When measuring the school performance of children, McNelis et al., (2007) and Austin et al., (1998) both used contrast groups consisting of children with chronic conditions other than asthma. This allowed them to go some way into separating the effects of a chronic condition on achievement from specific effects of asthma (e.g. asthma vs epilepsy). Therefore, adding to the validity of the research results and conclusions due to controlling for the 'general' effects of chronic conditions.

In addition to limitations in the age of participants, measures of achievement, inclusion and exclusion criteria, and the use of control groups, there are other factors which have been identified as having an effect on achievement. Analysing these factors allows the potential to add knowledge and go further to understanding the impact of asthma on children's achievement.

Factors Affecting the Achievement of Children

There is another set of factors which may be present and could further explain the different results in the reviewed studies of academic achievement. These are factors known to have an effect on the achievement of all children; lower intelligence, school absence and socioeconomic status. Many studies have shown that intelligence is related to achievement, and lower intelligence is linked with lower achievement (i.e. Karande & Kulkarni, 2005). Lower intelligence in a child with asthma could explain some of the reviewed findings. However, studies of intelligence including children with asthma have not shown that they are more likely to have lower cognitive abilities, on average. For instance, Annett, Bender, and Gordon (2007) studied children aged 6-12 years (N= 939), who had mild and moderate asthma, and who were part of a state- wide Childhood Asthma Management Program (CAMP). The authors focused on aspects of intelligence as measured by the Wechsler intelligence scales (WISC-III) (Wechsler, 1991). The results reported the mean IQ of the children with asthma was 106.2 (SD= 15.5) as compared to the IQ standard norm of M= 100, SD= 15. They found that there were no significant differences in the measured intelligence of children with asthma in this sample.

A study that measured the intelligence scores of children with asthma within a wider investigation of factors contributing to the academic achievement of children with moderate to severe chronic asthma reported similar results (Gutstadt, Gillete, Mrazek, Fukuhara, LaBrecque, and Strunk, 1989). Participants were 99 children between the ages of 9 and 17 years who had a confirmed diagnosis of moderate or severe chronic asthma (as defined by the American Thoracic Society). Intelligence was measured by the Slosson Intelligence Test (Slosson, 1963) which was chosen for its relative ease of use with administering to such large numbers of children (Gutstadt et al., 1989). The resulting scores of the participants on the IQ tests were generally normally distributed, and 88 (88.9%) participants had a mean IQ between 85 and 129. This is considered to be in the range of 'average to above average' intelligence in the general population. The authors concluded that children with asthma within their study sample did not have significantly lower than average IQ scores.

A child who has asthma and a comorbid learning difficulty or developmental delay is most likely going to experience difficulty with reading and subsequent achievement. Identified differences in the academic achievement of children with asthma may be due to variations in knowledge and experiences that happen over time (i.e. increase in age is related to an increase in general knowledge). This is highly dependent on experience and gradually increases across the entire lifespan (Carr, 2006). However, those factors aside, there is no evidence to suggest a causal link between having asthma and therefore having a lower intelligence.

School absence.

Another potential reason that children with asthma might have difficulty with achievement is related to higher rates of school absence. Various studies have shown that children who have more days off school are at a higher risk of having lower school performance (Needham, Crosnoe, & Muller, 2004; Peterson & Colangelo, 1996; Thies, 1993). Children who are not in school miss opportunities for learning; the longer they are absent, the more they miss. Children with asthma may be more likely to be absent from school compared to children without asthma (Moonie, Sterling, Figgs, & Castro, 2008; Millard, Johnson, Hilton, & Hart, 2008; Silverstein et al., 2001; Fowler, Davenport, & Garg, 1992). Silverstein et al., (2001) studied the school attendance rates of children with (N=92) and without asthma who were matched on age and sex. Data on the attendance rates of the children was obtained from the local community's public school system. Their results showed that children with asthma had m=2.21 more days absent from school per year than their peers without asthma.

Fowler, Davenport, and Garg (1992) used data from a National Health Interview Survey on Child Health (NHIS-CH) to identify school non-attendance rates of children with and without asthma. Data on 10,362 children aged between 6 and 18 years, 536 of whom had asthma (5.2%), were analysed. At the time of data collection, children were characterised as having asthma if respondents on the NHIS-CH reported the presence of the condition within the past 12 months. The results showed that children identified as having asthma had higher rates of school non-attendance days compared to 'well' children after adjusting for factors such as race, gender, age, and maternal education. Specifically, 2% of 'well' children missed between 11-15 days of school when 10% of children with asthma missed that number.

Additionally, 1% of ‘well’ children compared to 11% of children with asthma missed 16 or more days of school within a year. The mean number of days missed for the children with asthma was 7.6 whole days compared to 2.5 days absence in the ‘well’ group.

Newacheck and Halfon (2000) used data from 62, 171 children aged 18 years and younger who were included in the National Health Interview Survey carried out in 1994/1995. They aimed to compare school non-attendance rates of children with asthma (n= 939) against children with other ‘disability conditions’ (n=3119) as well as children without disability conditions (n= 58, 113). The results showed that children with diagnosed asthma had a mean of 9.7 days of non-attendance compared to 5.3 days of non-attendance by children with other conditions. Additionally, the results indicated around 40% of children with asthma were reported as being unable or limited in their ability to engage in school activities. Therefore, children may still be attending school but were experiencing consequences due to their condition that limited activity levels.

Research by Moonie, Sterling, Figgs, and Castro (2008) used data from a local standardised test, the Missouri Assessment Program (MAP) to identify a link between the presence of asthma and the rates of school attendance. During 2002-2003, 3, 812 children aged 8 to 17 were assessed on this test. Of those students, 403 were identified as having a diagnosis of asthma. Of the 403 students with asthma, 175 (43.4%) were able to be categorised into four different asthma severity categories: mild intermittent (N=59); mild persistent (N=35); moderate persistent (N= 23) and severe persistent (N=58). The results showed that students who had asthma missed school approximately 1.5 days more than the students without asthma. The authors also reported an increase in the mean of days non-attended as the severity of asthma increased. They concluded that a child was more likely to miss school if an asthma condition was present and was of a more severe presentation.

Krenitsky-Korn, (2011) reported on academic achievement and also studied the school absence rates of children with and without asthma. Absenteeism was measured by reviewing the attendance records of students from the previous academic year. Students with asthma (N=28) had a mean of 12.6 (SD= 11.7) days absent compared to students without asthma (N=29), who had a mean of 6.2 (SD= 5.0) days absent. Children with asthma had significantly more days absent from school when compared to children without asthma. No differences in school absence rates were found among the males and females who had asthma.

Bonilla, Kehl, Kwong, Morphew, Kachru, and Jones (2005) used data from school attendance records from 528 children and parent- reports to assess rates of absenteeism in a predominately Hispanic populated school. Children were separated into three groups: known/diagnosed asthma; high-probability of having asthma (HPA), and low-probability of having asthma (LPA). Parent reports were compared against school records for reliability and accuracy of responses. Results showed that children with known/diagnosed asthma, missed a mean = 5.2 days/per year and the groups with suspected asthma missed a mean of = 3.2 days/per year. For children of a younger age who were identified with known asthma, the number of days missed per year was significantly higher (m=7.9) when compared to children in the suspected asthma groups (m= 3.1 for high probability group and m=3.7 for the low probability group, respectively). However, these differences were not found among older children.

In contrast, Millard, Johnson, Hilton, and Hart, (2009) measured the effect of varying degrees of asthma on children’s school attendance rates during a specified school year. An asthma symptom-screening questionnaire was sent to 19 elementary schools within the Dallas, Texas area. Of the returned questionnaires, 477 children were identified as possibly having asthma. All of the children were aged between 9 and 12 years and underwent free school asthma testing. Of those tested 157 received confirmed diagnoses of asthma. All children who were attending the 19 ‘study schools’ had an annual absence rate of 2.85% whereas the children identified as having asthma had an annual absence rate of 2.86%. The authors concluded that there was no difference in the absence rates between children with and without asthma.

Liberty et al., (2010) reported on absence rates of young children (i.e. aged 5-6 years) with and without asthma as well as achievement. Absence rates were calculated from school attendance rolls after the children had been in school for 12 months. The results showed that children with asthma had a mean of 12.7 days (SD= 8.11) absent compared to a mean absence rate of 11.5 days (SD= 8.07) from children without asthma. Results of a stepwise logistical regression did not identify school absence as a significant independent predictor of low achievement in children with asthma. The authors concluded that children with asthma were not more likely to have lower attendance rates than children without asthma.

This section looked at the link between school absence in children with asthma and academic achievement. A number of studies compared children with and without asthma (i.e. Kohen 2010; Liberty et al., 2010; Silverstein et al., 2001; Newacheck & Halfon, 2000) with some studies comparing the effect of severity levels on resulting achievement (i.e. Moonie et al., 2008). Analysis of the research identified conflicting results regarding the link between school absence rates and asthma. The identified discrepancies in the reviewed studies may have been due to methodological differences employed by the researchers (i.e. in differentiating between severity levels of asthma). It is likely that school absence could be a contributing factor as opposed to an independent predictor in the lower academic achievement of children with asthma.

Socioeconomic Status (SES).

A fourth potential reason for the decreased performance of children with asthma reported in some studies is lower socioeconomic status (SES). Higher prevalence rates of asthma have been identified in low SES communities (Chen, Matthews, & Boyce, 2002). In New Zealand, asthma is also more prevalent in Maori children, who tend to come from lower SES families (Holt, & Beasley, 2001). Numerous studies have reported an association between lower SES and lower academic achievement (e.g. Stanton-Chapman, Chapman, Kaiser, & Hancock, 2004; Case, Fertig, & Paxson, 2005). In addition to this, studies have shown lower achievement for children with asthma who were identified as coming from a low SES background (e.g., Celano & Geller, 1993; Fowler, Davenport & Garg, 1992).

A study described earlier by Fowler, Davenport, and Garg (1992) used the data from NHIS-CH to look at the relationship between asthma and SES on academic outcomes (grade failure). In this research, SES was characterised by annual family income: low income was considered to be less than $20,000 and higher income was more than $20,000 per year. Participants with asthma were 536 children between the ages of 6 and 18 years. The percentage of children who were reported as having asthma with an annual family income of <$20,000 was 5.1%, and 4.9% respectively. The results showed that 30% of children with asthma who came from lower income families had failed grades compared to about 12% of children with asthma who came from higher SES (income) families. Additionally, 30% of children with asthma and who came from lower income families had failed grades compared to 20% of ‘well’ children from the same income bracket. Interestingly, there was very little difference (11.5% and 11%) between the grade failure of children with asthma and ‘well’ children from families belonging in the higher income bracket.

Research by Mielck, Reitmeir and Wjst (1996) used data from a questionnaire to identify and clarify a link between SES (defined by the highest educational level attained by parents) and severe asthma. Respondents were 4, 434 children (aged 9-11 years), 250 of whom had diagnosed asthma. Asthma was categorised into three severity levels: mild asthma (i.e. 1-4 attacks per/year); moderate asthma (i.e. 5-10 attacks per/year); and severe asthma (i.e. constant wheezing with acute attacks: >10 per/year). The results showed that when the asthma severity categories were compiled into one, there was no relationship between SES and asthma. However, 40% of children who were classified as having severe asthma came from a low SES background. Of children who came from high SES backgrounds, 16% were classified as having severe asthma. Children who came from a low SES background had 2.37 times higher risk of having severe asthma as compared to children with high SES. The authors concluded that there was a clear link between asthma and SES when asthma severity was differentiated.

In New Zealand, a longitudinal study ascertaining the relationship between SES and asthma spanning 25 years found different results (Hancox, Milne, Taylor, Greene, Cowan, Flannery et al., 2004). SES was categorised on a 6-point scale based on occupation (6= unskilled labourer, 1= professional). Participants (N=1037) were followed from birth through to the age of 25 (N=980) and measures were taken at 11 time points with 2-3 years between each point. Measures of lung function and airway responsiveness (spirometry), and atopy were included. Information on parental asthma, smoking, breast feeding and birth order was also gathered at various time points. The collected information allowed for the identification of relationships between SES, during childhood and early adulthood, and asthma outcomes. The results of the comprehensive analyses revealed no significant relationship between the mean SES during childhood and a diagnosis of asthma.

Claudio, Stingone, and Godbold, (2006) used information from a questionnaire reported on by parents about their children with asthma to examine the functions of socio-demographic factors (i.e. income; neighbourhood SES; hospitalisation rates). The questionnaire was completed by parents of 5,250 randomly selected students, who were aged between 5 and 12 years in 26 elementary schools in New York City during 2002/2003. Within this sample, there was an overall prevalence rate of 13% for current asthma status. The city's postal codes were clustered into approximately 15 equally sized groups based on the asthma hospitalisation rates. From the 15, three; highest, median, and low (H=86.3-163.2; M= 28.9-35.7; L= 0-4.99 hospitalisations per 10,000 children) groups containing eleven postal codes each were used for the analysis. In total, there were eight schools from the high and median groups and 10 from the low group. The results showed that 51% of the children living in the 'high' hospitalisation group were from families with low SES (income = <$20,000) compared to 35.1% and 34.1% of children from the 'median' and 'low' hospitalisation rate groups. Additionally, the prevalence rates of asthma differed amongst the three groups: 27% of children within the 'high' group were identified as having asthma whereas the rates were lower for the 'median' and 'low' hospitalisation rate groups (17.2% and 11.2% respectively). The authors concluded that children living in low-SES communities were at greater risk of having a diagnosis of current asthma.

Studies generally found that children who came from lower SES backgrounds had a higher risk or prevalence rate of asthma. Studies had different definitions and strategies to operationalize SES; therefore, comparisons between the studies were difficult. Whether a link between SES and asthma was observed or not was influenced by the methodology chosen by a study. Specifically, if asthma was differentiated into different severity levels then the influence appeared to be more pronounced (i.e. Mielck et al., 1996). Hancox et al.'s, (2004) results are pertinent to New Zealand and the population of individuals with asthma as the study cohort encompassed the entire SES range in this country. Liberty et al., (2010), found that SES was a factor in the low achievement of children; however, this was not as statistically significant as asthma.

The previous section outline factors identified to be contributing to the low achievement of children with asthma that are also present in the population of children without asthma. There are other factors which can affect achievement which are unique to the asthma condition. Through exploring these factors creates the opportunity to potentially add knowledge to understanding the impact of asthma on children's achievement.

Achievement-Related Factors Associated with Asthma

The final set of factors that could have an impact on the learning of children with asthma include factors related to the condition of asthma; such as asthma severity, medication adherence, breathing system development and control, medication effects on the voice, abnormal breathing, anxiety, and difficulties with breathing while reading aloud. The type and severity of asthma that a child is experiencing could play a role in their learning and therefore contribute to low academic achievement (Thies, 1993). However, studies of children with various degrees of asthma severity have shown that severity alone does not account for impacts on the child's learning (Reitveld & Colland, 1999; Liberty, Pattemore, Reid, & Tarren-Sweeney, 2010). For instance, a study by Reitveld & Colland (1999) compared report cards to determine the school performance of 10-13 year old children. Participants were identified either as having severe asthma (N=25) or without asthma and they were matched for SES background, sex, and age. Results showed that there were no differences in the academic achievement of the two groups of children.

Asthma severity.

The symptoms that occur with asthma place increased pressure on the respiratory system in order for the individual to continue to breathe. This extra pressure results in the system going into high respiratory drive, resulting in a high drive to breathe and fulfil metabolic needs (Loudon, Lee & Holcomb, 1988; Bailey & Hoit, 2002). Lee and Holcomb (1988) set out to compare measurements of breathing patterns and lung volumes in participants with (N=14) and without (N=10) asthma. These were measured by four different conditions; counting aloud at two different levels of 'loudness', reading a monologue aloud, and engaging in a conversation. In the conversation condition, the mean volume of gas expired without speech was greater in the asthmatic group 194ml (SD= 92) as compared to 91ml (SD= 75) expired in the non-asthmatic group. Overall, results indicated that the participants with asthma were most likely forced to prioritise breathing and use up expired air for those purposes instead of using it for communicating (Loudon, Lee, & Holcomb, 1988).

Medication adherence.

A factor that is strongly linked to asthma severity is adherence to treatment régimes; and adherence is influenced by familial, social, emotional, cognitive, and behavioural factors (Bourdin, Halimi, Vachier, Paganin, Lamouroux, Gouitaa et al., 2012). Medications that are used to decrease airway inflammation (e.g., inhaled corticosteroids or ICS's) are considered the 'gold standard' in the management and intervention of chronic asthma and adherence to medication has direct and positive effects to an individual's quality of life (Baiardini, Braido, Giardini, Majani, Cacciola, Rogaku, Scordamaglia, & Canonica, 2006). Anxiety about the adverse effects of the medication and the quality of communication between the patient and the physician are factors to consider. Additionally, motivational aspects such as self-efficacy, individual expectations, social influences, and personal attitudes all influence the intention to use asthma medications. Asthma control is largely determined by adherence to prescribed medication, with adherence being impacted on by a number of individual and systemic factors.

However, for children, adherence to medication is additionally complex, as it involves parents, who may or may not have asthma themselves. A study by McQuaid, Kopel, Klein and Fritz (2003) set out to investigate the asthma medication adherence of children (N=106) aged 8-16 years. Adherence was measured over a timeframe of 1 month by an electronic asthma medication monitor (MDILog). This device, containing a computer, was attached to each participant's inhaler and recorded the date and time of each metered dose inhaler actuation. The results showed the mean level of adherence across the children was m=.48 (SD= .29). The children in the study, on average, received about half of the preventative medication that had been prescribed to them. In addition, no differences in adherence rates were found across gender, asthma severity, or the socioeconomic status of the family. However, a significant difference in adherence was identified between Caucasian (m=.53, SD= .29) and non-Caucasian (m= .37, SD= .26) participants.

A cross-sectional study set out to identify possible factors contributing to adherence of children to ICS's. Participants included 232 children (7-14 years old) from four different ethnic backgrounds (Dutch, Moroccan, Turkish, and Surinamese), all of whom were identified as having asthma (Dellen, Stronks, Bindels, Dry, van Aalderen, & the PEACE Study Group, 2007). Participants were characterised as being either 'daily users', indicative of good adherence, or 'non-daily users', indicative of poor adherence. Adherence was assessed by three different components; self- report (i.e. self- management questionnaire); electronic pharmacy records (i.e. 'collects' or 'non-collects' of prescriptions in a 12-month period); and dosage per day (i.e. >1 mean puff of medication per day'= good adherence and <1mean puff of medication per day= poor adherence). Of the sample, 25% of children reported not using their ICS on a daily basis. Of the sample, 88% of children collected at least 1 of their prescriptions from a pharmacy during the specified time period. However, when the authors compared their adherence rates against international guidelines in respect to total 'puffs per day' on inhalers, the adherence rate was only 46% (Dellen et al., 2007). The authors suggested that encouragement from parents to take medications was a factor that was positively related to adherence. Overall, results showed no significant difference in adherence between the different ethnic groups.

Research by Gibson, Ferguson, Aitchison and Paton, (1995) used data from a Nebulizer Chronolog, a device which recorded inhaler puffs, which was attached to 26 children's asthma medication in order to assess two measures of medication compliance. The aim was to explore the relationship between parental involvement of medication administration and 'compliance'. Compliance was measured by computing the percentage of the total study days on which the prescribed number of puffs was recorded at the prescribed rate (e.g. 2 puffs four times a day). Compliance was further measured by calculating the proportion of medication 'actually' administered to the total recommended doses over the entire study period. The results showed variable and often insufficient compliance to prescribed medication. Additionally, self-reports from caregivers showed discrepancies in compliance, and were higher than what was actually measured by the Chronolog. Therefore, caregivers were falsely reporting higher levels of adherence. Overall, findings showed 58% of participants had days where no medication was taken at all. The authors concluded that adherence to asthma medication by preschool children reduced significantly with time, even with supervision of treatment administration by caregivers.

Adherence to medication is crucial in the management of chronic asthma. The studies discussed above indicate relatively poor rates of adherence (Bender et al., 2007; Jonasson et al., 2000; Dellen et al., 2007). In the study carried out by Dellen et al., (2007), the authors alluded to potential factors that may positively or negatively contribute to adherence, for example, encouragement from caregivers. Dependent on the child's age and developmental level, the responsibility lies with the caregiver of the child to ensure compliance to prescribed medication. The severity of asthma symptoms can be managed by adhering to physician prescribed medication schedules for asthma.

Breathing system development of children.

Resting breathing rate is the minimum amount of energy required in order to sustain vital functions (Nhung, Khan, Hop, Lam & Khanh, 2007). Literature has discussed the reliability of equations to calculate resting rates for individuals based on age, sex, weight and geographical position (Nhung et al., 2007). There appears to be a negative correlation between age and resting breaths per minute (bpm) with the greatest decrease occurring in the first 4 years of life. For children 4-6 years of age the rate is 20-25 bpm and for children between the ages of 6 and 12, it is 16-20 bpm. Adult resting breathing rates are between 12 and 16 breaths per minute (Family Practice Notebook, 2014). As the relevant systems mature, the result is a greater capacity to inhale and utilize oxygen and expend carbon dioxide, and so fewer breaths are required.

Fleming, Thompson, Stevens, Heneghan, Pluddemann, Maconochie, et al., (2011) reviewed the literature in order to create new reference charts of respiratory rates of children in relation to age. A total of 69 studies encompassing data on the respiratory rates of 3881 children were identified. The resulting centile charts indicated that during the period of birth to early adolescence, there is a steady decline in respiratory rate. The greatest decline appears to occur between birth and around 2 years of age (median 44 bpm at birth dropping to 26 bpm at 2 years). They concluded that there were large inconsistencies between the devised charts and the comparative charts found in the reviewed literature. The inconsistencies possibly illuminate the large variation in breathing rates among individuals of different age, sex, weight and height.

The nature of asthma and the impact on the breathing system results in a reduced ability to fulfil metabolic respiratory needs. A number of tools have been identified to measure and determine an individual’s lung function. Spirometry measures the amount (i.e. volume) and/or speed (i.e. flow) of air that can be inhaled and exhaled from the lungs

(WebMD, 2011). It is the most common pulmonary function tests (PFTs); and also looks at the lung's ability to put oxygen in and remove carbon dioxide from the blood. Lung function measures are valuable in determining the amount of airway obstruction caused by asthma symptoms (Bacharier, Strunk, Mauger, White, Lamanske and Sorkness, 2004) and impact on the fulfilment of metabolic needs.

A factor that can affect breathing rate in speech is the use of a pause during speech. Research reports have used many definitions of a 'pause' within speech as well as the duration of time that determines a pause. Oliveria (2002) used the definition set out by Hieke, Kowal, and O'Connell (1983), who termed it a pause as 'silent' that entails a "period of vocal inactivity of a certain duration embedded in the stream of speech" (p 2; as cited in Oliveria, 2002). Goldman-Eisler, (1968; 1972) discussed at length the idea of having a minimum cut-off point of 250ms for the definition of a pause, stating that because of the intricacies of speech production, many short (< 200ms) pauses are necessary in order for articulation. But many other definitions follow the general idea that it is a period of silence between vocalisations (Oliviera, 2002). Published studies on 'silent pause' durations clearly demonstrate that pause behaviour is highly variable depending on factors related to both the speaker (i.e. anxiety, breathing, interruption, syntactic complexity) and the discourse situation (i.e. speech rate, speaking style, emphasis) (Oliviera, 2002; Winkworth et al., 1994).

Influences on pause use.

The process of producing natural sounding speech when reading text requires a complex system. This involves dividing the text into intonational phrases and having pauses between the phrases (Zvonik & Cummins, 2002). Research shows that the basic skills required for producing speech are generally acquired by the middle of childhood. However, the development of the speech-breathing system is a process that takes place from about 3 up until 10 years of age (Hoit, Hixon, Watson, & Morgan, 1990; Boliek, Hixon, Watson, &

Jones, 2009). The maturation time suggests that there is a possibility that children who are in the early stages of reading any manner of text are at risk of struggling to carry out the tasks due to their speech-breathing system being underdeveloped.

Characteristics of the text, punctuation and grammatical structure, affect children's pausing during reading aloud. Narrative boundaries (i.e. punctuation and grammatical structure) are one of the frequently researched variables that influence the occurrence of a pause (Oliviera, 2002; Krivokapic, 2010; Winkworth et al; 1994; Zvonik & Cummins; 2002). In addition, longer pauses have an important role in speech planning and production during reading. Two of the main functions of longer pauses are: to allow the audience to cognitively digest the information and to give the speaker time to adequately formulate the production of the next group of sounds (i.e. words). Research by Oliviera (2002) found that the mean duration of pauses occurring at narrative boundaries was between 1ms and 92ms and this was significantly different from those at non-narrative boundaries, which ranged from 1ms and 74ms. He concluded that the results were a demonstration of how pausing behaviour and a longer pause can be regarded as a strong indication of the presence of a narrative boundary (i.e. full stop at the end of a sentence) within text.

Metabolic vs linguistic needs during speech.

The rate of reading is another factor that can influence the breathing of children whilst reading aloud. Grosjean and Collins (1979) analysed the breathing patterns of six university undergraduate students with no reported hearing or speech difficulties. Participants read 5 passages that were below or above 'normal reading rate' over a 90 minute session. The number of and length of breathing pauses were measured. A breathing pause was separated into 'pre-inspiration', 'inspiration' and 'post-inspiration'. The results found that as the reading rate increased, pauses diminished in number and length; and non-breath pauses disappeared almost completely. The authors concluded that when speaking at very fast rates participants attempted to delete all pauses but were stopped due to the need to breathe, then they would inhale as quickly as possible and continued reading.

Sufficient airflow is required when an individual breaths out in order for effective vibration of the vocal chords resulting in the generation of 'voice' (Dogan, Eryuksel, Kocak, Celikel, and Sehitoglu, 2005). Greater airway obstruction and resistance due to increased mucus secretions results in impairments in the generation of voice and the resultant need to breathe (Dogan et al., 2005; Bailey and Hoit, 2002). Additionally, speaking out loud further increases demands on the respiratory system and adjustments need to be made in order to accommodate the linguistic demands (Bailey & Hoit, 2002). These demands can differ dependent on the type of speech; whether it is 'free' speech (e.g. general speaking) or reading aloud from a text (e.g. a book or a newspaper article) (Bernadi Wdowczyk-Szulc, Valenti, Castoldi, Passino, Spadacini, & Sleight, 2000; Wang, Green, Nip, Kent, & Kent, 2010). When speech is produced, the patterns of breathing are different depending on the nature and purpose of the speech; breathing in (inhalation) is rapid, whereas, breathing out (exhalation) is slower in order to increase the amount of time that is available for speech production (Winkworth, Davis, Ellis, and Adam, 1994; Robb, Sinton-White, & Kaipa, 2011).

