The Effects of Chronic Aircraft Noise Exposure on Children’s Cognitive Performance and Stress Responses

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Abstract

The three studies in this thesis examine the effects of chronic exposure to aircraft noise on primary aged school children's cognition, motivation and health. The main aim of this thesis was to test whether the cognitive effects previously found in children are attributable to noise exposure and to test possible mechanisms. The major study (Studies 1 & 2) in the thesis is a repeated measures field study in which the cognitive performance and stress responses of children attending four schools exposed to high levels of aircraft noise (>66 dBA 16hr outdoor Leq) were compared with children attending four matched control schools exposed to lower levels of aircraft noise (<57 dBA 16hr outdoor Leq) around Heathrow Airport in West London. Measures included: reading comprehension, sustained attention, motivation, long and short term memory, noise annoyance, self reported stress, depression, anxiety and attributional style. Follow-up measures were taken after a period of one year. The results of the repeated measures study indicate that chronic exposure to aircraft noise was significantly associated with: a) impaired reading comprehension; b) impaired sustained attention; c) higher noise annoyance and d) raised self-reported stress adjusting for age, deprivation and main language spoken at home. Contrary to previous findings, chronic exposure to aircraft noise did not affect long term memory and motivation. These results do not support the hypotheses that either sustained attention or learned helplessness mediate the effects of noise on cognition in children. Within subjects analyses indicate that children's development in reading comprehension may be adversely affected by chronic aircraft noise exposure. Noise annoyance remains constant over a year with no strong evidence of adaptation. The final study in this thesis (Study 3) is a multi-level modelling study in which the National Standardised Scores (SATs study) for Key Stage 2 in Mathematics, Science and English were analysed in relation to aircraft noise exposure around Heathrow Airport for 11,000 scores of children aged 11. These results of the SATs study suggest that chronic exposure to aircraft noise is associated with school performance in reading and mathematics in a dose-response function after adjustment for school effects, but that this association is influenced by socio-economic factors. Taking all these results together it has been concluded that chronic aircraft noise exposure is a likely contributing factor that leads to impaired cognition and raised stress responses in children. The complex interrelationship between child performance and health, environmental stressors such as noise exposure and socio-economic status needs to be theoretically considered and empirically examined in the future.
Summary

Background

Studies around Los Angeles (Cohen et al., 1980, 1981, 1986) and Munich Airports (Evans et al., 1995, 1998) suggest that children are vulnerable to the effects of aircraft noise on cognitive performance, motivation, annoyance, blood pressure and the endocrine system. Unanswered questions remain about the nature and cause of these noise effects. The priority for the next stage of research is to confirm and clarify previous findings by further research. It is also critical to understand the mechanisms underlying the adverse health effects associated with chronic exposure to aircraft noise by testing and developing theories.

The three studies in this thesis address the limitations of previous research and also extend previous research. The studies tested more reliably than previous studies whether chronic aircraft noise affects child health by taking into account UK-specific social and educational factors which influence children’s education. For the first time in this field, multi-level modelling statistical techniques were conducted which enabled the results to be adjusted for the potential confounding effects of school characteristics on associations between noise and performance. To clarify the nature of the noise effect, a wider range of child stress and mental health outcomes were measured. To further elucidate mechanisms of noise effects, sustained attention and attributional style were tested as mechanisms to account for noise effects.

Aims

The studies in this thesis aim to examine the effect of chronic exposure to aircraft noise on primary aged school children’s cognition, motivation and health. The main objective of this thesis is to test whether the cognitive effects previously found in children are attributable to noise and to test possible mechanisms. The 5 specific aims are:

1) To test whether chronic high levels of aircraft noise exposure in children are associated with a) cognitive impairments (in reading, memory, sustained attention, and school performance); b) deficits in motivation c) noise annoyance after adjustment for potential confounding factors (social deprivation, main language spoken at home, age and school effectiveness).

2) To test sustained attention as a mechanism to account for the effect of noise on cognition.
3) To examine how children adapt to aircraft noise over a one year period.

4) To assess whether there is any evidence that chronic noise exposure affects other health outcomes apart from noise annoyance: a) child stress responses (self-reported stress) and sub-clinical mental health (anxiety, depression, deviant behaviour) and b) whether these psychological factors mediate the association between noise exposure and cognitive impairment and noise annoyance.

5) To test whether environmental factors (length of time exposed to aircraft noise at school and home noise exposure) influence the relationship between aircraft noise and impairment of child health.

Studies 1 & 2 Repeated Measures Study: Baseline and Follow-up

The major study (Studies 1 & 2) in the thesis is a repeated measures field study in which the cognitive performance and stress responses of children attending four schools exposed to high levels of aircraft noise (>66 dBA 16hr outdoor Leq) were compared with children attending four matched control schools exposed to lower levels of aircraft noise (<57 dBA 16hr outdoor Leq) around Heathrow Airport in West London. The high noise exposed schools were matched with the control schools for age of the children, other sources of environmental noise, school sound insulation and the socio-economic groups and ethnic composition of the population, at the level of the school's electoral wardgroup. It was hypothesised that chronic aircraft noise exposure would be associated with cognitive impairments (reading comprehension and long-term memory), motivation and stress responses (noise annoyance, self-rated stress, depression and anxiety) in school children. No effects were expected on simple memory tasks and short-term memory. Group administered testing was carried out in the classrooms. Noise measurements were conducted in the schools at the time of testing to assess acute noise exposure.

The overall child response rate was 77% at baseline and 81% of these at follow-up. The sample was well matched across noise levels for age, sex and socio-economic status variables. It was less matched on main language spoken at home, ethnic group and deprivation. The results of the repeated measures study suggest that chronic exposure to aircraft noise was significantly associated with: a) impaired reading comprehension; b) impaired sustained attention; c) higher noise annoyance and d) raised self-reported stress adjusting for age, deprivation and main language spoken at home. Contrary to previous findings, chronic exposure to aircraft noise did not affect long term memory.
and motivation. These results do not support the hypotheses that either sustained attention or learned helplessness mediate the effects of noise on cognition in children. Within subjects analyses indicate that children's development in reading comprehension may be adversely affected by chronic aircraft noise exposure. Noise annoyance remains constant over a year with no strong evidence of adaptation.

**Study 3 - SATs Study**

The results from the repeated measures study (Studies 1 & 2) suggest that aircraft noise exposure affects reading comprehension, but this relationship may be confounded by social class and school quality and also raises two further questions. Firstly, does aircraft noise exposure affect school performance uniformly or are impairments more likely to be found in language-based tasks? Secondly, are cognitive noise effects dose-response or threshold effects? In the SATs study it was hypothesised that chronic aircraft noise exposure would be associated with poorer performance in English and Reading in a dose-response function. No effects were expected on the control outcomes of Mathematics and Science.

The SATs study was designed as a multi-level modelling study in which the National Standardised Scores (SATs study) for Key Stage 2 in Mathematics, Science and English were analysed in relation to aircraft noise exposure around Heathrow Airport for 11,000 scores of children aged 11 from 128 schools. The multi-level analyses involved a cross-sectional comparison between noise exposure and performance in a sample of students using the 1996 and 1997 SATs results. The analyses were at both the school and individual level, controlling for socio-economic, environmental and school quality factors. These results of the SATs study suggest that chronic exposure to aircraft noise is associated with school performance in reading and mathematics in a dose-response function after adjustment for school effects, but that this association is influenced by socio-economic factors. These results suggest that it is still an open issue as to whether chronic aircraft noise exposure effects language-based tasks exclusively because aircraft noise had the strongest effect on mathematical performance.
Conclusions

To conclude, the central question of this thesis concerns the extent to which the cognitive and stress effects associated with noise are indeed attributable to noise. Considering the results of the three studies, the data do suggest that chronic aircraft noise exposure is a likely contributing factor that leads to impaired cognition and raised stress responses in children. Considering the strengths and limitations of the research, the following five specific conclusions have been drawn from the studies in this thesis:

1) High levels of chronic aircraft noise exposure in children were associated with cognitive impairments in reading comprehension and sustained attention.

2) Sustained attention did not act as a mediating factor to account for the association between noise exposure and impaired reading comprehension.

3) High levels of chronic noise exposure were associated with raised noise annoyance and perceived stress.

4) It is possible that these cognitive effects and stress responses do not lessen with continued exposure to high level of aircraft noise.

5) It needs to be clarified that these cognitive and stress effects found in children were not partly influenced by school level factors, main language spoken at home, or household deprivation.
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CHAPTER 1

Introduction to the Thesis and Literature Review
1.1 General introduction to non-auditory health effects of noise

Despite increased regulation of noise emissions, chronic high levels of noise are increasing in modern society. It is, therefore, important that more is known about the psychological and physical health effects, stress appraisals, stress reactions and coping responses of humans to noise exposure. The broad objectives of this thesis are to determine whether noise effects previously found in children are attributable to noise and to test possible causal mechanisms. The three studies in this thesis examine the effects of chronic aircraft noise exposure on primary aged school children’s cognition, motivation and health.

1.1.1 Definition and measurement of noise

Noise is generally defined as unwanted sound (Evans & Cohen, 1987). The physical property of ‘sound’ is necessary but not sufficient to produce noise. Thus, the concept of noise involves both a significant psychological component (‘unwanted’) as well as a physical component (sound must be perceived by the ear and then transmitted by the auditory nerve to the temporal lobe in the brain) (Bell et al., 1996). Noise is a disturbing environmental phenomenon precisely because it is an unwanted component of the environment. Recurrent ambient environmental stressors such as noise, which are frequently part of the ‘background’, may actually be more harmful for human health because they are more likely to cause long-term reactions than a one-off environmental event (Bell et al., 1996).

The measurement of sound is based on its physical components. Physically, perceived sound is created by rapidly changing air pressure at the eardrum. The description of noise or sound is typically characterised by intensity (e.g. dBA), frequency (e.g. pitch), periodicity (continuous or intermittent) and duration (acute or chronic). Other characteristics, which are not related to the physical components of sound, are also important in determining the interpretation of perceived sound. These include: the predictability of noise bursts (random or fixed interval); attitudes to the noise source; and degree of personal control over noise. In general, it has been concluded that intermittent, higher frequency, short-duration, intense sounds have greater effects on
health than do continuous, low-frequency, long-duration, low-intensity sounds (Baker & Holding, 1993). Berglund and Lindvall (1995) recommend the World Health Organisation guideline that the sound pressure level from steady, continuous noise in outdoor areas should not exceed 55 dB LAeq to protect the majority of people from being seriously annoyed during the daytime.

Chronic exposure to aircraft noise, rather than the less intrusive rail or road traffic noise, has been most studied for its effects on children. This is expected as aircraft noise in the vicinity of airports is more intense, more unpredictable and more difficult to mask than road or rail traffic. Hygge (1994) in an experimental study examining the differential effects of aircraft, road traffic, train noise and irrelevant speech on child performance found that aircraft noise had more effect on long-term learning than road traffic noise, which in turn had more effect than train noise.

1.1.2 General models of environmental stress

The studies in this thesis can be placed broadly within the environmental stress theoretical framework because noise exposure is considered to be an environmental stressor. An environmental stressor is an environmental condition that the average person would perceive as actually or potentially threatening, damaging, harmful, or depriving (Lepore & Evans, 1996). Stress in this context is used as a relational concept signifying an imbalance between environmental demands, individual and social resources to cope with those demands, and the individual’s appraisal of that relationship.

Although environmental stressors normally occur in multiples, very little is known about the adaptive consequences of coping with more than one stressor (Evans et al., 1996; Lepore & Evans, 1996). While acknowledging that the issue of multiple stressors is important, the research in this thesis is narrowly focused on effects of a specific environmental stressor, namely aircraft noise. At this stage, it is important to fully understand the effect of one environmental stressor on a particular population before examining multiple effects. Taking aircraft noise at school as the environmental stressor and school aged children as the sample, environmental stress models may be useful in providing an explanation for noise effects on child health. Evans & Cohen (1987) present two broad theoretical perspectives on stress: physiological and
psychological. These two perspectives will be briefly introduced below and the specific mechanisms developed from these models will be explained in detail in the following ‘cognition’ and ‘motivation’ sections. These models and mechanisms will be evaluated in the light of their theoretical plausibility and empirical evidence.

1.1.3 Physiological perspective

The first is the physiological perspective, which hypothesises that the link between environmental stressors and health is mediated by either the sympathetic nervous system or the pituitary-adrenocortical axis. Exposure to an environmental stressor disrupts internal equilibrium, causing both these complementary physiological responses of the body to be activated in order to achieve homeostatic balance. The sympathetic nervous system acts directly on the adrenal medulla to secrete the catecholamines (see Figure 1 below). Increased levels of catecholamines have direct links to cardiovascular diseases causing fibrin formation in arterial walls, platelet aggregation and hemodynamic effects like increased blood pressure.

![Figure 1 - Physiological models of environmental stress](image)

The second physiological model suggesting that the effects of environmental stress are mediated by the pituitary-adrenocortical axis is based on a process called the general adaptation syndrome (Selye; 1956, 1975, see Figure 2 below). In response to environmental stress the organism progresses through three stages: alarm, resistance and exhaustion. During the alarm phase the pituitary gland, under the control of the hypothalamus, secretes adrenocorticotropic hormone (ACTH) which stimulates the adrenal cortex to produce cortiosteroids. During the resistance phase the corticosteroids set up a feed-back loop stimulating the adrenal medulla, which is one pathway by which catecholamines are released. However, it is also possible that catecholamines may be released directly through the nervous system. See Evans & Cohen (1987) for a full discussion of the problems with these physiological theories.
Physiological arousal (e.g. raised blood pressure and catecholamine secretion) has been cited as empirical support for a general arousal mechanism to account for not only the physiological, but also the psychological responses to environmental stress. Arousal is one mechanism that can provide a link to explain the pattern of psychophysiological and cognitive and motivational functions affected by environmental stress (arousal and psychophysiology will be addressed again in further detail in relation to noise effects on health).

### 1.1.4 Psychological perspective

The second broad theoretical perspective advanced to account for the effect of environmental stress is psychological. Apart from the physiological effects of environmental stressors, individuals are psychologically affected by chronic exposure to environmental stress. It is sometimes difficult to distinguish between the physiological and psychological effects, especially in the case of physiological stress symptoms, which may be the underlying cause of the psychological stress. These psychological effects may be manifest as self-reports of stress and related symptoms (e.g. nervousness, tension, headaches, anxiety, depression, sleep disturbance), negative interpersonal behaviours and deficits in task performance (Hygge et al., 1998; Smith & Jones, 1992). From the psychological perspective there are many models of environmental stressors, but four major theoretical constructs have been adapted to explain the effects of environmental stressors on human performance and health (Cohen et al., 1986 & Evans & Cohen, 1987; see Figure 3).
Firstly, the *information overload model* proposes that environmental stressors produce an overload of physical stimulation in an individual’s environment which produces stress. Secondly, increased *arousal* has been suggested as an intervening process between the stressor and human responses. According to arousal theory, environmental stressors change arousal level, which either raises or lowers activity level and that, in turn, influences task performance (Cohen et al., 1986). The arousing properties of noise and its effects on performance have been linked for the first time to neurotransmitter function (Smith, 1998). The effect of arousal on human performance and health depends two factors: a) the individual’s baseline level of arousal and b) the level of performance task demands. During over-arousal, the individual may cope with the environmental stress by cognitive processing strategies, so that they can focus on the most important cues available in the situation.

*Cognitive coping strategies* is the third psychological theory to explain the effects of environmental stressors on human performance (Cohen et al., 1986; Evans & Lepore, 1993). According to this theory, task performance is affected by an environmental stressor to the extent that cognitive coping strategies are required for task completion. An individual’s efforts to alter cognitive strategies to cope with environmental stress can have physiological and motivational consequences. If these strategies become
habitual, then efforts to complete tasks under chronic environmental stress may cause long-term physiological and cognitive effects. This perspective differs from the information overload and arousal models in several respects (Cohen et al., 1986). It assumes that the stressor directly effects cognitive coping strategies, shifting the emphasis from decrements in human performance to changes in cognitive functioning. This theory does not claim that a single mechanism completely explains the changes in cognition under stress. The most important distinguishing feature of this theory is that it generates testable predictions for the effects of noises on psychological functioning (these will be outlined in the section 'cognitive mechanisms' in this chapter).

Fourth, loss of control can be viewed as a mechanism to explain some of the detrimental consequences of environmental stressors, especially motivational effects (Cohen et al., 1986). Research consistently shows that environmental stressors that are uncontrollable or unpredictable cause greater stress in human beings (Evans & Cohen, 1987; Glass & Singer, 1972). Generally, the research on control and environmental stress has found that stress is reduced when behavioural control is provided, and this amelioration of negative impacts has also been found in relation to noise (Cohen & Weinstein, 1982). Thus control may function as a powerful situational mediator of the stress process. Chronic exposure to uncontrollable ambient stressors, such as noise, decreases expectancies for control and increases susceptibility to helplessness (Lepore & Evans, 1996). This is because if an individual can not predict or assert control over an environmental source of stress, then they may learn that they have little ability to influence environmental outcomes, which is, in effect, learned helplessness (this will be further outlined in the motivation section in this chapter).

To summarise, theory about the relationship between environmental stressors and human performance and health is limited, and there is even less focused specifically on noise. This thesis focuses selectively on understanding the cognitive, motivational and psychological consequences of stress in children. The two classic psychological models of information overload and arousal are not entirely relevant because they do not adequately predict what kinds of psychological deficits are likely to be produced by exposure to environmental stress. Therefore, the main theoretical focus will be on cognitive coping strategies because it is the most recently developed and refined model used to account for cognitive effects of noise exposure in children, and because it provides testable predictions for main effects and mechanisms. The loss of control
model will be applied to the motivational noise effects. The way these general models of environmental stress have been applied to account for the effects of noise on cognition and motivation will be outlined in the following mechanisms sections. (For a more detailed overview of the stress paradigm and general theoretical perspectives on stress see Cohen et al., 1986; Evans & Cohen, 1987.)

1.1.5 Noise and adult health: a general introduction to the empirical evidence for child noise effects

The issue of whether environmental noise, particularly aircraft noise, affects health has been extensively researched in adults but not in children. The pattern of non-auditory health effects of noise found in children broadly mirrors those found in adults. The research and theory into the effects of noise exposure on child health were modelled upon the adult research. It has long been recognised that, as well as having detrimental effects on hearing, noise may be the cause of more subtle non-auditory health effects in adults. Non-auditory effects of noise refer to impacts not directly related to sound-induced damage to the auditory system. Noise may also be the cause of more subtle non-auditory health effects in children such as: impaired cardiovascular functioning, lower motivation, deficits in reading, memory, attention and school performance. It has already been established that there is a clear dose-response function such that: as sound levels increase so do the extent of auditory impairments in children and adults (see Kryter, 1985; and Mills, 1975 for a review of auditory health effects). The focus of this review and subsequent studies will be on the less established and more subtle non-auditory health effects of noise exposure.

There is evidence that noise exposure impairs adult cognitive performance. Laboratory studies on adults and children have generally shown that continuous noise (a laboratory analog of chronic environmental noise) affects the following tasks: continuous self-paced tasks (noise increases momentary inefficiency); vigilance tasks (noise reduces sustained attention); multiple tasks (noise leads to improved performance on the dominant component at the expense of other features); and irrelevant speech (performance is impaired while a subject learns and remembers verbal materials). Initially researchers found that the size of the noise effects were small and were not found across a range of cognitive tasks so they had to focus on specific tasks, the nature of the noise and personality differences in order to understand the relationship between
noise exposure and cognitive performance. Smith & Broadbent (1992) argued that the
effects of noise are complicated and are still only partially known, influenced by many
different factors such as the type of noise and the task being performed. In general,
cognitive noise effects have been attributed to increased arousal and decreased attention
through distraction and decreased focusing on stimuli peripheral to the task, as well as
through altering choice of task strategy (Stansfeld & Haines, 1997). The cognitive
noise effects previously found in children are assumed to be of the same nature and to
be caused by the same mechanisms as in adults, but this has not been proven. (For a
detailed review of the adult literature see Smith & Jones, 1992, which was updated by
Hygge et al., 1998).

The annoyance reaction to noise can be considered as ill-health within the World Health
Organisation definition of health that “health is a state of complete physical, mental and
social well-being, and not merely the absence of disease or infirmity” (1946). It has
been well established in adults that aircraft noise is related to annoyance (Schultz,
1978; Job, 1988; Fields, 1992; Berglund & Lindvall, 1995). There is, however, very
little child research, but the results are consistent with the adult findings (Evans et al.,
1995). Noise annoyance involves mild anger and fear, related to a belief that one is
being harmed in a way that could be avoided (Cohen & Weinstein, 1981). Annoyance is
not solely related to loudness itself; acoustic (intensity) and non-acoustic factors predict
whether a person experiences noise annoyance (Green & Fidell, 1991). Important non-
acoustic predictors of annoyance are noise sensitivity, fear of the noise source and
attitudes to the noise source. The annoyance response is the most precisely documented
and widespread finding in the adult literature in relation to environmental noise. There
is a clear dose-response relationship such that increasing sound pressure level is
associated with increasing annoyance response (McKennell, 1963; Griffiths & Langdon,
1968; OPCS, 1971; Schultz, 1978). This has also been demonstrated in several adult
studies around Heathrow Airport (McKennell, 1963; OPCS, 1971; Tarnopolsky &
Morton-Williams, 1980). It is of public health importance to establish whether the
distress caused by noise, in turn, affects other aspects of health. If noise exposure
affects the well-being of people, it is possible that it may also result in other physical
and mental health consequences (Lercher, 1996a). Is there evidence that aircraft noise
impairs mental or physical health?
Environmental noise has not been demonstrated to cause major mental illness in adults. There has not been any well-designed research into mental health effects of noise in children. Community studies of aircraft noise exposure have not consistently shown an association between noise and mental health (Tarnopolsky & Morton-Williams, 1980; Stansfeld et al., 1993; Stansfeld et al., 1998). Nevertheless, there continue to be studies which suggest that environmental noise exposure does have mental health effects beyond the demonstration of emotional responses to noise such as noise annoyance (Halpem, 1995, Lercher, 1996b, Stansfeld et al., 1996). There is some suggestion that there may be more mental hospital admissions (Kryter, 1990) and higher consumption of tranquilizer and hypnotic medication (Knipschild & Oudershoom, 1977; Lercher, 1996) in areas exposed to high levels of aircraft noise. Road traffic noise studies have shown mixed results with no associations with overall psychiatric disorder in the Caerphilly study but a small association between noise and anxiety levels (Stansfeld et al., 1996). However, it may be that there are certain groups of the population who may be more vulnerable to the mental health effects of aircraft noise (Stansfeld et al., 1985; Stansfeld, 1992). One reason why the adult mental health effects are slight and equivocal is because sub-clinical effects in anxiety and depression, health functioning, quality of life and self-reported stress may be more likely to be the result of noise exposure than clinical illness.

Noise may be responsible for individual symptoms, such as headaches, tension and subjective sleep disturbance (Bullen et al., 1991; Job et al., 1991a) in adults, but there is no evidence of this in children. These individual symptoms such as headaches, irritability, restless nights, and being tense and edgy, have been related to high levels of aircraft noise in adults in surveys conducted around Munich and Osaka airports (OPCS, 1971; Kokokusha, 1973; Finke et al., 1974; Ohrstrom, 1989). Well-being has been shown to be reduced in areas exposed to road traffic noise, but the results have not been found consistently and may be mediated by the effect noise has on sleep (Ohrstrom, 1989; Ohrstrom, 1993). There is both objective and subjective evidence for sleep disturbance by noise (Ohrstrom, 1982; Ohrstrom & Bjorkman, 1988; Lambert & Vallet, 1994). Although not all community studies confirm that chronic exposure to noise has much effect on sleep (Horne et al., 1994). Noise exposure during sleep may affect sleep onset and latency, awakening during the night, premature awakening in the morning, subjective sleep quality and have after-effects such as mood effects the next day. Although some noise effects on sleep may habituate over time (Vallet & Francois,
small sleep deficits may persist for years (Globus et al., 1973), with unknown effects on health.

Noise exposure causes a number of predictable acute physiological responses in the cardiovascular and endocrine systems possibly mediated through the autonomic nervous system (Stansfeld & Haines, 1997). There is evidence to suggest that chronic aircraft noise exposure leads to heightened activation of the cardiovascular system and may be related to high blood pressure in adults (Thompson, 1983; Thompson, 1996) and children (Cohen et al., 1980; Evans et al., 1995). The strongest evidence for the effect of noise on the cardiovascular system comes from studies of blood pressure in occupational settings (Thompson, 1996). The results of human environmental noise studies have not been consistent (Ising, 1983, Stansfeld & Haines, 1997). It may be that some groups are more vulnerable to raised blood pressure in noisy conditions, especially those with a predisposition to hypertension. This issue may be of clinical significance in that raised blood pressure and heart rate may be the result of noise exposure and/or indicators of increased predisposition to coronary heart disease.