Medication and voice.

Adding complexities to the process of voice generation are the local side effects of inhaled corticosteroids. Two side effects of ICS's have been researched heavily in adult populations but are less frequently researched in child populations (Dubus et al, 2001) are dysphonia (i.e. disorder of voice; an impairment in the ability to produce voice sounds using vocal organs) and 'cough during inhalation of ICS medication'. Numerous studies have documented the impact of ICS on varying asthmatic populations. Some of the most commonly reported side effects include 'hoarseness'; 'cough during inhalation of medication'; 'thirsty feeling'; 'dysphonia'; 'oral candidiasis' (i.e. thrush) and 'perioral dermatitis' (i.e. mouth) (Roland, Bhalla & Earis, 2004; Gallivan, Gallivan, & Gallivan, 2005; Lavy, Wood, Rubin, & Harries, 2000). In the literature, these local side effects have been termed as 'minor' and 'infrequent'. However, they have the ability to interfere with medication adherence as the side effects cause discomfort and can potentially reduce medication use. The subsequent decrease in adherence results in a decline of successful disease control (Roland et al., 2004). Therefore, reduced adherence to ICS medications may result in an increase in the severity of asthma symptoms, causing an individual to seek intensive treatment and/or hospitalization.

One of the few studies identified in the current research on a child population was conducted by Dubus, Marguet, Deschildre, Mely, Le Roux, Brouard, and Huiart (2001). The authors investigated the impact of medication, the dose, the child's age, and the device used to deliver the medication in relation to ICS-induced local side-effects in a prospective cross-sectional, multicenter survey. Participants were 639 children with asthma between the ages of 3 months and 16 years of age who were being treated by either inhaled beclomethasone dipropinate (BDP) or budesonide (BUD). Participants were categorised into two age groups: under the age of 6 years; and. all remaining participants (6- 16years). The survey contained questions that targeted information on local side effects such as hoarseness, dysphonia, 'thirsty feeling', and cough during inhalation of medication. Overall, 63.3% of the younger group reported one or more side-effects, and 59.5% of the older group. In terms of specific side effects, 39.7% of children reported cough during inhalation of the medication, 21.1 % reported a 'thirsty feeling', and 14.1% reported 'hoarseness' and 11.1% of all children reported dysphonia symptoms. The occurrence of cough during inhalation of medication was not related to drug type but results showed that incidence doubled when a spacer device, rather than another device was used (53.8% vs. 26.5% in the BDP drug group and 53.2% vs. 17.9% in the BUD group). Additionally, results indicated that dysphonia was more likely to be linked to the dose of the ICS and occurred more frequently with higher doses of BUD. The researchers concluded that the results suggest that the method in which the ICS is delivered should be re-evaluated and changed rather than the specific ICS itself.

A follow-up study by some of the authors of the previous research examined children with asthma taking ICS medication and the local side-effects, specifically ‘cough immediately after inhalation of asthma medication’. Additionally, the potential factors contributing to the incidence of this side effect (i.e. mode of inhalation, type of spacer, propellant, and drug-type) (Dubus, Mely, Huiat, Marguet & Le Roux, 2003) were measured. Participants were 402 children aged between 3 months and 15 years who were being treated for asthma by one of three ICS medications. These were BDP (n=331, 82.3% of sample), BUD (n= 47, 11.7%) and fluticasone propionate (FP) (n=24, (9%) with rates of once or twice a day (98.2% of cases). Additionally, two different spacer devices were being used within the sample; face -mask or mouthpiece. The results showed that just over half (53.7%) of participants reported the incidence of ‘cough after inhalation of medication’ of an ICS, daily, at each inhalation. There was no significant difference over the three types of ICS medications in the rate they induced cough (FP= 41.7%; BUD= 53.3%; and BPD= 53.8% of cases). Cough was not associated with the daily number of ICS inhalations but was connected to how long a participant had been using ICS therapy.

The previous section reviewed the limited literature available investigating the impacts of prescribed medications on voice of children with asthma. Common side effects identified were cough during and after inhalation of the perscribed asthma medication, a ‘thirsty’ feeling, hoarseness and dysphonia. Experiencing any one of these side effects would leave a child feeling uncomfortable and may then influence their subsequent medication use as well as their speech breathing.

Abnormal/dysfunctional breathing.

Dysfunctional breathing is another factor that can impact on the breathing and speech production of children with asthma. Abnormal or ‘dysfunctional’ breathing patterns have been found in adults with asthma. Patterns of breathing that are considered abnormal have been identified as causing chest tightness, breathlessness, chest pain and anxiety (Thomas, McKinley, Freeman, & Foy, 2001). Dysfunctional breathing, hyperventilation syndrome and behavioural breathlessness are various classifications for this group of symptoms within the literature and clinical settings. Thomas, McKinley, Freeman and Foy (2001) used data from a self-report questionnaire to estimate the prevalence of dysfunctional breathing in a group of adults with diagnosed asthma. The questionnaire was a 5- point scale (0 never- 5 very often) assessing 10 symptoms associated with abnormal breathing. Participants (N=7033) aged between 17 and 65 years were treated with ICS medication within their local community. Out of the questionnaires completed, 219 (71.3%) were able to be analysed. Scores that were higher than 23 were defined as indicative of ‘dysfunctional breathing’. The results showed that 28.8% (N=63) scored in this range. These participants were more likely to be younger women. There were no differences found across severity levels of asthma. The authors concluded further research was necessary to validate the screening tool and the study findings.

De Groot (2011) investigated the breathing abnormalities in children identified as having ‘breathlessness’. ‘Breathlessness’ is characterized by difficult, laboured or uncomfortable breathing which is highly prevalent in pulmonary diseases such as asthma. Breathlessness is considered a physiological function in the presence of physical exertion (exercise above normal tolerance). However, it is pathological when it occurs with very little or no activity at all (de Groot, 2011). There are no standard criteria for ‘breathlessness’, thus making it hard to differentiate symptomatic breathlessness in the presence of a pulmonary disease like asthma. Additionally, de Groot (2011) discussed the strong link between breathlessness and the presence of anxiety. It was concluded that when anxiety was present and chronic, it had a disabling impact on an individual's quality of life.

Asthma and anxiety.

Anxiety is another factor that can influence the breathing of children with asthma. Respiratory dysregulation is a very common symptom in anxiety as well as being a key diagnostic feature when making a diagnosis of an anxiety disorder (Paulus, 2013; Giardino et al., 2007; Thoren & Petermann, 2000). In children, anxiety is associated both with fear of somatic symptoms, such as breathlessness, and with 'public performances', such as reading aloud, which is one of the highest anxiety-inducing situations identified during the development of a child anxiety scale, (Beidel, Turner, & Morris, 1995). Non-clinical levels of anxiety are common in people of all ages; acute increases in breathing rate can be linked to an increase in state-anxiety (i.e. temporary situation related to the perception of a situation/threat). When the person and/or situation are no longer interpreted as threatening, the anxiety goes away. Trait anxiety is similar to state, in that it is in reaction to the individual's assessment of a potential threat. However, it tends to have increased duration, intensity and is experienced in a wider range of situations (Thoren & Petermann, 2000). For individuals with asthma, the 'threat' of an asthma attack and consequent inability to breath is a very real and present prospect. A child with asthma who is learning to read, which involves reading aloud, may have an increase in state anxiety.

Anxiety may be an important factor to consider in the treatment, planning and monitoring of a child with asthma. An individual's breathing can change in response to a change in emotion. Negative emotional experiences such as worry and anxiety can result in excessively fast breathing known as hyperventilation (Homma & Masaoka, 2008; Thoren & Petermann, 2000). Kelley (2001) discussed the importance of assessing the extent of a child's anxieties to minimize unnecessary increases in asthma treatments, specifically prescribed medicines. He proposed that investigations should extend beyond asthma symptoms as there are other difficulties that could be causing the breathing difficulties seen in individuals with asthma, such as anxiety, hyperventilation and laryngeal dysfunction.

High respiratory states.

Another possible factor influencing the breathing of children with asthma is the high need or 'drive' to breathe. Bailey and Hoit (2002) investigated several breathing characteristics (i.e. frequency, volume, inspiration and expiration duration) of 10 adult men in two different conditions; one with normal air quality and one with higher levels of CO_2. Participants completed breathing and reading tasks and breathing characteristics during both conditions were measured by magnetometers. The results showed a mean breathing rate of m=16.12 when reading in the CO_2 condition as compared to a mean of 13.01 when reading in the normal air condition. The authors concluded that the demands of linguistics (e.g. pausing at a comma) during the reading passage remained strong when the need to breath was high (CO_2 condition), however, the influence of linguistic structure was not as large of an influence as was observed in the oxygen condition. Therefore, when the need to breath is higher (e.g. asthma), there is a greater balance between fulfilling metabolic (i.e. breathing) and linguistic needs.

The linguistic demands of an utterance have a strong influence on breathing behaviour in high-drive states, at least during a scripted task such as reading aloud. However, linguistic demands do not exert exclusive control over speech breathing behaviour. Bailey and Hoit (2002) proposed two hypotheses to explain the perceived differences in 'work' when speaking as opposed to breathing in the CO_2 condition as reported by the participants in their study. One potential explanation was that speaking requires a greater motor output which may result in a feeling of an increased sense of effort. A second potential explanation was that the resultant high drive to breath (CO_2 condition) leads to a greater challenge of coordinating speaking with breathing. It may be that children with asthma, due to their symptoms, experience this state (high respiratory drive) during reading more often than children without asthma, and therefore, may struggle with reading aloud.

Early reading in New Zealand.

Early reading instruction in New Zealand requires children to read out loud; putting extra strain on cognitive capacity, working memory to both read and understand the text and demands on an immature speech-breathing system to transform it into spoken speech in front of others (Hoit et al., 1990; Boliek et al., 2009). A child with asthma who is beginning to read can be affected by interactions between the following factors: increased demand on the respiratory system (Wang et al., 2010); the greater demands of speaking aloud the need for balance between metabolic and linguistic needs (Bailey & Hoit, 2002); the underdevelopment of breath control mechanisms in children (Hoit et al., 1990; Boliek et al., 2009), and the anxiety that comes with reading aloud in front of others (Beidel, Turner & Morris, 1995). This task would cause stress for many children as it requires the juggling and handling of many tasks at once.

In late 2013, an editorial in an international journal highlighted the importance of investigating the breathing of children with asthma (Goyal & Sly, 2013). The editors emphasised main points including what constitutes ‘dysfunctional breathing’ as established by Thomas et al., (2001), psychological problems found in children with asthma and a correlation between scores on a self-report questionnaire and poor asthma control (De Groot, 2011). In addition to these considerations, it is important to determine if the breathing of children with asthma might affect early reading achievement.

Research Question

The primary research question of this study is whether reading difficult passages affects the breathing patterns of children with asthma.

Chapter 3 Methods

This study employed non-contact respiratory monitoring methods (Khalidi, Saatchi, Burke, Elphick and Tan, 2011) to compare the breathing patterns of children with asthma (N=11) across different types of quiet breathing and speech breathing tasks with the breathing of children without asthma (N=11).

Ethical considerations

Ethics approval was sought from the University of Canterbury Human Ethics Committee before the start of participant recruitment for the current research. A copy of the University of Canterbury Human Ethics Committee approval letter is included in Appendix A (page 123). A Locality Agreement was made between the researcher and Christchurch Hospital to allow the conduct of the study at the given locality. A copy of this agreement can be found in Appendix B, (page 124).

It was important that participants and their parents were well informed and knowledgeable of the procedures before consent was acquired. The information sheets (parent and child forms) were clear, age-appropriate and encouraged parents to talk with their children before consenting to participate in the study (Appendix C, page 125 and Appendix D, page 126). To ensure children were informed about participating in the study, the researcher explained briefly what would be happening in the sessions before beginning. After the explanation, the researcher asked for verbal consent from the child, if the child said "yes", the researcher began with the tasks. Throughout recruitment and data collection procedures, the researcher used a simple and clear communication style and allowed for questions and understanding to ensure that both parents and children were knowledgeable about procedures.

Participants

Eleven children with asthma and 11 gender- and age-matched children without asthma were recruited as participants in this pilot study. For the asthma group, the subject inclusion criteria were children who were between the ages of 5-9 years and who had been assessed at the Canterbury Public Hospital, Paediatric Asthma Clinic from 2011 to 2012 and presented with moderate to severe asthma over the years (medications prescribed for the children are shown in Table 5, page 58). For the non-asthma group, the subject inclusion criteria were healthy children who were recruited to match as closely as possible within the study time frame with participants in the asthma group on gender and age. For both asthma and non-asthma groups, children with any hearing, neurological, cognitive, or other medical conditions were excluded. Written consents from the parents and verbal consents from the participants were obtained.

The subject characteristics for the asthma and non-asthma groups are shown in Tables Table 1 (page 45) and Table 2 (page 46) respectively. A series of independent t tests showed that there were no significant group differences on chronological age ($t = 0.977$, $df = 20$, $p = 0.34$), years in school ($t = -0.132$, $df = 20$, $p = 0.896$), PPVT scores ($t = -1.007$, $df = 20$, $p = 0.326$), or PPVT-based language ($t = 0.016$, $df = 20$, $p = 0.987$).

Table 1
Characteristics of Children with Asthma

Subject Code	Gender	Chronological age (year:month)	Years in school	PPVT-4 standard score	PPVT-4 language (year:month)*	Asthma status
A1	F	6:1	1	**	**	Severe
A2	F	6:4	2	109	7:1	Moderate
A3	F	8:1	3	100	8:2	Mild
A4	F	8:4	3	109	9:1	Severe
A5	M	6:3	1	106	6:8	Severe
A6	M	7:3	2	96	6:9	Moderate
A7	M	8:3	3	99	8:3	Severe
A8	M	8:4	3	83	6:6	Moderate
A9	M	8:4	3	82	6:3	Severe
A10	M	8:7	3	100	8:7	Severe
A11	M	9:1	5	97	8:9	Moderate
Mean		7:8	2.64	95.27	7:2	
SD		1:0	1.12	12.96	1:7	

* age equivalents calculated by raw scores (Dunn, & Dunn, 2007)
**not able to complete administration

Table 2
Characteristics of Children without Asthma

Subject Code	Gender	Chronological age (year:month)	Years in school	PPVT-4 standard score	PPVT-4 language (year:month)*	Asthma status
N1	F	7:2	2	109	7:0	No
N2	F	7:2	3	99	8:6	No
N3	F	8:3	4	114	7:6	No
N4	F	8:4	4	93	7:3	No
N5	M	5:7	1	91	6:3	No
N6	M	8:1	4	90	6:11	No
N7	M	8:5	4	103	8:7	No
N8	M	8:5	3	98	8:2	No
N9	M	8:5	4	103	8:8	No
N10	M	9:4	5	75	6:6	No
N11	M	9:9	5	94	8:11	No
Mean		8:1	3.55	97.18	7:7	
SD		1:1	1.21	10.50	0:11	

* age equivalents calculated by raw scores (Dunn, & Dunn, 2007)

Experimental Tasks.

The present study looked to measure the breathing of children through a sequence of eight tasks outlined in Table 3 (page 47). The participant's tasks included: (1) breathing at rest ("Quiet breathing"), (2) sustaining an /a/ sound at a constant pitch on one breath ("Phonation"), (3) speaking and answering questions under no stress ("Free speech") (4) reciting the alphabet or counting ("Recital"), (5) reading at the first of the reading conditions: the easy level ("Easy reading"), (6) reading at the age-appropriate reading difficulty level ("Instructional reading") (7) reading at the challenging level ("Hard reading"), and (8) repeating the first task, which was breathing at rest. The Peabody Picture Vocabulary Test-4th edition, was administered after the eight conditions had been recorded. Table 3 presents the participant tasks along with the planned duration and frequency. (See Appendix F, page 128 for instructions read to each participant for each task).

Table 3
Experimental Tasks

Task	Duration	Number of trials
1. Quiet breathing	15 sec.	1
2. Phonation	On one breath	3
3. Recital	30 sec. – 1 min.	1
4. Free speech	Approximately 20 sec.	1
5. Read aloud Easy text	31 words (whole book), 30-60 sec.	1
6. Read aloud Instructional text	150 words, 1-2 min.	1
7. Read aloud Hard text	150 words, 2-3 min.	1
8. Quiet breathing	15 sec.	1

<u>Quiet Breathing</u>. The first and final task involved the child breathing at rest or silent breathing (Robb et al., 2011). The purpose of this task was to assess baseline measures of the

child's breathing at rest. The breathing task was repeated at the end of the experiment in order to have a measure of the child's breathing after work (Bernadi et al., 2000).

Phonation. The second task required children to maintain the /a/sound at a constant pitch and loudness level for as long as they comfortably could. This task provided an indication of participants' ability to sustain this sound after taking one deep breath (Hunter, 2009; Mendes Tavares, Brasolotto, Rodrigues, Pessin, and Martins, 2012). Participants did this three times, with a 10 second rest period in between each trial.

Free Speech. The third task involved talking or free recall. Children were asked open ended questions in order to have them using "free speech" (Wang et al., 2010; Bernadi et al., 2000; Bada, & Genc, 2008). Examples of such questions were "Tell me all about your favourite thing to do" or alternatively, if it was known that the child liked dancing, "Tell me all about your dancing". "Free speech" does not have the same grammatical junctures that naturally lead to pauses the way that structured formal reading does. This task was intended to enable researchers to have a comparison against "read speech" or "reading aloud".

Recital. The fourth task involved the child reciting the alphabet or counting to 25 at a comfortable rate of speed (Loudon, Lee, & Holcomb, 1988; Hunter, 2009). This was used as a measure of an elicited "structured" vocalisation that was not reading a story book. This allowed the researcher to have a comparison of structured vocalisation.

Easy Reading. The fifth task was the first of the "reading aloud" conditions. This level was termed "easy" and set at the level of 66 months or the level that a child would be expected to be reading halfway through their first year of school (approximately age 5 years, 3 months equivalent). All children read the same book, "The Wind" (Hill, 1984), which included 31 words. This took on average, 30 seconds for a child to read. A subjective professional judgment as to how well a child read this book was used as a gauge to determine the difficulty of the next reading task(e.g. less or more difficult in levels). For example, if a child had difficulty identifying and reading words such as “the”, “and”, “wind” and “blows”, a book less difficult than the “easy” book was chosen for the “Easy reading” task and the score for reading “The Wind” was later determined as fitting the criteria for ‘instructional’ or ‘hard’.

Instructional Reading. The sixth task was reading an ‘age-equivalent’ book. The book reflected the level equivalent to the child’s chronological age. This was determined by following the ‘Ready to Read’ colour wheel (Rainbow Reading, 2010). This task took around 1-2 minutes to complete, dependent on the reading speed of the individual child. The researcher gauged the degree of difficulty a child had with the ‘instructional’ text in order to determine whether to move up to the ‘hard’ book. For example, if a child did not make more than five errors in the first paragraph then the ‘pre-assigned’ ‘hard’ book would be given. Alternatively, if a child had significant difficulty with the ‘instructional’ book, the researcher picked a book a level down and the “instructional” book would in turn become the ‘hard’ book. All children read 150 words of an “instructional” book. This was in order to keep the amount of “work” each child was exposed to at a constant.

Hard Reading. In the seventh task, a participant progressed to a book that was of “hard” difficulty. This book was one that was about 1 year above the child’s chronological age. The “difficulty” level was determined by the child’s age. Additionally, the reading performance on the day of data collection (as described above for “Instructional Reading”) contributed to the choice of the ‘hard’ reading material. All children read a “difficult” book for a minimum of 150 words. They were able to discontinue after that time.

Settings

The experiment took place in the Health Sciences clinics at the School of Health Sciences, at the University of Canterbury. The clinic space consists of 4 clinic rooms, with remote-control cameras linked equipment in the observation rooms. Clinic rooms are set up with toys and activities for the opportunity to both sit and talk and also child to play. Each clinic room has an observation room with one way mirrors. There is also a meeting/interview room and a foyer/waiting area.

Due to accessibility and practicality, some sessions (6 participants in the asthma group and 18 participants in the non-asthma group) were carried out at the family home. The researcher went to the family's home when factors (i.e. young infants, convenience) made it difficult for the family to come to the Health Sciences Centre. It was specified that a "quiet place" was necessary in order to carry out the tasks within the family home.

Instrumentation.

The participants' responses to the experimental tasks were captured using the inbuilt microphone on a Hewlett Packard Notebook Laptop. The microphone is omni-directional and was used to capture the audio content of the child in all breathing and reading conditions. Audio content was captured using Audacity 1.2 (Audacity (n.d.), which is a free open source audio record-and-edit software providing a graphical display of audio content. Audacity has been used to analyse breathing, coughing, and wheezing (Marshall, & Boussakta, 2007; van der Giessen, Loeve, de Jongste, Hop, & Tiddens, 2009; Robb, Sinton-White, & Kaipa, 2011).

Audio content was exported from Audacity into WAV format and were analysed using TF32 Software Demo Level (Milenkovic, 2004). The TF32 software specialises in visualising properties of the acoustic speech signal or other audio-frequency waveforms by displaying waveform plots along with pitch, spectrograms, and other analyses computed from those waveforms. The TF32 software has been used in other studies to analyse numerous acoustic measures such as sustained vowels, and breathing patterns (Hunter, 2009; Max, Wallace, and Vincent, 2003; Rosen, Murdoch, Folker, Vogel, Cahill, Delatycki, and Corben, 2010).

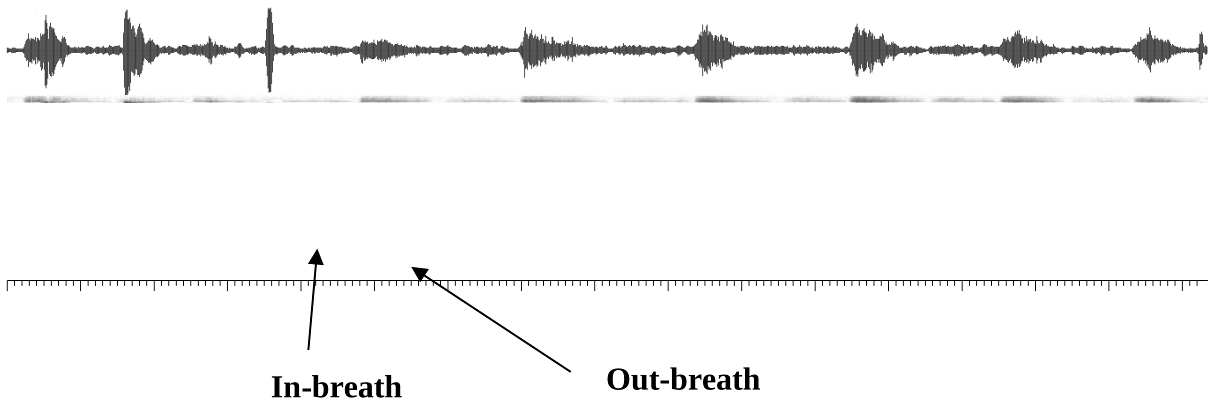


Figure 1 An example of the breathing cycles, showing the time waveforms (upper graph; X-axis: time, Y-axis: amplitude) and spectrogram (bottom graph; X-axis: time, Y-axis: frequency).

Figure 1 is a visual display of a breathing sequence in the time waveforms and in a spectrogram, which were derived from the TF32 software. It shows the clear beginning and end of the respiratory cycles. An outbreath is characterized by a higher level of intensity, which corresponds to a higher overall amplitude of the envelope of the time waveform in the time waveform display and a darker colour on the stripes shown in the spectrogram.

Measures

For participants in the asthma group, measures of asthma severity were obtained. For both asthma and non-asthma groups, three types of measures were obtained, including measures of receptive language and oral reading skills and acoustic measures.

Asthma measures. For participants in the asthma group, a parent-report questionnaire was developed to obtain the demographic information of the participants and assess the severity level of their asthma condition. Parents were asked to report on a range of asthma-related health conditions, such as wheezing and coughing of their children, as well as specific asthma questions including those about severity, implications to sleep/exercise, treatment seeking and medications. Fifteen questionnaire items were derived from the International Study of Asthma and Allergies in Childhood (ISAAC) (Asher, Keil, Anderson, Beasley, Crane, Martinez et al., 1995). An example of the questionnaire can be found in Appendix G (page 133). All questions applied to the 6 months before the experiment begun.

Measures of receptive language. To assess the language level of the participants, the Peabody Picture Vocabulary Test (PPVT -4), Fourth Edition, which is a norm referenced measure of receptive language (Dunn, & Dunn, 2007), was used. The PPVT-4 was introduced as an activity that would give the researcher an idea of how the child "looks at pictures and what words they could recognise as translated to the picture" and thus gave the researcher a relative measure of the child's receptive language skills (Dunn & Dunn, 2007). The PPVT-4 has been used in many research projects as it is simple to administer and does not require verbal responses. This test is particularly suited for children with asthma for testing language ability as they do not need to verbalise understanding or to speak aloud. It generally takes around 10-15 minutes to administer, depending on the individual child (Pearson Clinical Assessments, 2014).

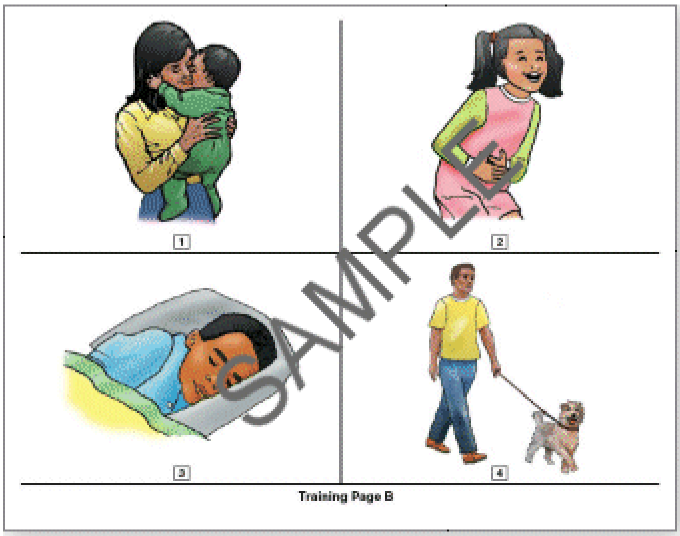


Figure 2 A Sample of a Stimulus Page Taken from the PPVT-4 Booklet.