The general pattern of endocrine responses to noise is consistent with noise exciting acute physiological responses, in the same way as other acute stressors. The most convincing physiological evidence relating noise and increased hormone secretion concerns noradrenaline and adrenaline levels, but this research is still at a preliminary stage. Laboratory studies have shown that acute noise elevates stress-related hormones in adults (Evans & Cohen, 1987). Field research has confirmed these results in relation to noradrenaline and adrenaline levels in adults (Cavatorta et al., 1987, Sudo et al., 1996) and children (Evans et al., 1995), although the results have not been completely consistent (Follenius et al., 1980). Some studies have found preliminary evidence that there is a significant rise in cortisol in relation to noise (Brandenberger et al., 1980; Follenius et al., 1980).

In summary, some noise effects are robust even though a number of uncertainties remain about the non-auditory effects of noise on adults and children. (For a fuller review of general noise health effects see Stansfeld & Haines, 1997.) The evidence for the effects of environmental noise on adult health is strongest for annoyance, sleep disturbance, ischaemic heart disease and cognitive performance. The child research is very limited, but the existing evidence is strongest for noise effects on cognitive
performance, motivation and blood pressure (these effects will be reviewed in detail in following sections). There are still some aspects of health and performance where noise effects need to be confirmed and most where noise effects need to be clarified. The next step should be to understand the mechanisms underlying the health impairments associated with chronic exposure to noise pollution.

The adult research introduces the broad themes and limitations of noise research. The aversiveness of noise depends on intensity, tonality, impulsiveness, predictability, attitude to noise and perceived control among other things. Whether noise influences performance depends on the type of noise, the complexity of the task and individual factors such as personality and adaptation level. The long-term health consequences of noise effects are as yet unknown. There is evidence that different groups within the population may differ in their susceptibility to the effects of noise. These vulnerable groups include the elderly, those with existing physical and mental illness and children. Children may be more susceptible to environmental stress than adults for a variety of reasons including, less cognitive capacity to understand environmental issues and anticipate stressors and a lack of well-developed coping repertoires (Cohen et al., 1986). Growing children are known to be particularly vulnerable to the adverse effects of other environmental pollutants apart from noise (Evans et al., 1991). Impairments of early childhood development and education by environmental pollutants such as noise, may have life-long effects on the achievement of academic potential and health (Evans et al., 1991). The potential importance of these effects on children’s education and health, coupled with the unanswered questions provoked by the limited available research, led to child noise effects being the subject of this thesis.

1.1.6 Aim and structure of the literature review

This literature review will selectively focus on the effects of noise on three aspects of child health and performance. Section 2 will contain a review the effects of noise on child cognitive performance. Section 3 will contain a review of the effects of noise on child motivation. Section 4 will contain a review of the effects of noise on child mental and physical health. Within each of these sections the empirical research evidence will be presented with an emphasis on field studies, followed by a critical account of possible mechanism and the research rationale of the present studies. Thus within each section there will be three sub-sections: a) the research evidence, b) possible
mechanisms to account for these noise effects, and c) research rationale. This method of analysing the previous research will lead directly to the reasoning for the aims, design and hypotheses to be tested in the studies in this thesis. Section 5 will be a methodological critique of common methodological problems in the studies reviewed and a discussion of factors which influence the size of the noise effects. The final section 6 will outline the specific research aims and a summary of the three studies in this thesis in terms of design and hypotheses tested.
1.2 The effect of noise on child cognitive performance

The most consistent effects of noise found in children are cognitive impairments, though these effects are not uniform across all cognitive tasks (Cohen et al., 1986; Evans et al., 1991; Evans & Lepore, 1993). Tasks which involve central processing and language comprehension, such as reading, attention, problem solving and memory appear to be most affected by exposure to noise (Cohen et al., 1986; Evans et al., 1995; Evans & Lepore, 1993; Hygge, 1994). In addition to noise, other sources of environmental stress such as: crowding (Evans et al., 1991; Rodin, 1977); air pollution (Bobak & Leon, 1992; Evans et al., 1991); rundown housing; and slums (Agenda 21, United Nations) have also been associated with cognitive impairments in school children. This effect of environmental stress on cognitive tasks with high processing demands is widely accepted in the environmental stress literature examining the general sources of environmental stress on cognition (Cohen et al., 1986; Smith, 1989).

In pre-school children Wachs & Gruen (1982) have accumulated data across cross-sectional and longitudinal studies indicating a negative association between home noise levels and cognitive development in children from 6 months to 5 years of age. Measures of cognitive development affected by noise include mental representations of objects, the use of objects as tools to achieve goals, and relating words to objects (see Evans and Lepore’s 1993 review of cognitive results in this age group). This review will mainly concentrate on the effects of chronic noise exposure on the health and performance of primary school children (aged 5 to 12 years) because this is a critical learning acquisition period for children in which future learning patterns are established and this is the same age range of children in the studies in this thesis.

1.2.1 The research evidence

Structure of the literature review

The literature review of child cognitive noise effects is ordered into two sections namely: 2.1.1 Earlier research and summary of effects found across cognitive functions and 2.1.2 In depth review of the main field studies. The literature review is organised in this structure because the cognitive effects of noise exposure on children is reasonably
extensive, which meant that a selective focus was required. The first section will introduce the main results found in both laboratory and field studies concentrating on a wide range of cognitive functions of which some were measured in the studies in this thesis. The cognitive functions reviewed are: auditory discrimination, auditory distraction, reading and school performance, memory and attention (the last three were measured in this thesis). Following on from this introductory section, the reasons for well-controlled field studies will be apparent. Taking a historical perspective, the second section will focus selectively on the main field studies (Bronzaft & McCarthy, 1975; Bronzaft, 1981; Cohen et al., 1973; Cohen et al., 1980, 1981; Evans et al., 1995, 1998; Evans & Maxwell, 1997). The emphasis of this review is placed on the results and methodology of the field studies because the main study in this thesis was modelled on these previous studies around Los Angeles, New York and Munich airports.

1.2.1.1 Earlier research and summary of effects found across cognitive functions

Auditory discrimination
Deutsch (1964) hypothesised that auditory discrimination mediated cognitive noise effects on the basis of preliminary correlational data. Auditory discrimination tasks, measured under quiet conditions, evaluate the child’s ability to distinguish between similar sounding words (e.g. boat-goat). There is evidence from other studies to support the first component of Deutsch’s model, namely, that there is a main effect of noise exposure impairing auditory discrimination. Experimental studies indicate that children have difficulty with auditory discrimination during acute noise exposure (Blue & Vergason, 1975; Glenn et al., 1978; Laraway, 1985; Nober & Nober, 1975). So it would seem that noise can directly interfere with children’s ability to discriminate between auditory stimuli. This is particularly relevant when it interferes with comprehension of spoken language (Glenn et al., 1978; Laraway, 1985; Lasky & Tobin, 1973). Cohen and colleagues (1973) and Moch-Sibony (1984) in field studies, that were well controlled for socio-economic status and pre-screened children for hearing loss, found an association between chronic noise exposure and auditory discrimination. (The important distinction between acute and chronic noise effects will be discussed in further detail in the methodological section of this chapter). However, two subsequent field studies (Cohen et al., 1980; 1986) were unable to replicate these findings. Evans & Lepore (1993) argue that this may be due to the fact that these field studies used a
different source of noise (aircraft as opposed to road traffic), and the children in the Los Angeles Airport Study (Cohen et al., 1980, 1981, 1986) came from a more poverty stricken area than did those in the other studies. Nonetheless, this main effect of noise on auditory discrimination needs to be confirmed by further field research. The role of auditory discrimination in the mediation of cognitive noise effects will be discussed further in the mechanisms section. Deutsch’s hypothesis that auditory discrimination mediates cognitive noise effects raises another question (Evans & Lepore, 1993). If children are unable to discriminate between words and sounds, is it because they have become so adept at filtering out noise that they become resistant to its distracting properties?

**Auditory distraction**

Studies measuring the extent to which auditory distraction interferes with task performance attempt to answer whether children become so adept at filtering out noise, that they become resistant to its distracting properties. Noise may interfere with the detection of auditory signals, an effect known as masking or distraction.

In studies, the auditory distractor can take the form of speech interference or white noise and the task can be any cognitive performance measure (Cohen et al., 1980, 1981).

Another way of measuring auditory distraction is to measure signal to noise ratio, by asking the child to adjust a story’s volume to their personal comfortable listening whilst manipulating background noise level (Evans et al., 1995). The underlying assumption is that if noise-exposed children are more resistant to acute auditory distractors, then the resistance may be due to the fact that they have an enhanced ability to tune out auditory stimuli.

Evans & Lepore (1993) claim that there is evidence to suggest that chronic noise exposure produces differential resistance to noise distractors (Cohen et al., 1980; Cohen et al., 1986; Hambrick-Dixon, 1986; Heft, 1979). The data from the field research around Los Angeles airport are complex and generally show that children chronically exposed to noise are less distracted by auditory stimuli during a task, but after very long exposure (four or more years), they appear to lose this advantage over non-noise-exposed children (Cohen et al., 1980, 1981, 1986). Children exposed for short periods of time to chronic noise may be able to block out auditory distractors more effectively during tasks whereas children exposed for long periods of time may, lose this blocking-out ability. This interaction between ‘chronic noise exposure’ and ‘length of time
enrolled in the school’ on auditory distraction may be explained by the change in perceived benefits of ‘tuning out’ as a coping mechanism. Blocking out unwanted sound may be an initial coping mechanism used by children when they first become exposed to chronic noise, but over time children may learn that this strategy is ineffective since the aircraft noise exposure is frequent and chronic (Evans & Lepore, 1993). In a well-designed and controlled field study in Munich, Evans and colleagues (1995) found that children chronically exposed to aircraft noise habituated to auditory distraction on a signal-to-noise task. The noise exposed children consistently chose a lower signal-to-noise ratio when readjusting a speaker’s voice against noisy background conditions. This result, consistent with the previous research, suggests that children may cope with chronic noise exposure by tuning out auditory stimuli. However, they did not test the interaction between chronic noise exposure and length of time exposed on auditory distraction found in Los Angeles. It must also be noted that the type of task (e.g. visual search/discrimination tasks), type of noise (speech or background noise distracters), and some individual difference (clinical or non-clinical child sample) are factors that also may influence whether auditory distraction affects task performance.

The reason children may be less resistant than adults to auditory distraction is that, in order to perform at school, and to talk and play, children need to cope with chronic noise interference by becoming resistant to it’s distracting properties and filter it out. If children are constantly distracted by noise and their coping mechanism of ‘tuning out’ overgeneralises to all situations, does it follow that because children are habitually 'tuning out' that this leads to deficits in other cognitive processes? Auditory distraction is not only important as a main effect of noise, but also it has been speculated to be the first part of a pathway to explain why noise affects child cognition. This will be discussed further in the mechanisms section.

School achievement tests
The studies examining the association between chronic noise exposure at school and/or home with standardised measures of reading and other intellectual achievement tests have found detrimental noise effects (Green et al., 1982; Michelson, 1968; Maser et al., 1978). The few studies that failed to find an association between noise exposure and school achievement may not have had high enough statistical power (Cohen et al., 1980, 1986; Moch-Sibony, 1984). Studies of school achievement confound chronic and acute noise exposure since they all have relied upon archival records of achievement.
tests. This is an important methodological flaw of all these studies. Despite this fault, these studies provide some evidence linking noise exposure to impaired school achievement although the roles of chronic and acute noise exposure cannot be determined. These results taken together raise the interesting question of whether it is general school achievement or whether the effects are more related to specific tasks such as reading (these studies using existing data sets will be reviewed in detail in the introduction to Chapter 5, the final study of the thesis).

Memory
There appears to be little or no effect of noise on simple memory tasks from chronic noise exposure (Hambrick-Dixon; 1986) or acute exposure (Johansson, 1983). However, experimental work has shown that if sufficient processing demands are placed upon memory, deficits begin to appear in children exposed to noise (Hygge & Bergquist, 1993; Hygge, 1994). Hygge & Bergquist (1993) reported that pop music exposure at 75 dBA equivalent noise level (Leq) impaired scores on a one-week delayed recall task, but for easier recognition items there were no effects of pop-music. However the memory results have not been entirely consistent. Nurmi and von Wright (1983), when studying the interactive effects of noise, neuroticism and learning, found no main effects of noise on immediate or delayed recall of a text read by school children.

Staffan Hygge’s laboratory work (which has been conducted concurrently with his field studies) corroborates the memory results found in the field (Evans et al., 1995; Hygge et al., 1996). In classroom studies of more than 800 children, Hygge (1994) found that aircraft and road traffic noise exposure at 66 dBA Leq impaired complex long-term recall tasks but not simple recognition tasks in 10 -12 year old children. Specifically, it was found that easy recall items showed a weaker noise effect while more difficult recall items showed a stronger effect.

These results have been interpreted to indicate that simple cognitive tasks, which require less attentional processing than complex tasks, are not affected by chronic noise exposure. Hygge (1994) rules out ‘distraction’, ‘reported effort’ and ‘perceived difficulty’ as mechanisms to account for the cognitive deficits produced in the high noise conditions. Hygge accounts for his finding that noise impacts on difficult but not simple tasks by an ‘information overload explanation’ because the noise affected
complex tasks with high information processing demands but not simple tasks. However, these performance results could also reflect a motivational account, consistent with the Yerkes-Dodson law (Yerkes & Dodson, 1908) because noise exposure could lead to increased excitation and arousal. According to the law this arousal would lead to the following predictions, which could also account for Hygge’s results: enhanced performance on simple tasks, no effect on medium difficulty tasks and low performance on difficult tasks.

More recent laboratory studies provide further evidence of this pattern of noise-related memory effects (Enmarker et al., 1998; Meis et al., 1998). Interestingly, these laboratory findings are consistent with the stress effects on complex and not simple tasks, and have been replicated in the field in Munich (Evans et al., 1995; Hygge et al., 1996). In Munich, chronic exposure to aircraft noise was associated with impairments in a complex long term recall memory task; however there was no association with the simpler working memory cognitive task.

**Attention**

Heft (1985) proposed that the interruptive, distracting effects of high ambient noise levels might directly affect the child’s abilities to sustain attention and concentration. Moch-Sibony (1984) found that kindergarten children exposed to aircraft noise had poorer sustained attention, and auditory discrimination than children in quiet schools on the Zazzo sustained attention task. Cognitive studies on children with differing exposures to chronic noise sources also indicate possible decrements in visual attention. Heft (1979) found that kindergarten children from noisy homes took longer to locate target pictorial stimuli within an array of pictures than did children from relatively quiet homes after adjusting for various socio-demographic variables. This study is limited because it relied upon observer ratings of home noise levels and no actual noise measurements were taken. Hambrick-Dixon (1986 & 1988) found limited evidence that pre-school children in daycare centres near railways had poorer performance on a vigilance visual search task. These results are difficult to interpret because it is unclear precisely what aspect of attention her experimental tasks measured (cross-out letters, 1986; visual stimulus detection with verbal or key press response, 1988). In addition to these experimental results, there is more anecdotal evidence from teachers reporting that children in noisy schools tend to have more **difficulties in concentrating** in comparison
to children from relatively quiet schools (Crook & Langdon, 1974; Ko, 1979; Ko, 1981 (road traffic noise); Kryter, 1985; Kyzar, 1977).

In the field the attention results have been mixed. Road traffic noise exposure at school was associated with poorer performance on two attention tasks in children aged between 6 - 11 years, in a study comparing two schools well-matched for socio-demographic factors in Valencia (Sanz et al., 1993). This study of only 136 children at two schools provides weak evidence for the following reasons: 1) the schools differed in size which could also effect the results and 2) the statistical analysis (a mean comparison of scores across grades) was not sensitive enough to distinguish between the two groups. Evans and colleagues (1995) did not find that chronic noise exposure was associated with poorer attention performance on an embedded figures task. In summary, the research to date does not provide a clear confirmation that noise affects child attentional processes. These preliminary results indicate that noise exposure influences attention over a range of tasks. They do, however, need to be supported in further research that can identify what precise aspect of attention is affected by chronic aircraft noise exposure.

1.2.1.2 In-depth review of the main field studies of environmental noise

Earlier preliminary research

Early studies in the 1960s and 1970s found preliminary evidence of cognitive impairments in children chronically exposed to noise (for a full review of the earlier research see Mills, 1975). Exposure to traffic noise at school was associated with deficits on measures of varying reliability of sustained attention, among elementary school children (Karsdorf & Klappach, 1968; Kyzar, 1977). Not all studies found noise effects on performance (Slater, 1968). These earlier studies examining the effect of noise on child attention suffer from methodological flaws that limit their interpretation such as: inadequate controls for socio-demographic factors (Kyzar, 1977; Kardorf & Klappach, 1968, Slater, 1968); inadequate screening for normal hearing (Kyzar, 1977; Kardorf & Klappach, 1968, Slater, 1968); and lack of objective noise measurements (Heft, 1979).

1970s field studies

In the 1970s the first well-designed naturalistic field study was conducted by Cohen, Glass & Singer (1973) who studied elementary school children living in four 32-floor
apartment buildings that were located on an expressway. The sample of 73 children were tested for auditory discrimination and reading level. Children living on lower floors of the 32-story buildings (i.e. higher noise levels) showed greater impairment of auditory discrimination and reading achievement than children living in higher-floor apartments. It was concluded that the results supported Deutsch’s hypothesis (1964), because auditory discrimination appeared to mediate an association between noise and reading deficits and length of residence in the building affected the magnitude of the correlation between noise and auditory discrimination. The results indicated that with a longer exposure duration, the association between noise and deficits in auditory discrimination become stronger. This seminal study has many elegant design features because it was a field study where noise exposure levels varied naturally but it also had limitations that either reoccur or are improved upon in the later field studies. First, it is difficult to accurately characterise the noise exposure of each child taking into account school noise exposure and other sources of noise apart from road traffic in the home (e.g. television, shouting, radio) in order to be certain that the deficits in reading are due exclusively to road traffic noise at home. This is a methodological problem that hinders most field research. It can be argued that there is no good reason to suppose that other sources of noise in the home differ across the noise exposed and the non-noise exposed groups. Alternatively, it is possible that to counter the effects of higher levels of road traffic noise in the home the television and radio are played at louder levels and family members need to shout to be heard. Second, given the small sample size it is possible that there is something else that may characterise people who live on the top of high rise apartments that could confound the effect.

Bronzaft & McCarthy (1975) argued that a more direct association may exist between noise and reading difficulties that was not mediated by auditory discrimination. They compared reading scores of elementary school children who were taught in classes on a noisy side of a school near a railway line with the scores of the school children in classes on the quiet side of the same school. They found that children on the noisy side of the school building had poorer performance on the school achievement tests than those in classes on the quiet side of the school. The mean reading age of children in the classes on the noisy side of the school was three to four months behind the children in the quiet classes.
The finding that there was a significant direct relationship between train noise and depressed reading scores supports one part of the Deutsch (1964) hypothesis that low reading achievement may be related to noise exposure. However, these data do not provide any evidence that this association may or may not be mediated by impaired auditory discrimination. In order to achieve their aim of testing whether the association between high noise exposure and impaired reading was a direct association or mediated by auditory discrimination, Bronzaft & McCarthy (1975) needed to measure the auditory discrimination and then conduct a mediational analysis. It is also possible that the effect of noise on reading was due to acute train noise at the time of testing and not to chronic exposure. This is because children who attended classes on the noisy side of the school took their reading tests in the same rooms. These testing conditions make it impossible to determine whether the noise effects on reading were the result of acute noise interference at the time of testing or whether the noise related deficits were due to chronic exposure to noise. This issue was addressed with refined methods in later studies where testing was conducted in sound proof trailers (Cohen et al., 1980; Evans et al., 1995; Evans & Maxwell, 1997).

A strength of Bronzaft & McCarthy’s (1975) results is that they cannot be attributed to self-selection, a methodological problem found in many field studies, because the noise effects were found in the same school. Children were not assigned in any systematic manner to classrooms on the noisy or quiet side of the school. Supplementing the laboratory research, these results in the field in the 1970s (Cohen et al., 1973, Bronzaft & McCarthy, 1975) demonstrated that noise exposure may have long-term behavioural consequences for children living and going to school in noisy environments in spite of noise adaptation, but more conclusive evidence was required.

**1980s field studies**

In order to provide a stronger answer to the question of whether laboratory findings applied to chronic environmental noise exposure, more well-designed field research on children who routinely live and go to school in high noise exposed areas was conducted in the 1980s and 1990s (Bronzaft, 1981; Cohen et al., 1980, 1981; Evan et al., 1995; Evans et al., 1998; Evans & Maxwell, 1997; Hygge et al., 1996).

In the 1980s, impaired performance on a difficult cognitive task was found in primary school children aged 8-9 years in a systematic well-controlled naturalistic field study.
around Los Angeles Airport (cross sectional results Cohen et al., 1980; longitudinal results Cohen et al., 1981). The aim of this study was to examine the association between aircraft noise at school and child cognitive and motivational performance and non-auditory physiological responses. Four of the noisiest elementary schools near Los Angeles International Airport (mean peak 74 dB) were matched to three quiet control schools (mean peak 56 dB) for grade level, ethnic distribution of children, percentage of children whose families were receiving government assistance, and for occupation and education of parents. There were 142 high noise children and 120 low noise children in years 3 and 4. All the tasks and questionnaires were administered in a sound insulated trailer and the children were pre-screened for hearing loss. Interior sound levels were measured inside each classroom and sound levels outside the homes were obtained from noise contours. The main outcome measures were: helplessness motivation performance measure, auditory discrimination, selective attention, scores on standardised reading mathematics tests collected from the school records, noise annoyance, and systolic and diastolic blood pressure. Socio-demographic data was collect from the parents. The samples were well matched on most factors except that the high noise group contained more Afro-American children and children who were more geographically mobile. The analyses were adjusted for number of children in the child’s family, the grade at school, length of time at school and race.

The results strongly showed that high noise exposed children had higher noise annoyance, and higher systolic and diastolic blood pressure than the control children. The results provide suggestive evidence that children exposed to high levels of aircraft noise were less capable of performing a cognitive task (puzzle solving) and were more likely to give up on a difficult task (poorer motivation, greater helplessness). There was some evidence that noise impairs selective attention during distraction but this was only significant after 4 years of chronic aircraft noise exposure in the school. Mathematics, reading and auditory discrimination were unrelated to noise exposure. Cohen and colleagues (1980) concluded that there results were strikingly similar to those reported in the laboratory setting, but that replication was required before definitive conclusions could be reached.

Cohen and colleagues (1981) report a one year follow-up of this same sample. They were asking the question of whether children re-tested one year later continue to show baseline effects or whether they adapt to noise over the one year period. The response
rate of the sample was 163 (high noise sample = 83 and quiet sample = 80) which indicates a moderate response rate of 62% and high attrition. The follow-up results showed that the noise effect on annoyance, selective attention during distraction and performance on a moderately difficult cognitive task were stable over time. At follow-up they did not replicate the baseline effects of noise on blood pressure and rate of giving up on a difficult task (Cohen et al., 1981). In general, it was concluded that there was little evidence for adaptation to noise over the one year period and that the effects related to noise exposure are stable over a one year period (see the introduction to Chapter 4 for a more detailed discussion of this work).

In agreement with their previous work, Cohen and colleagues (1986) in an analysis of a new sample of 165 grade 3 school children around Los Angeles Airport found that children in noisy schools: a) had higher blood pressure if they were enrolled for 2 years or less; b) were more likely to fail on a difficult cognitive puzzle; and c) suffered more impaired selective attention during distraction than the control children in quiet schools. They found no effect on auditory discrimination. These results, obtained in a small independent sample, broadly replicate their previous work confirming the existence of child noise effects, but do not provide any further understanding or stronger evidence for these noise effects.

Stronger evidence to suggest the existence of noise effects comes from intervention studies and natural experiments where changes in noise exposure are shown to be accompanied by changes in cognition. To date, there have been three studies examining the effects of noise reduction on children’s cognition: two intervention studies (Bronzaft, 1981, Cohen et al., 1981) with methodological flaws that limit their generalisability and one well-designed natural experiment (Evans et al., 1998; Hygge et al., 1996). Bronzaft (1981) found that following attenuation in rail noise there were no longer significant differences, as there had been previously (Bronzaft & McCarthy, 1975) in reading achievement between children from classrooms close to elevated train tracks and children on the opposite side of the building. Noise was lowered by acoustical treatment of classrooms and by one inch thick butyl-rubber pads on the rail tracks closest to the school (6-8 dBA reduction in total). Teacher self-reports showed that they really did notice a huge reduction in noise interference. Cohen and colleagues (1981) found that noise abatement in classrooms (7 dBA reduction) had small ameliorative effects on motivation and mathematics, but not on reading. These
intervention studies (Bronzaft, 1981; Cohen et al., 1981) suffered from no comparisons of reading ability before and after noise reduction; no objective measure of actual noise reduction; and insufficient sample sizes which makes the potential for selection bias more likely. The Munich Airport Study provides the best evidence that a reduction in noise level of only one year duration reduces noise-induced cognitive impairments (Hygge et al., 1996), but further intervention studies are needed to test practical and affordable interventions, such as insulating classrooms against noise exposure in areas where external noise levels are unlikely to change.