As shown in *Figure 2* (page 53) there are four pictures presented for each trial. The assessor says a word (e.g. 'sleep'), then the child points to one of four line drawings that best resembles their understanding of the word "sleep". If the child is above the age of 8 years, the assessor gives the child the option of saying aloud the number of the drawing that best resembles their understanding. Scores are interpreted by age-based standard scores (M= 100, and SD= 15).

Measures of oral reading.

A running record (RRs) technique was used to record the accuracy with which the child read the text (Clay, 2005). There are different types of reading errors that can occur. These errors included: 1) substitutions (e.g. another word with similar conceptual meaning is said), 2) omitted words (i.e. words that are left out), 3) skipped words (e.g. too hard, therefore, child is able to skip), 4) insertions (i.e. a word is read that is not in the text), 5) self-correction (i.e. a child originally gets word wrong but tries again on own accord and self-corrects), 6) correct words, 7) told words (e.g. a child is told the word in order to preserve storyline), and 8) repetitions (e.g. a child repeats word or partial sentence) (Clay, 2005). The child's reading errors were tabulated from the RRs to assess his/her oral reading skills at three reading difficulty levels: "Easy", "Instructional", and "Hard".

As previously mentioned, the "easy reading" level was set at the reading level for approximately age 5 years, 3 months equivalent. The "instructional reading" level was defined as an 'age appropriate' level (e.g. based on child's chronological age). The "hard reading" level was defined as the reading level for about 1 year above child's chronological age. Table 4 (page 54) lists the books that were used by the participants in the reading tasks, the publishers and identified reading age level. Each child read three of the books listed. The selection of books for each child was determined by the child's chronological age as well as his/her reading performance on the day of data collection.

Table 4 *Focus books used in the study*

Book Title	Publisher	Reading Age
"Going to the Beach"	Learning Media Limited	5.0 -5.2 years
"The New Cat"	Learning Media Limited	5.3- 5.5 years
"The Wind"*	Learning Media Limited	5.5- 5.8 years
"Purrfect"	Learning Media Limited	5.9- 5.11 years
"Te Tio Bay"	Learning Media Limited	6.0- 6.2 years
"Snap, Splash"	Learning Media Limited	6.3- 6.4 years
"Woolly Sally"	Learning Media Limited	6.5- 7.0 years
"Matthew Likes to Read"	Learning Media Limited	7.1- 7.5 years
"Nana's in the Plum tree"	Learning Media Limited	7.6- 8.0 years
"A Choice for Sarah"	Nelson Thomson Learning	8.1- 8.8years
"Survivors in the Frozen North"	Nelson Thomson Learning	8.9- 9.0 years
"Fire on the Farm"	Nelson Thomson Learning	9.1- 9.8 years
"A Medal for Molly"	Nelson Thomson Learning	9.9- 10.2 years

*Normally the first book presented to the child

Acoustic measures.

To monitor various aspects of breathing patterns, acoustic measures were extracted from the microphone signals recorded during the breathing and speech tasks. Acoustic analysis of voice and speech is a non-invasive, quantifiable method that is frequently used as part of a voice evaluation of normal and disordered voices. A selection of time durations were obtained in this study based on a visual inspection of the time waveforms and spectrograms of the microphone signals recorded during the quiet and speech breathing tasks as described in the "Participant's Task" section. The main experimental measures included breathing rate (BR), pause time (PT), expiration time (ET), and the time ratio of inspiration and expiration (IE ratio). Breathing rate was defined as the number of respiratory cycles per minute. A respiratory cycle (breath) consists of one inhale, followed by the sequential exhale. During speech, speech generally occurs during exhalation (Robb, Sinton- White, & Kaipa, 2011) and long pauses can be considered to be the inspiration phase. Consistent with past literature, four reasons for pausing during speech were identified within this research, including 1) pausing at normal grammatical junctures, 2) pausing because the word is too difficult (this is normal with learning), 3) pausing to take a breath, and 4) pausing to turn the page (Henderson, Goldman-Eisler, & Skarbek, 1965; Winkworth, Davis, Ellis, & Adams, 1994; Bock, Konopka, & Middleton, 2006). Consequently, the time durations of the inspiration (i.e., PT) and expiration phases were measured for both quiet and speech breathing tasks. As Goldman-Eisler (1968) indicated, generating speech can create pauses of around 200-250ms that are used for articulation. Therefore, in this study, pauses greater than 200ms were used to derive the measure of PT, which was assumed to be equivalent to the inspiration time. In addition, for signals obtained during speech breathing tasks, pauses were categorized as occurring at grammatical or ungrammatical junctions (Oliveira, 2002; Zvonik & Cummins, 2002; Bada, 2006; Wang, Green, Nip, Kent, & Kent, 2010).

Procedures

Before meeting a child and their family, the researcher ascertained basic information (age, sex, and asthma status) of the child based on information gathered through clinic records, phone conversations, and emails. The purpose of this information processing was to work out the “age equivalent” and “hard” books that the child would read, as well as the starting point for the PPVT-4.

Each family was greeted and welcomed individually into the Health Sciences clinic on a day that had been agreed upon between the family and the researcher. Or alternatively, the researcher visited the child and their family at their home. If conducted at the clinic, the parents and children were shown around the clinic room and also the observation room. For participants in the asthma group, the child’s parents sat and completed the questionnaire in the observation room while the child completed the tasks with the researcher in the clinic room. It was explained to the parent's that they were not able to sit with the child as there needed to be minimal noise made in order for the computer to record the child's breathing and reading only. The observation room had a two-way mirror so the parents were able to see their child at all times. Any siblings present were led into the playroom where they could sit and play with the toys or left to stay with their parents in the observation room for the duration of the tasks. If the measures of breathing and reading were taken at a child's home, a quiet space with a table was requested by the researcher.

Each child was seated upright in a small chair at a small table in the clinic room. Each child was asked to provide verbal consent to participate. Once verbal consent was obtained, the researcher demonstrated how the computer would record their breathing and reading to make the child familiar with the equipment and to ease any anxiety and build rapport. All tasks were presented and carried out whilst the child was seated at the table with the computer situated on a table close to the child. This sitting arrangement was made in order for the computer microphone to pick up and record the child's voice and breathing at a constant and relatively optimal distance. Each task was introduced to the participant as well as explaining why the researcher had to move away each time. The reason for the experimenter moving away from the child was to minimize external noise and experimenter breathing so that the amount of noise that was picked up by the microphone on the computer was only that from the child speaking and breathing. After the explanation was completed and understanding was checked, the researcher started the recorder on the computer, got up and moved away from the child. Once the task had been completed, the researcher came back to the computer to stop the recording. A new file was made for each condition and was labelled and saved appropriately in order to preserve the privacy and confidentiality rights of each participant.

For the “Easy reading” task, the “easy” book was the same for all children as previously mentioned. If the “easy” book was too difficult for a child, then an “easier easy” book was read and the change recorded. Each child started with the “easy” reading condition to ensure there was a baseline measure of reading and to allow each child to have some success. If a child was not able to read a word, the prompting procedures used in Clay (2005) were used. Or the child was told that they could ask for the word after trying to figure out the word themselves.

After the eight tasks used for breathing measurement were completed, the child then completed the PPVT-4 activity. Once all the tasks had been completed, the child was reunited with their family and the family was thanked for their time. Finally, a $10-gift voucher was given to the family to thank them for their participation in the research.

Data analysis.

The asthma questionnaires were used to identify the asthma severity and management status of the participants in the asthma group. The responses recorded during the PPVT-4 test were analysed to gauge the language age of all the participants. The acoustic recordings obtained during the three reading tasks (“easy”, “instructional”, and “hard”) were analysed to obtain scores of oral reading. The acoustic recordings obtained during the quiet and speech breathing tasks, including the three reading tasks, were analysed to yield the acoustic measures of breathing.

Asthma questionnaire.

Determining Asthma severity. Four levels of severity arose from the continuous severity scale: low, moderate, mild and high. Seven items from the ISAAC questionnaire were used to code 4 items to determine a prorated, estimated asthma severity rating score. The same severity rankings developed by Rosier et al. (1994) were used in the current study to determine the estimated severity of a child's asthma. An example of the adapted scale can be found in Appendix H (page 137).

Asthma management. The information on management (e.g. medication/treatment) of asthma was gained from the parent responses on the 'medication specific' questions in the ISAAC questionnaires. This was utilised to give a more informed overview of a child's asthma history, at least over the previous 6 months and the related situations when it is frequently used to manage symptoms (e.g. daily preventer, only when doing exercise). Table 5 (page 58) summarizes the medications used to manage the asthma of the children in the present study.

Table 5 *The Medications Prescribed, for the Participating children with Asthma, as Reported by their parents.*

Type of Medication	Brand	No. of Children
Preventive medication		
	Seretide	6
	Flixotide	5
	Montelukast	1
	Atrovent	1
	Servent	1
Reliever		
	Duolin	1
	Ventolin	10
	Monteluka	1
	Respigen	1
Bronchodilator		
	Atrovent	1
	Iprtropium	1
	Servent	1
Other medication		
	Flixonase	2
	Redipred	4
	Montelukast	1
	Lorapaed	1
	Antibiotics	1

PPVT-4 responses.

Each child's PPVT-4 responses from "Form A" were scored using the procedures specified in the user manual (Dunn & Dunn, 2007) in order to determine individual raw scores, standard scores (SS), and age-equivalent scores (AE) for each individual child. The raw score was calculated as directed by the manual, by subtracting the total number of errors from the ceiling item, which is the last item in the individual's highest reached set. The SS is an interval number, which indicates the distance of the child's raw score from the average of their age-related peers, after taking into account the range of scores among children in the specific reference group. For example; an 8 year 5 month child with a raw score of 128 would have a SS of 96 (CI: 89-103) (Dunn & Dunn, 2007, p 118). The AE scores locate an individual's performance along a growth curve across age to represent the age at which a child's raw score is the average score. For example, using the same example from above, a child with a raw score of 128 would be taken to equate to an age of 8.0 years, which is the age where that child's score would be the same as the average for children of that age. The raw scores and resulting calculations (SS and AE scores) of each participant are shown in Table 1 (page 45) and Table 2 (page 46).

Running records.

Running Records of reading were scored from the audio content, which was captured through the Audacity software, using a printed transcription of the book content and following the conventions and procedures described by Clay (2005). An example of a scored running record can be found in Appendix I (page 138). If two books had the same accuracy rates, then the most "difficult" book was used as the level indicator. Based on the running records, an error rate was calculated by dividing the number of error words by the number of correct words (Clay, 2005).

Acoustic analysis.

For each of the quiet and speech breathing tasks, measures of PT, ET, and IE ratio were obtained from the first five measurable respiratory cycles. The measure of BR was determined based on the whole length of five sequential respiratory cycles. To derive these measures, the acoustic recordings obtained during quiet and speech breathing were played back using the TF32 software. The researcher visualized the synchronized displays of the signal's time waveforms and spectrograms, cursor selected the selected segments for auditory playback, and marked the time points corresponding to the beginning and ending of an inspiration or expiration phase. *Figure 3* illustrates a respiratory cycle that contains speech as part of the exhalation. Descriptions for the acoustic analysis conducted on the signals recorded from the quiet breathing, phonation, and speech breathing tasks were shown as below.

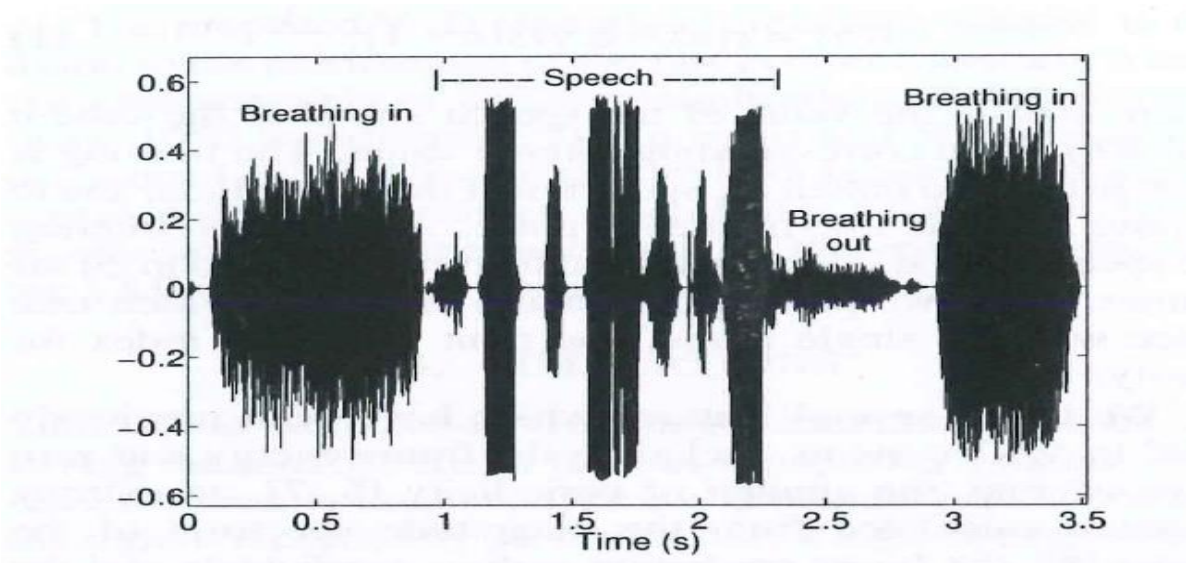


Figure 3 Respiratory cycle (Source: Myllymaki, & Virtanen, 2008)

Quiet breathing. The digitized signals obtained from the breathing task were played back and analysed using the TF32 software (Appendix J, page 139). The researcher identified the expiration and inspiration portions based on auditory perception (to rule out background noise) assisted by a visual inspection of the simultaneous two-window display of the time waveform and spectrogram of the signal. Vertical cursors were used to mark the start and end of a respiratory cycle and a pause, which are differentiable by their visual patterns on the spectrogram and by the audio/sound made. The duration of the breath and/or pause is automatically shown in microseconds by the TF32 software once the cursors are positioned.

From an auditory and visually identifiable sequence of alternating patterns, the segment associated with a time waveform with higher amplitude and a darker spectrographic display was defined as expiration. The middle one-third portion of the expiration segment was cursor-selected and the average spectrum (LTA, with pre-emphasis) of the selection was shown in a separate window. On the spectrum, the highest peak around 2 kHz was cursor-selected to generate an automatic reading of the amplitude of the peak. The same procedure was performed for the part of inspiration segment immediately preceding the expiration segment. For each pair of inspiration-expiration sequence, the amplitude of the spectral peak around 2 kHz for the selected portion of expiration segment and that for the selected portion of the inspiration segment were averaged to yield the cut-off value for the demarcation of expiration and inspiration phase.

Phonation. The time waveforms of the maximally sustained vowels were displayed and cursor-selected to derive the time duration. The time duration of the trial showing the longest duration amongst the three trials of maximally sustained vowel phonation was selected for each participant as their measure of maximum phonation time (MPT).

Speech breathing tasks. The digitized signals obtained from the five speech breathing tasks, including ”recital”, “free speech”, and the three reading tasks (“easy”, “instructional”, and “hard”), were played back and analysed using the TF32 software. The researcher identified the expiration and inspiration portions based on auditory perception and a visual inspection of the simultaneous two-window display of the time waveform and spectrogram of the signal. From an auditory and visually identifiable sequence of alternating pattern, the segment associated with a time waveform with higher amplitude and a darker spectrographic display was defined as expiration.

The first five inhalation/exhalation cycles were identified for each of the five speech breathing tasks. Specifically, a portion of the beginning segment was cursor-selected and played back in order to identify the end of the first expiration (“outbreath”). The time information of the beginning and the end of the selected segment was recorded on the analysis spreadsheet. Similarly, the beginning of the consecutive “outbreath” was identified and cursor selected. The duration between the end of an outbreath and the start of the subsequent outbreath was defined as a “pause” and calculated. This process was continued until five inhalation/expiration cycles had been identified, cursor-selected, and the times recorded for each speech task. The time durations of the inspiration and expiration phases were calculated as well as the breaths per min and length of 5 inspiration/expiration phases. The researcher used a transcript of the read book, as well as auditory playback, and the visual displays of the time waveform and spectrogram of the signal, to identify pauses. As mentioned previously, a break in reading was identified as a pause if it was more than 200 ms. Pauses that occurred during page turning were discarded.

A certified Speech Pathologist independently coded 25% of the data files to ensure reliability of coding. Reliability was high between coders.

Statistical Analysis

As no prior studies of breathing characteristics of children with asthma were identified, a number of separate analyses were conducted in order to yield a variety of statistical perspectives. First, l t-tests were used to compare the means of the groups on various measures. Next, because of the importance in understanding individual variation, graphs of each measure for each child were analysed to determine individual patterns of breathing with respect to the experimental tasks. Finally, multivariate analysis was used to evaluate task and group interaction. The significance level was set at 0.05.

Multivariate Statistical analysis was carried out using the statistical software package IBM SPSS Statistics 19. For each of the PT, ET, and IE ratio measures, a mean score was obtained for each participant from the five values measured from each task. Corresponding to each mean, a coefficient of variation (CV), which reflects the variability of the measure in question, was calculated by taking the ratio of an individual's standard deviation for the measure to the mean score and then multiplying the ratio by 100. Consequently, 18 means (i.e., 6 for PT, 6 for ET, and 6 for IE ratio) and 18 CVs (i.e., 6 for PT, 6 for ET, and 6 for IE ratio) were obtained from the six breathing tasks. The BR and the means and CVs of PT, ET, and IE ratio obtained from individual participants were submitted altogether to a two-way (2 groups X 6 tasks) Mixed Model multivariate Analysis of Variance (MANOVA), with participant group ("no asthma" vs. "asthma") treated as a between-subjects factor and task ("Quiet breathing", "Free speech", "Recital", "Easy reading", "Instructional reading", and "Hard reading") as a within-subjects factor.

If either factor was shown to have a significant effect on the overall measures, follow-up univariate ANOVAs were conducted to identify which of the seven breathing measures (i.e., Mean-PT, Mean-ET, Mean-IE ratio, CV-PT, CVET, CVIE ratio, and BR) were sensitive to the effects of group, task, and/or their interaction. Pairwise comparison procedures with Bonferroni corrections were also conducted if needed. A trend analysis was also conducted to determine whether there was a consistent change of the seven breathing measures with increasing reading difficulty. To determine whether reading difficulty level (i.e., "Easy reading", "Instructional reading", and "Hard reading") had an effect on the error rate, a two-way (2 groups X 3 reading difficulty levels) Mixed Model ANOVA was conducted on the error rate, with group treated as a between-groups factor and task treated as a within-group factor.

Justification of the choice of statistical tests.

Multivariate analysis of variance (MANOVA) was performed because the seven dependent variables (i.e., Mean-PT, Mean-ET, Mean-IE ratio, CV-PT, CVET, CVIE ratio, and BR) were correlated (see Table 6, page 65) and running a MANOVA procedure would answer the general question as to whether groups (asthma vs. non-asthma) and tasks were significantly different based on a linear combination of these breathing measures. The advantage of using MANOVA is that it increases the chance of finding a significant group and task effect without inflation of Type I error. In other words, the family-wise error rate (α = 0.05) can be reserved without adjusting for multiple tests and thus MANOVA may reveal significant differences not shown in separate univariate ANOVAs. Follow-up univariate ANOVAs and pairwise comparisons using the Bonferroni procedure were used to test specific hypotheses. Tests of the assumptions of normality and sphericity for running a MANOVA were passed using the Shapiro-Wilk test and Mauchly' tests respectively.

Table 6 *Correlation (Pearson's r) Between the Seven Breathing Measures*

	Mean-PT	Mean-ET	Mean-IE ratio	CV-PT	CVET	CVIE ratio	BR
Mean-PT	--	-0.37*	0.78*	0.29*	-0.25*	-0.03	-0.33*
Mean-ET	--	--	-0.64*	0.15	0.14	-0.37*	-0.63*
Mean-IE ratio	--	--	--	-0.08	-0.24*	-0.06	0.05
CV-PT	--	--	--	--	0.18*	0.43*	-0.27*
CVET	--	--	--	--	--	0.47*	0.05
CVIE ratio	--	--	--	--	--	--	-0.08

* $p < 0.05$.

Chapter 4 Results

Contextual report

All of the assessments and observations were conducted as planned. The initial aim was to measure the breathing and reading of children in the Health Sciences Clinics. However, 6 participants had measurements carried out in the clinic and the remaining 16 were carried out at participants' homes.

Characteristics of Breathing across Experimental Tasks

This section presents descriptive statistics and results of inferential statistics for all the experimental measures. These measures included error rates and breathing rates (BR) and the means and standard deviations of pause time (PT), expiration time (ET), and inspiration/expiration (I/E) ratio.

The descriptive statistics for the BR, PT, ET, and I/E ratio measures for individuals across the six tasks (i.e., "Quiet breathing", "Recital", "Free speech", "Easy reading", "Instructional reading", and "Hard reading") are presented in this section, and a correlational analysis of breathing and asthma severity. For the "Quiet breathing" task, data obtained from Task 1 (i.e., "Quiet breathing" data obtained at the beginning of the experiment) and Task 8 were combined (i.e., "Quiet breathing" data obtained toward the end of the experiment).

Table 7 (page 69) summarises the mean (SD) differences in children with asthma across the 6 breathing and reading conditions and the mean (SD) differences across the same conditions in children without asthma.

Children with Asthma.

The mean BR was significantly different between easy reading and hard reading (t= 3.848, df=20, p= .001) (Appendix K, page 141). Mean PT was significantly higher in hard reading as compared to easy reading (t= 2.249, df= 20, p=.04) (Appendix L, page142). For

ET, the mean was highest in the free speech and hard reading conditions and lowest in the quiet breathing condition, but there was no significant difference between easy and hard reading (Appendix M, page143). Mean I/E ratio was highest in the quiet breathing condition and lowest in the recital condition, but there was no statistically significant difference between easy and hard reading I/E **(**Appendix N, page 144).

Children Without Asthma.

The mean BR was lowest in recital and highest in the free speech and hard reading conditions, and there was no significant difference between easy reading and hard reading. (Appendix O, page 145). Mean PT was highest in the quiet breathing condition, and lowest in easy reading, but there was no statistically significant difference in mean PT between easy and hard reading (Appendix P, page 146). The mean ET was lowest in quiet breathing, and highest in recital, and there were no significant differences between mean ET on easy and hard reading (Appendix Q, page 147). Mean I/E ratio was highest in the quiet breathing condition and lowest in easy reading, and there was no significant difference between mean I/E ratio in reading easy material and reading hard material (Appendix R, page 148).

Correlation asthma severity and breathing rate

A correlation procedure using the Spearman's rho was carried out between Asthma severity (AS) and the calculated breathing rates (per/min) across the 6 breathing tasks. A significant correlation was found only for the "Hard reading" task ($r = -0.612$, $p = 0.046$). As asthma severity increased, breathing rate decreased.

Correlation Error rate (instructional) and PPVT-4 age equivalent scores

A correlation procedure using the Spearman's rho was carried out between error rates on the instructional reading condition and the calculated PPVT-4 age-equivalent scores. There was a non-significant correlation of .18 (p= n.s) between scores on the PPVT-4 and error rates for children with asthma. Additionally, for children without asthma, there was a non-significant correlation of -.47 (p= n.s).

Figure 4 and *Figure 5* (pages 71 and 72) present the method of summarisation of the breathing characteristics of a child with asthma (A7) during reading the ‘difficult’ book (i.e. *“Fire on the Farm”)* aloud. *Figure 6* and *Figure 7* (pages 73 and 74) present the same method for a child without asthma (N7) during reading the ‘difficult’ book (i.e. *“Fire on the Farm”)* aloud. A visual inspection shows how different the pausing patterns and lengths were between the child with and without asthma.

Table 7 *Group Mean (SD) Comparisons of Children with and without Asthma on BR, PT, ET and I/E ratio measures*

Group and Measure	Quiet Breathing	Recital	Free Speech	Easy Reading	Instructional Reading	Hard Reading
BR						
A	29.39 (5.85)	31.55 (9.56)	20.39 (7.67)	27.83 (3.96)	27.92 (9.84)	20.77 (4.62)
NA	26.10 (3.84)	23.26 (6.01)	27.57 (8.71)	24.85 (6.41)	25.82 (6.45)	26.87 (5.84)
PT						
A	1571 (291)	396 (69)	1296 (842)	502 (261)	672 (718)	1036 (743)
NA	1613 (315)	538 (286)	556 (119)	525 (142)	700 (272)	620 (304)
ET						
A	626 (163)	1672 (670)	2234 (746)	1732 (346)	1806 (697)	2042 (851)
NA	775 (226)	2218 (892)	2198 (890)	2015 (621)	1789 (701)	1708 (532)
I/E ratio						
A	3.00 (0.95)	0.42 (0.35)	0.88 (0.83)	0.55 (0.41)	0.51 (0.63)	0.77 (0.56)
NA	2.37 (0.87)	0.49 (0.58)	0.47 (0.23)	0.33 (0.15)	0.60 (0.40)	0.51 (0.40)

Note. A= Asthma group. NA= No Asthma group

Individual Changes in Breathing as Reading Difficulty Increased

Analysis of a child's response to the increase in reading difficulty was necessary to show what individual children did to compensate for this change. *Figure 8* (page 78) to *Figure 13* (page 87) show the error rates, breathing rate, and the means and standard deviations of PT, ET, and IE ratio across three reading levels ("Easy", "Instructional", and "Hard") for each of the participants with asthma (A1-A11) followed by the children without asthma (N1-N11). Observations regarding how text difficulty impacted the error rates, the types of pauses made, and the four breathing measures (BR, PT, ET, and IE ratio) in girl and boy individual participants with asthma are presented as follows.