1990s field studies
Stronger evidence for similar noise related cognitive effects found in the 1970s and 1980s has been found in experimental field research around Munich Airport in older children with a mean age of 10.8 years (cross-sectional results Evans et al., 1995; longitudinal memory results Hygge et al., 1996; longitudinal psychophysiological results Evans et al., 1998). In 1992 the old Munich airport closed and a new airport was opened, which gave the researchers an unprecedented opportunity to conduct a prospective longitudinal natural experiment with a change in noise exposure. Testing occurred in a climate-controlled, sound attenuated trailer at the children’s school, where they could disentangle chronic from acute noise effects. Beginning in 1991, before the change over of airports, children at both sites were recruited into two experimental and two control groups. The two experimental groups were: 1) the children at the old airport who were exposed to high levels of aircraft noise and 2) children at the new airport who were to become exposed to high levels of aircraft noise. The two control groups, one for the old airport and one for the new airport, were selected from areas that were not or would not be exposed to much aircraft noise. One wave of data collection occurred prior to the change over of airports, the second wave one year later, and the third wave a year after that.

The cross-sectional results of the first wave of data collection, compared the cognitive performance of 135 children living a high noise impact neighbourhood (24-hr Leq=68.1 dBA) with children from a quiet neighbourhood (24-hr Leq=59.2 dBA) around the old Munich International Airport indicate a mixed pattern of results. There were significant associations between high noise exposure and a) poorer long term memory; b) poorer performance on a German standardised reading test with the effect becoming more marked in the difficult section of the test and ; c) selection of a lower signal-to-
noise ratio indicating resistance to auditory distractors on a signal-to-noise task and this perceptual adaptation generalised across different noise sources (Evans et al., 1995). The two groups did not differ in performance on an embedded figures attention task, nor a simple choice reaction time task, or working memory. Overall, it was concluded that these cognitive results support the previous field and laboratory research that indicate selective impairments in cognitive functioning among children exposed to chronic aircraft noise.

Longitudinal analyses of the cognitive results are not yet complete but some results are known (Hygge et al., 1996). After three waves of testing, these results indicate improvements in long term memory recall task and the reading test (only significant for the difficult section) after closure of the old airport (Staffan Hygge, personal communication). Strikingly, these effects were paralleled by impairment of the same cognitive skills after the new airport opened (Hygge et al., 1996).

Even though the Munich study provides the strongest evidence to date of cognitive noise effects in children, the study is limited because it does not address the important question of what mechanisms cause these effects and the role of potential confounding factors. The overall sample size was 327 children at both sites (135 at the old airport, 192 at the new airport). In the cross-sectional analyses (Evans et al., 1995) there were approximately 68 children in each group (control and noise exposed groups). Even though the control and noise exposed groups did not differ in level of parental education, or occupation or in family size, there were not enough subjects in each group for the cross-sectional analyses to rule out the possibility of selection bias influencing the cognitive results. Munich does not have the same social class, ethnic and school differences that are present in the UK or USA, which means that these results need to be replicated in the UK and USA to test whether they generalise after adjustment for these potentially relevant confounding factors.

Evans & Maxwell (1997), in a field study around New York, directly tested possible mediating factors. The primary objective of this study was to determine whether the relation between noise exposure and reading is caused by deficits in language acquisition. They compared the cognitive performance of 58 children exposed to high levels of aircraft noise (65 Leq contour) from one school with the performance of 58 children from one school exposed to lower levels of noise. They found that chronic
noise exposure was significantly correlated with lower reading ability and poorer speech perception. Sound perception and phonemes did not differ between the two groups. They found that speech perception functions as a partial mediator of the association between aircraft noise exposure and the reading effects. This study is severely limited because the small sample of children was drawn from only two schools which might not be representative and because there were no objective noise measurements. These results need to be replicated in a much larger sample and across a wider range of children. For these reasons it is best to treat this New York study as pilot research that replicates previous noise effects on reading and provides suggestive evidence that the noise effect is mediated by speech perception.

**Summary of findings**

In studies examining the effects of chronic aircraft, train and road traffic noise on school children's cognitive performance, the following results have been found in children exposed to high levels of environmental noise:

1) deficits in sustained attention and visual attention (Hambrick-Dixon, 1986; Hambrick-Dixon, 1988; Heft, 1979; Karsdorff & Klappach, 1968; Kyzar, 1977; Moch-Sibony, 1984; Sanz et al., 1993)

2) difficulties in concentrating in comparison to children from quieter schools according to teachers’ reports (Crook & Langdon, 1974; Ko, 1979; Ko, 1981; Kryter, 1985)

3) poorer auditory discrimination and speech perception (Cohen et al., 1973; Cohen et al., 1980; Cohen et al., 1986; Moch-Sibony, 1984, Evans et al., 1995, Evans & Maxwell, 1997)

4) poorer memory that requires high processing demands (Fenton et al, 1974; Evans et al, 1995; Hygge, 1994; Hygge et al, 1996)

5) poorer reading ability and school performance (Bronzaft, 1981; Bronzaft & McCarthy; Cohen et al., 1973; Green et al., 1982; Lukas et al., 1981; Michelson, 1968; Maser et al., 1978; Evans et al., 1995, Evans & Maxwell, 1997)
1.2.2 Possible mechanisms to account for these noise effects

The research evidence outlined above focused on how noise directly affected cognitive outcome variables as separate correlates (namely: auditory discrimination, auditory distraction, memory, attention, school achievement and reading). It is possible that these variables form complicated causal links to one another. Because all of these cognitive functions are related to each other it is difficult to tease apart main effects from mediating factors. A mediator is defined as a variable through which the predictor variable, noise, operates to affect the outcome/s of interest (cognitive performance). Evans & Lepore (1993) suggest that both the direct and the indirect pathways of the non-auditory effects of noise on children need to be addressed. It is by testing the hypotheses of indirect pathways that the underlying mechanisms of noise effects can be discovered. Moreover, some hypothesised mechanisms may be complementary. The theoretical understanding of child noise effects is very limited, and is largely based on acute experimental research with adults. Only two studies (Cohen et al., 1973; Evans & Maxwell, 1997) have actually tested the mediating role of a hypothesised factor. This leaves us with the critical question of how does one explain the link between chronic exposure to noise and these adverse effects on child cognition?

The four major psychological theoretical models of environmental stress introduced in section 1 (arousal model; information overload model; cognitive coping strategies; loss of control and learned helplessness see Figure 3) have been applied to explain the effects of noise on human performance and health. These theories differ in their explanations of why the noise is stressful - because noise produces arousal, produces information overload, depletes coping strategies, or reduces a sense of environmental mastery (Cohen et al., 1986). The scope of these theoretical formulations is broader than any data from the noise and children literature. As argued previously, the theoretical focus of this thesis is on mechanisms that have been hypothesised from the cognitive coping strategies theory (Cohen et al., 1986; Evans & Lepore, 1993). The basic idea underlying this approach is that shifts in performance can be understood by examining the cognitive coping responses used to complete the tasks. In general terms, a coping response is defined as a behaviour or cognition that a person uses to adjust to a stressor (Lepore & Evans, 1996). A coping response might also mediate the effects of stressors. A stressor, such as chronic noise exposure, might influence a person’s coping response (e.g. reduced attention), which in turn may influence some outcome (e.g.
This definition of a coping response is very general because the scope of the definition applies to many sources of environmental stress such as noise, crowding, vibration, pollution and heat. In order to make this construct of a ‘coping response’ theoretically useful, specific behaviours and cognitive processes need to be hypothesised as coping responses to a specific source of environmental stress. Theories identifying specific cognitive and behavioural coping responses to noise will be explicated below.

Noise in the home or school environment causes increased distraction, which may overburden developing cognitive systems. If children cope with chronic exposure to noise by filtering-out strategies, then they should be less distracted by auditory stimuli. As stated above there is empirical evidence for noise exposed children to be less affected by auditory distraction than control samples. Children may adapt to noise interference during activities by filtering out the unwanted noise stimuli. This tuning out strategy may over-generalise to all situations when noise is not present, such that children tune out stimuli indiscriminately. This ‘tuning out’ response is supported by the findings that children exposed to noise have deficits in attention, auditory discrimination and speech perception (Cohen et al., 1973; Moch-Sibony, 1984, Evans et al., 1995). Under some circumstances these strategies may be detrimental and it is possible that the impairments in attention, auditory discrimination and/or speech perception may mediate the association between noise and child cognitive performance. It must be acknowledged that these three cognitive processes may be concurrently affected by noise exposure and it is possible that all three partially mediate the effects of noise on child cognition.

Other mechanisms to account for cognitive deficits have been suggested. These include: selective inattention, distraction, (reported) effort, perceived difficulty, information overload, mood effects, and sleep disturbance (Bell et al., 1996; Hygge, 1994), but there is little evidence for these mechanisms. Therefore this discussion will focus on attention, auditory discrimination and speech perception for which there is some evidence of mediation.
1.2.2.1 Attention difficulties: a narrowing of attention

Figure 4 - Sustained Attention as a mechanism to account for noise related cognitive deficits

Attentional processes have been hypothesised as mediators in noise-related memory effects (see Figure 4). Adult studies on memory effects have been interpreted as indicative of attention narrowing or focusing on dominant stimuli (Cohen et al., 1986). Attention narrowing appears to be common under arousing conditions in general (Broadbent, 1971) and under noise specifically (Hockey, 1979). Broadbent (1971) hypothesised that noise can affect task performance by increasing the likelihood that dominant or readily available information will be used in making decisions and attention is focused on these dominant cues to the detriment of peripheral cues. Greater attention to more central cues could lead to poorer encoding of more peripheral material when there are greater processing demands placed on memory. Several studies in adults have provided evidence of this narrowing of attention phenomenon, including poorer recall of irrelevant or peripheral information available during a task, or poorer ability to access uncommon or rarely used information (e.g. Hockey & Hamilton, 1970). Poulton (1977) argued that noise affects task performance because it ‘masks’ internal speech or it makes it more difficult to ‘hear ourselves think’. There is some experimental evidence for this hypothesis in adults, but does not indicate that this is the only way noise affects performance (Jones et al., 1979; Smith, 1988). The masking of internal speech has not been suggested as a mechanism to account for child cognitive impairments.

Based on this theory of ‘narrowing attention’ taken from adult studies, the main theory to account for general cognitive impairments in children has been that noise restricts
attention to central cues during complex language related tasks (Cohen et al, 1980; Heft, 1985). Children may adapt to noise interference during activities by filtering out the unwanted noise stimuli. This tuning out strategy may overgeneralise to all situations when noise is not present, such that children tune out stimuli indiscriminately. This filtering process may lead to poorer sustained attention. In turn, this may lead to noise exposed children having poorer ability to sustain attention in the classroom, which may continue over time to affect concentration and learning even in the absence of noise exposure. This is because sustained attention, which is necessary to comprehend the underlying patterns of complex objects or sequences, might be disrupted by the interfering effects of noise (Heft, 1985). (An alternative interpretation is that sustained attention could be lost due to the energy demands of the filtering process or due to a loss of motivation.) This attention theory has been supported by experimental studies on adults (Smith & Jones, 1992) and in children (Evans & Lepore, 1993). Earlier research was based on the theory that the restriction of attentional processes during noise exposure leads to cognitive deficits (Cohen et al, 1980). Later research has attempted to refine this theory through the examination of specific attentional processes such as sustained attention. This attention hypothesis has not been directly tested in children.

1.2.2.2 Auditory discrimination mediation hypothesis

Deutsch (1964) proposed a theory to account for the cognitive deficits. She claimed that a child reared in a noisy environment eventually becomes inattentive to acoustic cues and thus has impaired auditory discrimination. The inability to discriminate sounds is presumed to account, in part, for subsequent problems in learning to read. Deutsch (1964) reported preliminary correlational data consistent with her hypothesized relationship between auditory discrimination and reading. This evidence supports the second half of the model outlined in Figure 5 above. Other researchers have found
evidence for a main effect of noise exposure on impaired auditory discrimination, the
first half of Figure 5, in experimental studies (Blue & Vergason, 1975; Glenn et al.,
1978; Laraway, 1985; Lasky & Tobin, 1973; Nober & Nober, 1973) and field studies
(Cohen et al., 1973; Moch-Sibony, 1984).

Some research has shown that noise exposure is related to both impaired auditory
discrimination and reading (Cohen et al., 1973). It is difficult to interpret the causal
association between the two effects: is it that noise effects on reading are mediated by
impaired auditory discrimination or does noise affect both cognitive functions directly,
or are the reading and auditory discrimination effects mediated by another process that
is as yet unknown? Only one study directly tested the mediating role of auditory
discrimination (Cohen et al., 1973). This study, previously described, elegantly
examined the relationship between home road-traffic noise exposure on both reading
and auditory discrimination. A regression analysis was conducted to test the
interdependent effects of noise (predictor variable) and auditory discrimination (the
mediator) on reading (outcome). By using this analytical strategy, the researchers were
able to appropriately test the effect of the hypothesised mediating process. When
auditory discrimination was entered into a multiple regression analysis the previously
significant relationship between noise exposure and reading was reduced to zero
(adjustments were made for socio-economic factors, as they were entered before noise
level and auditory discrimination). This result provides evidence that the association
between noise exposure and impaired reading was largely explicable by auditory
discrimination.

1.2.2.3 Language acquisition, deficits in speech perception: a mechanism for
cognitive effects

Figure 6 - Speech perception as a mechanism to account for
noise related cognitive deficits

| Noise Exposure | Speech Perception | Impaired Reading & Memory |
Evans & Maxwell (1997) further developed this theory by postulating that this indiscriminate tuning out in the presence of noise also included tuning out speech. They studied whether speech perception may mediate the association between noise exposure and reading deficits. From the psycholinguistic literature they incorporated two language acquisition processes that have been shown to be robust in accounting for reading acquisition. Their reasoning is that there is evidence from psycholinguistic research that indicates the critical importance of speech perception in reading acquisition (Brady et al., 1983). Noise can mask speech which has implications for possible mediation by psycholinguistic processes. Speech perception and other phoneme awareness are more critical precursors to reading acquisition than auditory discrimination (Brady et al., 1983; Mann & Brady, 1988; Wagner & Torgesen, 1987). Evans & Maxwell (1997) found partial support for their speech perception hypothesis. They found that speech, and not sound perception, partially mediated the relation between ambient noise exposure and reading. Speech perception explained some but not all of the relation between noise exposure and reading impairments. Clearly, this will have to be replicated.

1.2.2.4 Teacher frustration and communication difficulties: a mechanism for cognitive and motivation effects

Distraction and annoyance from noise interruptions may have indirect effects on cognitive development because of alterations in parents’ and teachers’ behaviour (Evans et al., 1991). Noise exposure also affects communication in the classroom, which makes it more difficult for children to learn and teachers to teach and may lead to frustration, interruption in speech and a reduction in instruction time (Bronzaft & McCarthy, 1975; Crook & Langdon, 1974). Crook & Langdon (1974) claim that the principal changes in observed classroom behaviour around Heathrow Airport result from interference with speech. They measured the background level of aircraft noise which varied between 55 and 70 dB (A) and the mean peak flyover level varied between 70.6 and 72.2 dB (A). Speech interference jeopardises the continuity and flow of the lessons and is a nuisance that may result in teacher and child frustration. Ko (1979) reported in a survey of 139 schools in Hong Kong (mean peak aircraft noise level above 70 dBA) that aircraft noise disrupts verbal communication, resulting in speech and teaching interference during lessons and that teachers suffer from noise annoyance. Quantitative relationships have been found between the proportions of teachers bothered by noise and the noise levels to which they are exposed at school (Sargent et al. 1980).
It is possible that environmental noise may affect teachers' and parents' encouragement of children. In this way, noise may affect teachers' and parents' behaviours and may potentially indirectly contribute to the noise effects on child cognitive development and motivation. This account is based on anecdotal evidence which makes it the weakest theory to account for noise related cognitive effects in children. It is, however, still possible that 'teacher frustration and communication difficulties' may, in part, mediate the effects.

In summary, the theoretical focus of this thesis is on testing mechanisms that can be predicted from the general cognitive coping strategies models that have been applied to 'noise' as the specific environmental stressor. According to this theoretical position, a coping response to noise might also mediate the cognitive effects of noise. A summary of the discussion of the three main mechanisms is outlined in Figure 7 below. Chronic noise exposure, the predictor variable, might influence a person's coping response (e.g. reduced attention, impaired auditory discrimination, and speech perception), which in turn may influence some outcome (e.g. reading and memory performance). There is very little theory and few studies with appropriate analysis to test these mechanisms.

To test a mediator model the interdependent effects of noise and the mediator must be tested on the outcome (Evans & Lepore, 1992). The mediator and the predictor variable must be correlated, but not statistically interact (Evans & Lepore, 1992). There are only two studies that have conducted appropriate analysis to test for the mediating role of auditory discrimination (Cohen et al., 1973) and speech perception (Evans & Maxwell, 1997) on noise related cognitive effects in children. However, these studies had small sample sizes (Cohen et al., 1973 n=73; Evans & Maxwell, 1997, n=116) which may not be representative. This in turn increases the likelihood of random effects because of the possibility of sample selection bias. A small sample size also reduces the precision of the size of the effect, because the sample may not be representative. Attention as a mechanism has been studied in laboratory experiments in adults, but needs to be tested in children, which is one of the aims of the present research.
1.2.3 Research rationale

The aim of this thesis is to replicate and extend the past studies on school children living around airports. This research area is now at a stage where it is not enough simply to describe effects of noise, rather it is necessary to develop the appropriate theoretical framework to make interpretation possible. The sustained attention hypothesis will be directly tested. The complex cognitive outcomes measured where a noise effect is predicted are: reading, long term memory (recall), sustained attention, and school performance from standardised school achievement tests. The control simple cognitive outcomes measured where a noise effect is not predicted are: short-term memory and long-term memory (recognition). Even though the evidence for auditory discrimination and speech perception has theoretical importance, they were not included in the present studies because to measure them accurately required individual testing, which was not methodologically practical within the resources available.
1.3 The effect of noise on child motivation

The diminished performance in solving cognitive tasks associated with chronic noise exposure outlined in section two may result from cognitive factors exclusively or in combination with motivational factors. Motivation is generally defined as an intervening process that impels or drives an individual into action (Bernstein et al., 1988; Reber, 1985). In this sense it is an energiser of behaviour, but there are slightly differing views on this definition. Many different beliefs and dispositions affect motivation, such as fatigue, arousal, incentives, vicarious learning, and learned helplessness. It is helpful to distinguish between the constructs of ‘loss of control’, ‘learned helplessness’ and ‘impaired motivation’ to understand how they are related and because the terms are sometimes used interchangeably in the literature. Reduced motivation can be a behavioural consequence of a learned helplessness belief. Learned helplessness means that the organism learns that the outcomes are independent of its responses (Evans & Lepore, 1993). Thus noise researchers have tended to measure motivation with behavioural tasks that operationalise motivation as susceptibility to learned helplessness.

1.3.1 The research evidence

Uncontrollable noise has been shown to induce helplessness in adults (Hiroto, 1974; Hiroto & Seligman, 1975; Krantz et al., 1974). Experimental studies found that following exposure to uncontrollable noise, adults were less likely to persist with difficult after-effects puzzles than were their counterparts with prior exposure to controllable noise (Cohen, 1980; Glass & Singer, 1972). Similar effects have been found in children chronically exposed to noise and other environmental stressors.

In the Los Angeles Airport Study, motivation was measured as persistence on a difficult cognitive task that was preceded by a success or failure experience (Cohen et al., 1980). They found that children in the high noise exposed schools had poorer performance on soluble and difficult test puzzles and were more likely to give up on a difficult puzzle than the children in quiet schools (Cohen et al., 1980). A year later at follow-up they replicated the puzzle performance results, but did not find a noise effect on rate of giving up (Cohen et al., 1981). With a new sample of school children around Los
Angeles airport, Cohen and colleagues found that children in noisy schools failed a difficult puzzle more frequently and showed greater abdication of choice of rewards than the children from the quiet schools (Cohen et al., 1986). In Munich, children chronically exposed to high noise persisted less with an insoluble puzzle (Glass & Singer, 1972) than the control group of low noise exposed children (Evans et al, 1995). They also measured attributions for failure on the initial puzzle with direct questioning and did not find any evidence for sense of helplessness or the influence of aircraft noise (Staffan Hygge personal communication).

Reduced motivation has also been found in some studies of children exposed to other environmental stressors. Rodin (1976) found that children who lived in high residential density (3 bedrooms, 1 bathroom multi-apartment in a low income housing project with 2 - 8 others) were significantly less likely than children who lived in less dense housing to try and control the administration of available outcomes and that their problem solving performance was more affected by an insoluble puzzle. These results indicate that when children live in high density housing it may reduce their feelings of choice and control and hence make them more susceptible to helplessness. High-density housing also seems to be associated with increased helplessness in college students (Fleming et al., 1987). Saegert (1981), however, did not find any effects of home density on learned helplessness among children. All these results were found in relation to residential density. This may not necessarily mean that these children suffered crowding, which refers to the ratio of people per room in a dwelling. People residing near airports report high levels of annoyance, but they tend not to be motivated to complain to officials or take other actions to reduce noise levels (Jue, Shumaker & Evans, 1993). Teachers in schools chronically exposed to noise report more difficulties in motivating students to perform than do teachers from relatively quieter schools (Crook & Langdon, 1974; Kyzar, 1977; Moch-Sibony, 1984).

1.3.2 Possible mechanisms to account for these noise effects

It has been theorised that these links between chronic noise exposure and motivational processes are mediated by learned helplessness, which may be the result of a sense of loss of environmental control (Cohen et al., 1980; Cohen et al., 1986; Evans & Cohen, 1987; Evans & Lepore, 1993). The 'loss of control' psychological theory has been introduced previously, so here it will be demonstrated how learned helplessness has
been adapted as a mechanism for these specific effects of reduced motivation found in school children exposed to noise.

The reformulated learned helplessness model (Abramson, Seligman & Teasdale, 1978) is a diathesis-stress model, in which a maladaptive explanatory style is viewed as a factor that predisposes the individual to helplessness in the face of bad events. The reformulated helplessness theory offers a strong prediction concerning the causal influence of explanatory style on depression. Following from this theory it would be expected that children who possess an attributional style that habitually leads them to view the causes of bad events as stable in time, global in effect and internal to themselves will be, once they encounter bad events, especially vulnerable to a defined cluster of helplessness deficits. As predicted by the refined learned helplessness theory, it has been found that children who attribute bad events to internal, stable and global causes were more likely to report depressive symptoms than were children who attributed these events to external, unstable and specific causes (Blumberg & Izard, 1985; Kaslow et al., 1984; Nolen-Hoeksema et al., 1986; Seligman, et al., 1984). In further support, the maladaptive explanatory style was significantly correlated with high-depression scores and significantly predicted level of depression six months latter (Seligman, et al., 1984). If this learned helplessness hypothesis is correct, then it is possible that noise exposure might be related to depression in children. (This will be discussed further in the next section).

The main reason why this research on helplessness is important is because children who become helpless may exhibit motivational and cognitive deficits as well as greater susceptibility to depression. These same motivational and cognitive deficits have been found in children chronically exposed to noise. Carol Dweck and associates have found some evidence that children's vulnerability to learned helplessness is related to the development of school achievements and motivation (see Cohen et al., 1986 for a review). There is evidence from the learned helplessness literature to suggest that attributional style and sense of control are linked to motivational impairments. So learned helplessness has been applied as a mechanism to explain how chronic exposure to noise affects child motivation.
Given that school children have less control over their physical and social environments than adults, it may be the case that they are more susceptible to feelings of learned helplessness. For example, children can not decide to move away from a noisy neighbourhood. Noise in the home or school environment demand increased effort to performance tasks and induce frustration in children. It has been postulated that children feel that they have a 'lack of control' over their noise exposed environment and develop a learned helplessness state (Cohen et al, 1980; Evans & Lepore, 1993; Evans et al, 1995). Children may adapt to noise interference during activities by withdrawal strategies or by learning to be helpless in the presence of uncontrollable noise when performing tasks. This learned helplessness may become a generalised learned response that becomes manifest as low motivation during performance of all tasks regardless of the presence of noise.

Although this is an appealing theory there is little empirical evidence from the noise literature in general, let alone from the child research, to support it’s logical links (although there is other evidence for the logical links from the learned helplessness literature). Cohen and colleagues (1980) claimed that both laboratory and community noise research suggests the possibility that high-intensity noise exposure induces feelings of helplessness. It needs to be demonstrated that children chronically exposed to noise actually feel a loss of environmental control, because these children may have a sense of low control for many other reasons (e.g. social disadvantage or past experiences). The next claim in the theory that learned helplessness is the mechanism responsible for reduced motivation in children chronically exposed to noise also needs

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Figure 8 - Learned helplessness as a mechanism to account for noise related motivational deficits

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1.3.2.1 Learned helplessness: a mechanism for motivation noise effects
to be directly tested. Reduced motivation might well be the result of a school history of poor achievement. Individual differences need to be taken into consideration. Just as there may be individual differences in the way children respond to noise, it is also the case that there are individual differences in the way children respond to learned helplessness. It may also be valuable to gather preliminary data on other behavioural consequences of learned helplessness. In adults complaining about aircraft noise has been used as a crude behavioural indicator of learned helplessness. Perhaps other aspects of child behaviour at home and in the classroom may be indicators of learned helplessness. Cohen, Evans, Stokols & Krantz (1986) and Evans & Lepore (1993) suggested that future research into noise and motivation should examine differences in the way children attribute uncontrollable events.

1.3.3 Research rationale
The evidence that chronic exposure to aircraft noise is associated with reduced motivation in school children is suggestive but is not as clear as the cognitive noise effects. This is due to the fact that there are few studies that have measured motivation and because motivation is difficult to measure. Motivational effects warrant further research because the previously found effects (especially Cohen et al., 1980; Evans et al., 1995) need to be replicated and are theoretically plausible. The present research will extend the previous research by: 1) examining these motivation effects on a wider range of performance and behavioural measures, 2) testing the learned helplessness model by measuring the attributions children make about uncontrollable events (Cohen et al., 1986; Evans & Lepore, 1993), and 3) collecting data from parents and teachers on behaviour that may be a consequence of learned helplessness.
1.4 The effect of noise on child mental and physical health

As discussed in section 1.3, research indicates that exposure to chronic uncontrollable environmental stressors may lead to learned helplessness. So it is possible that noise induced learned helplessness may in turn, increase susceptibility to psychological disorders in children, such as depression, anxiety and self-reported stress. Given that there is some evidence from research that noise exposure may lead to impaired mental health (Halpern, 1995; Stansfeld et al., 1996) it is reasonable to assume that similar differences may be found in children. Generally, there is very limited research examining the effects of noise on child mental health, and only slightly more on child physical health.

1.4.1 The research evidence

1.4.1.1 Noise Annoyance
Children have been found to be annoyed by chronic noise exposure (Bronzaft & McCarthy, 1975; Evans et al., 1995). In Munich, it was found that children living in noisier areas were significantly more annoyed by noise in their community as indexed by a calibrated community measure that adjusts for individual differences in rating criteria for annoyance judgements (Evans et al., 1995). Children living in the noisy environment had lower psychological well-being than children living in quieter environments (Evans et al., 1995). The longitudinal data from around Munich show that, after the inauguration of the new airport, the newly noise-exposed communities show a significant decline in self-reported quality of life, after being exposed to the increased aircraft noise exposure for 18 months (third wave of testing), compared with a control sample (Evans et al., 1998). Emotional responses to noise, such as annoyance, may indicate that children perceive interference of noise in daily activities.

Another way of studying the adverse health effects of noise is to examine how it interacts with other stressors and behaviours. The likelihood of noise being linked to aggressive behaviour, a possible consequence of feeling noise annoyance, is tenuous. Laboratory studies have found some evidence for a relationship between aggression and noise (Donnerstein & Wilson, 1976; Green & O'Neal, 1969). Field research has shown noise in the environment makes subjects less helpful (Cohen & Spacapan, 1984; Jones et al., 1982; Mathews & Canon, 1975; Page, 1974). Noisy, overcrowded classrooms
may also contribute to increased aggression as children who desire some quiet work may become frustrated and aggressive (Bronzaft & Dobrow, 1988). It would be relevant and interesting to gather preliminary data on other behavioural consequences of increased annoyance and aggression. So if children are more annoyed by noise, does it in turn lead to poorer behaviour in the classroom and at home?

1.4.1.2 Depression, anxiety and self-reported stress

There have been only a few studies that have examined child psychological disorders in relation to noise. Nurmi & von Wright (1983), when studying the interactive effects of noise and neuroticism and learning in school children, found that noise during learning impaired the subsequent recall performance of 'neurotic' subjects and subjects with a high score of state-anxiety. Poustka and colleagues (1992) studied the psychiatric and psychosomatic health of 1636 children aged 4 to 16 in two geographical regions that differed according to the noise made by jet fighters exercising frequently at low altitude. Psychological and neurological outcomes were not related to noise exposure. They found that certain relationships with noise could be demonstrated in depression and anxiety beneath the threshold of clinical significance. These results are not convincing because the areas differed socio-economically and the results were not adjusted accordingly and also because there was no adequate measure of the noise exposure.

High levels of depression and anxiety have been associated with cognitive impairments in school children (Gaudry & Spielberger, 1971; Kaslow et al., 1984; Nolen-Hoeksema et al., 1986; Gladstone & Kaslow, 1995). These same cognitive impairments have also been found in school children chronically exposed to high aircraft noise in Los Angeles and Munich (Cohen et al., 1980; Evans et al., 1995). There is also evidence from: 1) the child depression and cognitive performance research (Nolen-Hoeksema et al., 1986; Kaslow et al., 1984) and 2) the child learned helplessness and motivation research (Nolen-Hoeksema et al., 1986; Gladstone & Kaslow; 1995) that suggests that psychological factors may mediate the relationship between chronic noise exposure and cognition.

1.4.1.3 Psychophysiological effects of noise

The Yerkes-Dodson inverse U shaped function between arousal and performance/learning (Yerkes & Dodson, 1908) suggests that because noise is arousing it will facilitate performance on simple tasks, up to a point. However, high levels of
arousal interfere with performance on complex tasks, and extremely high levels of arousal interfere with performance on simple tasks. The performance data which demonstrate that complex tasks such as memory, reading, and problem-solving abilities and not simple cognitive tasks (recognition and short-term memory) are affected noise are consistent with this explanation. There is empirical evidence for the arousal mechanism in the correlational evidence that children chronically exposed to noise have higher levels of physiological stress such as systolic and diastolic blood pressure (Cohen et al., 1980; Evans et al., 1995; Evans et al., 1998; Regecova & Kellerova, 1995) and catecholamine secretion (Evans et al., 1995; Evans et al., 1998).

Earlier studies found preliminary evidence that chronic noise exposure was associated with elevations of resting blood pressure in children (Karsdorf & Klappach, 1968; Karagodina, 1969). Data from the Los Angeles and Munich study and Regecova & Kellerova (1995) provide more reliable cardiovascular evidence of noise effects in children. In Los Angeles, the cross-sectional results indicate small but significant increases in systolic and diastolic blood pressure associated with chronic aircraft noise exposure at school (Cohen et al., 1980, 1986). This elevated blood pressure found in 1980 does not appear to habituate with continued exposure (Cohen et al., 1986). The ranges of blood pressure elevation in noise-exposed children in these studies are within normal levels and do not suggest hypertension. In Munich there was a relationship between noise exposure and baseline systolic blood pressure and lower reactivity in systolic blood pressure to a cognitive task presented under acute noise (Evans et al., 1995). The longitudinal results demonstrate that systolic blood pressure significantly increased in the noise-impacted communities after opening of the new airport (Evans et al., 1998). Diastolic blood pressure and reactivity were unrelated to noise exposure in the Munich school children. High levels of urban road traffic noise (>60 dBA Leq) at school were associated with higher systolic and diastolic blood pressure and mean heart rate compared with control children attending a schools exposed to low levels of road traffic noise, in children aged 3-7 years (Regecova & Kellerova, 1995). This cross-sectional study provides very strong evidence that noise may lead to elevated blood pressure in children because the sample size is large (1542 children), there were 30 schools examined, and controls for age, body weight, height and demographic and socio-economic factors were used in the analysis.
A study of 862 children aged 7-12 compared the blood pressure of deaf-mute children (noise-insensitive group) and children with normal hearing (noise sensitive group) exposed to high levels of road traffic noise at two schools (60 - 75 dBA). Multivariate analysis showed that the systolic and diastolic blood pressure of deaf subjects to be significantly lower than subjects with normal hearing after adjustments for the effects of confounding factors (Wu et al., 1993). This study is limited because it is questionable to assume that 'noise exposure' is the only factor that affects blood pressure in deaf children, which makes deaf children a problematic control group.

The Munich study was the first field study to examine neuroendocrine indices of chronic stress among persons exposed to community noise (Evans et al., 1995). Overnight resting levels of urinary catecholamines (adrenaline and noradrenaline) were significantly higher in children chronically exposed to aircraft noise than those unexposed cross-sectionally around the old-airport (Evans et al., 1995). Consistent with the elevations in blood pressure reported in the longitudinal analyses, adrenaline and noradrenaline increased sharply among children living in the flight paths of the new airport after it opened (Evans et al., 1998). Evans and colleagues did not find an association between chronic aircraft noise exposure and cortisol level in either the cross-sectional (Evans et al., 1995) or longitudinal (Evans et al., 1998) analyses.

1.4.2 Possible mechanisms to account for these noise effects

There has not been any theory that predicts precise mechanisms to account for how noise affects mental health. A main effect needs to be established before mechanisms can be hypothesised, and this has not been done. In general, mental health effects have been attributed as stress responses to the arousing properties of noise. The learned helplessness mechanism for motivation effects may also be a possible mechanism for these stress, annoyance, psychological and physiological effects. It has also been suggested that because noise exposure creates annoyance, it then may lead on to more serious psychological effects. This pathway remains unconfirmed, and it is more likely that noise causes annoyance, and independently, mental ill-health probably increases annoyance (Stansfeld & Haines, 1997). Whether anxiety, depression and self-reported health mediate the annoyance response will be explored in the present research. The possibility that the cognitive and motivation noise effects could be mediated by depression, anxiety and self-reported stress will also be explored in the present research.
The general pattern of endocrine and cardiovascular responses to noise is commensurate with noise exciting acute physiological responses, in the same way as other acute stressors (Stansfeld & Haines, 1997). It has been suggested that noise effects on blood pressure may be mediated through noise annoyance (Van Dijk, 1987; Lercher et al., 1993) and catecholamine secretion (Ising et al., 1985), and Passchier-Vermeer (1993) has a complex model that involves mediation through emotional disturbances such as discontent, anxiety and aggression. These mechanisms have never been directly tested and need to be tested in a controlled cohort study.

1.4.3 Research rationale
The evidence for noise effects on child mental and physical health range from the suggestive to the non-existent. Overall, it is difficult to relate noise directly to adverse effects on mental and physical health, because it is likely that the adverse effects of noise occur in conjunction with other stressors (Bell et al., 1996). It is also possible that general health functioning (e.g. headaches, sleep disturbance) might also be affected by exposure to noise in children in the same way as found in adults. Precisely because there is very little research testing whether noise directly affects child mental health, it warrants further study. The rationale and hypotheses for these mental health effects are exploratory because they are not based on strong predictions from previous research. The research in this thesis will focus for the first time on subclinical mental health effects of noise in children. In addition to testing whether noise has a main effect on subclinical mental health, the present research will explore whether depression, anxiety and annoyance mediate the cognitive and annoyance associations found with noise.
1.5 Methodological critique

Several important methodological issues have been touched upon in the review of previous research, that need to be more fully addressed. These methodological issues are important because they influence the size of effect and can further our understanding of how noise affects child health. Methodological issues can be divided into larger conceptual methodological issues that effect study design and more practical matters that affect research methods and data analysis. This methodological discussion, with a focus on field research, will selectively examine the following methodological topics: confounding factors, moderating factors, individual differences, sample bias, noise measurement issues, and practical limitations of previous research.

1.5.1 Confounding factors in the relationship between noise and health

Main effects of noise on health are usually small. The small effect sizes found may be due to other factors which confound the noise effects. In other words, supposed noise effects may be due to a third factor linked to both noise and the health outcome. Uncertainties remain as to how much previously found cognitive impairments in children can be attributed to noise effects because cognitive performance is also influenced by the quality of the school ('school effects': Cohen et al., 1980), main language spoken at home, and the level of social deprivation of the area in which the children live.

There is a substantial body of research showing that pupils from socially deprived areas have lower educational attainment than their counterparts from less disadvantaged areas (Higgs et al., 1997). Almost by definition, children from disadvantaged backgrounds are more likely than other children to live in a worse environment (Mortimore & Whitty, 1997) and these environmental factors may contribute to the poorer educational attainment. The interrelationship between environmental and social stressors are discussed in further detail in Chapter 5 SATS Study. Social class alone is not considered to be a satisfactory indicator of social disadvantage (Bartley, et al., 1994). This is because the Registrar General’s social classes are changing in size and composition as British social structure changes. In addition, as increasing numbers of people spend larger amounts of time outside the labour force, usual occupation becomes a less reliable indicator of living standards (Bartley et al., 1992).
Deprivation indices need to be understood and evaluated in terms of a) the purpose for which they are being used and b) the validity of the assumptions about social and economic life they embody (Bartley & Blane, 1994). Morris, Blane & White (1996) found that educational attainment was strongly associated with an index of social conditions. A more reliable measure of child disadvantage should combine social class with other indicators of disadvantage such as overcrowding and possession of household amenities to measure household deprivation (Bartley et al., 1994), such as Townsend’s Scale (Townsend et al., 1989).

1.5.2 Moderating factors in the relationship between noise and health
Apart from confounding effects, the impact of noise on health may be affected by moderating factors. Lepore & Evans (1996) give an example of a moderating factor as a resource or response that conditions the effect of the environmental stressor. The relationship between noise exposure and cognition, motivation, or health may be either increased or decreased by the presence of a moderating factor. A moderating factor can be distinguished from a mediating factor. A moderator indicates when and/or to what extent rather than how noise has an effect (Baron & Kenny, 1986). A mediating factor is part of the causal mechanism intervening between noise exposure and child performance outcome, whereas a moderating factor influences the size of effect. A moderator interacts with level of noise exposure (predictor variable) specifying under what conditions or when noise will have an effect. A moderator model requires an examination of the independent and conjoint (interactive) effects of noise and the moderating factor on an outcome (Evans & Lepore in press). This is most appropriately done by testing for a statistical interaction. To test for a moderating relationship the following conditions need to be considered: a) ideally the moderating factor should be uncorrelated with noise; b) a large sample size should be obtained because interaction tests tend to have low statistical power; c) an equal number of subjects within each of the groups in the design is desirable (Evans & Lepore, 1992).

The evidence suggests that both home (Evans et al., 1995) and school noise exposure (Cohen et al., 1980; Evans & Maxwell, 1997) are associated with deficits in reading in children (Evans, 1990). However, it may be that home noise exposure levels moderate school noise effects. Michelson (1968) has found that a quiet secluded place to study at home buffers the effect of school noise exposure on children’s reading ability. In
contrast, Cohen et al., (1980) found that living in a relatively quiet neighbourhood did not lessen the cumulative impact of exposure to noise at school.

Length of time exposed to the environmental noise source has been found to influence auditory distraction (Evans & Lepore, 1993), auditory discrimination (Cohen et al., 1973), reading (Cohen et al., 1973), attention (Cohen et al., 1980) and possibly school achievement results (Maser et al., 1978). These data suggest the trend that the greater the length of time exposed to noise, the more likely and larger the cognitive impairment. By contrast, the data from auditory distraction suggest that the longer the exposure the less likely the children are to be able to resist distraction. These auditory distraction results indicate that children may adapt to the noise source. Whereas the other cognitive results indicate a cumulative or sustained effect of exposure. Adaptive behaviours may reduce the immediate stress response, but the adaptive process itself may affect other aspects of child cognition and behaviour (Evans & Cohen, 1987). The issue of long-term adaptation to environmental stressors has only started to be addressed, and further longitudinal research is required (this will be discussed in further detail in Chapter 4, when introducing the follow-up study).

Even though it would seem that length of exposure to noise may influence the effect of noise on the outcome, it is questionable whether it can be interpreted as a moderating relationship. Length of exposure to noise is directly related to noise, thus violating a necessary condition that defines a moderating relationship, namely that the moderator and the predictor be unrelated. Differences in length of time exposed to noise can be thought of as increases in the ‘dose’ of the exposure.

1.5.3 Individual differences
Although there are clear overall trends showing that chronic exposure to noise is associated with impaired cognition over a range of functions, there may be individual differences in these effects. Some children in the population may be more vulnerable to noise effects than others. There is limited evidence that children who have lower aptitude (Cohen et al., 1986; Johansson, 1983; Maser et al., 1978) or other difficulties such as learning difficulties (Glenn et al., 1978; Lasky & Tobin, 1973) and cerebral palsy (Laraway, 1985) may be more vulnerable to the harmful effects of noise on cognitive performance. The evidence is not conclusive because some studies have not found any noise effects with learning disabled and hyperactive children (Fenton et al.,
However, the findings will depend on the sensitivity of the tests for the various populations.

Evans and Lepore (1993) claim that noise effects seem to be more pronounced in children from the upper elementary grades compared with their younger counterparts (Cohen et al., 1973; Evans et al., 1991; Green et al., 1982; Lukas et al., 1981; Maser et al., 1978). Cohen and colleagues (1986) found that the longer the children had been attending the noisy schools, the stronger the effects. This age related trend may be due to several reasons. Children in the upper grades generally have had longer noise exposure. It is also possible that cognitive measures may be more sensitive for older children and thus more reliable in measuring the harmful effects of noise. Although Evans & Maxwell (1997) found a significant noise effect on reading in children in younger grades (grades 1 and 2), it may be that the earlier studies did not detect noise effects in younger children because it is harder to reliably measure reading and school performance in younger children. It is still an open question as to when noise exposure begins to affect childrens’ cognitive functioning.

A further issue is whether girls and boys are equally effected by noise pollution. Smith & Jones (1992) claim that there is inconclusive evidence for sex differences in adults. In occupational settings, one study found that noise reduced the pace at which female subjects worked but had little effect on the rate of male subjects (Gulian & Thomas, 1986), although other studies have not found sex interactions (Edmonds & Smith, 1985; Loeb et al., 1982). In children the pattern of results is equally inconclusive and contradictory. Ising and colleagues (1990) found that high levels of low altitude military aircraft flights leads to an increase in systolic and diastolic blood pressure in girls but not boys; but conversely they found that noise significantly increased heart rate in boys but not girls. Hambrick-Dixon (1988) found that high levels of acute train noise significantly affected the attention of girls aged 5 -7 years, but had no effect on boys’ attention. Christie & Glickman (1980) have also found that girls may be more distracted by acute noise exposure. In studies of young children and infants, it would seem that boys are more susceptible to chronic noise related problems in comparison with girls (Wachs, 1978; 1987; 1989). Sex differences have also been found in the association between chronic residential crowding (people per room) and well-being in children aged 10 -12 living in urban India (Evans et al., 1998). Boys but not girls are adversely effected physiologically by crowding; whereas girls but not boys are more
vulnerable to the induction of helplessness. Given that there are known existing sex
differences in various health and performance outcomes at baseline, it is possible that
noise affects boys and girls in different ways. The nature of and reason for these
possible sex differences is at this stage unknown and warrants consideration in future
research.

1.5.4 Sample bias
Random assignment of subjects into environmental conditions in the field is virtually
impossible. Subjects are self-selected into environmental conditions. The different
environmental settings often vary on dimensions other than noise exposure. For
example, people more tolerant of negative physical conditions are probably over­
represented in studies of environmental stressors. Those least likely to adapt have
probably already moved away. These problems can be substantially reduced by
carefully matching the noise and quiet samples on important dimensions and by
statistically controlling for other possible confounding factors (Cohen et al., 1980).

1.5.5. Noise measurement issues
Some previous studies examining the effects of chronic exposure to aircraft noise on
school children’s performance, have conducted testing sessions in noisy conditions
(Cohen et al., 1973; Bronzaft & McCarthy, 1975; Sanz et al., 1993). These testing
conditions made it impossible to determine whether the noise effects were the result of
acute noise interference during the time of testing or whether the noise related deficits
were due to chronic exposure to noise. Other studies have tried to address this question
by controlling noise at the time of testing by using a sound proof laboratory (Cohen et
al., 1980; Evans et al., 1995) or by using head phones (Evans & Maxwell, 1997). The
same reading deficits found previously (Cohen et al., 1973; Bronzaft & McCarthy,
1975) have been found in these studies where noise at the time of testing is continually
controlled to be quiet (Cohen et al., 1980; Evans et al., 1995). These results have been
interpreted to suggest that chronic noise exposure is the cause of the noise related
reading deficits and that acute noise does not seem to influence the reading results.

There are three other general methodological noise measurement issues that need to be
briefly raised. First, estimating an individual’s noise exposure is a problem that
plagues all noise research in the field (Evans et al., 1991). Second, it is still unknown
whether noise effects occur after a specific threshold of exposure or whether there is a
dose-response function such that, as noise levels increase, so does the degree of the impairment. There is evidence for both a threshold (Hygge, 1994) and a dose-response (Green et al., 1982) relationship. Evans et al., (1991) argue that future research needs a larger range of noise exposure levels to determine dose-response relations. Third, one of the basic underlying assumptions of noise research is that people living in noisy environments do perceive the noise as stressful and as a threat. This assumption needs to be tested by measuring the way the sample perceives and appraises the noise. This may be especially important when studying children. The objective environmental conditions may only be important to the extent that they influence the individual’s perception of the environment.

1.5.6 Practical methods issues
Most of the previous research examining noise effects in children has serious practical methodological flaws limiting the conclusions that can be drawn from the data. These flaws include: data were not provided to indicate how well socio-economically matched the noise exposed children were to the control sample (Karsdorf & Klappach, 1968; Kyzar, 1977; Heft, 1979; ), sample size was not large enough to be representative (all of the studies); not enough schools to rule out a school effect confounding the results (Cohen et al., 1980, 1981, 1986; Evans & Maxwell, 1997; Sanz et al., 1993); statistical methods were not sensitive enough (Sanz et al, 1993) and most studies were cross-sectional. Future research needs to be designed to take account of potential confounding factors, taking repeated measures with a large sample of school children from many schools with a wide range of noise exposure.

1.5.7 Rationale for research methods
The results from two longitudinal field studies that control for socio-economic factors, show that chronic aircraft noise exposure is consistently and reliably associated with cognitive impairments in school children (Cohen et al., 1980; Evans et al., 1995). These well-designed field studies need to be methodologically extended in future research by measuring other potential confounding factors, investigating moderating factors, carefully matching samples, and extending noise exposure measurement. Given that previous research may have been confounded by socio-economic status and differences in quality between schools, the analyses in the present research examining chronic aircraft noise effects on children take into account UK specific social and educational factors that influence British children’s education. Home noise exposure
and length of time in the school environment are potential factors that may influence the relationship between school noise exposure and child performance and health. As noise effects are usually evident in children in upper elementary grades, this age group was selected to be the sample for the three studies in this thesis. In addition, children in primary school are in 'a critical period' for language and reading acquisition, which means that they may be more susceptible to factors that are detrimental for reading acquisition. Physical measures of the acute interference by aircraft noise at the time of testing will be supplemented by corresponding perceived measures of noise exposure.
1.6 Specific aims and thesis overview

Non-auditory health effects of environmental noise exposure in children clearly warrants further research. Previous research suggests that there are grounds for concern about the effects of chronic aircraft noise on cognition, motivation, blood-pressure, and annoyance in children. Past studies also indicate that endocrine disturbance and mental health may be affected by noise exposure. Throughout the discussion of previous work many areas for future research have been identified. However, the priority for the next stage of research is to confirm and clarify previous findings by further research. It is also critical to understand the mechanisms underlying the adverse health effects associated with chronic exposure to aircraft noise by testing and developing theories. As this is a relatively new field of research, there is also a need for exploratory work assessing the potential effect of noise on other health outcomes and possible new mediating factors.

The studies in this thesis aim to examine the effect of chronic exposure to aircraft noise on primary aged school children’s cognition, motivation and health. The main objective of this thesis is to test whether the cognitive effects previously found in children are attributable to noise and to test possible mechanisms.

The specific aims are:

1) To test whether chronic high levels of aircraft noise exposure in children are associated with a) cognitive impairments (in reading, memory, sustained attention, and school performance); b) deficits in motivation (behavioural performance task, attributional style, teacher rating); c) noise annoyance after adjustment for potential confounding factors (social deprivation, main language spoken at home, age and school effectiveness).

2) To test sustained attention as a mechanism to account for the effect of noise on cognition.

3) To examine how children adapt to aircraft noise over a one year period.
4) To assess whether there is any evidence that chronic noise exposure affects other health outcomes apart from noise annoyance: a) child stress responses (self-reported stress) and sub-clinical mental health (anxiety, depression, deviant behaviour) and b) whether these psychological factors mediate the association between noise exposure and cognitive impairment and noise annoyance.

5) To test whether environmental factors (length of time exposed to aircraft noise at school and home noise exposure) influence the relationship between aircraft noise and impairment of child health.

The studies in this thesis will address the limitations of previous research and will also extend previous research. These studies will be able to test more reliably than past studies whether chronic aircraft noise affects child health by taking into account UK-specific social and educational factors which influence British children’s education. For the first time, sustained attention and attributional style will be tested as mechanisms to account for noise effects. For the first time, multi-level modelling statistical techniques will enable the results to be adjusted for the potential confounding effects of school characteristics on associations between noise and performance. By measuring the effects of noise on a wider range of child stress and mental health outcomes, the research will explore the possibility that the adverse effects of noise exposure extend beyond cognitive and physiological effects.

**Overview of the studies.**

The first two classroom studies in this thesis are linked. They are a repeated measures field study comparing the cognitive performance, motivation and mental health of children attending four schools exposed to high levels of aircraft noise (>66 dBA 16hr outdoor Leq) with children attending four matched control schools exposed to lower levels of aircraft noise (<57 dBA 16hr outdoor Leq) around Heathrow Airport in West London. Study 1 was the baseline measure and Study 2 the follow-up. The final Study 3 was an multi-level analysis examining the effect of aircraft noise exposure on the performance of school children from 127 schools on pre-existing national standardised tests for English, Mathematics and Science after adjustment for potential environmental and social confounding factors.
Study 1 - Baseline Study - 1996

The first study involved the baseline cross-sectional comparison of child cognition, motivation and mental health between the two groups exposed to high and low levels of aircraft noise at school.