Figure 4 Annotated page of ‘difficult’ book read by child with asthma (A7).

Figure 4 (*colour*). The figure shows an annotated page Fire at the Farm (Cartwright, 2003) as read by a child with asthma (A7) from the ‘difficult’ level task. Annotations in green indicate a pause at a grammatical juncture and red a reading error and/or a pause at a ungrammatical juncture.

a. reading mistake, i.e., omitted “their”.

b. grammatical pause of 397*ms* at the end of a sentence. i.e., “phone. *PAUSE* Shannon..”.

c. grammatical pause of 619*ms* at the end of a sentence. i.e., “back. *PAUSE* Dad..”.

d. ungrammatical pause of 222*ms* in the middle of a phrase. i.e., “keep it *PAUSE* with me..”.

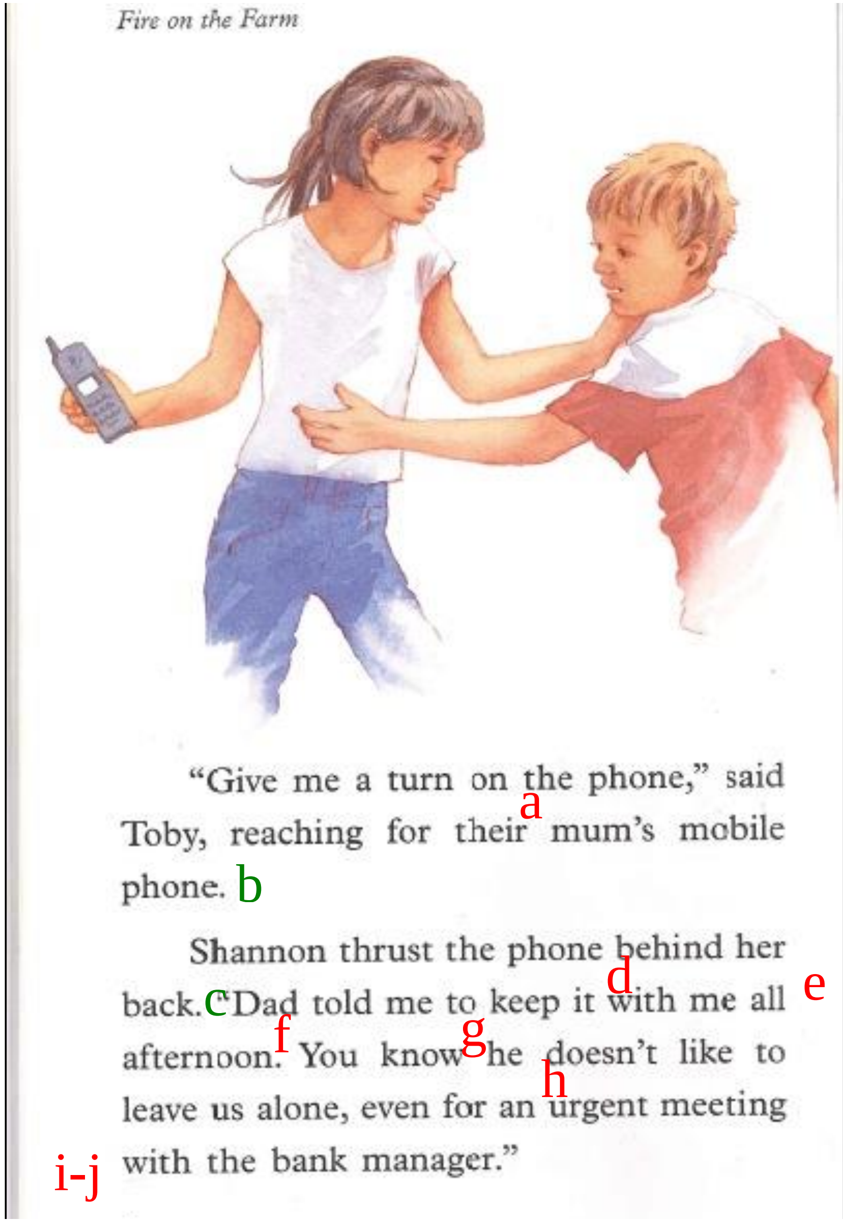
e. ungrammatical pause of 228*ms*. i.e.,. “all *PAUSE* after..noon..”.

f. reading error of repeating the word “afternoon” followed by grammatical pause of 657*ms* at the end of a sentence after i.e.,. “afternoon afternoon. *PAUSE* You..”.

g. ungrammatical pause of 399*ms* in the middle of a sentence. i.e., “know *PAUSE* he..”.

h. ungrammatical pause of 824*ms* for a difficult word, followed by mispronounced word, i.e. an *PAUSE*, “argent”.

i-j. ungrammatical pause of 325*ms* at the end of the line, i.e., “meeting PAUSE followed by reading error, omitted word ‘bank and mispronounced manager.


Fire on the Farm

“Give me a turn on the phone,” said Toby, reaching for their a mum’s mobile phone. b

Shannon thrust the phone behind her back. c Dad told me to keep it d with me all e afternoon. f You know g he h doesn’t like to leave us alone, even for an urgent meeting
i-j with the bank manager.”

Figure 5 Audio waveform and spectrograph of child with asthma reading the passage in *Figure 4*

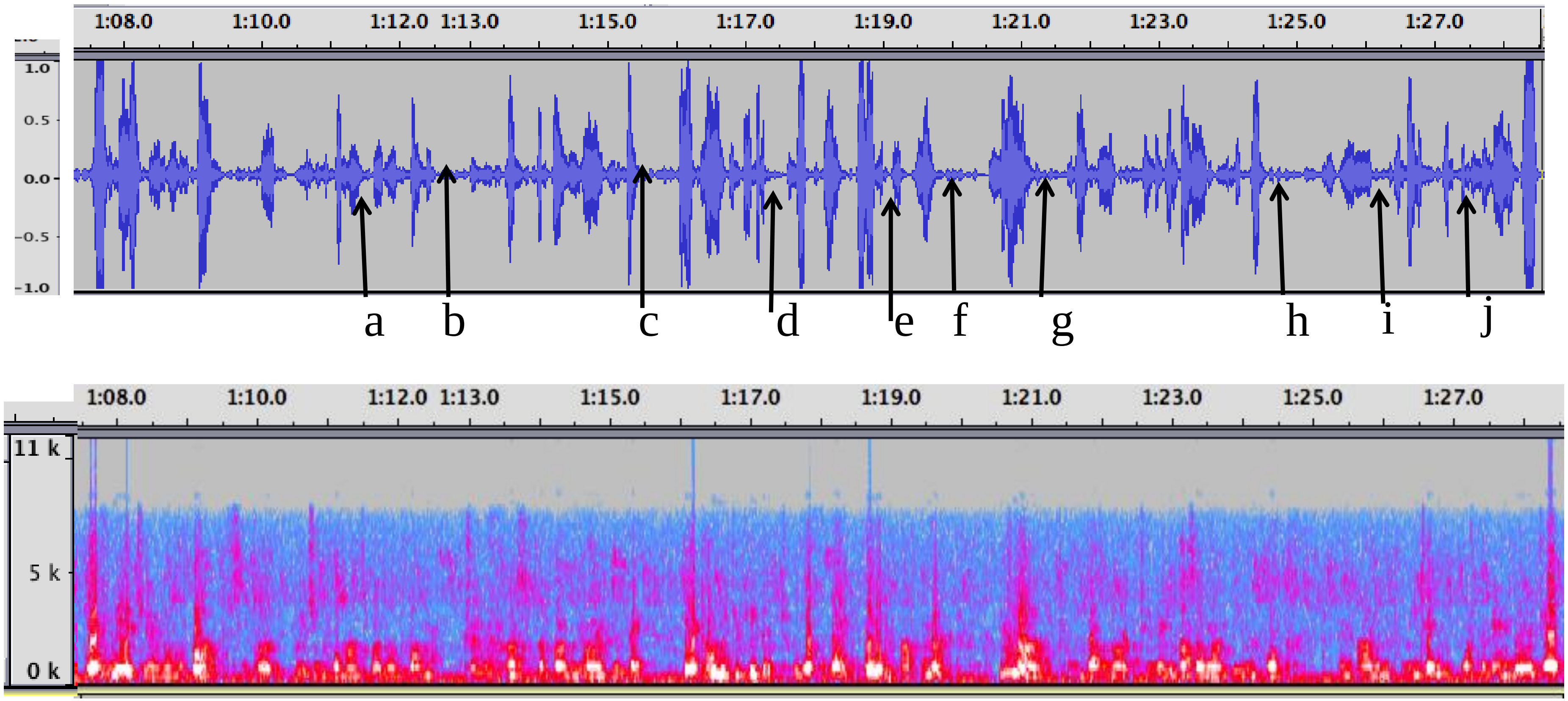


Figure 5 (colour). The top portion of the figure shows the audio waveform and the bottom shows the spectrograph of a child with asthma (A7) reading the passage shown in Figure 2. Breathing Rate (BR) in this passage=22.9/ minute. Mean Pause Time (PT) in this passage =458.9 *ms*

Click here for audiofile. A7.wav (or listen to attached mp3 file for A7).

Figure 6 Annotated page of ‘difficult’ book read by child without asthma (N7).

Figure'6'(*colour*).''The'figure'shows'an'annotated'page'Fire'at'the'Farm' (Cartwright,'2003)'as'read'by'a'child'without'asthma'(N7)'from'the''difficult''level' task.'**!**Annotations'in'green'indicate'a'pause'at'a'grammatical'juncture'and'red'a' reading'error'and/or'a'pause'at'a'ungrammatical'juncture.'**!**

a.'grammatical'pause'of'647*ms*'at'the'end'of'a'sentence.'i.e.,'“phone.'*PAUSE*'said'.”.'''

b.'grammatical'pause'of'638*ms*'at'the'end'of'a'sentence.'i.e.,'“mobile'phone''*PAUSE*' Shannon..”.'

'**c.**'ungrammatical'pause'of'534*ms*'in'the'middle'of'a'phrase.'i.e.,'“Shannon'*PAUSE*' thrust..”.'''

d.'ungrammatical'pause'of'332*ms*,'i.'e.,.'“phone-*PAUSE*'behind..”.'''

e.'ungrammatical'pause'of'733ms,'i.e.,'“behind'*PAUSE*'her.”'

f.'''grammatical'pause'of'4228ms,'i.e.'“'her'*PAUSE*-back.”'

g.'grammatical'pause'of'953ms.'''i.e.,'back'*PAUSE*''Dad'

h.'ungrammatical'pause'of'420ms,'i.e.,'‘to'*PAUSE*'keep”'

i.'grammatical'pause'of'754ms.'i.e.,'“afternoon.'*PAUSE*.'You.”'

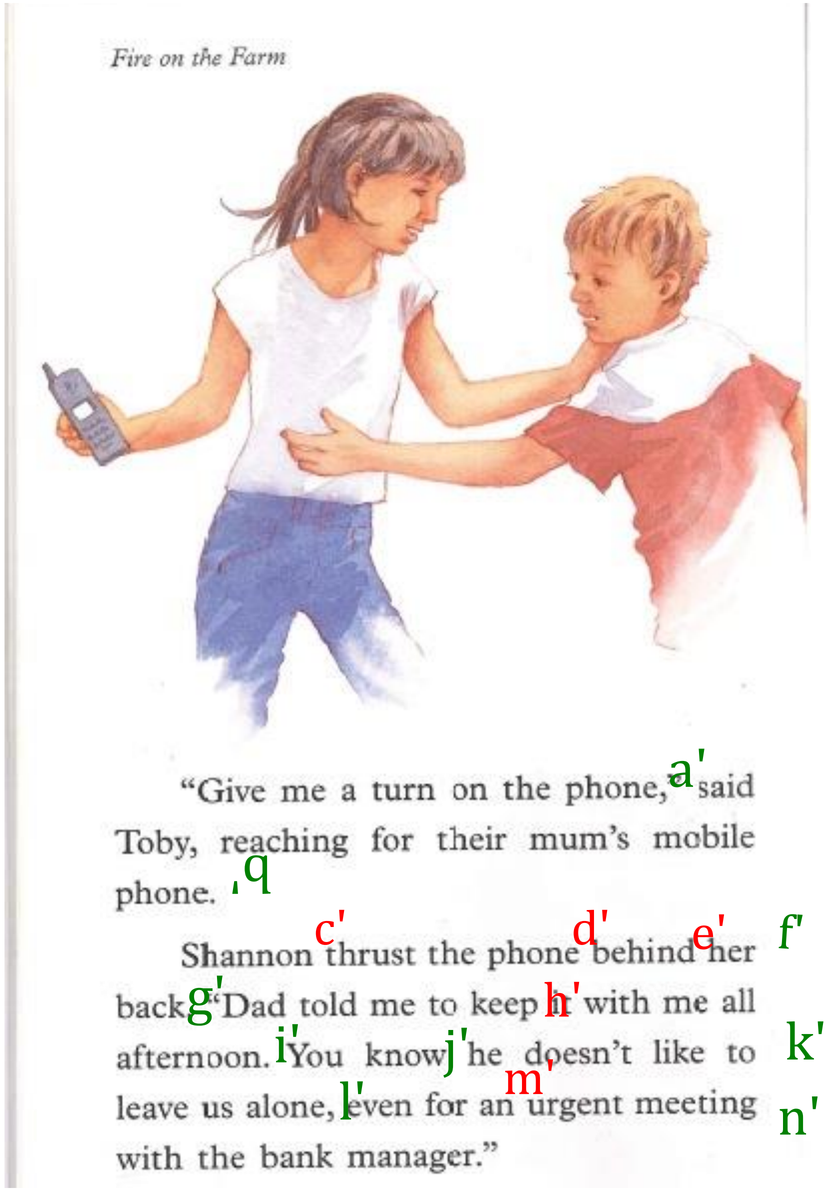
j.'grammatical'pause'of'265ms''i.e.,'“'you'know'*PAUSE*'he'doesn’t”'

k.'grammatical'pause'at'end'of'line,'672ms.,'i.e.,''like'to'PAUSE'leave'us'“'

l.'grammatical'pause'following'a'comma,'407ms,'i.e.,'“leave'us'alone,'PAUSE,'even”'

m.''ungrammatical'pause'before'a'difficult'word,'1060ms,'i.e.,'“an'*PAUSE*'urgent' meeting”'

n.'grammatical'pause'of'509ms'at'the'end'of'a'line,'i.e.,'‘meeting'PAUSE'with'the' bank'manager.'



Fire on the Farm

“Give me a turn on the phone,” said Toby, reaching for their mum’s mobile phone.

Shannon thrust the phone behind her back. “Dad told me to keep it with me all afternoon. You know he doesn’t like to leave us alone, even for an urgent meeting with the bank manager.”

Figure 7 Audio waveform and spectrograph of child without asthma reading the passage in Figure *6*

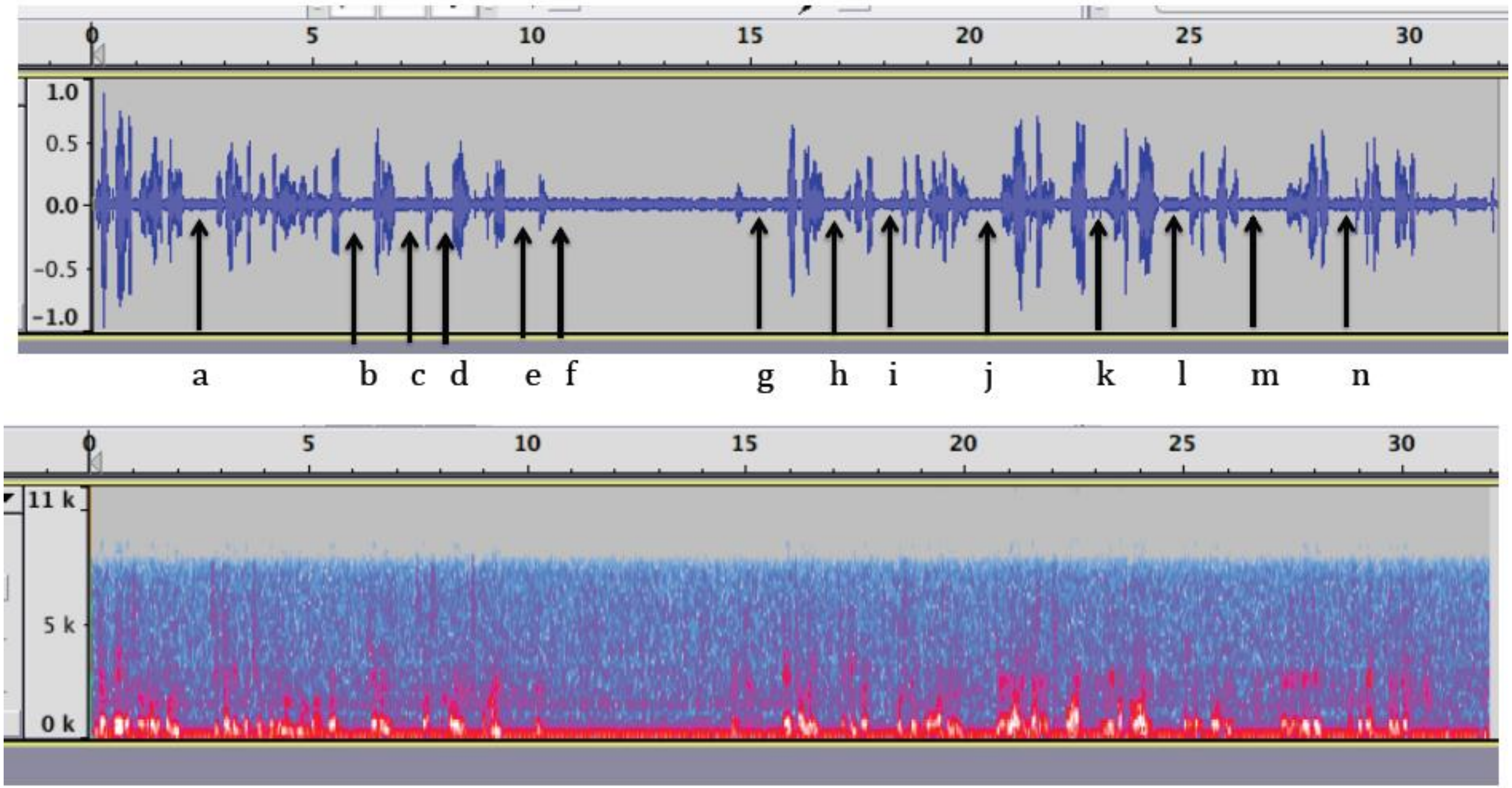


Figure 7(colour). The top portion of the figure shows the audio waveform and the bottom shows the spectrograph of a child without asthma (N7) reading the passage shown in Figure 4. Breathing Rate (BR) in this passage=28/ minute. Mean Pause Time (PT) in this passage =868*ms*. *click for audiofile.* (or listen to attached file N7)

N7.wav

A1. The text selections for A1, who was 6 years 1 month, indicated that the texts increased in difficulty and that she may be reading below expectation for her age. Breathing rate decreased, while pause time and expiration time increased (Figure 8, page 78). A1 made 0% ungrammatical pauses with easy reading, 50% ungrammatical pauses at the instructional level, and 25% ungrammatical pauses at the hard level. I/E ratio was higher during the instructional level reading.

A2. This girl was 6yrs 4 months, and had error rates in excess of 10% at the instructional level, which indicates that she may be reading below expectation for her age. Breathing rate was highest at the instructional level. However, pause time, expiration time and I/E ratio were maintained at similar levels for both easy and instructional reading. During hard reading, breathing rate decrease, pause time increase, expiration time decreased and I/E ratio increased to 1.57 (Figure 8, page 78). Ungrammatical pauses were 40% during easy text, 66% during instructional reading and 100% during hard reading.

A3. The error rates for A3 indicate that she was able to accurately read material set one year in advance of her chronological age, 8 years 1 month, which indicates that she may be reading above expectation for her age (Figure 8, page 78). Breathing rate was maintained across all levels, and pause time, expiration time and I/E ratio showed little variation across levels. However, A3 paused at ungrammatical junctures 40%, 20% and 40% of the time in easy, instructional and hard texts, respectively.

A4. The error rates for A4 also indicate that she was able to accurately read material above her chronological age, 8 years 4 months (Figure 8, page 78). Her breathing rate decreased, pause time increased, expiration time increased while I/E ratio was maintained across the changing levels of text difficulty. She paused at 40% ungrammatical junctures during instructional reading, but all of the pauses in the other two reading tasks were at grammatical points.

A5. This 6yr 1 month old boy may be reading below age expectations, as his error rate in reading each of the texts exceeded 15% (Figure 9, page 79). During reading, his breathing rate decreased, and pause time increased. Of the pauses, 66%, 100% and 75% of the pauses were at ungrammatical junctures in the easy, instructional and hard texts, respectively. The lowest expiration rate and highest I/E ratio were recorded during instructional reading.

A6. The error rates for this 7 year 3 month boy indicate that he may be reading above expectations for his chronological age, as the error rates were all below 5% (Figure 9, page 79). Breathing rate decreased as the text increased in difficulty. However, pause time was more than twice as high, and much more variable, when reading the most difficult text, and 100% of the pauses were at ungrammatical junctures. Ungrammatical pauses were lower at 40% for both easy and instructional levels. Expiration time was lower and I/E ratio was higher while reading the more difficult text.

A7. The error rates for this 8 year 3 month old boy indicate that he is likely reading at the expected level (Figure 9, page 79). As the text increased in difficulty, breathing rate decreased. Pause time was the highest for the hard reading. Ungrammatical pauses were 60%, 75% and 50% at the easy, instructional and hard levels. Expiration time was lower and I/E ratio was higher for the hard reading as compared to the instructional level.

A8. This boy was 8 years 4 months old, and the error rates indicate that he may be reading at above the expectation for his age. The breathing rate was lowest for the instructional level, and pause time decreased as the text difficulty increased (Figure 9, page 79). For the easy task, 60% of the pauses were at ungrammatical junctures and at 100% for each of the other levels. Expiration time was highest for the instructional level, and I/E ratio was lowest for the hard level.

A9.The error rates for this 8 year 4 month old boy show that he is likely reading above his expected level (*Figure 10*, page 80). At the text increased in difficulty, breathing rate decreased. Although, the decrease showed the increasing difficulty, the reading was still accurate. Pause time was more than twice a high, and much more variable, when reading the most difficult text. Ungrammatical pauses were 75%, 75% and 80% at the easy, instructional and hard levels. Expiration time was similar across the easy and hard reading levels, and was shortest in the instructional level. I/E ratio was three times as high for the hard reading as compared to the instructional level.

A10. The error rates for A10 indicate that he was able to accurately read material above his chronological age, 8 year 7 months (*Figure 10*, page 80). His breathing remained relatively consistent across the instructional and hard difficulty levels. Pause time increased from easy to instructional and remained the same for hard. Expiration time increased while I/E ratio was maintained across the changing levels of text difficulty. Of the pauses, 25%, 50% and 25% of the pauses were at ungrammatical junctures in the easy, instructional and hard texts respectively.

A11. The error rates for this 9 year 1 month old boy indicate that he is likely reading above the expected level (*Figure 10*, page 80). His breathing rate decreased, pause time increased and was much more variable in the hard reading level. Expiration time was similar across easy and hard text difficulty and I/E ratio was the highest in the hard reading level. Ungrammatical pauses were 60%, 75% and 60% at the easy, instructional and hard levels respectively.

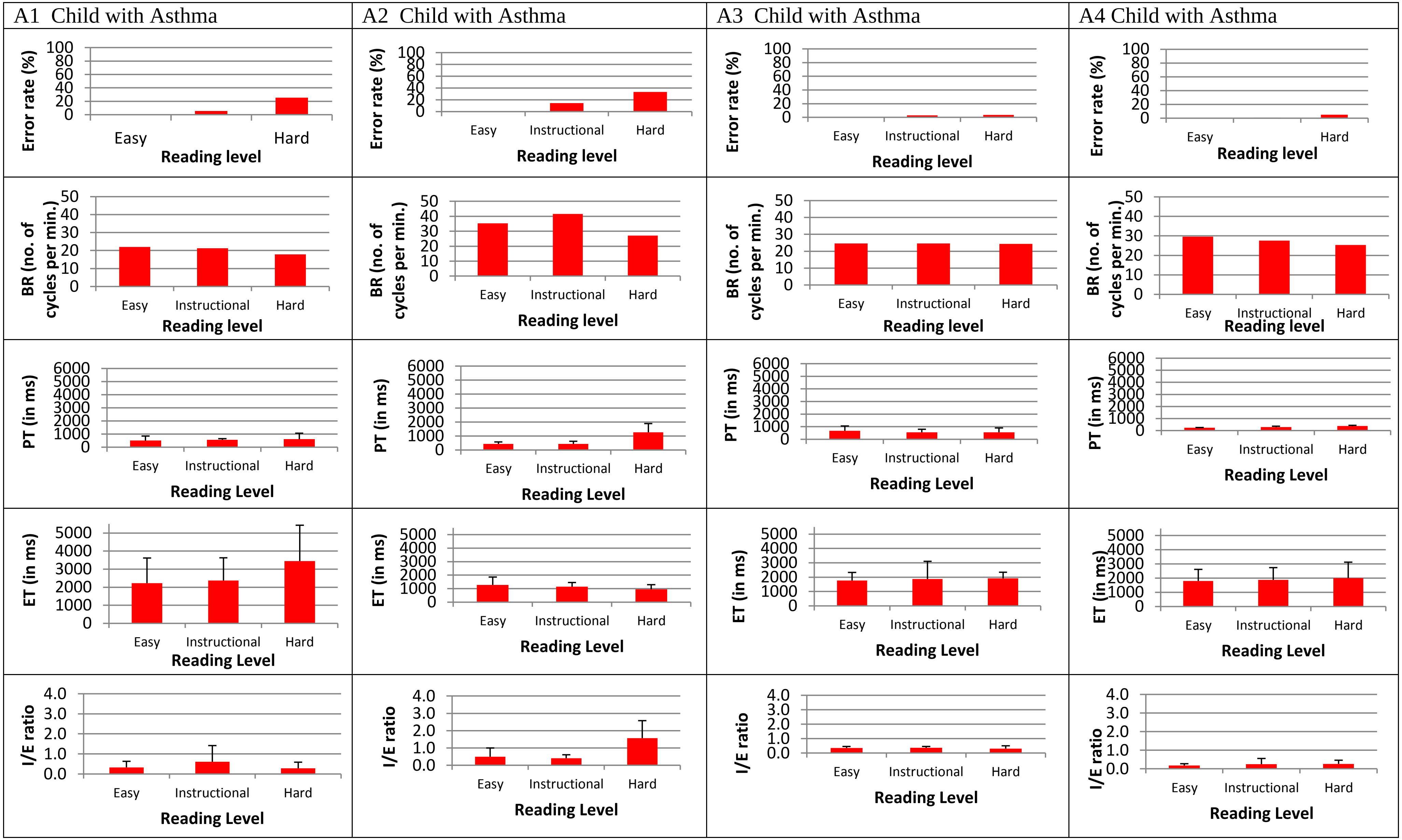


Figure 8 Girls with Asthma: Error rates, breathing rates, mean pause time (milliseconds), mean expiration time (milliseconds) and mean I/E ratio during three reading conditions.

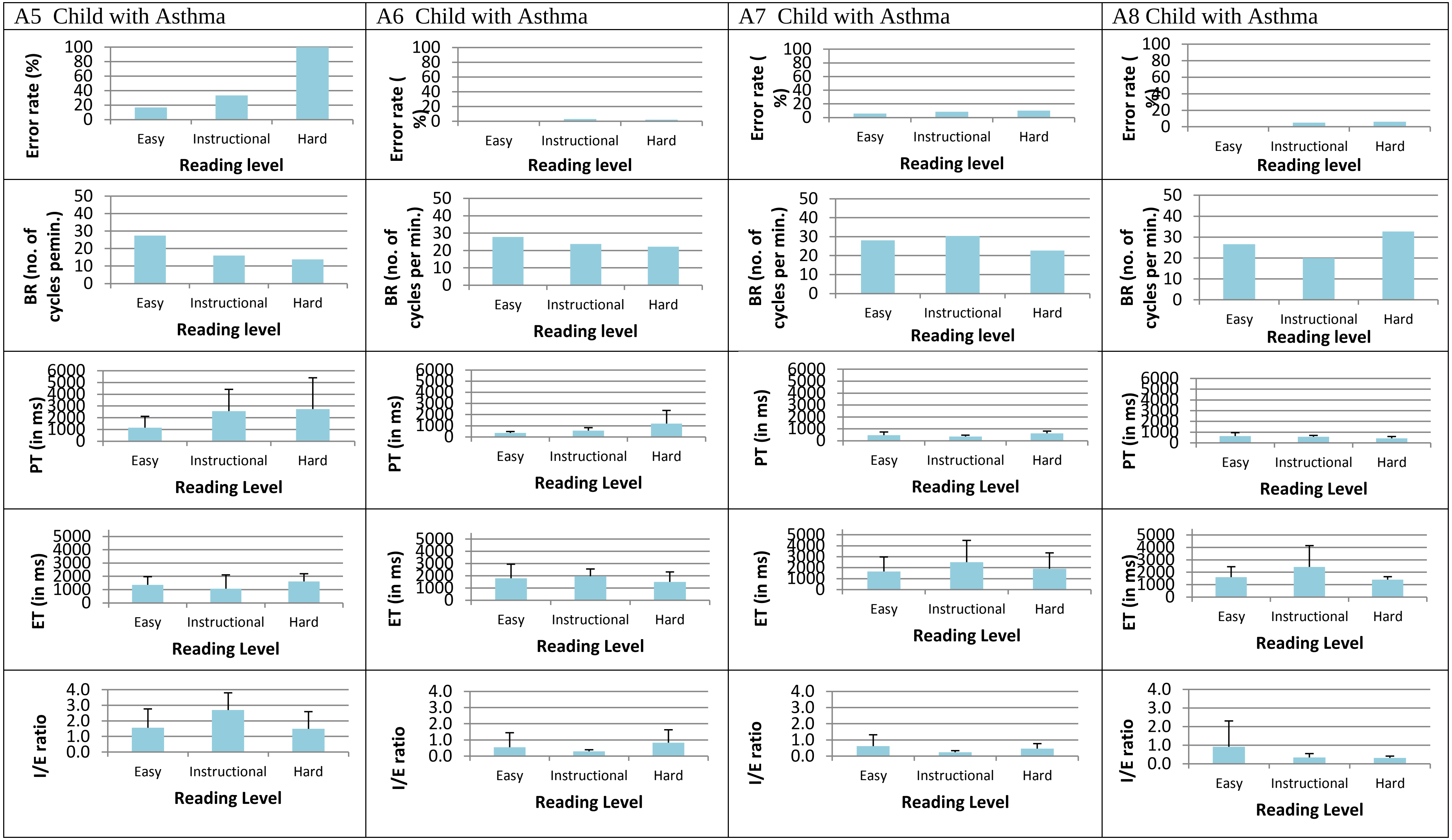


Figure 9 Younger boys with Asthma: Error rates, breathing rates, mean pause time (milliseconds), mean expiration time (milliseconds) and mean I/E ratio during three reading conditions.

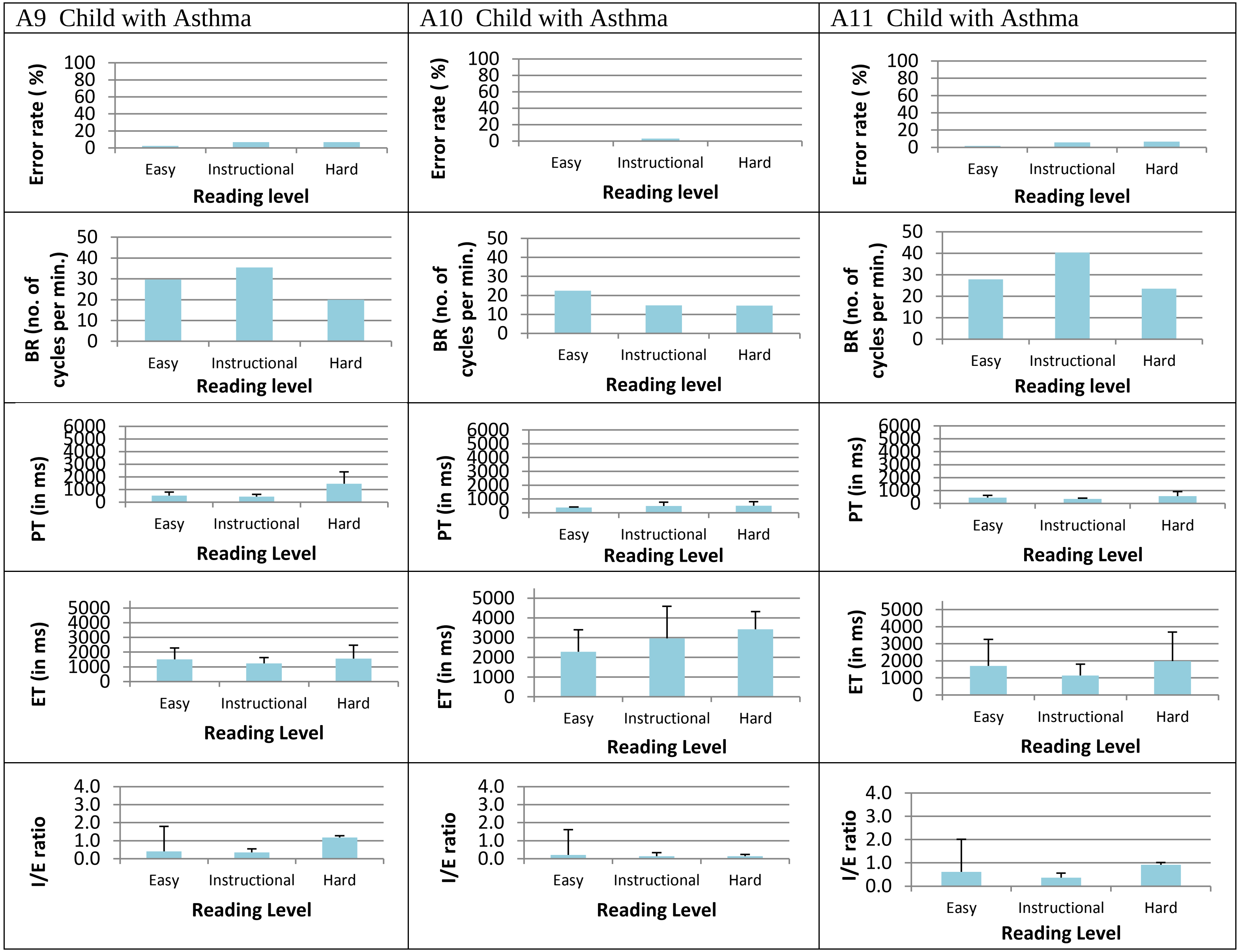


Figure 10 Older boys with Asthma: Error rates, breathing rates, mean pause time (milliseconds), mean expiration time (milliseconds) and mean I/E ratio during three reading condition.

Children without asthma.

Similar to the section above, this section presents children without asthma's responses to an increased difficulty in reading material. The following section presents observations on what children did to compensate for increasing difficulty, as shown by the error rates and the four breathing measures (BR, PT, ET, and IE ratio) in individual female and male participants without asthma.

N1. The text selections for N1, who was 7 years 2 month, indicated that the texts increased in difficulty. Breathing rate increased, while both pause time and expiration time decreased. N1 made 60% ungrammatical pauses with easy reading, 20% ungrammatical pauses at the instructional level, and 40% ungrammatical pauses at the hard level. I/E ratios were higher during the hard level reading (Figure 11, page 85).

N2. This girl was 7yrs 2 months, whose error rates indicate that she was able to read material above her age accurately. Her breathing rate was the same across the easy and hard reading difficulties, and was lower during instructional reading. Pause time was relatively consistent during instructional and hard reading. During hard reading, expiration time decreased and I/E ratio increased to 1.6 (Figure 11, page 85). Ungrammatical pauses were 60% during easy text, 20% during instructional reading and 60% during hard reading.

N3. The error rates for N3 indicate that she was able to accurately read material set one year in advance of her chronological age, 8 years 3 month, which indicates that she may be reading above expectation for her age (Figure 11, page 85). Breathing rate increased and PT, ET and I/E ratio decreased considerably during the hard reading level. Pauses were identified at ungrammatical junctures 20%, 60% and 80% of the time in easy, instructional and hard texts, respectively.

N4. This girl was 8 years, 4 months, and had error rates in excess of 10% at the instructional level, which indicates that she may be reading below expectation for her age. (Figure 11, page 85). Her breathing was maintained and increased during hard reading. Pause time increased with more variation where expiration time decreased with little variation in the hard reading level. I/E ratio increased to 1.6 and showed more variation in the hard reading. She paused at 60% ungrammatical junctures during both easy and instructional reading, and at 100% in hard reading.

N5. This 5 years, 7 month old boy may be reading below age expectations, as his error rate in reading each of the texts exceeded 15% (Figure 12, page 86). During reading, his breathing rate remained similar across instructional and hard text difficulty. Pause time decreased with more variability. Expiration time was maintained across all three text difficulty levels and the highest I/E ratio was recorded during instructional reading. Of the pauses, 50%, 80% and 100% of the pauses were at ungrammatical junctures in the easy, instructional and hard texts, respectively.

N6. The error rates for this 8 year, 1 month boy indicate that he may be reading above expectations for his chronological age, as the error rates were all below 8% (Figure 12, page 86). Breathing rate decreased in the hard reading and pause time was maintained across the three difficulty levels. Ungrammatical pauses were 66%, 80% and 100% for easy, instructional and hard levels, respectively. Expiration time was highest in the easy reading level, considerably lower in instructional and higher but more variable in the hard. I/E ratio was consistent across all three levels.

N7. The error rates for this 8 year 5 month old boy indicate that he is likely reading above expectations for his chronological age, as the error rates were all below 2% (Figure 12, page 86). As the text increased in difficulty, breathing rate decreased. Pause time was the highest for the easy reading. Ungrammatical pauses were 20%, 60% and 60% at the easy, instructional and hard levels. Expiration time increased and I/E ratio decreased with increasing text difficulty.

N8. This boy was 8 years 5months old, and the error rates indicate that he may be reading at above the expectation for his age. The breathing rate decreased, and pause time increased as the text difficulty increased (Figure 12, page 86). For the easy task, 80% of the pauses were at ungrammatical junctures, and pauses were 40% and 60% for the instructional and hard. Expiration time was highest for the hard level, and I/E ratio decreased from instructional to hard text difficulty.

N9. The error rates for this 8 year 5 month old boy show that he is likely reading above his expected level with all errors 6% (*Figure 13*, page 87). As the text increased in difficulty, breathing rate increased. Pause time was the lowest when reading the most difficult text. Ungrammatical pauses were 40%, 60% and 100% at the easy, instructional and hard levels. Expiration time was similar across the instructional and hard reading levels, and was the highest in the easy level. I/E ratio was lower for the hard reading as compared to the instructional level.

N10. The error rates for N10 indicate that he was able to accurately read material above his chronological age, 9year 4months (*Figure 13*, page 87). His breathing remained relatively consistent across the instructional and hard difficulty levels. Pause time was maintained from easy to instructional and increased with more variability for hard. Expiration time was highest for easy reading, decreased in instructional and remained consistent in hard. I/E ratio slightly decreased from instructional to hard. Of the pauses, 80%, 80% and 60% of the pauses were at ungrammatical junctures in the easy, instructional and hard texts respectively.

N11. The error rates for this 9 year 9 month old boy indicate that he is likely reading above the expected level (*Figure 13,* page 87). His breathing rate increased and expiration time decreased with increasing text difficulty. Pause time was the highest in the instructional reading level and I/E ratio remained consistent across the difficulty levels. Ungrammatical pauses were 25%, 60% and 20% at the easy, instructional and hard levels respectively.

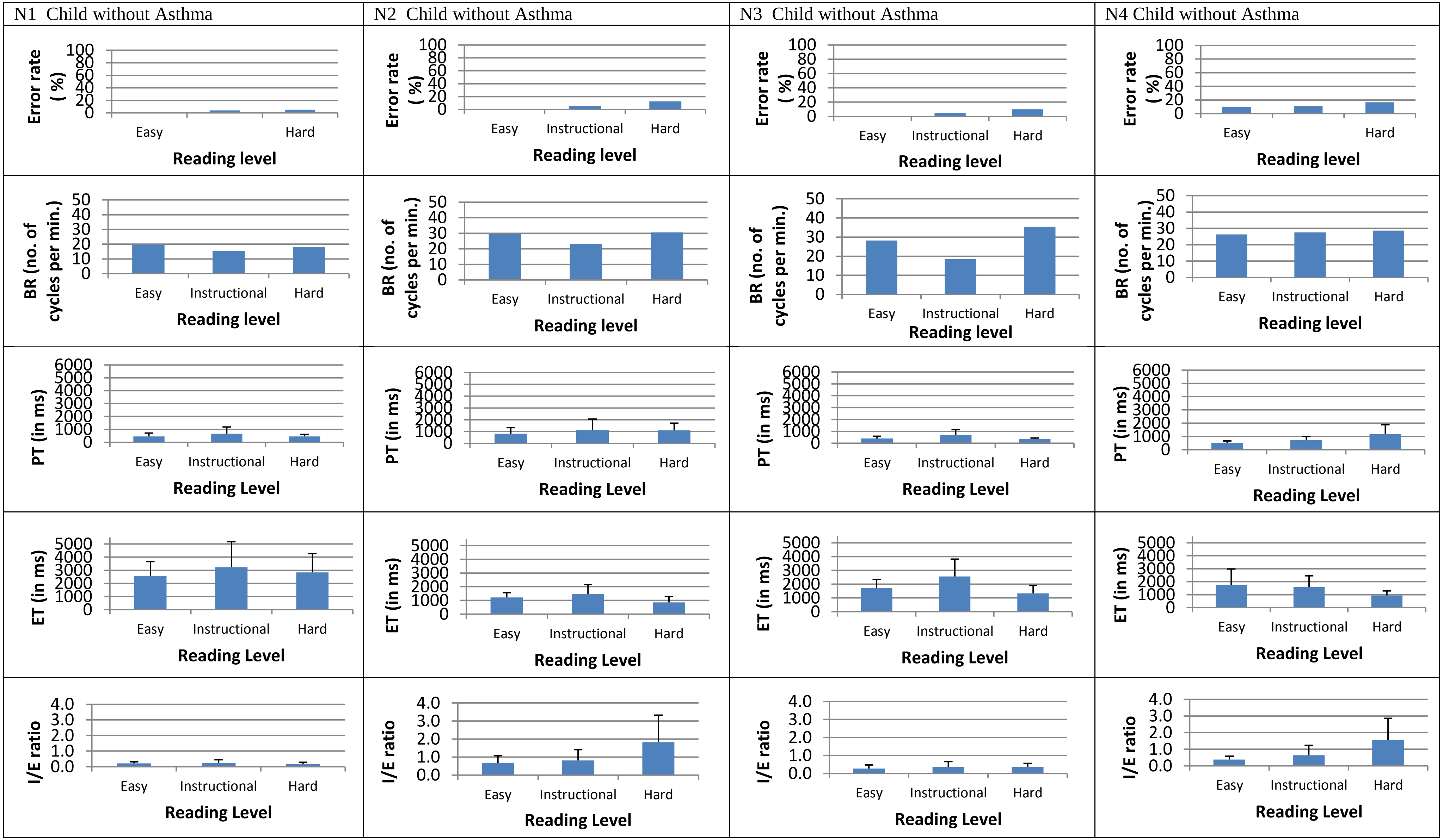


Figure 11 Girls without Asthma: Error rates, breathing rates, mean pause time (milliseconds), mean expiration time (milliseconds) and mean I/E ratio during three reading conditions

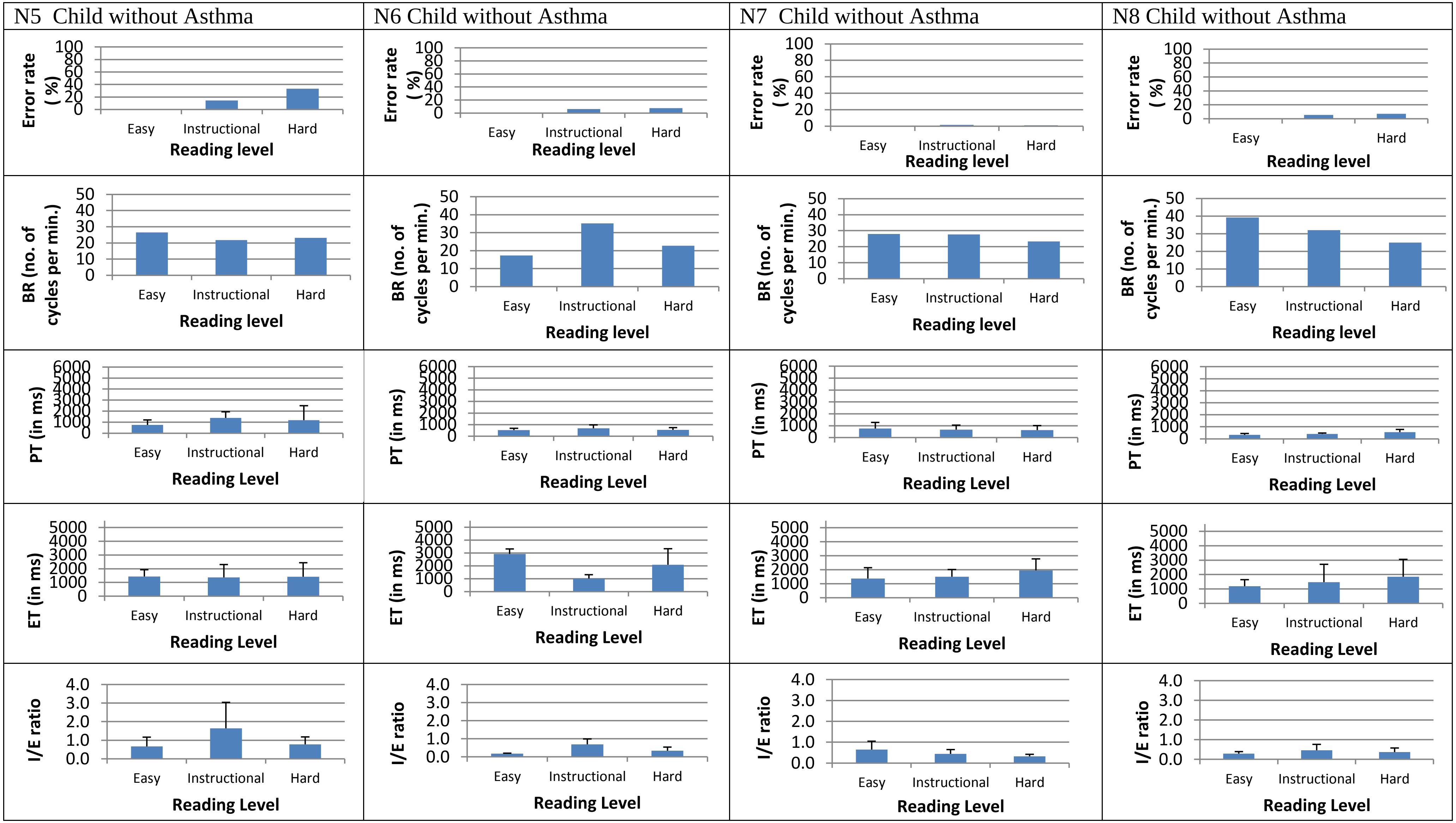


Figure 12 Younger boys without Asthma: Error rates, breathing rates, mean pause time (milliseconds), mean expiration time (milliseconds) and mean I/E ratio during three reading conditions.

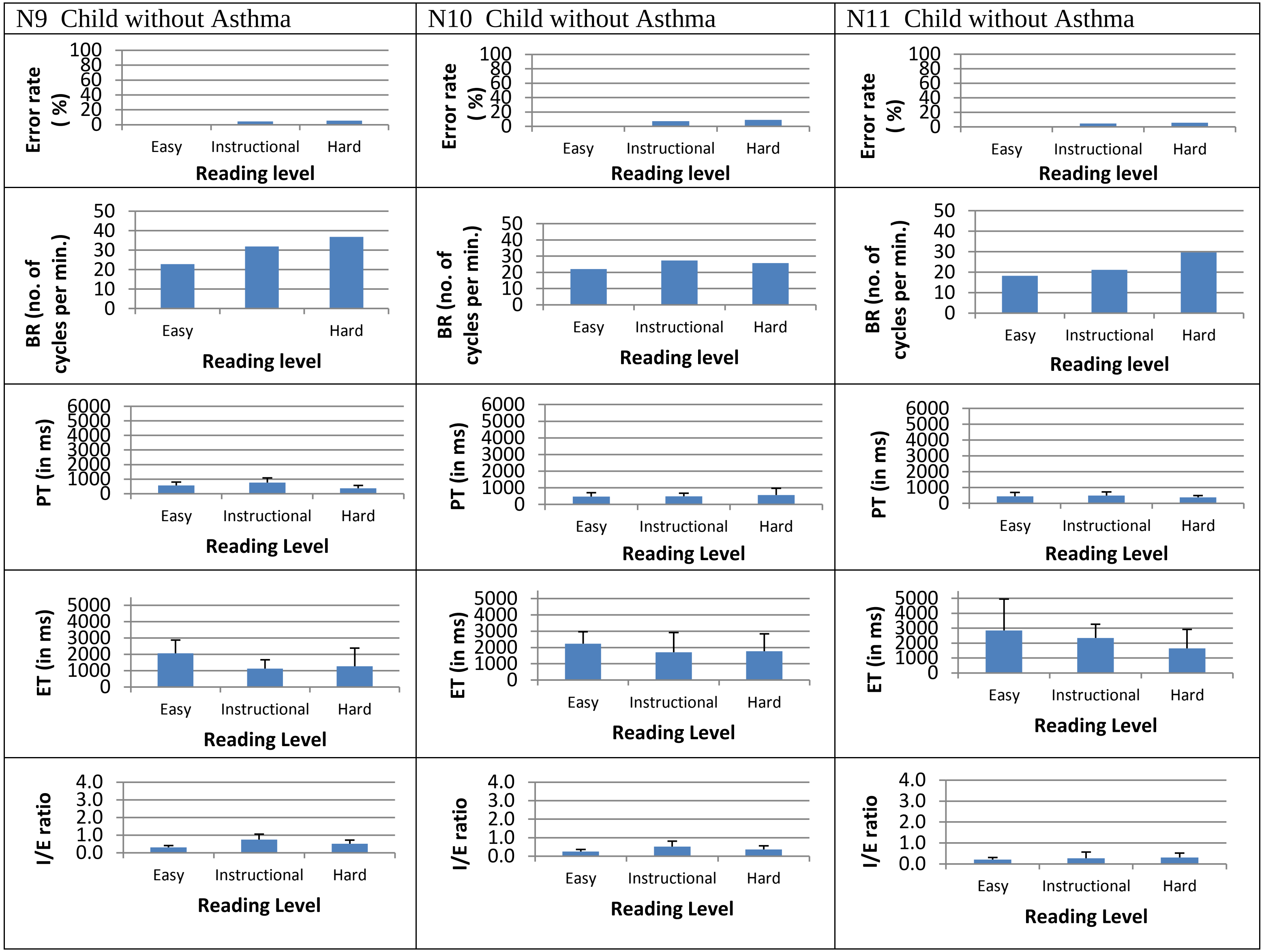


Figure 13…. Older boys without Asthma: Error rates, breathing rates, mean pause time (milliseconds), mean expiration time (milliseconds) and mean I/E ratio during three reading conditions.

Summary of Individual Differences

As the increase of error rates with increasing reading difficulty level was consistent when comparing between easy and hard reading levels. Additional summary tables that show the direction of related changes from easy to hard reading level for children with asthma are provided in Appendix S (page 149) and in Appendix T (page 150) for children without asthma. Results from an inspection these tables are summarized as follows:

Error rate: As would be expected, the error rates of all 22 children were higher when comparing the easy reading level to the hard reading level.