Hypotheses

(1) Chronic aircraft noise exposure produces cognitive impairments in reading comprehension, and long term memory recall in school children. No effects are expected on the control cognitive outcomes: recognition and short term memory.

(2) Chronic aircraft noise exposure decreases motivation and induces learned helplessness.

(3) Chronic aircraft noise exposure in school children will be associated with higher levels of annoyance by noise than children in schools exposed to lower levels of aircraft noise.

The following hypotheses are exploratory and are not based on strong predictions from previous research

(4) The prevalence of depression, anxiety, general psychological disturbance and health symptoms will be higher in high aircraft noise exposed schools than in low aircraft noise exposed schools.

(5) Depression, anxiety, noise annoyance and motivation may have a mediating relationship between chronic aircraft noise exposure and cognitive performance.

(6) Depression and anxiety may have a mediating relationship between chronic aircraft noise exposure and annoyance.

(7) Deprivation, main language spoken at home and acute noise levels at the time of testing may act as confounding factors on the association between chronic aircraft noise exposure and cognitive performance.
Chronic home aircraft noise exposure and length of time in the school environment may moderate the association between chronic aircraft noise exposure and cognitive performance.

**Study 2 - Follow-up Study - 1997**

Study 2 arose out of study 1. Study 1 was a cross-sectional study that confirmed an association between noise exposure at school and impairments in cognitive performance and aircraft noise annoyance. The question remained as to whether the noise effects persisted over time. The aim of Study 2 was to examine how children adapt to aircraft noise over the one year period and to test sustained attention as a mechanism to account for the reading comprehension results. A measure of self-reported stress was included at follow-up. Study 2 involved follow-up measures taken one year after baseline on the same sample of school children.

**Hypotheses**

1. Chronic aircraft noise exposure produces cognitive impairments in reading comprehension. *(Between subjects analysis)*

2. Chronic aircraft noise exposure produces a delay in the progress of reading comprehension over the period of a year. *(Within subjects analysis)*

3. Sustained attention mediates the noise effects on reading comprehension. *(Between subjects analysis)*

4. Chronic aircraft noise exposure produces cognitive impairments in sustained attention. *(Between subjects analysis)*

5. Chronic aircraft noise exposure in school children is associated with higher levels of noise annoyance. *(Between subjects analysis)*

6. The baseline psychological mediating results are replicated. Specifically:
   6.1 That depression, anxiety, self-reported stress and noise annoyance do not mediate the relationship between chronic aircraft noise exposure and cognitive performance.
   6.2 That depression, anxiety and self-reported stress do not mediate the relationship between chronic aircraft noise exposure and annoyance.
The following hypotheses are exploratory and are not based on strong predictions from previous research. It is hypothesised that:

(7) Chronic aircraft noise exposure in school children will be associated with higher levels of self-reported stress than children in schools exposed to lower levels of aircraft noise. (*Between subjects analysis*)

(8) Parental interest in school work influences the effect of noise on cognitive performance. (*Between subjects analysis*)

**Study 3 - SATs Study - 1998**

The results from studies 1 & 2 suggest that aircraft noise exposure affects reading comprehension, but this relationship may be confounded by social class and school quality. The aim of Study 3 was to analyse the National Standardised Scores (SATS) for Key Stage 2 in Mathematics, Science and English from the primary schools in three boroughs around Heathrow Airport to examine the effect of chronic exposure to aircraft noise on school performance. The multi-level analyses involved a cross-sectional comparison between noise exposure and performance in a samples of students using the 1996 and 1997 results. The analyses were at both the school and individual level, controlling for socio-economic, environmental and school quality factors.

**Hypotheses**

1) Chronic exposure to aircraft noise at school is associated with poorer performance in English after adjustment for school effects. Noise effects will be larger for the reading performance than for spelling, writing and handwriting performance.

2) Chronic exposure to aircraft noise at school is not associated with poorer performance on the control outcomes, of Mathematics and Science after adjustment for school effects.

The following hypothesis is exploratory and is not based on strong predictions from previous research. It is hypothesised that:

3) The effects of noise on performance are a dose-response function such that: the impairments in school performance will monotonically increase as noise exposure levels rise.
CHAPTER 2

Methods for Study 1: Baseline and Study 2: Follow-Up
The methods for the repeated measures classroom study (Study 1-Baseline and Study 2 - Follow-up) will be outlined in this chapter which is ordered into 5 main sections: 1) design, 2) sample, 3) selection and matching of schools, 4) materials and 5) procedures. The methods used at baseline were generally adhered to at follow-up; the main differences lie in the measures taken. These differences will be noted within each section with separate sub-headings for both the baseline study and the follow-up study.

2.1 Design

In this repeated measures study, the school performance and health of children attending four schools exposed to high levels of aircraft noise (16-hr outdoor Leq > 66 dBA) were compared with four matched control schools exposed to lower levels of aircraft noise (16-hr outdoor Leq < 57 dBA) around Heathrow Airport. The children first examined at baseline in 1996 were examined again after a period of one year at follow-up in 1997. The schools were chosen such that children were matched across high and low aircraft noise by: age, sex, and sound level at the school from non-aircraft sources; existing noise protection in the schools; socio-economic status and ethnicity of electoral wards. There is no reason to assume that these matching criteria would have changed over the year between baseline and follow-up. The children were already randomly selected into mixed-ability classes. The performance measures and health questionnaires were group administered in the classrooms. Teachers and parents of all the school children were given a questionnaire to complete at baseline. Noise measurements were conducted in the schools at the time of testing to assess acute noise exposure at both baseline and follow-up.

2.2 Sample

*Baseline sample*

Eight co-education state primary schools were chosen according to the noise exposure of the school area. The participants were 340 fourth (n=163) and fifth (n=177) grade pupils (mean age = 9 years and 8 months). 169 attended school in a high-aircraft noise-impact urban area (16-hr outdoor Leq > 66 dBA) and 171 attended school in a low-aircraft noise-impact urban area (16-hr outdoor Leq < 57 dBA) surrounding Heathrow Airport in West London. The participants were 169 boys and 171 girls, 21 teachers and 284 parents.
The participants from 7 schools were selected randomly in whole classes from all the classes in year 4 and 5, that is the classes or the individuals were not selected according to academic achievement nor on a volunteer basis. The headteacher of each school was asked to choose a class in year 4 and 5 which was representative of that year at the school. None of the classes selected were streamed but a class provided by one school, although not supposedly streamed, had a higher proportion of children of lower ability than others in the school (see methods section 2.5.5 procedural error for a discussion of the 8th school). All pupils in the selected classes were eligible to be approached for the study (see exclusions section 2.5.5). In each selected class every child was eligible to take part in the study and every child in the class was invited to take part in the study. (See results section in chapter 3 for the socio-demographic characteristics of the sample and response rate).

**Follow-up sample**
The participants were 275 fifth (n=121) and sixth (n=154) grade pupils (mean age = 10 years and 8 months) first tested in 1996 at baseline. 148 attended school in a high-noise-impact urban area (16-hr outdoor Leq > 66 dBA) and 127 attended school in a low-noise-impact urban area (16-hr outdoor Leq < 57 dBA) surrounding Heathrow Airport. The participants were 132 boys and 143 girls. (See results section in chapter 4 for the socio-demographic characteristics of the sample and response rate).

### 2.3 Selection and matching of schools

**The selection procedure**

The selection and matching of the schools was a four stage procedure.

**First**, all co-education state primary schools were examined in the Boroughs of Hounslow, Hillingdon, and Windsor and Maidenhead around Heathrow Airport. Although Windsor and Maidenhead were also considered for inclusion in this phase of the study, it seemed that the social class matching between Windsor and Maidenhead and Hounslow schools was going to be problematic and that closer matching would be obtained between high noise schools in Hounslow and comparable low noise schools in Hillingdon and Hounslow.
Initially, in Hounslow 17 schools were considered in higher aircraft noise areas and 8 schools in low aircraft noise areas. In Hillingdon 18 schools were considered in low aircraft noise areas.

Second, the selection of the high noise schools preceded the selection of the low noise schools. Hounslow, an area of high aircraft noise exposure seemed a suitable setting for selecting the high noise schools because of: (i) intensity of sound level from aircraft fly-overs and (ii) geographical extent of high noise exposure.

Third, the high noise schools were chosen and matched to the control schools according to the following criteria in this order of priority:

i. **Age of children**
The age of the children was matched across high and low noise schools by choosing children in classes 4 and 5.

ii. **Noise level**
High noise schools were selected to be exposed to more than 63 Leq-16hr dBA according to the 1991 published contours of 16 hour outdoor Leq. Low noise schools were selected to be exposed to less than 57 Leq-16hr dBA. (NB: In fact, all the high noise schools selected were exposed to more than 66 Leq-16hr dBA according to the 1994 CAA contours) Noise contour data from the published 1991 CAA noise contour maps was obtained from the Environmental Protection Unit in Hillingdon and Environmental Services in Hounslow. High and low noise schools were chosen not to be exposed to high levels of other sources of environmental noise and other significant noise sources were deliberately avoided. Site inspections were carried out to observe directly whether schools to be selected were exposed to high levels of other sources of environmental noise. Achieving this criterion was confirmed by noise measurements during testing which are reported in the results section.

iii. **The extent of existing noise protection in the schools**
The presence of double glazing in the school was taken into consideration. High noise schools selected for the study could not have any existing double glazing as this might ameliorate the effects of chronic aircraft noise exposure. These data were obtained
from the property divisions of the Education Department in Hounslow and Education Services in Hillingdon.

iv. *Socio-Economic Group*
Schools were then matched on socio-economic group distribution and unemployment rate of the surrounding area based on electoral ward analysis obtained from the 1991 census. The census data were obtained from the Department of Planning and Transport in Hounslow (Census 1991 Hounslow, Summary Census Data for Wards small area statistics), The Local Services Group in Hillingdon (Hillingdon Census Monitor 1991 Census 100% Small Area Statistics; Hillingdon’s Ethnic Communities 1991 Census; Hillingdon Employment Monitor 1991 Census 10% Small Area Statistics) and The Forward Planning Unit in Windsor and Maidenhead.

v. *Ethnicity*
Proportion of ethnic groups attending the school was a matching variable to counter any potential cultural and language differences that may effect cognitive performance and motivation across the noise samples. The proportion of ethnic groups in the school wards and in the schools were matched, as far as this was practicable, across the schools. The proportion of ethnic groups living in the school wards were obtained from: The Department of Planning and Transport in Hounslow (small area statistics), The Local Services Group in Hillingdon, Forward Planning Unit in Windsor and Maidenhead. The proportion of ethnic groups of children attending the schools were obtained from: Education Department in Hounslow and Education Services in Hillingdon. It was difficult to match the high and low noise schools on ethnicity because of the difference in proportion of Asians living in Hounslow and Hillingdon. From the 1991 Census the proportions of white residents in Hillingdon was 87.1 %, and in Hounslow was 75.5 %, the proportion Asian residents living in Hillingdon was 9.6 %, and in Hounslow 19.7%. As ethnicity was the fifth matching criteria and because ethnic differences could be controlled for in the statistical analysis it was given less priority than the other variables above.

vi. *Exposure to other sources of environmental noise*
School site environmental inspections were carried out to examine whether the schools were exposed to road and rail noise and any other source of environmental stress (e.g air pollution).
Schools selected

See Tables 1 and 2 below for the 8 schools selected. Appendix 1 contains 4 tables which demonstrate the extent to which each pair of schools was matched on the background variables.

Thirteen schools with high aircraft noise exposure were not selected for the following reasons: 1 could not participate; 3 had double glazing; 2 had noise levels that were not loud enough (because the schools were not on a flight path); 2 Special Schools; 1 Non-State School; 2 did not have students in the correct age range; 1 was not able to be ethnically matched; and, 1 had high levels of road traffic noise.

Twenty-two schools with low aircraft noise exposure were not selected for the following reasons: 7 refused to participate; 3 had high levels of road traffic; 7 could not be matched environmentally (e.g. they were rural, placed in a housing estate); 5 could not be matched socio-economically.

It was more difficult to get the schools exposed to low levels of aircraft noise to agree to participate in the research than the schools exposed to high levels of aircraft noise. In the second set of schools the first preference of matched pairs was not possible. Six schools did not agree to participate because testing was later on in the school year when other commitments were given priority. Testing in the second four schools (2 noise exposed and 2 control schools) was conducted in May and July 1996 because the proposal to extend the study was granted in January 1996.

Table 1.
The schools selected for the March 1996 testing. (Chapter 2 Methods)

<table>
<thead>
<tr>
<th>School exposed to high levels of aircraft noise</th>
<th>The matched school exposed to low levels of aircraft noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 Bedfont Junior</td>
<td>Strand on the Green Junior</td>
</tr>
<tr>
<td>Pair 2 Chatsworth Junior</td>
<td>Hermitage Junior</td>
</tr>
</tbody>
</table>
Table 2.
The schools selected for the May 1996 testing. (Chapter 2 Methods)

<table>
<thead>
<tr>
<th>School exposed to high levels of aircraft noise exposure</th>
<th>The matched school exposed to low levels of aircraft noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wellington Primary</td>
<td>Wood End Park Junior</td>
</tr>
<tr>
<td>Springwell Junior</td>
<td>Feltham Hill Junior</td>
</tr>
</tbody>
</table>

2.4 Materials

Baseline

The content and wording of all the questionnaires and tasks were designed for an 8-11 year old sample. A pilot study was conducted in February 1996 to test the procedure and materials on an 8 year old sample at Gillespie Road Primary School in Highbury. See Appendix 2 for the pilot study report.

One questionnaire per testing session was administered to the child participants. There were two versions of the cognitive questionnaires and three versions of the psychological scales. See Table 3 below for an outline of the parts of the 3 child questionnaires at baseline. See Table 4 below for an outline of the parts of the 3 child questionnaires at follow-up.

Follow-up - main changes to note about the questionnaire

Subjects who had version 1 of the Suffolk reading scale and long term memory task in 1996 had version 2 in 1997 and those that had version 2 in 1996 had version 1 in 1997. The version order was alternated over the two years in order to reduce the possibility of an effect of experience influencing cognitive performance. Measures of short-term memory, attributional style and motivation that were taken in 1996 were not measured again in 1997. The short-term memory results in 1996 did not need to be replicated over time. As there were doubts after baseline about the reliability and validity of the motivation measure it was not included in 1997. Attributional style was not included because it showed no effect at baseline. Sustained attention and stress were measured for the first time in 1997. The Health and Environment Questionnaire was expanded in 1997 to include more detailed questions on class room noise interference and a measure of parental involvement in school work and reading.
Table 3.
Baseline - An outline of the parts of the 3 child questionnaires. (Chapter 2 Methods)

<table>
<thead>
<tr>
<th>Day</th>
<th>Sections</th>
<th>Version and Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>DAY 1</strong> (see Appendix 3)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Socio-Demographic</td>
<td>1) Name [2] Sex [3] Race [4] All the languages spoken at home [5] The main languages spoken at home</td>
</tr>
<tr>
<td>1</td>
<td>Reading Passage</td>
<td>Version 1: Our Friend the Dolphin [Version 2: Top Secret]</td>
</tr>
<tr>
<td></td>
<td><strong>DAY 2</strong> (see Appendix 4)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Consent Form</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Long Term Memory</td>
<td>Version 1: Our Friend the Dolphin [Version 2: Top Secret]</td>
</tr>
<tr>
<td>2</td>
<td>Reading Comprehension</td>
<td>Suffolk Reading Comprehension Test Level 2 [Version 1: Form B [Version 2: Form A]</td>
</tr>
<tr>
<td></td>
<td><strong>DAY 3</strong> (see Appendix 5)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Psychological Scales</td>
<td>Version 1 &amp; 2 &amp; 3 alternate order of: [Child Depression Inventory [Child Attributional Style Questionnaire [Child Manifest Anxiety Scale</td>
</tr>
<tr>
<td>3</td>
<td>Short term memory</td>
<td>6 trials of a serial digit recall task</td>
</tr>
<tr>
<td>3</td>
<td>Motivation</td>
<td>Two puzzles adapted from Glass &amp; Singer's after-effects paradigm by Evans, Hygge and Bullinger (1995) used in the Munich Airport Study</td>
</tr>
</tbody>
</table>
Table 4.
Follow-up an outline of the parts of the 3 child questionnaires * (Chapter 2 Methods).

<table>
<thead>
<tr>
<th>Day</th>
<th>Sections</th>
<th>Version and Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>DAY 1</strong> (see Appendix 6)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Information Sheet</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Reading Passage</td>
<td>Version 1: Our Friend the Dolphin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Version 2: Top Secret</td>
</tr>
<tr>
<td></td>
<td><strong>DAY 2</strong> (see Appendix 7)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Consent Form</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Long Term Memory</td>
<td>Version 1: Our Friend the Dolphin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Version 2: Top Secret</td>
</tr>
<tr>
<td>2</td>
<td>Reading Comprehension</td>
<td>Suffolk Reading Comprehension Test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Level 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Version 1: Form B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Version 2: Form A</td>
</tr>
<tr>
<td></td>
<td><strong>DAY 3</strong> (see Appendix 8)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Psychological Scales</td>
<td>Version 1 &amp; 2 &amp; 3 alternate order of:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child Depression</td>
</tr>
<tr>
<td>3</td>
<td>Health and Environment Questionnaire</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child Manifest Anxiety Scale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lewis Child Stress Scale *</td>
</tr>
<tr>
<td>3</td>
<td>Sustained Attention</td>
<td>1) General Symptoms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) General perception of environmental hazards apart from noise</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3) Parental involvement in their child’s school work and reading *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4) Self reported home and school noise exposure from 4 sources of environmental noise: trains, road traffic, planes, neighbour noise</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5) Noise annoyance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6) Expanded questions of level of noise interference in classroom activities *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7) Emotional response to aircraft noise</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 measures from the Tests of Everyday Attention for Children (TEACh) battery.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1) Code Transmissions *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Score *</td>
</tr>
</tbody>
</table>

* New Measures included in 1997
2.4.1 Cognitive measures

At baseline measures were taken of: reading comprehension, long term and short term memory. At follow up repeat measures were taken of reading comprehension and long term memory. Sustained attention was measured for the first time at follow-up.

Baseline Cognitive Measures
These measures were: reading comprehension, long term and short term memory

Reading Comprehension
A nationally standardised reading comprehension test was used to replicate the German standardised reading comprehension measure used in Munich (Evans et al., 1995). Reading comprehension was measured by the Suffolk Reading Scale (Hagley, 1987) Level 2 with 2 versions (Form A & B). The Suffolk Reading Scale was designed to measure the reading ability and reading standards of 6 year 4 month to 13 year 11 month students in the United Kingdom. The Level Two Suffolk Reading Scale contains 70 multi-choice questions with 4 potential answers. The task was introduced as ‘a complete the sentence activity’. The task was conducted in the classroom without talking and timed out after 30 minutes. The children was instructed to:

“Please choose which word fits best into the sentence. Look at each of the five words underneath the sentence. Sometimes more than one word will fit into the sentence. Decide which one fits best. Circle the word that fits in best. You may find some items more difficult than others. If you are not sure circle the one that you think fits best. Only miss out a sentence if you really can not do it.”

For example:

1. You drink from a ____________.

been bus cup hop tack

The Suffolk Reading Scale was chosen over other reading comprehension scales because: a) it was normed for use on a racially and socio-economically mixed sample (Hagley, 1987); b) it has 2 forms which are required for follow up research; c) it
produces a standardised score. The Suffolk Reading Scale was standardized on a large randomly selected and representative national sample of 38,625 primary aged school children. The scale has good construct validity as the Suffolk Reading Scale was highly correlated with teacher’s estimates of reading ability (Hagley, 1987). The test-retest reliability of scores and correlation between the parallel forms and internal consistency were high (Hagley, 1987). Age standardised scores range from: -70 up to +130. The higher the score the greater the reading comprehension.

**Long Term Memory**

Long term memory was measured by a task designed to model the long term memory task used in the Munich study (Evans et al., 1995). The task was designed to measure the recall and recognition of reading material one week after reading the passage.

The reading passages were taken from *Comprehension Plus Book 2* (Hunt, 1985). The child was instructed to:

“Read this passage very carefully in silence. You will be asked questions about it next week. Try to remember as much as you can. If you can’t understand a word please raise your hand and I will help you.”

Two tasks called *Our Friend the Dolphin* and *Top Secret* were administered to test for a passage effect (Hunt, 1995). The two reading passages each one page long (with a small descriptive picture) were administered one week prior to the long term memory task. The time to read the passage was not timed. The long term memory task was timed out after 10 minutes. The recognition task involved 6 multi-choice questions. The recall task involves 3 open questions requiring written recall answers. Two scores were calculated: 1) recognition task score was the number of correct items in the multi-choice task, 2) recall task score was calculated by coding the written recall items using a method similar to that of Evans et al., (1995) (see Appendix 9 for the scoring manual).

**Short Term Memory**

Short term memory was measured by 6 trials of a digit serial recall task (2 five digit trials, 2 seven digit trials and 2 nine digit trials). The answers were scored for correct serial recall. The total short-term memory score was calculated by summing the average score across the 2 trials of the same length. Six trials were recorded on tape. The tape was played in the classroom. If any source of noise or class-room disturbance
interfered with sound perception on any trials then the trial was re-played. There was no need to replay the tape due to noise interference. The child was given 15 seconds to write down the answers. The child was instructed:

“When the numbers have stopped please write down the numbers you have just heard in the order you heard them on the sheet. You will be given 15 seconds to write them down.”

**Follow-up Cognitive Measures**

These measures were: reading comprehension (same as above), long term memory (same as above) and sustained attention.

**Sustained Attention**

Sustained attention or vigilance was measured with 2 sub-tests taken from the Tests of Everyday Attention for Children (TEACh) battery of measures for the assessment of attention in children (Manly et al., 1998, version A). This standardised and normed clinical assessment battery of measures of different attentional functions is designed for children from the ages of 6 to 16. Code Transmission and Score sub-tests were used, both group administered in the classrooms with a tape cassette. If any source of noise or class-room disturbance interfered with sound perception on any trials then the trial was re-played. There was no need to replay the tape due to noise interference. The first trial of Score had to be replayed in year 6 of Springwell Junior (high noise school) because of a classroom disturbance. TEACh is designed for individual assessment and testing should take place on a one-to-one basis, so the results may not entirely match up with the normative data. Advice was taken from a member of the team who developed the test and he felt that group administration of Score and Code Transmissions would still provide valid results (Tom Manly, personal communication).

**Score** is a version of one of the best validated measures of sustained attention in adults (Manly et al., 1998). In Score children are asked to imagine that they are keeping score by counting the scoring sounds in a computer game. This test measures ability to count tones with irregular inter-stimulus intervals. The children were instructed with: “This test is all about counting. I am going to play you this tape and you have to count how many sounds you hear - as if you were keeping score by counting the number of scoring sounds in a computer game.... For each game count the number of sounds and write
down how many you heard.” The children were not allowed to count on their fingers. There are 10 trials each scored for correct number of items counted. The raw scores range from 0 - 10. The higher the score the better the sustained attention.

**Code transmissions** is a continuous performance test of sustained attention. During this task children must sustain their attention on a rather monotonous series of spoken digits and detect rare targets. The children are asked to listen to a 12 minute tape segment of spoken numbers that will contain a code. They have to listen out for a two digit sequence and report the target number that came immediately before to break the code. The test has 40 such targets. The children were instructed with: “On the tape there is going to be a very long list of numbers between 1 and 9. You have to find certain numbers in the list, like a code. The code is that you have to listen out for two 5’s in a row. A 5 on its own is no good. It has to be two 5’s in a row. When you hear two 5’s in a row you have to tell me the number that came just before.” If the children did not remember the target number they were instructed to mark the score sheet with an X. The test sheet was scored for correct serial recall of target items. The raw scores range from 0 - 40. The higher the score the better the sustained attention.

An auditory sustained attention task was chosen over a visual task because it is less likely to be confounded by visual and reading abilities. This sample of children was known not to have any hearing difficulties from parental reports taken at baseline, that could potentially effect an auditory task. These tests are designed to be appealing to younger children without patronising older children. The tone of the tests is one of games, particularly the style and imagery associated with computer games that gives the assessment greater ecological validity. Ecological validity in the context of neurocognitive tasks, refers to the capacity of a measure to tap skills which are required in day-to-day life rather than skills that are required to perform successfully in a laboratory.

Normative data from 293 children are currently being collected and analysed, however some preliminary results are known (Manly *et al.*, 1998). The test re-test correlation coefficients after 6-15 days re-administration were high for both Score and Code Transmissions. The results for Code transmissions were r=0.779 and Score had a percentage agreement of 76.2% (this was because SCORE had a ceiling effect). The pattern of results comparing these two measures of sustained attention with other
cognitive measures provide further indication of the validity of TEACH, especially the SCORE task. As expected SCORE did not correlate with measures of selective attention and IQ of general ability (WISC-R) but it did correlate significantly with measures of response impulsivity and reading, spelling and arithmetic achievement scores. Code Transmissions correlated with all the cognitive tests namely: selective attention, response impulsivity, IQ and reading, spelling and arithmetic achievement scores. These correlations indicate that SCORE is a highly sensitive measure of sustained attention in non-clinical children, but that Code Transmissions may not be as reliable and may measure a more specific ability. These psychometric results were obtained after both these measures were selected and administered in 1997. The test developer advised that the Code Transmission is a better measure of sustained attention in a clinical sample (AD/HD) rather than a non-clinical sample (Tom Manly, personal communication). This matter will be raised again in the discussion section of Chapter 4 when interpreting the TEACH results.

2.4.2 Motivation measures

Motivation was measured only at baseline, in 3 ways: child performance measure (Glass and Singer, 1972 puzzles: Evan et al., 1995); child self reported attributional style (Child Attributional Style Questionnaire: Seligman et al., 1984) and teacher rating of child motivation (Student Behaviour Checklist: Fincham et al., 1989).

Performance Measure
Two puzzles adapted from Glass & Singer’s after-effects paradigm animal puzzle used in Munich test were used to measure motivation (Evans et al., 1995). Soluble and insoluble puzzles have been used as a performance measure of motivation in other studies of school children (Hokoda et al., 1989). The puzzles consisted of pictures of animals and food connected together by lines. The child was instructed to touch each object along the connecting lines without lifting their pencils or retracing any line. The child attempted the first puzzle until they gave up or wanted to start the next puzzle. The initial food puzzle was insoluble and the index of motivation was the number of attempts to solve this puzzle (Evans et al., 1995). The second animal puzzle was soluble. The order of the puzzles was deliberately fixed so that each child would experience success following initial failure on the first food puzzle. The task to complete the two puzzles was timed out at 10 minutes. The children were placed in
small groups of 3 - 6 with different researchers to record completion time in minutes and seconds, to answer questions and monitor that the children completed the puzzles individually.

**Child Attributional Style**

Attributional style was measured with the revised measure of the Child Attribution Style Questionnaire (CASQ; Kaslow & Nolen-Hoeksema, 1991). It includes 24 forced-choice items consisting of hypothetical situations. The child was instructed to imagine the event happening to them, then to choose which of the two explanations best describes why the event would happen to them. For example: ‘You make a new friend’ and two possible explanations for why the event occurred e.g. ‘I am a nice person’ versus ‘The people that I meet are nice’.

The scale was revised on the basis of the item analyses obtained on the earlier 48 item questionnaire (Seligman et al., 1984). The scale was shortened to make it easier to administer to groups of children. Half of the situations represent positive (good) outcomes and half negative (bad) outcomes. Three dimensions of attributions (internal-external, stable-unstable, global-specific) are assessed. Positive composite and negative composite scores are derived. The lower the positive and the higher the negative composite score, the more depressive the attributional style. An overall composite score is obtained by subtracting the composite score for the negative events from the composite score for the positive events. The lower this overall composite score, the more depressive the attributional style.

A number of researchers have examined the psychometric properties of the CASQ and the revised CASQ (e.g., Nolen-Hoeksema et al., 1986; Panak & Garber, 1992; Seligman et al., 1984). The Cronbach Alpha’s measures of internal consistency in healthy samples are moderate, ranging from .47 to .73 for positive composite scores and from .42 to .67 for negative composite scores (Gladstone & Kaslow; 1995). The internal reliability of the overall composite score has been reported to be .62 (Gladstone & Kaslow; 1995). The CASQ has been shown to be temporally stable over time, with test-retest reliabilities of .61 for the overall composite score over 3 months, .71 and .66 for positive and negative events, respectively, across 6 months, and .35 for the overall composite over 12 months (Gladstone & Kaslow; 1995).
**Student Behaviour Checklist**

Teachers were asked to rate, on the 24 item Student Behaviour Checklist (SBC; Fincham *et al.*, 1989), the extent to which a child engages in learned helplessness or mastery oriented behaviour. They are asked to rate the observed motivation level of each child in the classroom on the mastery orientated (e.g. 'expresses enthusiasm about his/her work') and learned helpless (e.g. 'when s/he begins a difficult problem, his/her attempts are half hearted') subscales. Teachers rate on a 5-point scale the frequency with which a child engages in each behaviour. 3 scores are produced: 1) scores on the 12 learned helplessness items are summed to give a total learned helplessness score; 2) scores on the 12 mastery oriented items are summed to give a total mastery oriented score; 3) a total learned helplessness score.

SBC has high internal consistency and stability. Fincham & Cain (1984) reported coefficient alphas of .90 for the learned helplessness scale and .94 for the mastery oriented scale of the Student Behavior Checklist. Fincham, Kokoda, & Sanders, (1989) in their 2 year follow up study report a coefficient alpha at time 1 = .96 and at time 2 Alpha = .95. Fincham, Kokoda & Sanders (1989) reported a significant test-re-test correlation (r=.49, P<.01) of the SBC after 2 years. The SBC has good construct validity. Fincham, Kokoda, & Sanders (1989) reported that SBC was significantly correlated with a self report of learned helplessness the Children’s Ability Effort Scale (CAES) (r = -.36, p<.01) on a sample of 5th grade children. The SBC was significantly correlated with the child self-report scale the Children’s Attributional Style Questionnaire (CASQ) (Nolen-Hoeksema *et al.*, 1986). The SBC was included as an additional measure of motivation because SBC measures learned helplessness in relation to academic performance. The higher the total score the greater the learned helplessness.

### 2.4.3 Stress and psychological health measures

At baseline measures were taken of: annoyance, depression and anxiety and parent report of poor behaviour and child psychological well-being. At follow up repeat measures were taken of annoyance, depression and anxiety. Self-reported stress was measured for the first time at follow-up.

**Baseline Measures**

These measures were: annoyance, depression and anxiety, mood and parent report of deviant behaviour.
Annoyance
Noise annoyance was measured with 7 child adapted standard questions (Fields, 1992; 1997). These questions assessed the level of annoyance (very much, quite a bit, a little, not at all) felt by the child when they heard 4 sources of environmental noise at home and school. The sources of environmental noise were: aircraft noise, train noise, road traffic and neighbours noise (only at home). Aircraft noise at school was the annoyance item used in the analyses. The higher the score the higher the noise annoyance (range 0 - 3).

Depression
Depression was measured with the short version of the Child Depression Inventory (CDI; Kovacs & Beck, 1977, modified for an English sample, Charman, 1994). The CDI is the most widely used instrument to measure childhood depression in children from 8 - 16 years old (Kazdin, 1981). The CDI is a 14-item forced choice self-report inventory measuring depressed mood. The child is asked to indicate which of 3 descriptions best fits how they have been feeling over the past two weeks (e.g. ‘I am sad once in a while, I am quite often sad, I am sad all the time’). The items are drawn from the emotional, motivational, cognitive and somatic symptoms of depression. It takes 10 minutes to complete. The scores range from 0 - 28. The higher the score the greater the depressed mood. The short version of the CDI is just as sensitive as the longer version of the CDI (Personal communication Dr. Fundudis). The CDI has relatively high internal consistency and stability (Carlson and Cantwell, 1980; Finch et al., 1985; Fundudis et al., 1991; Helsel & Matson, 1984; Saylor et al., 1984; Smucker et al., 1986). The cut off score for a high rate of depression was 9 which was based on the score used in past studies (Carlson & Cantwell, 1980, Fundudis et al., 1991). This cut off has been used as a criterion for screening children with a depressive episode (Carlson & Cantwell, 1980).

Anxiety
Anxiety was measured with the Revised Child Manifest Anxiety Scale (CMAS; Reynolds & Richmond, 1978). The CMAS is a 28 item forced choice self report inventory of chronic anxiety reactions. The child is asked to indicate by answering yes or no whether a statement is generally true about themselves (e.g. ‘You are afraid of a lot of things’). The scores range from 0 - 28. The higher the score the greater the anxiety. Included with this scale is a 9 item lie scale, with a range of 0 - 9.
The CMAS produced a high Kuder-Richardson reliability estimate of .85 in a cross validation study of the revised scale (Reynolds & Richardson; 1978). The cut off score for a high rate of anxiety was 17 which was based on the normative data reported in Reynolds & Richmond (1978). They reported a group mean on the anxiety scale of 13.84 with a standard deviation of 5.79. The cut off of 17 was selected because it was just more than half a deviation above the mean.

Modified Rutter Parent Questionnaire

The Modified Rutter Parent Questionnaire is an expanded version of the Rutter A2 questionnaire (Rutter et al., 1970). The Revised scale contains 8 health items, 5 habit items and the 25 item Strength and Difficulties Questionnaire (SDQ). The Strength and Difficulties Questionnaire asks about 25 attributes, 10 of which are considered strengths (e.g. ‘thinks things out before acting’), 14 of which are considered difficulties (e.g. ‘often unhappy, down-hearted or tearful’) and one of which is neutral (‘gets on better with adults than with other children’). Each item is marked as ‘not true’, ‘somewhat true’ or ‘certainly true’. This SDQ contains 5 sub-scales: hyperactivity scale, emotional symptoms scale, conduct problems scale, peer problems scale, prosocial scale. A total difficulties score can be calculated ranging from 0-40. The Rutter Health and Habits section can be scored in the standard way to generate scores for probable disorder, conduct problems, emotional symptoms (Rutter, 1967, Rutter et al., 1970; Schachar, Rutter & Smith, 1981).

Scores derived from the parent SDQ and the Rutter Questionnaire were found to be highly related (total difficulties score r=0.88 ) (Goodman, 1997). Goodman, 1997 concluded that: ‘given the well-established validity and reliability of the Rutter questionnaires (Elander & Rutter, 1995), the high correlation between the total scores generated by the SDQ and the Rutter questionnaires is evidence for the concurrent validity of the SDQ’. The ROC analyses reported in Goodman (1997) indicated that the SDQ had equivalent predictive validity to the Rutter questionnaire. These results indicate that the revised questionnaire has equivalent predictive validity with the Rutter Questionnaire (Goodman, 1997). The modified version of the Rutter A2 was used because it has the advantage of focusing on children’s strengths as well as weaknesses which a) increases parent compliance and b) reduces possible halo effects. The total deviance score is a summation of hyperactivity, emotional, conduct and peer problems subscales. The higher the score the greater the total deviance.
Follow-up Measures
These measures were: annoyance (same as above), depression (same as above), anxiety (same as above) and self-reported stress.

Self-Reported Stress
Child stress was measured with the child stress scale (Lewis et al., 1984). The scale consists of 20 stress-provoking circumstances that were generated through interviews with children concerning sources of stress in their lives. The child stress scale was selected because it defines 'stress' from the child's perspective and has been used in previous research with children (Lewis et al., 1984; Lewis & Lewis, 1985; Brown & Siegel, 1988). The 20 items included situations that would make children feel bad (e.g. not having homework done on time), nervous (e.g. changing schools) or worried (e.g. not getting along with your teacher). The 20 items were repeated in two subscales. The first scale asks the children to rate how bad would they feel if each of the 20 situations happened to them on a 5 point scale: 'not bad', 'a little bad', 'pretty bad', 'very bad', 'terrible'. The second scale asks the children to rate how often each of the 20 situations happened to them on a 5 point scale: 'never', 'once or twice', 'sometimes', 'often', 'all the time'. Three scores were used in the analysis: 1) a perceived stress score: a summation of the first scale how bad would they feel if an event happened to them, 2) a frequency score: a summation of the second scale to calculate how often negative life events had occurred, 3) An overall stress score is calculated by individually multiplying each item from the first scale ('how bad they would feel') by the second scale (frequency of occurrence) and summing the total for the 20 items.

Normative data from 2,480 5th grade American students found high internal consistency (alpha=0.82). with the feel-bad score (Lewis et al., 1984). A principle components factor analysis on the same data set with varimax rotation yielded three factors of the scale are: 1) anxieties surrounding conflicts with parents, 2) self-image, self-esteem and peer-group relationships and 3) dislocations (changes in living arrangements) (Lewis et al., 1984).
2.4.4 Child health and environment questionnaire

Baseline

Child health and environmental attitudes were measured by a multi-choice questionnaire that was read aloud to the children who answered in writing on the questionnaire. Health was measured by using standard self-report questions about general symptoms (headaches, tiredness, trouble sleeping) adapted from the Whitehall II Study (Marmot et al., 1991).

Environmental attitudes measured were: general perception of environmental hazards apart from noise (level of air pollution, safety, neighbourhood friendliness), environmental mastery, self reported home and school noise exposure from 4 sources of environmental noise (trains, road traffic, planes, neighbour noise), level of classroom noise interference (Bronzaft & McCarthy, 1975) and emotional response to aircraft noise.

Follow-up

Child health and environmental attitudes were measured by a multi-choice questionnaire that was read aloud to the children. All parts of this questionnaire were identical to the 1996 questionnaire, except for the following two sections: 1) level of noise interference in classroom activities and 2) parental involvement in their child’s school work.

An expanded version of level of classroom noise interference was included in 1997 (Bronzaft & McCarthy, 1975). These questions were included in the follow-up to obtain more detailed information about the sources of environmental noise that may interfere with classroom activities.

Four questions were also included at follow-up to examine whether parental involvement in child school work was a factor that may influence child cognitive performance. These questions measured: how much help the child got with home work, reading aloud to parents at home, having parents read aloud to children and level of parental interest in children’s school work.
2.4.5 Teacher questionnaire and access to school records
The teacher questionnaire was administered only at baseline. It was divided into 2 sections (See Appendix 10 for the Questionnaire). Section 1 contained questions on each child’s: last assessed National Curriculum Levels in Mathematics, English and Science, length of time at the school, date of birth and home address. Unfortunately a majority of the teachers misunderstood the question related to National Curriculum Scores and didn’t answer it properly. Section 2 was the Student Behaviour Checklist (SBC; Fincham et al., 1989) to rate the observed motivation level of each child in the classroom on the mastery orientated and learned helpless subscales.

2.4.6 Parent questionnaire
A questionnaire was sent home with the child for a carer to complete (mother suggested as the preferred respondent). This questionnaire measured: child physical and mental health (Modified Rutter Parent Questionnaire, Goodman, 1994) and socio-demographic variables for this thesis (see Appendix 11). This questionnaire had other sections related to the parent’s own health, which were not data collected for this thesis.
2.5 Procedure

2.5.1 Ethical approval and procedural techniques

Ethical approval was granted by the following three ethics committees to conduct the study.

1) The Joint University College London and University College London Hospital Committees on the Ethics of Human Research: Committee Alpha.
2) The Hillingdon Health Agency Ethics Committee
3) The Ealing, Hammersmith and Hounslow Health Authority Hounslow Research Ethics Committee.

Ethical measures that were used in the study were: child and parent written consent for participation, child and parent information sheets, child information days one week before the testing sessions so that they are informed about the research and have time to consider whether to take part. One child from a low noise school refused to take part in the study. Children were free to withdraw from the study at any point and did not have to answer any question they do not want to. There was a debriefing of the children after the testing sessions.

2.5.2 Testing at the schools

For an summary outline of the classroom testing at baseline see Table 5, and for follow-up see Table 6.

Baseline Testing

The headteachers were asked for permission to conduct the research in their schools. The headteachers then approached the school governors and staff to ask for permission. Parents in the selected year 4 and 5 classes were sent letters explaining the research, an information sheet and a consent form to be signed. The study was introduced as a Health and Environment study in parents and children to the teachers, parents and children. This introduction did not focus on noise to avoid response bias, a technique successfully used in previous studies (Job et. al, 1991b). Cognitive performance tests,
motivation tasks and the questionnaire were group administered to the children in the morning in the classroom. Although the tasks were administered in the classroom, the tasks were carried out individually under exam conditions. Group administration was used since a questionnaire completed in a group situation is known to be conducive to co-operation in answering sensitive questions (Job & Bullen, 1987). The testing was conducted on 3 days each a week apart, controlling for questionnaire order and time of day across noise exposure. Children who were identified as having a severe learning problem were assisted by the researchers. These children were already excluded on 'a priori' grounds (see exclusions section). This small sub-group were assisted so that they were not upset by failure and so they felt they could take part in the project.

The psychological scales were administered before the motivation task so that any feelings of failure induced by the first insoluble puzzle would not interfere with the responding. The motivation task was given as the last task of testing so that any transient mood effects possibly induced from completing the psychological scales would be diminished. During piloting any change in mood induced by the psychological scales had passed by the time of the motivation task. Activities that were read aloud to the children or were administer using an audio-tape were repeated if classroom noise or aircraft noise detracted from audibility.
Testing was conducted in the classrooms in order to produce a more realistic setting. Children's performance may be a more accurate assessment of their everyday functioning than laboratory testing as the testing was conducted in the same situation that all other school performance is measured. The teachers were given the teacher questionnaire in the same month as the testing sessions.

Table 5.
An outline of the protocol of the classroom testing at baseline. (Chapter 2 Methods)

<table>
<thead>
<tr>
<th>Testing Day</th>
<th>Week 1 Testing Day 1</th>
<th>Week 2 Testing Day 2</th>
<th>Week 3 Testing Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Activities</td>
<td>Explanation of the study to the children</td>
<td>Child and parental written consent obtained</td>
<td>Psychological Scales. depression anxiety attributional style</td>
</tr>
<tr>
<td></td>
<td>Information sheets handed out to the children</td>
<td>Long term memory and reading comprehension cognitive performance tests</td>
<td>Health and Environment Questionnaire</td>
</tr>
<tr>
<td></td>
<td>Socio-demographic data collected from the children</td>
<td>Acute noise measurements Throughout</td>
<td>Short-term memory</td>
</tr>
<tr>
<td></td>
<td>The reading task was given.</td>
<td></td>
<td>Motivation behavioural performance task</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Acute noise measurements throughout</td>
</tr>
<tr>
<td>Time Taken</td>
<td>30 minutes</td>
<td>75 minutes</td>
<td>75 minutes</td>
</tr>
</tbody>
</table>

Follow-up testing

Testing at the schools was conducted in exactly the same way as in 1996 as far as possible, with the same research team. The head teachers were approached and asked for permission to conduct the follow-up research in their schools. Parents of the 1996 sample were sent letters explaining the research, an information sheet and a consent form to be signed. The study was introduced as a continuation of the 1996 study which was a health and environment study in parents and children.
In March 1997 testing was conducted in two schools exposed to high levels of aircraft noise (Bedfont Junior and Chatsworth Junior) and two schools exposed to low levels of aircraft noise (Feltham Hill Junior and Hermitage Junior). In April 1997 testing was conducted in two schools exposed to high levels of aircraft noise (Springwell Junior and Wellington Primary) and two schools exposed to low levels of aircraft noise (Wood End Park Junior and Strand on the Green Junior). The time delay between baseline and follow-up was not exactly 12 months for all schools; it was 11 months later for 3 schools, 12 months later for 3 schools, 10 months later for 1 school, 9 months later for 1 school. Due to pragmatic constraints (e.g. school timetable) it was impossible to have a uniform time delay across all the schools.

The testing was conducted on 3 days each a week apart, controlling for questionnaire order and time of day across noise exposure (see Table 6, below). The question order remained the same as in 1996, except the sustained attention task replaced the motivation task at the end of the third day of testing. The sustained attention task was given as the last task of testing of that any transient mood effects possibly induced from completing the psychological scales would be diminished.

The classrooms in which the testing was conducted differed from 1996, so it is possible that noise exposure at the classroom level may have changed between 1996 and 1997. This possibility will be considered when interpreting the results. Noise measurements were taken at the individual schools during testing will help quantify this difference.
Table 6.
An outline of the protocol of the classroom testing at follow-up. (Chapter 2 Methods)

<table>
<thead>
<tr>
<th>Testing Day</th>
<th>Week 1 Testing Day 1</th>
<th>Week 2 Testing Day 2</th>
<th>Week 3 Testing Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Activities</td>
<td>Explanation of the study to the children</td>
<td>Child and parental written consent obtained.</td>
<td>Psychological Scales. Depression Anxiety Stress</td>
</tr>
<tr>
<td></td>
<td>Information sheets handed out to the children</td>
<td>Long term memory and reading comprehension cognitive performance tests</td>
<td>Health and environment questionnaire</td>
</tr>
<tr>
<td></td>
<td>The reading task was given.</td>
<td>Acute noise measurements Throughout</td>
<td>Sustained task</td>
</tr>
<tr>
<td>Time Taken</td>
<td>20 minutes</td>
<td>60 minutes</td>
<td>70 minutes</td>
</tr>
</tbody>
</table>

2.5.3 Procedures adopted to attain reliable results with a child sample

Many procedures were adopted to increase the likelihood of obtaining reliable results. Question order effects were accounted for by randomly altering the question order across the testing sessions. Noise questions were embedded in the health and environment section to counter the possibility of 'halo effects' biasing responding. Socio-demographic measurements were taken on the whole sample approached in order to check for representativeness of the participating sample. The distribution of ethnic group and main language spoken at home was compared between the eligible sample and those who agreed to take part in the study. There was no significant difference in socio-demographic variables between the participants and those who declined to take part.

To ensure reliable child data the following techniques were used:

1) The introduction and child consent form implied an informal contractual commitment for the co-operation and honesty of the children. It has been shown by
Oksenberg, Vinokur & Cannell (1979) that an implied contractual agreement promoted degree of accuracy and completeness of answers.

2) The scientific importance of the research was signaled which is a technique used to promote serious responding in child samples (Fisher & Leitenberg, 1986; Haines & Job, 1994).

3) Psychological scales and questionnaires were read aloud by the researcher to avoid difference in reading ability affecting self-report. This technique is known to increase the validity of the responses (Dr. Eric Fombonne, Personal Communication).

4) The children were encouraged to ask questions for clarification of the instructions.

5) To guard against the likelihood of the children producing ‘expected answers’ the fact that there was no right or wrong answer was stressed verbally.

6) The children were administered with each consecutive part of the questionnaire by the researchers. This procedure was adopted to: a) ensure that the subjects answered the questions in the correct order and b) that they could not look over previous answers.

7) The researchers adopted a ‘task-oriented’ approach that has been found to produce more accurate data (Cannell, 1979).

2.5.4 Noise measurement procedure

The noise measurement procedure was the same at baseline and follow-up.

Chronic Noise Measurements:
The key exposure examined in this study was aircraft noise (air noise, rather than ground noise) from the aircraft taking off from and landing at Heathrow Airport. Schools were chosen within the published 1991 Civil Aviation Authority dBA Leq, 16hr (92 days) contour maps indicating the average continuous equivalent sound level of aircraft noise within a particular area for 16 hour daily periods during June 15 to September 15. The high aircraft noise exposure was greater than 66 dBA Leq (Taken from the 1994 CAA contour maps). The high aircraft noise exposure contour includes the residential areas with the highest exposures round Heathrow airport. Low aircraft noise exposure schools were located outside the 57 dBA Leq contour. (For the dBA Leq, and maximum sound levels for each school see results sections in Chapters 3 & 4).
**Acute Noise Measurements**

Noise measurements at individual schools were carried out by the Hillingdon and Hounslow Local Authorities to assess indoor levels of aircraft noise during testing. Acute noise measurements during fly-overs were taken in the classrooms at the time of testing to measure the maximum and average sound pressure levels during testing. These measurements were taken using a small hand-held sound level meter mounted on a tripod and a portable DAT recorder. These noise recordings were analysed to produce two noise measurements were used to measure the acute noise interference: 1) SEL dBA to describe the acute levels of noise interference at the time of testing. Single event noise exposure level (SEL) is defined as the total sound energy of an event expressed as a one second equivalent. SEL is a measure of sound energy which allows for the direct comparison of sound events of differing duration.

2) **LAeq(T)** for the specific period of task completion. This measure is for consideration in analyses examining the effect of chronic noise on performance. LAeq is the sound level of a steady sound having the same sound energy as a fluctuating or intermittent sound over a specified measurement period (T). (For the acute sound pressure levels in the schools at the time of testing see results sections in Chapters 3 & 4).

**Other Noise Exposure**

Data on aircraft noise exposure levels at each participating child’s home were also taken from the 1991 Civil Aviation Authority dBA Leq-16hr (92 days), contour maps for the area surrounding Heathrow Airport. These data were obtained from the Environmental Protection Unit in Hillingdon and Environmental Services in Hounslow. Self reported home and school noise exposure from 4 sources of environmental noise (trains, road traffic, planes, neighbour noise). The noise measurements taken at the time of testing also quantified the exposure to these other sources of environmental noise (road and trains). Length of time that the child had been enrolled in the school was collected from the children and school records.
2.5.5 Statistical procedures

All statistical tests are two-tailed and alpha was set at 0.05.

Between-Subject Analyses at Baseline and Follow-up

Analyses of Covariance (ANCOVA), which is the same test as linear regression analysis were used to examine the cross-sectional main noise effects. The ANCOVA function in SPSS was used, so that continuous and categorical variables could be included in the analyses. Two models were used: model 1 was age adjusted and in model 2 three factors were adjusted for namely: age (at the time of testing), main language spoken at home (a variable with two levels: English and non-English) and deprivation (a variable with two levels: deprived and non-deprived). These factors were included in the analyses to control for the possibility that any difference in cognitive performance between high and low noise groups might be explained by socio-demographic factors. The possibility of type I errors being increased by the number of main analyses conducted will be considered in the interpretation of the results.