Breathing rate: The breathing rates of 9 out of the 11 (81.8%) children with asthma, that is, the breathing rates of all children with asthma except for A2 and A8, were lower at the hard reading level compared to the easy reading level (see Appendix S). In contrast, the children without asthma did not show such a distinctive pattern, with seven children (N2, N3, N4, N6, N9, N10, and N11) showing a higher BR and four (N1, N5, N7, and N8) (36%) showing a lower BR at the hard reading level compared to the easy reading level (see Appendix T). A chi-square analysis indicated the difference between the proportion of children showing a lower BR in each group was significant (X^2=4.701, p= 0.03).

Pause time: Nine out of the 11 (81.8%) children with asthma, namely, all children with asthma except for A3 and A8, paused for a longer period of time while reading at the hard reading level compared to the easy reading level (see Appendix S). However, in the non-asthma group (Appendix T), six children (54.5%) (N2, N4, N5, N6, N8, N10) also showed a longer pause time at the hard reading level compared to the easy reading level while five children (N1, N3, N7, N9, and N11) did not. Results of a chi square analysis show that there was no significant difference between the proportion of children who paused for longer periods of time while reading the hard passage as compared to the easy passage in the groups with and without asthma (X^2= 1.886, p= .17).

Expiration time: The expiration time of 8 out of 11 (72.7%) children with asthma, that is, the expiration time of all children with asthma except for A2, A6, and A8, was longer when reading at the hard reading level compared to the easy reading level (see Appendix S). In contrast, most of the children without asthma exhibited a lower expiration time at the hard reading level compared to the easy reading level. Only three children without asthma (N1, N7, N8) showed a longer expiration time when reading at the hard reading level compared to the easy reading level (see Appendix T). Results of a chi square analysis show that proportion of children in the group with asthma with increased expiration time was significantly different than the proportion of children without asthma who increased expiration time (X^2= 0.878, p= .0349).

I/E ratio: The I/E ratio for 6 (A1, A2, A4, A6, A9, A11) out of 11 children with asthma was higher when reading at the hard reading level compared to the easy reading level (see Appendix S). In children with asthma, it appears that females (i.e. 75%; three out of four) were more likely to have a higher inspiration /expiration ratio than the males (i.e. 43%; three out of seven). A clearer pattern was shown in the children without asthma. Out of the 11 children without asthma, 9 had inspiration/expiration ratios that were higher when reading at the hard reading level compared to the easy reading level. It is noteworthy that all female children without asthma showed a higher I/E ratio in the hard reading level than in the easy reading level (see Appendix T). Results of a chi square show that there was no significant difference between the proportion of children with higher I/E ratios did not differ between the groups (X^2= 1.886, p= .170). It is evident, when comparing between the easy and hard reading levels, that the inspiration/expiration ratio of children with asthma was more variable than that of children without asthma.

Based on these results, most children with asthma appear to cope when reading more difficult materials by breathing more slowly, increasing their pause time and increasing expiration time during difficult reading. This appears to be similar to how many children without asthma approach reading difficulty, with the exception of changes in breathing rate. In the next section, a quantitative analysis of the differences adds further detail.

Multivariate Analysis of Breathing of Children with and without Asthma

The next section includes multivariate analysis in order to examine the overall differences between the group with asthma and the group without asthma on breathing as reading difficulty increased. There was a significant reading difficulty level effect on error rate [$F(2, 40) = 8.996$, $p = 0.001$, np2= 0.31] but no significant group effect [$F(1, 20) = 0.656$, $p = 0.427$] or group by reading difficulty level interaction effect [$F(2, 40) = 0.725$, $p = 0.49$]. Overall, the hard reading level (Mean = 14.23) yielded a significantly higher error rate than the easy (Mean = 1.68) and instructional (Mean = 7.17) reading levels, which were not significantly different from each other. As the level of reading material increased in difficulty the children with and without asthma made more errors.

Results of the two-way (2 groups X 6 tasks) Mixed Model MANOVA conducted on the seven breathing measures, including Mean-PT, Mean-ET, Mean-IE ratio, CV-PT, CVET, CVIE ratio, and B, revealed a significant task effect [Pillai's Trace = 1.467, $F(35, 415) = 4.923$, $p < 0.001$] and task by group interaction effect [Pillai's Trace = 0.667, $F(35, 415) = 1.825$, $p = 0.003$] but no significant group effect [Pillai's Trace = 0.384, $F(7, 11) = 0.98$, $p = 0.491$]. As shown in Table 8 (page 94) follow-up univariate ANOVAs revealed a significant task effect on all of the seven measures except for BR and a significant task by group interaction effect on Mean-PT, CV-PT, and BR. For measures showing a significant task by group interaction effect, the between-group different in each task (i.e., simple group effect across tasks) and the between-task difference in each group (i.e., simple task effect across groups) were also examined. Results of follow-up univariate ANOVAs are reported as follows. No significant difference between the asthma and non-asthma groups was found on MPT ($t = -0.353$, $df = 20$, $p = 0.728$), which ranged from 5.89 to 36.05 sec (Mean = 15.28, SD = 6.38). There were no differences between children with and without asthma in the sustained phonation task.

Error rate.

There was a significant reading difficulty level effect on error rate [$F(2, 40) = 8.996$, $p = 0.001$, $\eta_p^2 = 0.31$] but no significant group effect [$F(1, 20) = 0.656$, $p = 0.427$] or group by reading difficulty level interaction effect [$F(2, 40) = 0.725$, $p = 0.49$]. Overall, the hard reading level (Mean = 14.23) yielded a significantly higher error rate than the easy (Mean = 1.68) and instructional (Mean = 7.17) reading levels, which were not significantly different from each other. As the level of reading material increased in difficulty the children with and without asthma made more errors.

Main task effect. Regarding the between-task comparisons with data from both the asthma and non-asthma groups combined, the “Quiet breathing” task showed significantly lower Mean-ET and CVET and significantly higher Mean-IE ratio than all of the five speech tasks. The “Quiet breathing” task also showed a significantly lower CVIE ratio than all the speech tasks except for the “Recital” task. These findings indicate that, in children with or without asthma, expiration time was shorter and less variable. Additionally, the time ratio between inspiration and expiration was higher and also less variable during quiet breathing compared to the speech tasks whether or not there was an asthma condition involved. During rote counting or alphabet naming (i.e., “Recital” task), the variability of the time ratio between inspiration and expiration was also relatively low like that for quiet breathing.

Similar speech breathing patterns were identified between the two groups with an increase of IE ratio, and greater variability of expiration time, during speech compared to quiet breathing. In addition, the control mechanism for "recital" appears to be different from that for reading and spontaneous speech, with the former maintaining a more consistent IE ratio over time.

Simple task effect. In the asthma group, the "Quiet breathing" task had a significantly higher Mean-PT than the "Recital" and "Easy reading" tasks (see Appendix L, page 142). In the non-asthma group, the "Quiet breathing" task showed a significantly higher Mean-PT than all the speech tasks (see Appendix P, page 146). Children with asthma had a tendency to pause for longer when reading difficult material.

Another significant simple task effect was found for BR only in the asthma group, which showed a significantly higher BR in the "Easy reading" task than in the "Hard reading" task (see Appendix K, page 141). The breathing rate of children with asthma was more variable when reading at a higher difficulty level.

In summary, inhalation time was found to be longer during quiet breathing compared to speech tasks. Children with asthma paused for longer and breathed slower when reading difficult material.

Simple group effect. Within each of the six tasks, a significant between-group difference was only found for the measures of Mean-PT, CV-PT, and BR. Specifically, the asthma group showed significantly higher Mean-PT and CV-PT than the non-asthma group during the "Free Speech" task. During the "Recital" task, the asthma group exhibited a significantly higher BR than the non-asthma group. However, during the "Hard reading" task, the asthma group had a significantly lower BR than the non-asthma group.

During talking, children with asthma tend to pause longer (i.e., increased Mean-PT) and vary more in pausing time (i.e., increased CV-PT). During rote counting or alphabet naming, children with asthma breathe faster than those without asthma. However, during reading a more difficult text, children with asthma breathe slower than those without asthma.

Table 8 *Means (standard deviations) for Measures across Six Tasks in the Asthma (n = 11) and Non-Asthma groups (n = 11) and Significant ANOVA Effects*

	Quiet Breathing	Recital	Free Speech	Easy Reading	Instructional Reading	Hard Reading	ANOVA Effects (df = 5, 85)
BR, cycles/min							Task: p= n.s.
Asthma	29.39 (5.85)	31.55 (9.56)	20.39 (7.67)	27.83 (3.96)	27.92 (9.84)	20.77 (4.62)	Task by Group: $F = 4.101$, $p = 0.002$,
Control	26.10 (3.84)	23.26 (6.01)	27.57 (8.71)	24.85 (6.41)	25.82 (6.45)	26.87 (5.84)	$\eta_p^2 = 0.194$
Mean-PT, ms							Task: $F = 19.042$, $p < 0.001$, $\eta_p^2 = 0.528$
Asthma	1571 (291)	396 (69)	1296 (842)	502 (261)	672 (718)	1036 (743)	Task by Group: $F = 3.41$, $p = 0.007$,
Control	1613 (315)	538 (286)	556 (119)	525 (142)	700 (272)	620 (304)	$\eta_p^2 = 0.167$
Mean-ET, ms							
Asthma	626 (163)	1672 (670)	2234 (746)	1732 (346)	1806 (697)	2042 (851)	Task: $F = 16.565$, $p < 0.001$, $\eta_p^2 = 0.494$
Control	775 (226)	2218 (892)	2198 (890)	2015 (621)	1789 (701)	1708 (532)	Task by Group: p= n.s.
Mean-IE ratio							
Asthma	3.00 (0.95)	0.42 (0.35)	0.88 (0.83)	0.55 (0.41)	0.51 (0.63)	0.77 (0.56)	Task: $F = 45.402$, $p < 0.001$, $\eta_p^2 = 0.728$
Control	2.37 (0.87)	0.49 (0.58)	0.47 (0.23)	0.33 (0.15)	0.60 (0.40)	0.51 (0.40)	Task by Group: p= n.s.
CV-PT, %							Task: $F = 8.112$, $p < 0.001$, $\eta_p^2 = 0.323$
Asthma	15.02 (13.1)	32.88 (12.3)	79.94 (44.01)	43.02 (24.4)	38.62 (18.5)	61.97 (26.7)	Task by Group: $F = 2.717$, $p = 0.025$,
Control	25.77 (20.3)	35.49 (36.7)	43.73 (18.15)	46.18 (13.6)	46.45 (14.8)	51.87 (26.9)	$\eta_p^2 = 0.138$
CVET, %							
Asthma	28.84 (16.1)	66.15 (25.1)	55.27 (14.70)	59.44 (16.7)	53.17 (22.9)	54.14 (19.2)	Task: $F = 8.469$, $p < 0.001$, $\eta_p^2 = 0.333$
Control	23.41 (12.0)	54.64 (25.8)	60.43 (23.43)	43.35 (18.2)	53.93 (17.3)	59.82 (16.2)	Task by Group: p= n.s.
CVIE-ratio, %							
Asthma	40.31 (29.8)	53.00 (23.0)	76.43 (37.1)	94.59 (34.5)	76.66 (35.3)	84.33 (18.1)	Task: $F = 5.899$, $p < 0.001$, $\eta_p^2 = 0.258$
Control	35.86 (16.6)	64.50 (41.8)	85.40 (38.5)	57.14 (23.0)	70.79 (21.4)	58.29 (16.2)	Task by Group: p= n.s.

Note. n.s. = not significant.

To determine whether the mean and variability of pause time were affected by the asthma status and the pause type, the Mean-PT and CV-PT averaged from scores obtained from the four connected speech tasks, namely, the “Free speech”, “Easy reading”, “Instructional reading”, and “Hard reading” tasks, were compared between pauses at the grammatical junctions and those at the ungrammatical junctions. Results from a two-way (2 groups X 2 pause types) Mixed Model ANOVA revealed only a significant group by pause type interaction effect on the average CV-PT score [$F(1, 20) = 5.655$, $p = 0.027$, $\square_p^2 = 0.22$]. For pauses at the grammatical junctions, the asthma group (Mean = 53.5%, SD = 20.9%) showed a significantly greater CV-PT ($t = 2.349$, $df = 20$, $p = 0.029$) than the non-asthma group (Mean = 34.1%, SD = 17.7%). Children with asthma paused at grammatical junctions about half of the time with a large variation in the time spent pausing compared to children without asthma.

Chapter 5 Discussion

In Relation to Research Question

The main research question of this study was how would the increase of reading difficulty affect the breathing patterns of children with asthma. The results of the current study found that children with asthma had significantly different breathing rates on particular tasks compared to children without asthma. In particular, children with asthma breathed more slowly when reading aloud from books that were 'difficult' as compared to children without asthma, and the individual analysis shows that this held for 9 of the 11 children with asthma. A significant negative correlation was found between breathing rate and asthma severity in the 'hard' reading task. The more severe a child's asthma condition, the lower the breathing rate while reading difficult text. Children with asthma also appeared to cope when reading aloud more difficult material, by pausing for longer periods of time and by increasing their expiration time.

There are several potential explanations as to why children with asthma had lower rates of breathing whilst reading difficult material. The first possible explanation could be a child's experience with language and syntax. For instance, a child with a broad experience of language may not need to pause for such a long time before attempting an unknown word. However, children's receptive language was estimated in the present study using the PPVT-4 (Dunn & Dunn, 2007). The scores indicated no significant differences in the means of the asthma and no asthma groups. Therefore, it is not likely that language skills had contributed to the differences between the breathing rates of children with and without asthma during the hard reading task.

Another explanation for the differences found between the asthma and no asthma groups may be related to the development of and the control of speech and the speech breathing system. In the current study, the mean breathing rate during instructional reading for children with and without asthma was higher than that of the adult men in Boliek et al.'s, (2009) study when reading age-appropriate material. The chronological age and the average breathing rate of the children in the current study suggest that these children might not have reached maximum growth in terms of the speech-breathing system (Hoit et al., 1990). Boliek et al., (2009) found that differences in the speech breathing of children were influenced by age, and children continue developing their speech breathing until age 10 (Hoit et al., 1990). Since the group with asthma in the present study showed a lower chronological age and fewer years in school, it is likely that asthma may affect the rate at which children develop speech breathing and thus contribute to the differences between children with and without asthma on various breathing measures.

The places where children paused may have contributed to the differences in breathing rates between groups and across reading levels. The present study found that all children made pauses at what was considered to be inappropriate places between 60-66% of the time when reading difficult material. It is likely that children with asthma and children without asthma paused when their reading brought them to a word that they did not know (Henderson et al., 1965; Winkworth et al., 1994; Bock, et al., 2006). However, children with asthma paused for longer periods of time than the children without asthma. The children with asthma may have been managing an increase in cognitive load (i.e. difficult material) as well as the asthma effects on their speech breathing system, and using the longer pause to breathe more deeply.

In Relation to Previous Findings

Liberty et al (2010) reported that children with asthma within their study were more likely to be low achieving after one year of school. The present study indicates that the breathing of children with asthma was different to the breathing of children without asthma.

Whether this difference can contribute to low achievement should be the subject of future research.

The severity of the condition could have been a possible explanation for the current findings. The results found that breathing rate was lower in children with asthma and this was related to asthma severity (.i.e. higher asthma severity resulted in a lower breathing rate when reading difficult material). This could be related to subsequent reading achievement and needs to be investigated further. However, Liberty et al (2010) found that the low reading achievement in children with asthma was not related to asthma severity. This variation could be explained by methodological differences between the studies. Factors that are known to influence reading achievement were not measured and/or controlled for in the current study as they were in Liberty et al (2010) (i.e. time in school, ‘readiness’, and age). It is possible that the results of the current study were impacted on by the stated developmental factors and at the same time these factors amplified the effects of severity.

The severity of asthma is related to the difference in the breathing rates of the children with asthma in the present study. According to the adapted Rosier measure of severity, 54.5% of children had severe asthma. However, using older criteria (i.e. Becker et al., 1984), all of the children could be classified as severe using their measured I/E ratio. Severity of asthma is related to asthma management. The better asthma is able to be managed, the lower the severity. All of the children in the present study were recruited from a clinic list as they were still showing asthma symptoms even when on current asthma management programmes. It may be that children with asthma which is better controlled than the asthma of the children in the current study would not have difficulty managing their breathing rate whilst reading difficult stories. Therefore, research with children with asthma who have mild or no symptoms may have a different result.

All children within the current study had a higher resting respiratory rate as compared to the criteria set out by (Family Practice Notebook, 2014). For children aged 6-12 years the normal rate is considered to be between 16 and 20 breaths per minute. The children in the current study had resting respiratory rates between 20 and 37 breaths per minute, with no significant difference between the groups. This difference could be due to the children being anxious as this was a new situation in which they had to talk and read aloud books of increasing difficulty to a strange adult. Research by Giardino et al., (2007) has shown that when an individual is experiencing anxiety their respiratory rates increase. Therefore, one explanation for the children's higher breathing rates is task-related anxiety and worry.

Hoit, Hixon, Watson and Morgan (1990) studied the breathing rate of children aged 6 to 17 years whilst reading aloud a 12 sentence passage of first grade-equivalent reading material. The children included in the study were identified as having no history of respiratory or reading difficulties. In the current study, children with asthma had breathing rates that were 33% higher than the children aged 7-10 in the study by Hoit and colleagues (1990) with a possible explanation being a difference in methods. The children received the reading passage several days before the measuring session took place and were instructed to practice it (Hoit et al., 1990). Therefore, potential anxiety in reading may have been reduced or erased, unlike the situation in the present study where children were faced with unfamiliar reading material.

This section summarized the findings of the present study and compared them with research covered in the review of the literature. There is no identified literature investigating the same breathing characteristics of children with asthma as the current study. Furthermore, a number of studies reviewed had disclosed that measures such as 'silent' pauses had been left out of analyses (i.e. Winkworth et al., 1994). The omitting of certain measures of breathing resulted in a smaller pool of literature that was available to make direct comparisons with. There were a number of possible explanations for the differences in breathing between the children with and without asthma. The influence of developmental stage and maturation is one to be highly aware of when making interpretations from the results of the current study. Some of these identified and discussed were language, age, and asthma severity, appropriateness of pause location, low achievement, and anxiety.

Limitations and Strengths of the Study

The current pilot study had a number of major limitations that impacted on the results and subsequent conclusions.

The main limitations to the current research included the sample size and the characteristics of the participants (i.e. gender, age, and ethnicity). A small sample with an uneven spread of demographics results in a sample that is not representative of the general population of children with asthma. A representative sample is essential in order to be able to generalize the results to the wider population of children with asthma (Rust & Golombok, 2009). A non-representative sample can affect the results by skewing the data a particular way and therefore, affecting conclusions made about the study. Due to limited resources a representative sample was unable to be achieved. However, it is important to note that even though the current pilot had a small sample with skewed sample characteristics, significant results were still achieved.

No measure of mental health, specifically a measure of anxiety was included in the current study. A higher respiratory rate has been associated with an increase in state and trait anxiety (Paulus, 2013; Giadino et al., 2007). Anxiety inventories such as the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 2005) is a screening tool used to measure the amount of anxiety an individual is currently experiencing on both the state and trait dimensions. The trait anxiety test is useful in identifying children who may experience anxiety more frequently and intensely. Anxiety has also been repeatedly linked with children with asthma, specifically around breathing related difficulties (i.e. Paulus, 2013; Thoren & Petermann, 2000). A measure of a child's anxiety would have provided an indication of the level of anxiety a child may be feeling on the day of data collection (state anxiety).

Originally, the aim was to recruit beginning readers in order to reduce the effects of time and experience in school on the children's oral reading skill (Buckingham et al., 2013). The sample consisted of a wider age spread of children with most not considered as being 'beginning readers', as these were the children on the current clinic list from which participants were recruited. On the other hand, by asking children to read difficult material, the demands of beginning reading were modeled. The wider age range in the present study meant that findings do not necessarily explain the differences in the reading achievement of six year olds with asthma previously reported by Liberty et al., (2010).

Children within the current study may have previously read the books that were used to measure breathing which could have resulted in an influence of practice effects. Practice effects are when an individual has a change in performance or different results simply because of repeated testing or exposure (Shaughness & Zechmeister, 2012). This may have affected the results and may not have indicated a child's actual reading performance. The books were selected because they were readily available and similar to books the children would see at school. These gave a sense of familiarity and ease for children and appeared to reduce potential worry. It was noted that very few children verbalized whether they had read the book before. It is recommended that each child is asked whether or not they had read the book before and this be noted.

Parents of children and the children with asthma in the current study were not required to answer questions about the status of their child's health, including respiratory health on the day of testing. Gaining an indicator of a child's health is an important factor to be considered as it can influence many facets of a child's wellbeing, including their learning performance (Haas, 2007; Thies, 1999). A child who is living with asthma will be experiencing symptoms such as narrow and swollen airways, feelings of tightness in the chest and wheezing (Celano & Geller, 1993; Lai et al., 2008). Additionally, a child may have had rhinopharyngitis (common cold) or other health complications which could have further compounded the asthma symptoms and resultant struggle to breathe. However, a strength of the study was that information was gathered on the health of children within the last 6 months and visual observations were noted. On the day of data collection, no child appeared to be ill enough that measurement of breathing conditions had to be terminated. The record of the children's health is considered a strength as a number of other studies of breathing did not report on the individual's health (i.e. Hoit et al., 1990; Winkworth et al., 1994). However, additional information on the participants' health status may have improved understanding of the impacts on the breathing of children with asthma on the day that breathing was measured.

Another limitation in the information available included details on the precise dosage of medication prescribed to the children and the intervals of administration in the current study. Adherence to prescribed medication is essential in the effective management of the symptoms of chronic asthma (i.e. Bourdin et al, 2012; McQuaid et al., 2003; Jonasson et al., 2000). Information gathered from the questionnaire given to parents identified that all children with current asthma had doctor-prescribed medication to manage symptoms. Considerations about the severity of a child's asthma symptoms on the day of data collection were unable to be made. By not knowing the usage of medication on the day of data collection, the effects of not using (i.e. worsening of symptoms), or using (i.e. voice effects, cough after inhalation) could have contributed to the differences found in the children with asthma.

A related limitation of the current study was that parents of the children were not questioned on the medication use at the particular time of data collection (i.e. 'has your child used their inhaler before coming here today?'). Research has identified localized side- effects on the voice after use of prescribed asthma medication (i.e. Dubus et al., 2001; Dubus et al., 2003; Erickson & Sivasankar, 2010). Gaining information on the medication use of the child on the day of the breathing measures would have allowed for the consideration of these factors as possible contributors to the results of the differences in breathing as the child progressed from easy to difficult oral reading tasks. Therefore, this raises questions around the child's asthma status on the day of data collection and on the possible impacts this may have had on the child's breathing during increasingly difficult reading material.

A limitation in the setting of the current study was inconsistencies in the location that the breathing measures occurred (i.e. at the clinic or participant's home). There were substantial differences between the clinic setting, where measures of 6 participants occurred, and the homes of the 18 participants, where their measures occurred. It is widely known that when conducting research it is important to control extraneous variables in order to focus on the variable being targeted or manipulated (Shaughnessy & Zechmeister, 2012). Peripheral noises (i.e. birds) were recorded on the sound file causing difficulty with subsequent coding and well as for a child sustaining attention on the task. This may have disrupted a child's reading flow, thus producing differences in breathing. Due to some families living rurally and/or having younger children (i.e. infants) this was the only way that the family could participate in the study. However, the fact that measurements occurred at 18 of the children's homes can be considered a potential strength for the younger children as they were more comfortable within their own home environment.

Another limitation of the current study is the possible attributions made by the children between 'reading' and 'school'. Children who are having difficulties with school and/or reading and language can have negative attributions towards these tasks (i.e. “I am going to be tested and I am going to fail”) (Craske, 1988). This could have had an impact on results due to causing anxiety about being tested and therefore influencing the breathing of the children with asthma (Giardino et al., 2007; Homma & Masaoka, 2008). This raises unanswered questions about whether or not a child with asthma may have breathed at a higher rate because of task- based anxiety or because they were running out of oxygen, or because of a combination of factors. The researcher tried to alleviate anxiety by reiterating that the situation was not a test and that the children were not going to be marked or graded. None of the children appeared to be overly anxious and all were able to complete the breathing and reading tasks. However, the uncertainty around the amount of anxiety a child may have been feeling is an unknown factor possibly contributing to the differences identified in the breathing of children with asthma.

Limitations related to measurements

Reading.

There are a number of limitations that are related to the measurement of reading. The first was that no measure of cognitive functioning through standardized testing or other information gathering (i.e. school records on reading achievement) was included in the current study. A measure of cognitive functioning gives an indication of a child is functioning in relation to their peers in areas such as comprehension, reasoning, working memory and processing (Carr, 2006; Wechsler, 2003). Furthermore, it is beneficial to have information on overall functioning on hand in order to consider whether a child’s cognitive abilities were impacting on their reading performance and resultant breathing. This was not viable due to limited resources and the study design. However, the measure of receptive language (PPVT-4) has been used in other studies as an indicator of cognitive functioning (i.e. Guo & Harris, 2000). The PPVT-4 gave a general indication of children's strengths and difficulties with understanding language in the current study.

Another limitation was that reading accuracy was not measured during the period that breathing was coded and analysed. Running records were analyzed to determine the accuracy of reading for each specific reading task. However, the level of accuracy of the words read during the first five pauses was not determined. Reading accuracy was calculated for the whole reading session), however, only the first 5 pauses were used in the analysis of breathing. This may have affected the results as the reading accuracy may have been different within the portion that was used for analysis. Therefore, the accuracy and error rates may not be a fair depiction of the child's reading ability during the period of time that the five paused were recorded.

Breathing.

A number of limitations can be related to the recording and analysis of the breathing and reading of children. The quality and sensitivity of the microphone and laptop may have been lower than equipment used in other studies to record breathing. Sensitivity of equipment, along with close proximity to the skin, is essential for capturing changes in breathing (Kraman et al., 1995). Some children's breathing on the preliminary tasks was not able to be recorded. This ultimately affects the validity of the results. An advantage of this system was the acceptance by the children, and even so when given increasingly difficult reading material. As well as producing input that was suitable for software analysis. No session had to be terminated due to a child being overwhelmed by the measurement method. This can be considered a strength in the study as the children felt more comfortable and therefore were able to focus on the task at hand. This is important in terms of looking at the repeatability of the method with young children.