1) Age

All child analyses were adjusted for age of the child at the time of testing. 24 missing values for age were entered with either: 9 yrs 2 months (the mean age of all the year 4 children) or 10 yrs and 2 months (the mean age of all the year 5 students).

2) Deprivation

Household deprivation was assessed with an index based on Townsend’s Scale incorporating income, home tenure, car ownership, social class and unemployment in a single scale (Townsend et al., 1989). Deprivation has two levels: deprived and non-deprived. All missing values for deprivation were excluded from the analyses.

3) Main Language Spoken at Home

Main language spoken at home confounded the relationship between noise level and reading comprehension (Suffolk Reading Scale) more than ethnicity, therefore it was included as a covariate. In addition, if adjustment is made for ethnicity it is unclear exactly what this controls for (e.g. cultural differences, motivation, language proficiency and fluency etc.). It is reasonable to assume that main language spoken at home could influence English performance. Main language has two levels: English and non-English. All missing values for main language spoken at home were excluded from the analyses.
**Mediating Analyses at Baseline and Follow-up**

The ANCOVA models used to analyse the hypothesised mediating relationships are described in the results sections of Chapters 3 and 4. The hypothesised mediating variables were entered separately as covariates into a general ANCOVA model where the independent variable was school noise exposure (high & low) and the dependent variable was child performance or annoyance.

**Within-Subject Analyses at Follow-up**

One of the main advantages of repeated measures research designs is that they reduce overall total variance because it can be partitioned into between subjects and within-subjects variability. Another advantage of a repeated measures design is that it allows for progress of children's performance to be studied.

There are potential problems with repeated measures that can affect the reliability of the results, that particularly pertain to this study which is examining the effects of noise on child performance namely: ordering or learning effects and there is also the possibility that subject attrition can affect longitudinal results as may have happened in Los Angeles (see Cohen et al., 1981). By conducted the repeated measurements one year after the initial measurement and whereever possible different versions of the same task were administered in 1997 we hopefully minimised the possibility of ordering or learning effects influencing the results. The response rate in 1997 was high enough and attrition levels did not differ by noise which rules out the possibility of selective attrition influencing the longitudinal results.

Two statistical methods were used to assess the noise-effects over time. These two methods were: analyses of covariance adjusting for baseline performance (ANCOVA) and multiple analysis of variance (MANOVA). These two methods were used because they measure different aspects of adaptation to noise over time. ANCOVA measures how noise affects progression of development over time adjusting for baseline performance. This is a more sensitive measure of child development because the unit of analysis is at the child level. This method removes more error because we are adjusting for individual variation in performance that may not be noise related. This statistical method is the most sensitive when measuring outcomes where you expect linear
progression in development such as reading comprehension or when you predict that increased exposure to a noise may increase the level of annoyance.

MANOVA assesses group differences over time. It produces three tests of differing levels of relevance, firstly a noise effect, a year effect and an interaction. The noise effect takes an average of performance over the two years and includes it in one analysis. The advantage of this test is that it doubles the scores entered into the analyses, hence increases the power of the tests for main noise effects. This is a more reliable measure of a total noise effect than the two cross-sectional comparisons. The interaction is a test of group adaptation to noise. This interaction test examines group differences for both time points, but is more likely to be confounded by other factors which makes any found effect directly attributable to noise. It is a cruder measure than the ANCOVA and is of limited interest.

These methods were selectively applied to the 2 dependent variables measured both in 1996 and 1997: reading comprehension, noise annoyance for two reasons. First, based on previous literature, testable hypotheses could only be generated for reading and annoyance. Secondly the statistical pre-requisite to test for within subjects effects is that significant noise effects must be found at both baseline and follow-up on the relevant outcome and this was only the case for reading and noise annoyance.

**ANCOVA Models**

The results of two ANCOVA models will be presented in the within subjects results section of Chapters 4. Two models were used so that unadjusted results could be compared with those adjusted for the potential confounding factors.

**Model 1** adjusts for baseline performance only.

Dependent Variable: 1997 child performance measure

Independent Variable: school noise exposure (High & Low)

Covariate: 1996 child performance measure

**Model 2** adjusts for age, main language spoken and deprivation as well as baseline performance. The independent and dependent variables are the same as in model one and the model 2 covariates are: 1996 child performance measure, age at the time of testing in 1996, main language spoken at home and deprivation.
MANOVA Models

The results of two MANOVA models will be presented.

**Model 1** adjusts for age only.

Independent Variable 1: school noise exposure (High & Low)  
Dependent Variable 1: 1996 child performance measure  
Dependent Variable 2: 1997 child performance measure  
Covariate: age at the time of testing in 1996.

**Model 2** is adjusted for age, main language spoken and deprivation. The independent and dependent variables are the same as in model one and the model 2 covariates are: age at the time of testing in 1996, main language spoken at home and deprivation.

**Exclusions**

The ‘a priori’ criteria for excluding subjects were divided into 2 categories: 1) those participants that were excluded from all tests and 2) those that were excluded from the cognitive tests. Whether children were excluded was made on the basis of information about language, hearing and difficulties that were collected from the teacher and parent questionnaires. The exclusion cases were decided upon by two researchers (one blind to the noise level of the school).

**Exclusions from all the Tests**

The 3 criteria were:

1) Children with very little English, who could not understand the tests, tasks and questionnaires.
2) Children that had a learning difficulty that was so severe that they were helped throughout the testing.
3) Severe hearing difficulty and fine motor skills problem.

**Exclusions from the Cognitive Tests**

The 2 exclusion criteria were:

1) Children with a learning difficulty that were helped through out the cognitive tests.
2) Children that have a non-English language as their main language and have very poor English language skills.
Baseline Exclusions

Three subjects were excluded from all tests (1 high noise, 2 low noise); 2 subjects were excluded because they had very little English and 1 because of a very severe learning difficulty. No child had a severe hearing and fine motor skills problem. Thirty one children were excluded in the cognitive analyses (14 from high noise schools; 17 from low noise schools) because these children had a learning difficulty or language problem to the extent that they were helped through out the cognitive tests. It was not considered ethically reasonable from an educational perspective to preclude such help.

Follow-up exclusions

Exclusions were made on the basis of ‘a priori’ criteria in 1996. The same children excluded in 1996 were excluded in 1997. One child was excluded from all tests (1 low noise) because they had very little English. No child had a severe hearing and/or fine motor skills problem. Twenty children were excluded in the cognitive analyses (11 from high noise schools; 9 from low noise schools) because these children had a learning difficulty or language problem to the extent that they were helped through out the cognitive tests.

Procedural Error

A procedural error occurred in the testing session at baseline, over which there was no control. The final low noise control school (26 students included in the analyses) supplied classes of lower ability rather than the requested representative children. Inclusion of this school may have lowered levels of attainment in the low noise sample as a whole, thus masking any possible noise effect. The classes selected were streamed to be the lowest standard in the year. This is supported by the fact that 22 % of the participating sample were excluded from the analyses for learning difficulties. 71 % of the sample came from deprived homes which was much higher than the average level of deprivation in the 8 schools (43.5%). Controlling for deprivation in the statistical analysis may not be sufficient to adjust this school’s results as the children were selected into a low standard class. This school’s performance in reading comprehension was significantly different from the other low noise schools confirming that it was an outlier (F(3,122)=9.46, p=0.0001). After the data was collected, corroborative independent evidence about the outlier class was obtained using the
results National Standardised Scores (SATS) for 1997 which confirmed the suspicion that this class was indeed an outlier (For these further analyses see Appendix 12). All this evidence together indicates that it might not be appropriate to include this school with the other three low noise schools in a combined analysis.

**Threats to Validity**

The following threats to validity were addressed prior to the data analysis: question and version effects, floor/ceiling effects, social desirability and patterns of missing data. None of these potential problems substantially influenced validity of the data, except that there was a version effect on long term memory task. The Dolphin passage was significantly easier than the Top Secret passage.

Value substitutions were made for missing data on the psychological scales. Only a small number of subject's total scores were excluded because of missing data. (See Appendix 13 for further details of these analyses both baseline and follow-up and value substitutions)

**Results Presentation**

All statistical tests are two-tailed and alpha was set at 0.05. The baseline and follow-up results will be presented on all 8 schools and the 7 schools excluding the outlier school identified in 1996. The 1997 data analyses was conducted in the same as the 1996 in order to test for replication of effects. The ANCOVA and MANOVA result tables will contain mean performance scores, F-tests and p-values. Confidence intervals will be presented in the text only for the means of most important main effects.
CHAPTER 3

STUDY 1: BASELINE

Introduction, Results & Discussion
3.1 Introduction

The rationale for this baseline study has been outlined in the literature review (Chapter 1) and the method in the previous chapter (Chapter 2). By way of introduction, the basic research issues and specific hypotheses will be repeated here to structure the presentation of the results.

The analyses presented in this chapter will focus on four basic issues:

I. Is there a relationship between chronic noise exposure and a) child cognitive performance, b) motivation and c) psychological health?

II. Do socio-demographic factors and acute noise exposure confound the relationship between chronic school noise exposure and child health?

III. Are the main noise effects found in children mediated by depression, anxiety, noise annoyance and motivation?

IV. Do environmental factors moderate the relationship between chronic school noise exposure and child health?

The Specific Hypotheses are:

(1) Chronic aircraft noise exposure produces cognitive impairments in reading comprehension, and long term memory recall in school children. No effects are expected on the control cognitive outcomes: recognition and short term memory.

(2) Chronic aircraft noise exposure decreases motivation and induces learned helplessness.

(3) Chronic aircraft noise exposure in school children will be associated with higher levels of annoyance by noise than children in schools exposed to lower levels of aircraft noise.
The following hypotheses are exploratory and are not based on strong predictions from previous research:

(4) The prevalence of depression, anxiety, general psychological disturbance and health symptoms will be higher in high aircraft noise exposed schools than in low aircraft noise exposed schools.

(5) Depression, anxiety, noise annoyance and motivation may have a mediating relationship between chronic aircraft noise exposure and cognitive performance.

(6) Depression and anxiety may have a mediating relationship between chronic aircraft noise exposure and annoyance.

(7) Deprivation, main language spoken at home and acute noise levels at the time of testing may act as confounding factors on the association between chronic aircraft noise exposure and cognitive performance.

(8) Chronic home aircraft noise exposure and length of time in the school environment may moderate the association between chronic aircraft noise exposure and cognitive performance.
3.2 Results

The results will be divided into three sections. Section 1 contains the descriptive results. Section 2 contains the analyses of the main noise effects in children. Section 3 contains the analyses examining the role of mediating and moderating variables.

3.2.1 Section I - Descriptive results

3.2.1.1 Response rate
The overall response rate among the children was at 77% across the eight schools. The response rate was similar between the high and low noise schools (78% response rate for the high noise schools, 76% for the low noise schools). The teacher response rate was 100%. The participating sample was socio-demographically representative of the eligible sample. Socio-demographic data were collected on the whole child sample that was approached to take part in the study. The children who declined to participate did not differ by proportion of sex, age or race to those who decided to participate.

3.2.1.2 Samples
The sample was well matched across noise levels for: class at school, sex, proportion of socio-economic groups (see Table 7). The high noise school sample had a higher proportion of non-white pupils and pupils with languages other than English as the main language spoken at home than the low noise schools (see Table 7). The high noise school sample had a slightly higher proportion of manual social class and deprived participants than the low noise schools (see Table 7). Concerns about confounding by these variables were addressed by adjusting for them statistically in the analyses of noise effects.
Table 7.
The socio-demographic characteristics of the high and low noise child samples: frequencies and proportions. (Baseline Study)

<table>
<thead>
<tr>
<th>Socio-Demographic Characteristic</th>
<th>High Noise N=169</th>
<th>Low Noise N=171</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 4</td>
<td>82 (49%)</td>
<td>81 (47%)</td>
</tr>
<tr>
<td>Year 5</td>
<td>87 (51%)</td>
<td>90 (53%)</td>
</tr>
<tr>
<td>Girls</td>
<td>86 (51%)</td>
<td>85 (50%)</td>
</tr>
<tr>
<td>Boys</td>
<td>83 (49%)</td>
<td>86 (50%)</td>
</tr>
<tr>
<td>White</td>
<td>58 (37%)</td>
<td>147 (88%)</td>
</tr>
<tr>
<td>Non-White</td>
<td>98 (63%)</td>
<td>20 (12%)*</td>
</tr>
<tr>
<td>English - Main Language Spoken at Home</td>
<td>101 (65%)</td>
<td>154 (93%)</td>
</tr>
<tr>
<td>Non-English</td>
<td>55 (35%)</td>
<td>12 (7%)*</td>
</tr>
<tr>
<td>Non-Manual Social Class (1,2,3N)</td>
<td>47 (47%)</td>
<td>62 (60%)</td>
</tr>
<tr>
<td>Manual Social Class (3M,4,5)</td>
<td>54 (53%)</td>
<td>41 (40%)*</td>
</tr>
<tr>
<td>Professional Groups SEGs (1,2,3,4)</td>
<td>21 (20%)</td>
<td>32 (30%)</td>
</tr>
<tr>
<td>Other non-manual workers SEGs(5,6)</td>
<td>27 (26%)</td>
<td>33 (31%)</td>
</tr>
<tr>
<td>Skilled Manual Workers SEGs (8,9,12)</td>
<td>28 (27%)</td>
<td>29 (28%)</td>
</tr>
<tr>
<td>Semi-Skilled Manual Worker SEGs(7 &amp;10)</td>
<td>14 (14%)</td>
<td>9 (9%)</td>
</tr>
<tr>
<td>Unskilled SEG(11)</td>
<td>12 (12%)</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Others SEGs (13,14,15,16,17)</td>
<td>1 (1%)</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Not Deprived</td>
<td>76 (53%)</td>
<td>87 (64%)</td>
</tr>
<tr>
<td>Deprived</td>
<td>68 (47%)</td>
<td>49 (36%)*</td>
</tr>
</tbody>
</table>

*Note. Total percentages reported are of those known. Missing data are generally a small proportion of the sample, except in the case of social class, socio-economic group and deprivation. * Chi-squared tests (χ²) p<0.05.

3.2.1.3 Noise exposure

Chronic Aircraft Noise at School

The schools were selected on the basis of the published 1991 Civil Aviation Authority (CAA) dBA Leq, 16hr contour maps. During the course of testing the 1994 CAA maps were published. The aircraft noise exposure levels of each of schools were taken from the 1994 CAA maps to produce a more recent noise exposure contour. In fact, all the high noise schools lay within higher aircraft exposure contours in 1994 than 1991. The 54 noise contour was introduced in 1994. When the aircraft noise exposure levels of the low noise schools were taken from the 1994 CAA maps three out of the four low noise schools lay outside the 54 contour. See Table 8 for chronic aircraft noise levels at the 8 schools.
Table 8.

Chronic aircraft noise levels at the 8 schools taken from the 1994 Civil Aviation Authority dBA Leq (16hr) contour maps. (Baseline Study)

**High Noise Schools**

<table>
<thead>
<tr>
<th>Name of the School</th>
<th>dBA Leq (16hr) CAA (1994)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedfont Junior</td>
<td>On the 69 dBA Leq contour</td>
</tr>
<tr>
<td>Chatsworth Junior</td>
<td>66 - 69 dBA Leq</td>
</tr>
<tr>
<td>Springwell Junior</td>
<td>69 - 72 dBA Leq</td>
</tr>
<tr>
<td>Wellington Primary</td>
<td>On the 66 dBA Leq contour</td>
</tr>
</tbody>
</table>

**Low Noise Schools**

<table>
<thead>
<tr>
<th>Name of the School</th>
<th>dBA Leq (16hr) CAA (1994)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hermitage Junior</td>
<td>&lt; 54 dBA Leq</td>
</tr>
<tr>
<td>Strand on the Green Junior</td>
<td>&lt; 54 dBA Leq</td>
</tr>
<tr>
<td>Feltham Hill Junior School</td>
<td>&lt; 57 dBA Leq</td>
</tr>
<tr>
<td>Wood End Park Junior</td>
<td>&lt; 54 dBA Leq</td>
</tr>
</tbody>
</table>

**Home Aircraft Noise Exposure**

Noise exposure at home was strongly associated with noise exposure at school according to local noise contours (1991 CAA noise contours). 80% of the children in high noise exposed schools lived in high noise exposed homes (>63 dBA Leq 16hr) and 86 % of the children in low noise schools lived in low noise homes (<57 dBA Leq 16hr). This justified the choice of primary school children, who live fairly close to their schools as being suitable for the study day-long noise exposure (see Table 9).
Table 9.

Proportion of high and low school noise samples in high, moderate and low aircraft noise exposed homes taken from the 1991 CAA noise contour maps. *(Baseline Study)*

<table>
<thead>
<tr>
<th></th>
<th>High Noise School Sample</th>
<th>Low Noise School sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Noise Home</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(greater than 63 dBA Leq 16 hr)</td>
<td>80 % n=113</td>
<td>3 % n=4</td>
</tr>
<tr>
<td>Moderate Noise Home</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(in between 57 - 63 dBA Leq 16 hr)</td>
<td>17 % n=24</td>
<td>11 % n=18</td>
</tr>
<tr>
<td>Low Noise Home</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Less than 57 dBA A Leq 16 hr)</td>
<td>3 % n=5</td>
<td>86 % n=135</td>
</tr>
</tbody>
</table>

* there were some missing data for home aircraft noise exposure

Acute Aircraft Noise at The Time of Testing

There was a clear distinction between high and low chronic aircraft noise exposed schools in terms of acute aircraft noise exposure during testing. The acute levels of noise interference at the time of testing by aircraft overflights are displayed in Tables 10 & 11 below in single event noise exposure level (SEL dBA). On day 2 of testing the schools chronically exposed to high aircraft noise had 193 aircraft overflights during the testing sessions (which lasted 534 hours in total). On day 2 of testing the schools exposed to low aircraft noise had 3 aircraft overflights during the testing sessions (588 hours) (see Table 10).

On day 3 of testing the schools chronically exposed to high aircraft noise had 183 aircraft overflights during the testing sessions (588 hours). On day 3 of testing the schools exposed to low aircraft noise had 1 aircraft overflight during the testing sessions (662 hours) (see Table 11).

The acute levels of noise interference at the time of testing by road and rail noise is displayed in Table 12 below in single event noise exposure level (SEL dBA). The schools chronically exposed to high aircraft noise had no acute rail noise exposure and had 50 road traffic events during the testing sessions on days 2 and 3. The schools exposed to low aircraft noise had 17 rail noise events and had 11 road traffic events during the testing sessions on days 2 and 3.
Table 10.

*Acute aircraft noise levels at the time of testing on Day 2 by class. (Baseline Study)*

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean SEL dBA</th>
<th>Max SEL dBA</th>
<th>Min SEL dBA</th>
<th>Number of Events</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HIGH NOISE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedfont - 4</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Bedfont - 5</td>
<td>72</td>
<td>86</td>
<td>61</td>
<td>52</td>
</tr>
<tr>
<td>Chatsworth - 4</td>
<td>70</td>
<td>77</td>
<td>61</td>
<td>14</td>
</tr>
<tr>
<td>Chatsworth - 5</td>
<td>64</td>
<td>70</td>
<td>50</td>
<td>17</td>
</tr>
<tr>
<td>Wellington - 4</td>
<td>69</td>
<td>76</td>
<td>60</td>
<td>28</td>
</tr>
<tr>
<td>Wellington - 5</td>
<td>69</td>
<td>77</td>
<td>56</td>
<td>14</td>
</tr>
<tr>
<td>Springwell - 4</td>
<td>77</td>
<td>86</td>
<td>59</td>
<td>52</td>
</tr>
<tr>
<td>Springwell - 5</td>
<td>70</td>
<td>77</td>
<td>58</td>
<td>16</td>
</tr>
<tr>
<td><strong>LOW NOISE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hermitage - 4</td>
<td>69</td>
<td>70</td>
<td>68</td>
<td>3</td>
</tr>
<tr>
<td>Hermitage - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Strand on Green - 4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Strand on Green - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feltham Hill - 4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feltham Hill - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wood End - 4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wood End - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Equipment malfunction in Bedfont Class 4
Table 11.
Acute aircraft noise levels at the time of testing on Day 3 by class. (Baseline Study)

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean SEL (dBA)</th>
<th>Max SEL (dBA)</th>
<th>Min SEL (dBA)</th>
<th>Number of Events</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HIGH NOISE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedfont - 4</td>
<td>71</td>
<td>85</td>
<td>57</td>
<td>52</td>
</tr>
<tr>
<td>Bedfont - 5</td>
<td>71</td>
<td>86</td>
<td>57</td>
<td>57</td>
</tr>
<tr>
<td>Chatsworth - 4</td>
<td>66</td>
<td>70</td>
<td>59</td>
<td>28</td>
</tr>
<tr>
<td>Chatsworth - 5</td>
<td>66</td>
<td>70</td>
<td>59</td>
<td>28</td>
</tr>
<tr>
<td>Wellington - 4</td>
<td>66</td>
<td>73</td>
<td>57</td>
<td>14</td>
</tr>
<tr>
<td>Wellington - 5</td>
<td>71</td>
<td>74</td>
<td>67</td>
<td>4</td>
</tr>
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<td>Springwell - 4</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Springwell - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>LOW NOISE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hermitage - 4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hermitage - 5</td>
<td>0</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Strand on Green - 4</td>
<td>67</td>
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<td>67</td>
<td>1</td>
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<td>Strand on Green - 5</td>
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<tr>
<td>Feltham Hill - 4</td>
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<td>Feltham Hill - 5</td>
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<tr>
<td>Wood End - 4</td>
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<tr>
<td>Wood End - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 12.

Acute road traffic and rail noise levels (Mean SEL) and number of events on testing Day 2 and 3 by class. (Baseline Study)

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean SEL DBA</th>
<th>Mean SEL dBA</th>
<th>Mean SEL dBA</th>
<th>Mean SEL dBA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 2</td>
<td>Day 3</td>
<td>Day 2</td>
<td>Day 3</td>
</tr>
<tr>
<td>Road Traffic Noise</td>
<td></td>
<td></td>
<td>Road Traffic Noise</td>
<td></td>
</tr>
<tr>
<td>HIGH NOISE</td>
<td></td>
<td></td>
<td>Rail Traffic Noise</td>
<td></td>
</tr>
<tr>
<td>Bedfont - 4</td>
<td>*</td>
<td>0</td>
<td>*</td>
<td>0</td>
</tr>
<tr>
<td>Bedfont - 5</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
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<td>Chatsworth -4</td>
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<td>0</td>
</tr>
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</tr>
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<td>LOW NOISE</td>
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<td>Rail Noise</td>
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<td>Hermitage - 4</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wood End -4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wood End -5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Equipment malfunction in Bedfont Junior Class 4

Length of time at the school

92% of high noise sample had been attending the high noise schools for more than 4 years. 88% of the low noise sample of the children had been attending the low noise schools for more than 4 years. Thus, the description of the relevant noise exposures as chronic is well justified.
Perception of aircraft noise exposure

Aircraft noise exposure at school was strongly associated with the perception of plane noise at school: 92% of the children in high noise schools agreed that they could hear plane noise at school, compared with 61% of the children in low noise schools ($\chi^2 (1, 311) = 41.63, p=0.0001$). Aircraft noise exposure at school was also associated with the perception of plane noise at home: 91% of the children in high noise schools agreed that they could hear plane noise at home, whereas 68% of the children in low noise schools agreed that they could hear plane noise at home ($\chi^2 (1, 315)= 26.51, p=0.0001$). The two groups did not differ in these attitudes towards aircraft noise: perception of safety of aircraft and fear response to aircraft.
3.2.2 Section II - Noise effects in children

The results will be presented on all 8 schools and the 7 schools excluding the procedural error school in four sub-sections:

3.2.2.1) Noise effects on cognitive performance
3.2.2.2) Noise effects on motivation
3.2.2.3) Noise effects on stress responses and psychological health.
3.2.2.4) Environmental Perceptions and Responses

Both the age adjusted and the fully adjusted (age, language spoken at home and deprivation) results will be presented. The description of the results will focus on the significant fully adjusted results because these results are more explicitly unconfounded than the age adjusted results. Confidence intervals will be presented in the text only for the means of most important main effects.

3.2.2.1 Noise effects on cognitive performance

Reading Comprehension

Chronic exposure to aircraft noise had no effect on reading comprehension in the analyses of the eight schools (see Table 13). However, in the 7 schools, children in the four high noise exposed schools had poorer reading comprehension than children in the three low noise schools after adjusting for age (HN mean=98.01 (CI:96.16-99.84), LN mean=102.46 (CI: 104.42-104.5), F(1,265)=10.1, p=0.002, see Table 23) and after adjustment for age, main language spoken and deprivation (HN mean=98.48 (CI:96.20-100.41), LN mean=102.66 (CI:103.35-104.92), F (1, 220)=6.93, p=0.009, see Table 13). This fully adjusted difference in performance is equivalent to 6 months delay in reading ability.