A limitation of the study was the definition of a 'pause'. Distinctions were not made between a pause with an inhalation, which would be defined as a 'breath pause' and a non-breath pause (Oliveria, 2002; Wang et al., 2010; Grosjean & Collins, 1984). The current study found that children with asthma tended to pause more often at grammatical junctions; however, the length of the pause was more variable when compared to children without asthma. Pauses to take a breath are directed by a number of needs; respiratory or the physiological need to take in oxygen is one and another is due to the demands of grammatical structure (Wang et al., 2010; Grosjean & Collins, 1984). The operationalization of a pause as 200ms in the current study was chosen due to recommendations based on previous literature outlined by Oliviera (2002).

A limitation of the current study was that posture was not corrected when a child was completing the breathing and reading measurements. Most children in the current study were observed to bend over the books when reading out loud even after instruction to sit up straight. The position and posture that a child takes influences the production of speech. It is likely that the child's diaphragm was compressed resulting in an upset to the natural changes to the chest wall when reading aloud. Consequently, this affected the child's ability to breathe efficiently during speaking. It is possible that the incorrect posture displayed by children impacted on their breathing whilst reading increasingly difficult material in an unpredictable way. Further research should control for children's posture during reading tasks.

A methodological limitation in regards to breathing was the absence of information on the lung function of the children with asthma. Lung function can be measured by a spirometer gaining this measure of lung function would have required resources that were beyond availability. A measure of lung function would have given a more 'standardized' indication of a child's current amount and flow of air that can be inhaled and exhaled at one time. Lung function measures would have allowed for conclusions to be made on the impact on physiology induced by a lowered breathing rate of a child with asthma. However, these sorts of measures which require attaching machines to the individual's body are difficult to do reliably in young children due to age and development of the respiratory system (i.e. Beydon, Davis, Lombardi, Allen, Arets, Aurora, 2007). As well as considering the possibility that this may have put the child under unnecessary stress which then would have led to confounded results as anxiety has been shown to affect breathing (i.e. Paulus, 2013). Having a measure of lung function, prior to a child completing the reading tasks may have given an indication of the amount of airway obstruction a child may be experiencing, depending on the sensitivity of the equipment.

The portion of audio file that was chosen to be analysed (beginning) as well as the number of 'pauses' (n=5) were related limitations. As the start of the breathing/reading condition was most likely where a child would be feeling the most 'anxious', it is possible that this would have affected the resultant breathing of the children. Selecting the first five pauses may or may not be representative of their breathing at the end or in the middle. An explanation for this could be because a child has been reading for a certain amount of time and has been able to settle into the task. Although resources limited the amount of analysis, the study still provides a foundation for further analysis and findings direct attention toward the important consideration of how breathing may affect oral reading of children with asthma.

Implications of the study

The following section aims to identify and illuminate the possible implications of the current research in regards to applications within a practical setting as well as for future research within this area.

The present study reported significant differences in the breathing patterns of children with asthma during challenging oral reading tasks, as compared to children of the same age and gender who did not have asthma. Although there were important limitations to the study, future research should be directed at the questions raised by this study, whilst addressing the limitations. Determining whether the breathing of children with asthma is different needs to be explored fully in order to mark its presence as a factor contributing to the reading achievement of children with asthma. The present findings gave a ‘first glance picture of the characteristics of breathing in children with asthma and a base to develop further investigations of the impact of asthma on reading achievement. Previous studies have identified other contributing factors such as school absence, living with a chronic condition, school readiness and low SES. However, further exploration into the breathing of children with asthma as they read, or learn to read, in order to confirm, disconfirm and/or add information is greatly needed.

Future research should look to employ more controlled measures such as measure of oxygen or carbon dioxide in the blood stream (oximetry) during the reading tasks (Bishop & Nolan, 1991), with greater measurement sensitivity and an environment in which extraneous sounds can be controlled to ensure the quality of breathing samples. Further to this point is that recruitment of a larger, more representative community sample of the population of children with asthma is recommended. Careful consideration should be taken when setting inclusion criteria for the characteristics of a ‘control’ group. Mention should be given to children with differing levels of asthma severity as well as children with chronic conditions besides asthma such as, diabetes or epilepsy (McNelis et al., 2007; Austin et al., 1998). This is due to the impact of the ‘general effects’ that chronic conditions have on children’s’ health and well-being. Having a chronic condition has been linked to an increase in the absence rates of children (i.e. Moonie et al., 2008; Newacheck and Halfon, 2000).When children are absent from school they miss opportunities to learn which needs to be learned by the child on other days, increasing the required amount of learning. This results in more time and energy requirements by child, teacher and parent. Because of the cumulative nature of learning, missed opportunities and a subsequent inability to catch up can result in lowered academic achievement.

Another aspect for future research to consider is having a measure of the current cognitive abilities and mental health (i.e. anxiety) of prospective participants. Due to the relatively break-through nature of the current study, it is imperative that researchers have a measure of comorbid difficulties that children are experiencing that may potentially be impacting on their reading development. Research should aim to include children who do not have learning difficulties or other chronic health/psychological difficulties. These are well known to impact on reading achievement and proficiency (Carr, 2006; Goodwin, Jacobi & Thefeld, 2003; Thies, 1999). Having information which indicates the cognitive and mental health status of children will enable further research to identify the type and direction of influence that these factors have on children with asthma when learning to read.

The results of the current study have identified significant differences in the breathing of children with asthma. It is important that future research also aims to identify and examine what strategies children with asthma employ in order to manage cognitively challenging material. Once identified, priority should be given to determining whether these strategies are used consciously and whether the child is aware of the effect on learning. The findings of such research will help to inform possible interventions to either help other children with asthma unlearn problematic strategies that may be detrimental to their learning and/or to build on positive strategies that enhance learning.

Future research should also aim to continue investigations on the relationship between severity and asthma and the consequent influence on a child’s breathing when reading. Moreover, the relationship between asthma management and the impact on breathing during reading should also be investigated. It would be beneficial to identify what the effects of using prescribed medication before reading are on young children. This could be achieved through gaining a measure of air flow and volume rates (i.e. Hancox et al., 2004). This would gather much needed information on the medication effects on breathing, specifically before an oral reading session.

This is an exciting and new area of research; through consideration and incorporation of the above recommendations and reduction of the methodological limitations previously stated this area is full of potential research opportunities. With more controlled and different measurement methods, and larger sample numbers it may be possible to replicate the current findings and to establish research on the breathing patterns among children with asthma during oral reading, which are influenced by different levels of asthma severity. Findings from a series of research studies will add literature to this area which will possibly lead to practical applications of the information.

The following section outlines possible practical applications if the identified limitations of the current study are considered and are upheld by future research. The limitations reiterate the importance of replication of the current results.

The standard answer to asthma related difficulties for children has been to investigate enhances to medication and development of new drugs. Recently, Hancox, Le Souef, Anderson, Reddel, Chang, and Beasley, (2010), proposed an alternative approach to costly drug developments. The authors suggested focusing on what is already currently available and optimising the widely-used and efficacious asthma medications. Strategies identified and discussed were increasing access to medications, ensuring appropriate prescribing of medications, maintaining proper technique by patients and clinicians when using inhalers and compliance to treatment regimes. Correct diagnosis of asthma and subsequent appropriate prescribing of medication to the unique individual, as well as ongoing compliance with continued inhaler-use instruction were all important factors discussed that could dramatically improve the outcomes for individuals with asthma. Providing a holistic systems approach with a focus outside of medication may have vital implications when considering the breathing of children with asthma while reading aloud.

An implication for practical applications can be drawn from Research carried out by Thomas, McKinley, Freeman, Foy, Prodger and Price (2003). They found positive results using breathing retraining in a group of adults with ‘dysfunctional breathing’. Participants were taught diaphragmatic breathing exercises which focused on breathing patterns, emphasizing slow, regular, nasal, abdominal breathing. The breathing strategies are able to be practiced at home as well as when experiencing symptoms of asthma. Therefore, it would be worthwhile to investigate the possibility and efficacy of implementing breathing training with young children in order to enable them to learn strategies to control their breathing whilst reading aloud or learning to read.

Breathing training for children with asthma specifically targeted around oral reading may possibly alleviate and/or reduce comorbid factors such as anxiety and worry (Thoren & Petermann, 2000). The diagnosis of asthma as a chronic condition entails difficulties with airway inflammation and subsequent ability of fulfilling respiratory needs. Breathing difficulties may cause anxiety or worry about the child’s perceived capability to breathe in certain educational situations (i.e. reading aloud in the classroom or speaking in front of peers). Breathing training and/or breath therapy may enable children to manage their breathing and therefore reduce anxiety. By reducing the degree of anxiety or worry a child may have about their breathing during oral reading allows them to give more attention and concentration to the reading task at hand.

Recent research has identified a link between the importance of correct posture and an improvement in breathing and oxygen intake in adults. Lagier, Vaugoyeau, Ghio, Legou, Giovanni and Assaiante (2010), investigated the direction of effects of body movement in relation to respiratory behaviours in health adults. Their results showed a positive relationship between posture and voice production, with body movements having a specific role in the vocal effort behavior. When an individual is speaking out loud there are changes in the dynamics of the chest wall. More specifically, in order to allow for compression of the rib cage to facilitate expiration, the abdomen is displaced further inward (Bailey & Hoit, 2002). To facilitate inspiration, the rib cage needs to be expanded and a straight and open upper body posture is needed to allow for an efficient expansion of the rib cage through the lowering of the diaphragm and the lifting of the rib cage. Therefore, alongside medication, posture training and correction could be integrated as a component in the management of children with asthma. Through implementation of such programs whilst reading, children with asthma could strengthen their ability to control difficulties with breathing while reading aloud.

Inhaled corticosteroid (ICS) medications are widely known as effective treatments of the physiological symptoms of asthma. Continued priority should be given by parents and clinicians of children who are receiving medication to monitor for signs of adverse reactions and effects. For example, changes to voice quality due to asthma medication (i.e. Dubus et al., 2001) might affect comfort of a child when reading aloud. If adverse effects are suspected, careful assessment and re-evaluation of the treatment effect on voice should occur.

This study is the first of its kind to measure six of the characteristics of the breathing of children during reading (i.e. breathing rate, pause time, grammatical juncture, error rate, expiration time, and inspiration/expiration ratio). The results found that children with asthma breathed more slowly when reading difficult material, paused for longer periods of time and showed increased expiration time when asked to read challenging material aloud. Asthma severity negatively increased breathing rate (i.e. as severity increased, breathing decreased). An emerging picture of the breathing of children with asthma when reading material of increasing difficulty aloud was achieved within this research. The identified methodological limitations are important to consider when generating conclusions from the study results. The current study highlights a need for further research to add to the literature in this emerging area.

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Appendix A

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

HUMAN ETHICS COMMITTEE

Secretary, Lynda Griffioen
Email: human-ethics@canterbury.ac.nz

Ref: HEC 2012/130

14 September 2012

Beth Wiechern
Health Sciences Centre
UNIVERSITY OF CANTERBURY

Dear Beth

The Human Ethics Committee advises that your research proposal "Analysis of breathing during oral reading of young children with and without asthma" has been considered and approved.

Please note that this approval is subject to the following:

- The incorporation of the amendments you have provided in your email of 3 September 2012.
- In the information sheet for children, please remove "Mum and Dad" and replace with "Parent/Caregiver" or similar wording.

Best wishes for your project.

Yours sincerely

pp L Griffioen

Lindsey MacDonald
Chair
University of Canterbury Human Ethics Committee

University of Canterbury Private Bag 4800, Christchurch 8140, New Zealand. www.canterbury.ac.nz

E 8

Appendix B

Locality Authorisation for Canterbury District Health Board

[Please return documentation to CDHB Research Office, (03) 364 3630, 38 Cashel St, Christchurch]

Locality authorisation is a standard condition of HDEC approval for the conduct of a study at a given locality. Locality review is the process by which a locality assesses its suitability for the safe and effective conduct of a study.

Part one: General

Project title:	The Analysis of Breathing during Oral Reading by Young Children with and without Asthma
Locality to be assessed:	Christchurch Hospital, Canterbury DHB
Brief outline of study:	The study is an MSc thesis project in Child and Family Psychology by Beth Wiechern, a postgraduate student, University of Canterbury. The aim is see how young children with and without asthma are able to control their breathing during reading. Children who are beginning reading (5-8 years old) will be sampled. Recruitment of asthmatic children will be through the Paediatric Asthma Clinic and acute admissions through CAA at Christchurch Hospital over 3 months. Recruitment of non-asthmatic children will be through informal contacts. The testing will be conducted at the Health Sciences Clinic, University of Canterbury and will involve observations of breathing during rest, counting, talking and reading. The Peabody Picture Vocabulary Test will assess the child's knowledge of language. The underlying reason for the study is that previous work at the University of Canterbury has identified that having asthma at school entry is a risk factor for poor reading achievement in the first years at school. This study looks at one hypothesis – that breathing control impairs the oral reading skills of children with asthma. The study is observational and non-invasive and has been given ethics approval by the Human Ethics Committee, University of Canterbury – HEDC approval not required.
Local Principal investigator:	Philip Pattemore (advisor to Beth Wiechern)
Contact person & contact details:	Assoc.Prof. Philip Pattemore Dept of Paediatrics 80734 philip.pattemore@otago.ac.nz
Other local investigators:	Professor Kathleeen Liberty, Dept of Health Sciences, University of Canterbury. Phone 3642545. Email: Kathleen.liberty@canterbury.ac.nz (Beth Wiechern's Master's supervisor) Beth Wiechern, BA, Masters student, Dept of Health Sciences, University of Canterbury. Phone: 027 3340344 email: bjw96@uclive.ac.nz

Part two: Locality Issues

1) **Suitability of local researcher**
Is the investigator(s) at the locality suitably qualified, experienced, registered and indemnified to take professional responsibility for the conduct of the study at the locality? ✓☐ Yes ☐ No

2) **Suitability of the local research environment**
Are all the resources and/ or facilities that the study requires appropriate and available? ☑ Yes ☐ No

Would conducting the study at the locality impact on the provision of publicly funded health care at that locality? ☐ Yes ☑ No

Have all potentially affected managers of resources such as patient records or laboratory managers been notified? ☑ Yes ☐ No

Appendix C

Beth Wiechern

Telephone: 03 348 6169

Email: bjw96@uclive.ac.nz

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

02/08/2012

Analysis of Breathing During Oral Reading by Young Children With and Without Asthma

Information Sheet for Children (for the Parent to read to the child)

Beth is doing a project at the university. She is a student who is learning to work closely with children and families. She is going to work with you to find out about your asthma, breathing, and reading.

It is your choice whether you want to help Beth or not, and you can choose to stop helping at any time and that is fine. If you choose to help Beth, and then change your mind about being in the project, even if you are in the middle of helping Beth, that is fine too. All you have to do is to tell your Mum or Dad and they can let me know or tell me if you are working with me at the time.

She will instruct you and watch you do 9 tasks involving you talking and reading out loud. All of the tasks will take different amounts of time to do with the longest one being 10minutes. These are not tests and you will not be marked on them but Beth does ask that you try your best. She will also have a computer with her that will record your breathing and your voice. This is called an audio recording but it will not record any pictures of you. Beth will need your help for about 30minutes on a day that you and your parents/caregivers can come.

If you decide to help you will be given a code name so that no-one will know your name. Only Beth and three of her teachers will be able to see your audio recording and none of them are allowed to tell anybody about you or any of the help you give. All the information will be stored in a locked cabinet. After the project has been written up all the information collected will be destroyed.

I have also asked your Mum and Dad to help me too. They will help me with information about your asthma and the symptoms that you experience.

If you have any questions, you can talk to your Mum or Dad and they can ask me.

If you are happy to help me with my project and you know what it is that I want you to help me with please with your parents' help, complete the consent form.

Thank you in advance for helping with the project. I am really happy that you want to be a part of it.

Beth Wiechern

Appendix D

Beth Wiechern

Telephone: 03 348 6169

Email: bjw96@uclive.ac.nz

02/08/2012

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Analysis of Breathing During Oral Reading by Young Children With and Without Asthma

Information Sheet for Parents

I am a postgraduate student at the College of Education, University of Canterbury. I am interested in finding out more about the breathing during oral reading of children with asthma who are in the early stages of reading development. I am particularly interested in looking at pauses and the reasons behind the pause. This research will add much needed data to the literature on asthma and early reading development.

I would like to invite you to participate in this study. If you agree to take part you will be asked to do the following:

o Go through the information sheet and consent form with your child to ensure they understand what participating in this research means. Provide your assent on the child consent form.

o Bring your Child to the University of Canterbury, Education Campus at a time agreed by both parties, in order to complete the analysis of the conditions.

o Complete a short questionnaire about your child's current asthma symptoms and demographic questions (i.e. age). This will take approximately 10 minutes.

Please note that participation in this study is voluntary. If you do participate, you have the right to
withdraw from the study at any time without penalty. If you withdraw, I will do my best to remove
any information relating to you, and your child, provided this is practically achievable.

I will take particular care to ensure the confidentiality of all data gathered for this study. All the data will be securely stored in password protected facilities and locked storage at the University of Canterbury for five years following the study. It will then be destroyed. I will also
take care to ensure your anonymity in publications of the findings. My thesis, once completed, will be publically available in the UC Library.

The results of this research may be used and condensed into an article for an empirical Journal. All participants will receive a report on the study.

If you have any questions about the study, please contact me (details above) or my supervisor Kathleen Liberty (Kathleen.liberty@canterbury.ac.nz). If you have a complaint about the study, you may contact the Chair of Research Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (humanethics@canterbury.ac.nz).

Appendix E

Beth Wiechern

Telephone: 027 334 0344

Email: bjw96@uclive.ac.nz

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

02/08/2012

Analysis of Breathing During Oral Reading by Young Children With and Without Asthma

Consent Form for Parents

I have been given a full explanation of this project and have been given an opportunity to ask questions.

I understand what will be required of me if I agree to take part in this project.

I understand that my participation is voluntary and that I may withdraw at any stage without penalty.

I understand that any information or opinions I provide will be kept confidential to the researcher and that any published or reported results will not identify me or my child. I understand that a thesis is a public document and will be available through the UC Library.

I understand that all data collected for this study will be kept in locked and secure facilities at the University of Canterbury and will be destroyed after five years. This is standard procedure in accordance with the University of Canterbury Policy.

I understand that I will receive a report on the findings of this study. I have provided my email details below for this.

I understand that if I require further information I can contact the researcher, Beth Wiechern or supervisor Kathleen Liberty (kathleen.liberty@canterbury.ac.nz). If I have any complaints, I can contact the Chair of the University of Canterbury, Educational Research Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (humanethics@canterbury.ac.nz).

By signing below, I agree to participate in this research project.

Name: ____________________________________

Date: ____________________________________

Signature: ____________________________________

Email address: ____________________________________

Appendix F

Discussion before starting conditions about why I have to move away each time:

R: "Every time we do a different activity, I will explain it to you, give you a demonstration, and I will make sure you know what you have to do. I will then press play on the computer and move away. I have to move away so that the computer only records your breathing and voice and not mine."

Script	Notes
Condition 1- Breathing at rest R1: "The first thing we are going to do is just record you breathing when you are doing nothing else. So I just want you to sit there and breathe how you normally would and I will record it. I will show you what I mean." R2: "Are you ready to have a go? R3: "Great, once I start record you just do what we just practised." R4: "One, two, three, go" R5: "Great job."	GENERAL: If there is outside noise or any other external noise then REPEAT condition. Open new file Explain task Record and move away Measure for about 15secs Stop recording Save file date/participant no.

Condition 2- 'Phonation' R1: "For this one, what I want you to do is to take a deep breath in and say the sound | a | sound for as long as you can." R2: "But it has to be comfortable for you; so what I mean is I don't want you to be falling over because you're so out of breath. So when you need to take a breath again, please do." R3: "I will do it to show you what I	GENERAL: If there is outside noise or any other external noise then REPEAT condition. Open new file (3 in 1) Explain task Press record and move away Measure until child has inhaled again Stop recording Save file date/participant no.

mean.” R4: “You will get to do this three times and we can see how long you can do it for.” R5: “Ready to try? Any questions?” R6: “Right, when I press record remember to take a deep breath and then say the |a | sound for as long as you can. And take a breath when you need to.” R7: “Ready to go?” R8: “One, two, three, go.”	
Condition 3- ‘Free Speech’ R1: “In this task you get to tell me ALL about your favourite toy or game or thing to do. I want you to tell me all there is to tell, what it is, what you do with it, where you play it, what colour is it, what does it look like..” R2: “Ok, so what do you want to talk about for this task?” R3: “So when I start recording, you will talk about your favourite ______.” R4: “Ready to go?” R5: “Ready? One, two, three, go.”	GENERAL: If there is outside noise or any other external noise then <u>REPEAT</u> condition. Open new file Explain task Press record and move away Measure for about <u>30secs-1min</u> max Stop recording Save file date/participant no.

Condition 4- 'Alphabet'	GENERAL:
R1: "In this one I just want you to tell me the alphabet." R2: "Do you know the whole alphabet?" R3: (Dependent on response) "Great, are you ready to go? When I press play you can tell me the alphabet." OR "That's ok, do you know some of it? We can record you telling me how much you know of the alphabet" OR "That's ok, we can do something else. Can you count to 25?" R4: "When I press play, you will tell me the alphabet/ count to 25." R5: "Ready? One, two, three, go."	If there is outside noise or any other external noise then <u>REPEAT</u> condition. Open new file Explain task Press record and move away Measure for <u>entire</u> alphabet Stop recording Save file date/participant no. If cannot recite alphabet. Then <u>count to 25</u>. If participant unable to recite whole alphabet= most likely difficulty with reading. Therefore, start on easiest books, and just have to do best.
Condition 5- 'Easy' reading *"The Wind"* R1: "Now you get to read a book. In this task what I want you to do it to read the book out loud, like you would at school." R2: "This book, I just want you to read this page (show page) because it has the whole book on one page." R3: "If you are having trouble with a word… R4: "So you tell me what you are going to do when I press record and move away?" R5: "Ready to go? Any questions?" R6: "One, two, three, go."	GENERAL: If there is outside noise or any other external noise then <u>REPEAT</u> condition. Open new file Explain task Press record and move away Measure reading <u>whole</u> book Stop recording Save file date/participant no. If participant has difficulty with "The Wind". Then this becomes their 'difficult' book. Give them "Going to the beach". If successful with that then "The New Cat" will be their equivalent book.

Condition 6- 'Instructional' reading R1: "Here is another book. Now I want you to read it out loud, just like you did in the previous task." R2: "Have you read this one before?" R3: "Just like in the last book, if you have trouble with a word….Understand?" R4: "Ready? One two three, go."	GENERAL: If there is outside noise or any other external noise then <u>REPEAT</u> condition. *Book based on age of child* Open new file Explain task Press record and move away Measure reading <u>whole</u> book Stop recording Save file date/participant no.
Condition 7- 'Hard' reading R1: "Now for this task, there is another book. It might be a bit harder than what we have been reading today. All I want you to do is try your best; it doesn't matter if you don't know some words or get some wrong. I just want you trying hard." R2: "If a word it too hard, after trying your best, you can skip it." R3: "Ready to go?" R4: "One, two, three, go."	GENERAL: If there is outside noise or any other external noise then <u>REPEAT</u> condition. *Book based on1-3 levels above child's age-equivalent* Open new file Explain task Press record and move away Measure minimum 1min Stop recording Save file date/participant no.

Condition 8- ‘Quiet Breathing’ R1: “Ok so this is the last task before we do something a little bit different. Can you remember what the very first thing that you did was?” R2: “Yeah, so for this one, I just want you to breathe like you normally would. Can you remember what to do or would you like me to show you again? R3: “Are you ready to have a go? R4: “Great, ready? R5: “One, two, three, go” R6: “Great job.”	GENERAL: If there is outside noise or any other external noise then REPEAT condition. Open new file Explain task Press record and move away Measure roughly 15secs Stop recording Save file date/participant no.
PPVT-4 Administration R1: “Now we are going to do something different.” TRAINING PAGE B R2: “Point to or say the number of the picture that shows the meaning of ____”	Child to my left, me on side Training page B To qualify for testing: Child must get at least 2 training items without help If child gets either B1 or B2 incorrect; go to training page A and follow procedures. Once child understands task, can say each stimulus word without further prompts or instruction. Prompting “try one that you think it might be” Basal Set: child makes one or no errors in first item set. Continue to more difficult sets > 1 error on first item set: drop back to previous set; administer all 12 items (1-12 in order). Keep going back sets until Basal is reached. Ceiling Set: after establishing basal, continue testing forward until the highest set of items administered contains ≥ 8 errors= Ceiling Set. When this is reached discontinue testing.

Appendix G

Questionnaire for Participants with Asthma

Beth Wiechern
Contact Telephone: 027 334 0344
Email: bjw96@uclive.ac.nz

Parent Questionnaire

Instructions for completing the questionnaire

On this sheet are questions about your child's name, school, and birth dates, please write your answers in the space provided.

All other questions require you to tick your answer in a box. If you make a mistake put a cross in the box and tick the correct answer. Tick only one option unless otherwise instructed.

Examples of how to mark questionnaires:

To answer Yes/No, put a tick in the appropriate box as per example

TODAY'S DATE:

CHILD'S NAME:

CHILD'S AGE: Age (years and months)

CHILD'S DATE OF BIRTH

GENDER:

Has your child had a cough in the last 4 weeks? Yes

No

Has your child had the flu or a chest infection in the last 4 weeks? Yes

No

Has your child ever had a problem with sneezing

or a runny or blocked nose when he/she Yes

DID NOT have a cold or flu? No

If so, what is the frequency?

Once a fortnight

Once a week

Once a day

More than once a day

Has your child ever had wheezing or Yes

whistling in the chest at any time in the past? No

IF YOU ANSWERED "NO" PLEASE SKIP TO QUESTION 10

Has your child had wheezing or whistling in the chest in the last 6 months?

Yes

No

IF YOU ANSWERED "NO" PLEASE SKIP TO QUESTION 10

Was the wheezing a result of the flu or rhinitis? Yes

No

How many attacks of wheezing has your child had in the last 6 months?

None

1 to 2

3 to 6

More than 6

In the last 6 months, how often, on average, has your child's sleep been disturbed due to wheezing?

Never woken with wheezing

Less than one night per week

One or more nights per week

In the last 6 months, has wheezing ever been severe enough to limit your child's speech to only one or two words at a time between breaths?

Yes
No

In the last 6 months, has your child's chest sounded wheezy during or after exercise?

Yes
No

In the last 6 months, has your child's chest sounded wheezy during or after talking?

Yes
No

Has your child ever had asthma?

Yes
No

IF ANSWERED "NO" FINISH QUESTIONNAIRE HERE

When do you seek treatment for your child with asthma?

Routine check-up

When asthma attack

When unwell

Other:

Please state "other":

In the past 6 months, has your child used any medications, pills, puffers or other medication for wheezing or asthma?

Yes
No

IF YOU HAVE ANSWERED "YES", THEN PLEASE NAME THE MEDICATION(S):

"Western" medicines	How often? *(please circle one or both)*
____________________________	When wheezy / regularly
____________________________	When wheezy / regularly
____________________________	When wheezy / regularly
____________________________	When wheezy / regularly

Regularly means every day for at least 2 months of the year

"Traditional" or "Alternative" therapies

______________________________ When wheezy / regularly

______________________________ When wheezy / regularly

In the past 12 months, has your child used any medicines, pills, puffers or other medication for wheezing or asthma before, during or after exercise?

Yes
No

IF PARENT ANSWERED "YES", THEN PLEASE NAME THE MEDICATION(S):

"Western" medicines How often? *(please circle one or both)*

______________________________ When wheezy / regularly

______________________________ When wheezy / regularly

______________________________ When wheezy / regularly

______________________________ When wheezy / regularly

"Traditional" or "Alternative" therapies

______________________________ When wheezy / regularly

______________________________ When wheezy / regularly

THANK YOU FOR YOUR TIME IN FILLING OUT THIS QUESTIONNAIRE

Appendix H

Adaptation of the Rosier Asthma Functional Severity Scale

ID ☐

			Score
Item 1			
Frequency of wheeze attacks in the last 6 months			
Q. 4-7	None	0 (never)	
	1 to 2	1 (< monthly)	
	3 to 6	2	
	More than 6	3 (weekly)	
	More than 6	4 (daily)	**1.** .....
Item 2			
Frequency of disturbed sleep due to wheeze in the last 6 months			
Q. 8	Never	0	
	Less than 1 night/ fortnight	2	
	1 or more nights per week	4	**2.** .....
Item 3			
Speech affected by wheeze			
Q. 11	Never	0	
	Prior to last 6 months	1	
	Affected in last 6 months	2	
Q. 9	Limited to two words	4	**3.** .....
Item 4			
Wheeze during or following exercise			
Q. 10	Never	0	
	Prior to last 6 months	2	
	Affected in last 6 months	4	**4.** .....

Total score/ 16 . .....

Appendix I

√ = word read correctly
SC= word read correctly after self correction
X = word read incorrectly
Circle = skipped or omitted word
T = told word
___ = write in word substituted

Participant Number ___1

(reading first 150words- can continue after)

Book Name	Text	# C	# E	% C
	Dad had to use the service station telephone because he'd left his mobile phone at Grandma's house. He was always forgetting things! The short cut has been the best news I'd heard all day! Long car trips are so boring. If it hadn't been Grandma's birthday, I would've stayed at home. But she'd have been disappointed if I hadn't gone to her party. Mum had stayed at home, she was expecting a baby in a month's time and everyone said the trip would be too tiring for her. "This must be the turn-off now," Dad said, as he swung the steering wheel to the left. Not long after that, the road turned to dirt. "Why didn't the attendant tell me about this?" Dad grumbled. It was getting darker and it had started raining. I closed my eyes, wishing I could sleep to make the trip seem shorter (pagebreak) (200words).	1?8/200	8/200	95%

(Clay, 2005)
Easy: 95-100% correct

Appendix J

Manual for analysing the breathing signals

Step 1. Identifying expiration and inspiration segments.

Files>Open: the signal recorded as the wave file that is opened will be displayed on a window showing the time waveform in the upper channel and the spectrogram in the lower channel.

On the time waveform window, click on mouse to turn on cursor (click again to turn on the second cursor).

Use the left and right cursors to select the segment to be listened to.

Play>Interval: The cursor-selected segment will be played back via the headphones.

Step 2. Determining the cut-off value for differentiating between expiration and inspiration

View>Spec: a window will pop up showing the spectrum of the signal selected.

In the spectrum window, click on the "pre-emphasis" and "LTA" boxes.

On the time waveform channel, zoom in the time scale using the "down" arrow key (zoom out using the "up" arrow key) while a segment has been cursor-selected.

Move cursors to the beginning and end of a target segment (i.e., the middle portion of the expiration segment or that of the inspiration segment immediately preceding the expiration segment).

Go to the spectrum window to move the cursor, for a few times, below and above the peak around 2 kHz, the target peak will be locked in to generate a reading of the frequency and the amplitude of the selected peak.

Manually enter the readouts of the frequency and amplitude to the spreadsheet

Take the average of the two peak amplitudes derived for the expiration and the inspiration segments and use it as the cut-off value to differentiate between the expiration phase and the inspiration phase.

Step 3. Demarcation of the expiration phase and inspiration phase

In the spectrum window, click off the “LTA” box

On the time waveform channel, move the cursor to the end of the first expiration; find tune the position until it reaches the cut-off value (i.e., the portion associated with a 2 kHz peak amplitude smaller than the cut-off value is consider the inspiration segment and higher than the cut-off value is considered the expiration segment)

Enter the time information (showing in the upper corner on the left hand side) into the Excel spreadsheet

Continue to move the cursor, compare the corresponding spectral peak amplitude with the cut-off value to determine the boundaries between expiration and expiration, and enter the time information into the spreadsheet

Step 4. Calculation of the inspiration-to-expiration time ratio and breathing rate

The Excel spreadsheet was arranged so that the duration of each expiration and inspiration and the inspiration/expiration time ratio were automatically calculated. The breathing rate, defined as the number of breaths/pauses per minute, was also calculated after all time information has been entered.

Appendix K

Children with Asthma: Breathing rate (in number of respiratory cycles per minute) across six tasks for individual participants

Participant (Age)	Quiet Breathing	Recital	Free Speech	Easy Reading	Instructional Reading	Hard Reading
A1 (6.1)	31.33	36.82	12.55	22.06	21.29	17.83
A2 (6.4)	21.58	31.86	12.30	35.36	41.54	27.13
A3 (8.1)	---	35.95	25.63	24.59	24.65	24.33
A4 (8.4)	37.69	35.95	25.86	29.60	27.61	25.30
A5 (6.3)	36.47	23.31	29.72	27.51	16.08	13.80
A6 (7.3)	31.68	24.05	14.08	27.82	23.81	22.19
A7 (8.3)	32.04	33.86	20.29	28.08	30.39	22.70
A8 (8.4)	---	63.07	15.70	26.66	20.00	32.67
A9 (8.4)	25.24	50.46	27.09	29.70	35.41	19.93
A10 (8.7)	26.16	30.05	11.71	22.50	14.81	14.57
A11 (9.1)	22.32	17.63	29.13	27.83	40.30	23.48
Mean (SD)	29.39 (5.85)	31.55 (9.56)	20.39 (7.67)	27.83 (3.96)	27.92 (9.84)	20.77 (4.62)

Note. Participants A1- A4 are girls.

Appendix L

Children with Asthma: Mean[+] (SD) of Pause Time across Six Tasks for Individual Participants

Participant (Age)	Quiet Breathing	Recital	Free Speech	Easy Reading	Instructional Reading	Hard Reading
A1 (6.1)	1491.56 (151.10)	446.94 (120.98)	2555.79 (3160.45)	494.95 (345.84)[a]	560.18 (81.87)[a]	602.79 (454.32)[a]
A2 (6.4)	2086.89 (323.82)	403.71 (118.27)	2765.78 (3029.70)	426.38 (153.52)	431.79 (184.90)	1260.12 (636.02)
A3 (8.1)	---	412.54 (146.84)	567.60 (196.53)	666.45 (395.12)	555.93 (230.66)	553.68 (350.47)
A4 (8.4)	1428.85 (670.51)[a]	319.47 (100.78)	664.66 (479.40)	234.96 (27.56)	298.39 (58.02)	373.38 (71.76)
A5 (6.3)	1160.42 (24.48)[c]	441.49 (116.84)	886.04 (875.31)	1160.46 (969.07)[b]	2571.28 (1837.4)[a]	2733.81 (2670.27)
A6 (7.3)	1464.51 (143.40)[b]	355.15 (99.94)	894.95 (345.18)	364.36 (129.81)	561.54 (274.47)	1198.52 (1175.64)
A7 (8.3)	1449.06 (301.21)	272.32 (102.89)[c]	1145.45 (537.73)	475.45 (252.63)	346.54 (124.51)[a]	623.38 (195.27)[a]
A8 (8.4)	---	305.04 (104.81)	1992.21 (2220.0)[a]	642.07 (308.50)	572.35 (127.90)	436.35 (159.76)
A9 (8.4)	1527.18 (131.28)[a]	489.83 (210.36)	600.24 (175.48)[b]	523.32 (269.87)[a]	428.32 (177.49)[a]	1447.02 (950.13)
A10 (8.7)	1528.30 (118.18)	441.89 (256.70)[a]	1619.30 (2517.47)	385.80 (39.07)[a]	500.41 (266.61)[a]	508.93 (296.81)[a]
A11 (9.1)	2002.11 (272.75)	394.33 (57.57)[b]	534.94 (241.21)	456.66 (162.58)	350.87 (69.05)	572.44 (352.64)
Mean (SD)	1571 (291)	396 (69)	1296 (842)	502 (261)	672 (718)	1036 (743)

[+]*Note.* n=5 unless otherwise indicated: $n^a = 4$; $n^b = 3$; $n^c = 2$
Note. Participants A1- A4 are girls.

Appendix M

Children with Asthma: Mean[+] (SD) of Expiration Time (in ms) across Six Tasks for Individual Participants

Participant (Age)	Quiet Breathing	Recital	Free Speech	Easy Reading	Instructional Reading	Hard Reading
A1 (6.1)	561.85 (263.34)	1182.61 (771.41)	2225.84 (1874.29)	2224.66 (1389.78)	2371.78 (1258.73)	3449.25 (1978.95
A2 (6.4)	821.51 (251.29)	1479.53 (940.99)	2111.27 (1010.47)	1270.42 (587.06)	1155.50 (308.57)	951.52 (346.20)
A3 (8.1)	---	1256.29 (1132.83)	1773.71 (637.90)	1773.13 (555.12)	1877.95 (1230.55)	1912.14 (426.18)
A4 (8.4)	626.48 (251.31)	1349.46 (418.11)	1655.66 (897.64)	1791.80 (817.99)	1874.64 (868.58)	1997.92 (1121.99)
A5 (6.3)	484.95 (97.98)[c]	2132.96 (1242.63)	1132.97 (635.31)	1356.11 (610.53)	1076.43 (1030.02)	1615.12 (581.22)
A6 (7.3)	429.25 (170.79)[b]	2139.51 (1980.23)	3136.41 (1368.22)	1792.54 (1156.85)	1957.97 (600.24)	1504.81 (816.64)
A7 (8.3)	423.31 (75.96)	1499.85 (1265.30)[c]	1811.90 (1229.27)	1661.19 (1314.77)	2495.08 (1992.60)	1896.46 (1458.85)
A8 (8.4)	---	646.23 (208.60)	1830.19 (474.78)[a]	1608.83 (837.61)	2428.16 (1710.66)	1399.94 (245.61)
A9 (8.4)	849.88 (65.88)[a]	699.12 (677.60)	1885.42 (606.04)[b]	1513.34 (769.70)[a]	1230.02 (407.16)	1562.86 (912.01)
A10 (8.7)	765.41 (56.11)	1554.81 (1206.99)[a]	3503.19 (1964.10)	2280.48 (1117.97)[a]	2958.63 (1622.79)	3417.13 (900.79)
A11 (9.1)	668.49 (327.62)	3009.68 (775.55)[b]	2644.43 (1465.73)	1699.32 (1563.76)	1138.04 (662.80)	1983.26 (1694.62)
Mean (SD)	626 (163)	1672 (670)	2234 (746)	1732 (346)	1806 (697)	2042 (851)

[+]*Note.* n=5 unless otherwise indicated: n[a] = 4; n[b] = 3; n[c] = 2
Note. Participants A1- A4 are girls.

Appendix N

Children with Asthma: Mean[+] (SD) of I/E Ratio across Six Tasks for Individual Participants

Participant (Age)	Quiet Breathing	Recital	Free Speech	Easy Reading	Instructional Reading	Hard Reading
A1 (6.1)	3.44 (2.18)	0.47 (0.23)	2.89 (3.70)	0.33 (0.32)	0.61 (0.83)	0.28 (0.29)
A2 (6.4)	2.71 (0.88)	0.33 (0.11)	1.27 (1.37)	0.50 (0.55)	0.41 (0.21)	1.57 (0.97)
A3 (8.1)	---	0.72 (0.95)	0.36 (0.20)	0.35 (0.12)	0.36 (0.13)	0.30 (0.23)
A4 (8.4)	2.53 (1.17)	0.26 (0.12)	0.53 (0.43)	0.18 (0.14)	0.25 (0.26)	0.26 (0.18)
A5 (6.3)	2.45 (0.55)[c]	0.26 (0.13)	1.00 (0.93)	1.56 (1.20)[a]	2.70 (1.09)	1.49 (1.05)
A6 (7.3)	3.91 (1.99)[b]	0.30 (0.19)	0.36 (0.23)	0.55 (0.87)	0.29 (0.14)	0.82 (0.79)
A7 (8.3)	3.46 (0.76)	0.24 (0.13)[c]	0.84 (0.46)	0.61 (0.74)	0.24 (0.13)	0.47 (0.29)
A8 (8.4)	---	0.52 (0.23)	1.21 (1.24)[a]	0.91 (1.40)	0.34 (0.23)	0.31 (0.12)
A9 (8.4)	1.80 (0.19)a	1.29 (1.11)	0.32 (0.01)[b]	0.40 (0.19)[a]	0.35 (0.13)	1.18 (1.04)
A10 (8.7)	2.01 (0.23)	0.49 (0.39)[a]	0.45 (0.46)	0.21 (0.12)[a]	0.14 (0.04)	0.14 (0.06
A11 (9.1)	4.70 (4.86)	0.14 (0.02)[b]	0.24 (0.13)	0.62 (0.66)	0.36 (0.15)	0.92 (0.81)
Mean (SD)	3.00 (0.95)	0.42 (0.35)	0.88 (0.83)	0.55 (0.41)	0.51 (0.63)	0.77 (0.56)

[+]*Note.* n=5 unless otherwise indicated: $n^a = 4$; $n^b = 3$; $n^c = 2$
Note. Participants A1- A4 are girls.

Appendix O

Children without Asthma: Mean (SD) Breathing Rates (in number of respiratory cycles per minute) across Six Tasks for Individual Participants

Participant (Age)	Quiet Breathing	Recital	Free Speech	Easy Reading	Instructional Reading	Hard Reading
N1 (7.2)	23.96	28.50	12.81	19.78	15.39	18.23
N2 (7.2)	---	22.25	20.90	29.55	23.20	30.56
N3 (8.3)	30.11	32.67	29.31	28.24	18.37	35.45
N4 (8.4)	26.67	16.38	26.51	26.35	27.51	28.65
N5 (5.7)	29.92	21.68	28.99	26.53	21.71	23.17
N6 (8.1)	21.43	24.53	18.91	17.32	35.22	22.69
N7 (8.5)	23.48	27.67	39.35	27.98	27.62	23.32
N8 (8.5)	20.89	19.54	19.92	39.19	31.99	24.93
N9 (8.5)	29.93	28.07	39.84	22.79	31.87	36.82
N10 (9.4)	30.74	19.75	26.59	22.14	27.38	25.73
N11 (9.9)	23.87	13.84	33.52	18.19	21.19	29.68
Mean (SD)	26.10 (3.84)	23.26 (6.01)	27.57 (8.71)	24.85 (6.41)	25.82 (6.45)	26.87 (5.84)

Note. Participants N1- N4 are girls

Appendix P

Children without Asthma: Mean[+] (SD) of Pause Time (in ms) across Six Tasks for Individual Participants

Participant (Age)	Quiet Breathing	Recital	Free Speech	Easy Reading	Instructional Reading	Hard Reading
N1 (7.2)	1515.12 (164.71)	348.42 (49.89)	869.98 (338.12)[a]	448.71 (263.09)	667.53 (514.41)	448.22 (154.42)
N2 (7.2)	---	396.24 (153.23)	1046.25 (455.13)	807.39 (519.95)	1111.48 (947.72)	1105.62 (612.01)
N3 (8.3)	1485.71 (192.29)	532.78 (52.00)	551.59 (302.90)	403.33 (185.99)	709.80 (424.94)	368.75 (72.62)
N4 (8.4)	1469.05 (898.17)	559.49 (58.75)[b]	516.76 (137.13)	512.53 (147.33)	722.98 (278.61)	1162.67 (711.78)
N5 (5.7)	1081.38 (118.43)	350.04 (69.69)[b]	499.32 (129.21)	753.32 (441.80)[a]	1395.27 (544.21)	1175.59 (1322.62
N6 (8.1)	2131.33 (114.50)	478.00 (142.48)	552.02 (65.21)	535.15 (143.71)[b]	684.60 (297.99)	560.22 (177.36)
N7 (8.5)	1948.26 (959.00)	1213.72 (1577.57)	514.01 (355.10)	770.32 (508.02)	676.78 (380.80)	628.75 (380.82)
N8 (8.5)	1978.75 (223.70)	283.13 (68.28)[a]	601.98 (328.83)[a]	331.84 (114.74)	400.87 (89.97)	558.91 (221.16)
N9 (8.5)	1458.80 (260.22)	408.66 (127.02)[a]	517.39 (206.09)	569.08 (217.94)	762.47 (315.01)	363.84 (193.51)
N10 (9.4)	1460.54 (405.68)	844.25 (542.35)[a]	427.47 (255.05)	479.45 (234.52)	483.45 (200.04)	561.17 (406.86)
N11 (9.9)	1605.23 (806.62)	364.33 (77.23)	504.88 (283.34)	447.26 (246.13)[a]	496.58 (223.72)	371.30 (123.85)
Mean (SD)	1613 (315)	538 (286)	556 (119)	525 (142)	700 (272)	620 (304)

[+]*Note.* n=5 unless otherwise indicated: $n^a = 4$; $n^b = 3$; $n^c = 2$
Note. Participant N1- N4 are girls.

Appendix Q

Children without Asthma: Mean[+] (SD) of Expiration Time (in ms) across Six Tasks for Individual Participants

Participant (Age)	Quiet Breathing	Recital	Free Speech	Easy Reading	Instructional Reading	Hard Reading
N1 (7.2)	1285.92 (340.35)	1756.50 (1692.91)	3813.84 (2191.94)[a]	2584.59 (1073.34)	3232.27 (1934.72)	2842.89 (1417.66)
N2 (7.2)	---	2299.81 (1112.39)	1824.86 (767.39)	1223.09 (336.29)	1474.78 (686.66)	857.90 (428.69)
N3 (8.3)	507.25 (177.08)	1303.91 (1069.98)	1495.44 (995.98)	1721.64 (624.54)	2557.25 (1259.10)	1323.77 (585.21)
N4 (8.4)	780.44 (27.64)	3102.71 (215.86)[b]	2145.07 (645.37)	1764.54 (1212.95)	1577.65 (872.49)	931.59 (360.58)
N5 (5.7)	844.18 (118.25)	2417.07 (837.84)[a]	1815.64 (1519.70)	1430.95 (490.61)	1368.89 (934.20)	
N6 (8.1)	571.23 (104.36)	1967.53 (1450.45)	3388.74 (735.66)	2928.18 (374.77)[b]	1019.02 (289.47)	2084.55 (1249.57)
N7 (8.5)	607.53 (83.64)	954.73 (508.85)	1010.82 (444.23)	1373.81 (775.05)	1495.23 (518.61)	1944.28 (822.68)
N8 (8.5)	893.02 (252.99)	2787.78 (1595.22)[a]	2410.05 (1982.19)[b]	1199.25 (452.64)	1474.50 (1239.23)	1848.04 (1210.46)
N9 (8.5)	638.41 (290.95)	1729.09 (781.28)[a]	1313.94 (728.74)	2063.24 (809.86)	1120.31 (545.74)	1265.82 (1111.91)
N10 (9.4)	715.22 (143.88)	2194.29 (1315.45)[a]	1977.66 (1842.62)	2230.97 (731.59)	1708.15 (1208.92)	1770.85 (1073.89)
N11 (9.9)	908.66 (264.72)	3969.68 (1466.61)	2608.48 (1822.43)	2851.07 (2101.60)[a]	2335.22 (934.13)	1650.20 (1270.82)
Mean (SD)	775 (226)	2218 (892)	2198 (890)	2015 (621)	1789 (701)	1708 (532)

[+]*Note.* n=5 unless otherwise indicated: $n^a = 4$; $n^b = 3$; $n^c = 2$
Note. Participants N1-N4 are girls.

Appendix R

Children without Asthma: Mean[+] (SD) I/E Ratio across Six Tasks for Individual Participants.

Participant (Age)	Quiet Breathing	Recital	Free Speech	Easy Reading	Instructional Reading	Hard Reading
N1 (7.2)	1.23 (0.28)	0.35 (0.23)	0.65 (0.99)[a]	0.21 (0.15)	0.24 (0.15)	0.19 (0.10)
N2 (7.2)	---	0.20 (0.10)	0.57 (0.08)	0.67 (0.41)	0.81 (0.61)	1.83 (1.47)
N3 (8.3)	3.24 (1.17)	0.91 (0.89)	0.86 (1.13)	0.27 (0.20)	0.36 (0.32)	0.35 (0.23)
N4 (8.4)	1.91 (1.26)	0.18 (0.01)[b]	0.27 (0.17)	0.38 (0.19)	0.63 (0.60)	1.56 (1.25)
N5 (5.7)	1.29 (0.18)	0.16 (0.05)	0.45 (0.33)	0.67 (0.49)[a]	1.63 (1.36)	0.78 (0.38)
N6 (8.1)	3.82 (0.59)	0.29 (0.11)	0.17 (0.05)	0.18 (0.02)[b]	0.69 (0.32)	0.34 (0.20)
N7 (8.5)	3.17 (1.57)	2.00 (3.05)	0.64 (0.68)	0.65 (0.39)	0.45 (0.22)	0.32 (0.10)
N8 (8.5)	2.35 (0.65)	0.14 (0.10)	0.41 (0.37)[b]	0.29 (0.11)	0.46 (0.30)	0.38 (0.15)
N9 (8.5)	2.77 (1.35)	0.26 (0.09)[a]	0.70 (0.71)	0.30 (0.14)	0.75 (0.32)	0.51 (0.42)
N10 (9.4)	2.11 (0.70)	0.52 (0.47)[a]	0.30 (0.17)	0.26 (0.18)	0.51 (0.54)	0.37 (0.23)
N11 (9.9)	1.76 (0.80)	0.11 (0.06)	0.24 (0.13)	0.20 (0.11)[a]	0.27 (0.18)	0.31 (0.19)
Mean (SD)	2.37 (0.87)	0.49 (0.58)	0.47 (0.23)	0.33 (0.15)	0.60 (0.40)	0.51 (0.40)

[+]*Note.* n=5 unless otherwise indicated: $n^a = 4$; $n^b = 3$; $n^c = 2$

Note. Participants N1- N4 are girls.

Appendix S

Direction of individual changes ("+": increase; "-": decrease) of error rate, BR, PT, ET, and IE ratio from 'easy' to 'hard' reading level in girls (A1-A4) and boys (A5-A11) with asthma.

	Maximum error rate (in %)	Error rate difference (in %)	Error rate	BR	PT	ET	IE ratio
A1	25.0	25.0	+	-	+	+	+
A2	33.3	33.3	+	+	+	-	+
A3	3.5	3.5	+	-	-	+	-
A4	5.0	5.0	+	-	+	+	+
A5	100.0	83.3	+	-	+	+	-
A6	2.2	2.2	+	-	+	-	+
A7	10.0	4.1	+	-	+	+	-
A8	6.3	6.3	+	+	-	-	-
A9	6.7	4.5	+	-	+	+	+
A10	0.6	0.6	+	-	+	+	-
A11	6.7	5	+	-	+	+	+

Appendix T

Direction of individual changes ("+": increase; "-": decrease) of error rate, BR, PT, ET, and IE ratio from 'easy' to' hard' reading level in girls (N1-N4) and boys (N5-N11) without asthma.

	Maximum error rate (in %)	Error rate difference (in %)	Error rate	BR	PT	ET	IE ratio
N1	5.0	4.4	+	-	-	+	+
N2	12.5	12.5	+	+	+	-	+
N3	10.0	10.0	+	+	-	-	+
N4	16.7	6.7	+	+	+	-	+
N5	33.3	33.3	+	-	+	-	+
N6	7.7	7.7	+	+	+	-	+
N7	1.1	1.1	+	-	-	+	-
N8	7.1	7.1	+	-	+	+	+
N9	5.6	5.6	+	+	-	-	+
N10	9.1	9.1	+	+	+	-	+
N11	5.9	5.9	+	+	-	-	+

Appendix U

Number of tokens used to derive the Mean and CV values of the PT and IE ratio measures for each task

		PT	I-E ratio
Task	No. of tokens	No. of participants	No. of participants
Breathing ("Quiet breathing")			
	2	3	3
	3	4	4
	4	2	2
	5	7	9
	>5	2	
Talking ("Free speech")			
	2		
	3	1	1
	4	4	4
	5	17	17
Alphabet ("Recital")			
	2		
	3	2	2
	4	6	6
	5	14	14
Easy ("Easy reading")			
	2		
	3	1	1
	4	1	1
	5	20	20
Instructional ("Instructional reading")			
	2		
	3		
	4		
	5	22	22
Hard ("Hard Reading")			
	2		
	3		
	4		
	5	22	22