Long and Short Term Memory

Chronic exposure to aircraft noise had no effect on long term memory recognition in the analyses of the eight schools (see Table 13). However, in the 7 schools, children in the four high noise exposed schools had poorer long term memory recognition than children in the 3 low noise schools after adjustment for age, main language spoken and deprivation (F (1, 215)=3.8, p=0.05, see Table 13). The age adjusted difference in recognition was not significant. The high noise exposed and low noise groups did not differ in long term memory recall performance and short term memory (see Table 13).
### Cognition and Performance Outcome

<table>
<thead>
<tr>
<th>Cognition and Performance Outcome</th>
<th>Four High Noise Schools Mean</th>
<th>Four Low Noise Schools Mean</th>
<th>Three Low Noise Schools Mean</th>
<th>F statistic, degrees of freedom and p-value for 8 schools comparison</th>
<th>F statistic, degrees of freedom and p-value for 7 schools comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suffolk Reading Comprehension Scale age adjusted</td>
<td>98.01</td>
<td>99.96</td>
<td>102.46*</td>
<td>F(1,292)=1.99 p=0.16</td>
<td>F(1,265)=10.19 p=0.002</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>98.48</td>
<td>100.01</td>
<td>102.66*</td>
<td>F(1,241)=0.94 p=0.33</td>
<td>F(1,220)=6.93 p=0.009</td>
</tr>
<tr>
<td>Long-term memory recall task age adjusted</td>
<td>2.59</td>
<td>2.44</td>
<td>2.68</td>
<td>F(1,270)=0.41 p=0.52</td>
<td>F(1,243)=0.23 p=0.64</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>2.56</td>
<td>2.47</td>
<td>2.66</td>
<td>F(1,228)=0.11 p=0.74</td>
<td>F(1,207)=0.19 p=0.67</td>
</tr>
<tr>
<td>Long-term memory recognition task age adjusted</td>
<td>3.93</td>
<td>4.07</td>
<td>4.17</td>
<td>F(1,277)=0.55 p=0.46</td>
<td>F(1,250)=1.666 p=0.20</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>3.84</td>
<td>4.12</td>
<td>4.26*</td>
<td>F(1,236)=1.51 p=0.22</td>
<td>F(1,215)=3.84 p=0.05</td>
</tr>
<tr>
<td>Short term memory age adjusted</td>
<td>8.59</td>
<td>8.57</td>
<td>8.66</td>
<td>F(1,273)=0.00 p=0.957</td>
<td>F(1,261)=0.03 p=0.86</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>8.53</td>
<td>8.77</td>
<td>8.75</td>
<td>F(1,225)=0.35 p=0.56</td>
<td>F(1,215)=0.12 p=0.73</td>
</tr>
</tbody>
</table>

* P<0.05
3.2.2.2 Noise effects on motivation

**Behavioural Performance Measure**

The high and low noise exposed groups did not differ in level of motivation measured by the Glass and Singer performance measure of motivation (see Table 14).

**Attributional Style and Learned Helpless Classroom Motivation**

The high and low noise exposed groups did not differ in self-reported child attributional style and teacher ratings of class-room motivation (see Table 14).

**Attributional style a moderator of the noise effect on motivation**

In order to test the attributional style theory a multiple regression analysis was conducted to test the prediction that the combination of depressogenic attributional style and noise will result in motivational deficits. In order to test for an interaction, a regression analysis was conducted to test whether attributional style acted as a moderating factor in the seven schools. Noise level was the independent variable (dummy coded) and number of attempts on the insoluble puzzle was the dependent variable. An interaction term was created with the dummy coded noise variable and attributional style. This interaction term was entered into the model. The interaction in the multiple regression was not significant, indicating that there is no evidence that attributional style moderates the association between noise and motivation.
Table 14.
Motivation outcome mean scores adjusted for a) age only and b) adjusted for age, deprivation and main language spoken in the 4 high-noise schools, the 4 low-noise schools and the 3 low-noise schools (excluding the procedural error school). (Baseline Study)

<table>
<thead>
<tr>
<th>Motivation Outcome</th>
<th>Four High Noise Schools Mean</th>
<th>Four Low Noise Schools Mean</th>
<th>Three Low Noise Schools Mean</th>
<th>F statistic, degrees of freedom and p-value for 8 schools comparison</th>
<th>F statistic, degrees of freedom and p-value for 7 schools comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation performance measure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age adjusted</td>
<td>5.58</td>
<td>5.72</td>
<td>5.81</td>
<td>F(1,288)=0.06 p=0.81</td>
<td>F(1,261)=0.2 p=0.66</td>
</tr>
<tr>
<td>Fully adjusted</td>
<td>5.86</td>
<td>5.91</td>
<td>5.93</td>
<td>F(1,236)=0.01 p=0.94</td>
<td>F(1,215)=0.01 p=0.91</td>
</tr>
<tr>
<td>Child Attributional Style (composite score)**</td>
<td>3.95</td>
<td>3.89</td>
<td>3.64</td>
<td>F(1,314)=0.03 p=0.86</td>
<td>F(1,282)=0.68 p=0.41</td>
</tr>
<tr>
<td>Age adjusted</td>
<td>4.07</td>
<td>3.73</td>
<td>3.51</td>
<td>F(1,251)=0.65 p=0.42</td>
<td>F(1,229)=1.78 p=0.18</td>
</tr>
<tr>
<td>Fully adjusted</td>
<td>-14.58</td>
<td>-14.34</td>
<td>-16.05</td>
<td>F(1,325)=4.73 p=0.09</td>
<td>F(1,291)=0.72 p=0.40</td>
</tr>
<tr>
<td>Classroom Motivation (Total Score SBC)***</td>
<td>-15</td>
<td>-15.68</td>
<td>-16.86</td>
<td>F(1,258)=0.05 p=0.83</td>
<td>F(1,236)=0.77 p=0.38</td>
</tr>
</tbody>
</table>

* P<0.05

** the lower the total score on the CASQ the more depressive the attributional style.

*** the higher SBC the more depressive the attributional style.
3.2.2.3 Noise effects on stress responses and health

**Annoyance**
Chronic exposure to high levels of aircraft noise was associated with higher levels of annoyance in the analyses of the eight schools after adjustment for age (HN mean=1.23 (CI: 1.08-1.38) LN mean=0.50 (CI:0.28-0.62), F(1,312)=47.6 p=0.0001) and after adjustment for age, deprivation and main language spoken (HN mean=1.18 (CI: 1.01-1.35) LN mean=0.54 (CI:0.32-0.71), F(1,250)=25.65, p=0.0001 see Table 15). This effect was also found in the analyses of the seven schools after adjustment for age (HN mean=1.23 (CI: 1.08-1.38) LN mean=0.50 (CI:0.35-0.64), F(1,280)=46.42, p=0.0001) and after adjustment for age, deprivation and main language spoken (HN mean=1.18 (CI: 1.01-1.35) LN mean=0.51 (CI:0.37-0.72), F(1,228)=23.15, p=0.0001 see Table 15).

**Anxiety and Depression**
The two groups did not differ in mean scores of anxiety and depression (see Table 15). No difference was found in the scores above the cut off for high levels of depression between the number of children in schools chronically exposed to high noise (21%) and the number of children chronically exposed to low noise (17%) ($\chi^2(2,316)= 1.99$ p=.36). In relation to anxiety, the children in schools chronically exposed to high noise did not have a higher prevalence rate of high anxiety(33%) as indicated by established cut off scores than the children chronically exposed to low noise (24%) as measured by the CMAS ($\chi^2(1,316)= 2.92$ p=.08).

**Child and Parent Reported Health and Behaviour**
Aircraft noise exposure at school had no effect on child self reported general health, headaches, tiredness and sleeping troubles.

Aircraft noise exposure at school did not affect the total deviance score of the Modified Rutter Parent Questionnaire nor any of the subscales: prosocial, hyperactivity, emotional symptoms, conduct problems and peer problems (see Table 15 for the main total deviance result, see Appendix 14 for the sub-scale results). Aircraft noise level at school did not affect the level of psychiatric caseness on the total score and sub-scales of the Strengths and Difficulties Questionnaire (see Appendix 14).
Table 15.

Stress responses and health outcome mean scores adjusted for a) age only
and b) fully adjusted for age, deprivation and main language spoken in the 4 high-noise
schools, the 4 low-noise schools and the 3 low-noise schools (excluding the procedural
error school). (Baseline Study)

<table>
<thead>
<tr>
<th>Stress and Health Outcome</th>
<th>Four High Noise Schools Mean</th>
<th>Four Low Noise Schools Mean</th>
<th>Three Low Noise Schools Mean</th>
<th>F statistic, df, and p-value for 8 schools comparison</th>
<th>F statistic, df and p-value for 7 schools comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annoyance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age adjusted</td>
<td>1.23</td>
<td>0.5*</td>
<td>0.5*</td>
<td>F(1,312)=47.6 p=0.0001</td>
<td>F(1,280)=46.42 p=0.0001</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>1.18</td>
<td>0.54*</td>
<td>0.51*</td>
<td>F(1,250)=25.65 p=0.0001</td>
<td>F(1,228)=23.15 p=0.0001</td>
</tr>
<tr>
<td><strong>Depression (CDI)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age adjusted</td>
<td>5.38</td>
<td>5.00</td>
<td>4.92</td>
<td>F(1,313)=0.94 p=0.33</td>
<td>F(1,281)=1.11 p=0.29</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>5.24</td>
<td>4.56</td>
<td>4.53</td>
<td>F(1,250)=1.91 p=0.17</td>
<td>F(1,228)=1.81 p=0.18</td>
</tr>
<tr>
<td><strong>Anxiety (CMAS)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age adjusted</td>
<td>13.1</td>
<td>12.3</td>
<td>12.23</td>
<td>F(1,314)=1.03 p=0.31</td>
<td>F(1,282)=1.2 P=0.28</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>12.6</td>
<td>11.9</td>
<td>11.96</td>
<td>F(1,251)=0.71 p=0.40</td>
<td>F(1,229)=0.96 P=0.33</td>
</tr>
<tr>
<td><strong>Total Deviance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Modified Parent Rutter Questionnaire)</td>
<td>8.81</td>
<td>8.45</td>
<td>8.49</td>
<td>F(1,279)=0.0001 p=0.96</td>
<td>F(1,256)=0.24 F=0.62</td>
</tr>
<tr>
<td>age adjusted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fully adjusted</td>
<td>8.77</td>
<td>8.86</td>
<td>8.34</td>
<td>F(1,261)=0.02 p=0.90</td>
<td>F(1,239)=0.59 p=0.45</td>
</tr>
</tbody>
</table>

* P<0.05

3.2.2.4 Environmental perceptions and responses

Attitudes towards aircraft noise exposure at school and home

More high noise children agreed that ‘planes passing overhead make it hard for me to
think’ ($\chi^2(1,314) = 16.6, p=0.0008$). Aircraft noise exposure at school was not
associated with: sense of environmental mastery, perception of safety of aircraft, fear
response to aircraft, and noise interfering in the classroom. Children in high noise
schools were more likely to be annoyed by plane noise at home (43 % rated their
annoyance as quite a bit or very much) compared with the children in low noise schools
(14 % rated their annoyance as quite a bit or very much) ($\chi^2 (3,314) = 32.60, p =
0.0001).
Other environmental factors apart from noise at school and home

The high and low noise groups did not differ on perception of road traffic at school. More children in low noise schools claimed that they could hear train noise at school (35%) than the children in high noise schools (17%) ($\chi^2(1,313) = 12.94$, $p=0.0003$). There was no difference between the samples on how annoying they found the train noise at school. The high and low noise groups did not differ on perception of neighbourhood safety, neighbourhood friendliness, road traffic, train noise, neighbour noise at home.
3.2.3 Section III - Role of mediating and moderating variables

3.2.3.1 Psychological mediating factors

Psychological mediation of the effects of noise on reading
Child depression inventory score, child manifest anxiety score, noise annoyance score, number of attempts on the insoluble motivation puzzle were entered separately as covariates into an ANCOVA model (with the Independent Variable - school noise level: high or low and the Dependent variable - reading comprehension score). None of these factors explained the significant association between noise and reading comprehension (see Table 16 below). This is indicated by the fact that the significance level of the main effects are not altered by the partialling out the effects of child depression, anxiety, annoyance and motivation.

Nevertheless higher levels of depression ($r = -0.15, p=0.01$), anxiety ($r = -0.18, p=0.002$), noise annoyance ($r = -0.13, p=0.02$), and lower levels of motivation ($r=0.13, p=0.02$) were significantly correlated with lower reading comprehension scores in the 8 schools. The large sample size from the 8 schools allows for even small correlations to be significant, this applies to all the correlations reported on the repeated measures study in Chapters 3 & 4.
Table 16.
The role of psychological mediating factors in the relationship between chronic noise exposure at school and reading comprehension. (Baseline Study)

<table>
<thead>
<tr>
<th>Covariate</th>
<th>8 schools F statistic, degrees of freedom, p-value</th>
<th>8 schools B, p-value</th>
<th>7 schools F statistic, degrees of freedom, p-value</th>
<th>7 schools B, p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression (CDI)</td>
<td>F(1,273)=2.22, p=0.14</td>
<td>B= -0.46, p=0.01</td>
<td>F(1,248)=11.42, p=0.001</td>
<td>B= -0.42, p=0.02</td>
</tr>
<tr>
<td>Anxiety (CMAS)</td>
<td>F(1,273)=2.22, p=0.14</td>
<td>B= -0.33, p=0.003</td>
<td>F(1,248)=11.37, p=0.001</td>
<td>B= -0.34, p=0.002</td>
</tr>
<tr>
<td>Annoyance</td>
<td>F(1,271)=0.83, p=0.36</td>
<td>B= -1.61, p=0.04</td>
<td>F(1,247)=7.49, p=0.007</td>
<td>B= -1.03, p=0.17</td>
</tr>
<tr>
<td>Motivation (number of attempts to solve insoluble puzzle)</td>
<td>F(1,273)=2.43, p=0.12</td>
<td>B= 0.31, p=0.03</td>
<td>F(1,248)=11.79, p=0.001</td>
<td>B= 0.25, p=0.06</td>
</tr>
</tbody>
</table>
Psychological mediation of noise annoyance effects

Child depression inventory score, child manifest anxiety score were entered separately as covariates in an ANCOVA model (with the Independent Variable - school noise level: high or low, dependent variable - noise annoyance). None of these factors explained the significant association between noise exposure and annoyance (see Table 17 below). Higher levels of anxiety ($r=0.14$, $p=0.011$), were significantly correlated with higher noise annoyance. Depression ($r=0.06$, $p=0.27$) was not significantly correlated with higher noise annoyance.

Table 17.
The role of psychological mediating factors in the relationship between chronic noise exposure at school and aircraft noise annoyance. (Baseline Study)

<table>
<thead>
<tr>
<th>Covariate</th>
<th>8 schools</th>
<th>8 schools</th>
<th>7 schools</th>
<th>7 schools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F statistic, degrees of freedom, p-value</td>
<td>B, p-value</td>
<td>F statistic, degrees of freedom, p-value</td>
<td>B, p-value</td>
</tr>
<tr>
<td>Depression (CDI)</td>
<td>F(1,310)=48.94</td>
<td>B= 0.01</td>
<td>F(1,279)=47.57</td>
<td>B= 0.0009</td>
</tr>
<tr>
<td></td>
<td>p=0.0001</td>
<td>p=0.43</td>
<td>p=0.0001</td>
<td>p=0.95</td>
</tr>
<tr>
<td>Anxiety (CMAS)</td>
<td>F(1,311)=47.52</td>
<td>B= 0.019</td>
<td>F(1,280)=45.76</td>
<td>B= 0.018</td>
</tr>
<tr>
<td></td>
<td>p=0.0001</td>
<td>p=0.02</td>
<td>p=0.0001</td>
<td>p=0.04</td>
</tr>
</tbody>
</table>

3.2.3.2 Environmental moderating factors

Length of Time at School

The moderating effect of the length of time that the children had been attending the schools exposed to high levels of aircraft noise on the association between chronic noise and reading comprehension could not be examined because most of the children had been attending the high noise schools for more than 4 years (92% of high noise sample). Most of the children had been attending the low noise schools for more than 4 years (88% of the low noise sample). Clearly there is insufficient variance to look at the very interesting question as to whether length of exposure to aircraft noise might relate to degree of impairment in reading comprehension.
**Home Noise Exposure**

The moderating effect of home noise could also not be examined because home aircraft noise exposure and school aircraft noise exposure were highly related. 80% of the children who went to high noise schools lived in homes exposed to high levels of chronic aircraft noise, whereas in the low noise school sample only 3% lived in high noise homes (Table 9 in the descriptive results section). 86% of the children who went to low noise schools lived in homes exposed to low levels of aircraft noise, whereas in the high noise school sample 3% lived in low noise homes (Table 9). This made it impossible to tease apart noise effects from home and school on cognitive performance.

**Acute Noise Exposure**

The confounding effect of acute aircraft noise on the associations between chronic aircraft noise and reading comprehension and between chronic noise and annoyance could not be examined across both groups because acute noise and chronic school noise were highly related. Both high chronic noise and acute noise interference were associated with lower reading comprehension scores and higher annoyance scores. As all chronic high noise schools had acute noise interference at the time of testing and only one class in a low noise school had an acute interference of a minimal level, to adjust for acute noise would involve an over adjustment for chronic noise (see Tables 10 & 11 for the results).
3.3 Discussion

There were three main findings in this study. First, the association between chronic aircraft noise exposure and reading comprehension and long term memory recognition, although not consistent across all the schools tested, is suggestive that chronic aircraft noise exposure impairs cognitive function. Second, chronic aircraft noise exposure was consistently and strongly associated with higher levels of noise annoyance in children. Third, the association between aircraft noise exposure and annoyance and reading comprehension could not be accounted for by the hypothesised psychological mediating factors (motivation, depression and anxiety) and potentially confounding socio-demographic factors (age, main language spoken at home, household deprivation). The data provide evidence that there are strong grounds for concern regarding the effect of chronic aircraft noise on child stress responses and cognition and that further research is required to examine the causal mechanisms and long term implications of these effects.

3.3.1 Reading comprehension

When the reading comprehension results from the eight schools were combined no difference was found in reading comprehension between the high and low noise schools. Excluding the procedural error school, the analysis carried out on the remaining seven schools resulted in a significant difference between the high and low noise schools on reading comprehension. The children in four schools chronically exposed to high levels of noise had poorer reading comprehension than the children in three schools exposed to lower levels of noise, even after adjustments for age, household deprivation and main language spoken at home. Although deprivation and main language spoken at home (both related to reading comprehension) may have had a small confounding effect on the association between noise exposure and reading comprehension they did not explain the association. This is in partial support of hypothesis 7 that: “deprivation, main language spoken at home and acute noise levels at the time of testing may act as confounding factors on the association between chronic aircraft noise exposure and cognitive performance”. The difference in reading comprehension indicates that the children chronically exposed to aircraft noise have a reading age six months behind the children not exposed to aircraft noise.
This reading comprehension results is consistent with hypothesis 1 "Chronic aircraft noise exposure produces cognitive impairments in reading comprehension, and long term memory recall in school children. No effects are expected on the control cognitive outcomes: recognition and short term memory" and previous field research around Los Angeles and Munich airports. In Munich children living in noisy communities had poorer performance on the standardised reading test compared with children living in quiet areas (Evans et al., 1995). In Los Angeles children in four noisy schools were more likely to fail on a cognitive task compared with three quiet schools (Cohen et al., 1980). Evans & Lepore (1993) found that chronic exposure to noise was associated with reading deficits in seven out of nine studies reviewed.

It is possible that the characteristics of individual schools may have a more powerful effect than noise exposure on reading comprehension. The issue of school standards or 'a school effect' is an obvious problem that may confound the reading comprehension results (Cohen, et al. 1980, Rutter, 1985). This 'school effect' is likely to be a consequence of differences in the quality of individual schools (resources, head teachers, teachers, reputation and selection factors such as the children in attracts). The potential confounding of 'a school effect' was noted in Los Angeles by Cohen, Evans, Krantz & Stokols (1980). When discussing their results from seven schools around Los Angeles Airport they made the point that: 'In the present study, noise sample children and quiet sample children attend different schools, were in different classrooms, and had different teachers. It is likely that these factors add substantial error variance to the equation, making the detection of a small effect of noise quite difficult' (Cohen et al., 1980, p.242). Further research needs to increase the sample size of schools, obtain a measure of school quality and analyse the data at the school level as well as the individual level. This will be addressed in Study 3.

The critical contribution of the present findings was to test exploratory hypothesis 5 that: “Depression, anxiety, noise annoyance and motivation may have a mediating relationship between chronic aircraft noise exposure and cognitive performance”. For the first time it was found that neither noise annoyance, nor depression, nor anxiety, nor motivation mediate the link between noise exposure and reading comprehension. Deficits in reading have previously been accounted for by suggesting that it may be that children adapt to noise interference during activities by filtering out the unwanted stimuli (Cohen et al., 1980; Cohen et al., 1986; Evans & Lepore, 1993; Heft, 1985).
This tuning out strategy may overgeneralise to all situations when noise is not present, such that children tune out stimuli indiscriminately. In turn, this may lead to noise exposed children having poorer ability to sustain attention in the classroom, which may continue over time to affect concentration and learning even in the absence of noise exposure. Little recent research has been conducted to examine the effects of chronic noise exposure on attention and the results have been equivocal (Moch-Sibony, 1984; Evans et al., 1995). Sustained attention will be tested as a mechanism in Study 2.

3.3.2 Long and short term memory

Short term memory (the control cognitive outcome) did not differ between the high and low noise schools consistent with hypothesis 1. This result replicates the findings on noise and short term memory around Munich Airport (Evans et al., 1995). Noise appeared to affect long term memory recognition but not recall in the seven schools. This result is not consistent with the Munich long term memory results which may be attributed to the task used to measure long term memory. Even though the long term memory task was designed modeled on the Munich task, it was a new measure that had not been used on British school children before. A difference was found between the two tasks indicating that the two versions used were not of equal difficulty or sensitivity (see Appendix 13 Threats to Validity). In Munich, the longitudinal long term memory results provide strong evidence that memory is a cognitive process affected by noise exposure (Hygge et al., 1996). The present negative results are not strong evidence to exclude the possibility that high levels of aircraft noise may affect long term memory.

3.3.3 Annoyance

The most consistent finding in this study supports hypothesis 3 “Chronic aircraft noise exposure in school children will be associated with higher levels of annoyance by noise than children in schools exposed to lower levels of aircraft noise.” It was found that children exposed to high levels of aircraft noise at school have higher levels of noise annoyance than children in low noise exposed schools. This effect remained after adjustments for age, deprivation and main language spoken. Children in high noise schools also reported greater perception of aircraft noise at school and at home than the low noise sample. Although anxiety and depression correlated with raised annoyance, they did not mediate the effect of noise on annoyance, which was contrary to exploratory hypothesis 6 that: “depression and anxiety may have a mediating relationship between chronic aircraft noise exposure and annoyance”.
It is important to recognise that even young children report disturbance by environmental noise. It might be argued, however, that annoyance responses are merely transmitted to children by their parents. However, the evidence does not support this contention because parent annoyance level (usually mothers’ annoyance level) and child annoyance levels were not related in this study ($r=0.1, p=0.07$). Therefore, it is unlikely that these child results can be attributed to parental influence over children’s responses. In many ways child noise annoyance may be less subject to bias because children might be less affected by other factors that influence annoyance in adult samples, namely: political and environmental attitudes (Berglund, & Lindvall, 1995; Fields, 1992; Job, 1988, 1996). Also it is reasonable to assume that noise annoyance responses should be associated with behavioural manifestations of emotional disturbance. However, there was little evidence from the results of the Modified Rutter Parent Questionnaire that annoyance had behavioural consequences, such as, undisciplined behaviour, because there was no difference between the two groups in level of deviance.

‘Annoyance’ is generally understood to be a mixture of anger, fear and mild irritation (Averill, 1982; Cohen & Weinstein, 1981). Annoyance is a stress response that is widespread and but the implications of annoyance raise further, as yet unanswered, questions (Stansfeld, 1992). The first uncertainty is that, the long term health consequences of persistent annoyance are unknown. Studies in adults have found mixed results in relation to noise annoyance over time: in some studies community noise annoyance does not habituate over time if the noise source persists (Weinstein, 1982), in others it either diminishes (MIL, 1971) or increases (Weinstein, 1978). To examine how children’s noise annoyance is effected by aircraft noise exposure over time follow-up data are required. Second, the underlying mechanism and precise description of annoyance are unknown. A more direct measure of child self-reported stress responses may clarify the annoyance response and be a more sensitive measure of general child stress responses.

3.3.4 Motivation and learned helplessness
Chronic exposure to noise was not associated with decreased motivation to persist with a difficult task or learned helplessness. This did not support hypothesis 2 “Chronic aircraft noise exposure decreases motivation and induces learned helplessness” nor previous research. The results of teacher reports of motivation in the classroom and
child attributional style did not show any differences between the high and low noise children. In fact, the means of the high and low noise sample are in the opposite direction to that expected, indicating a less depressogenic attributional style and less learned helpless classroom behaviour in the children exposed to high levels of aircraft noise.

The result of this study are not consistent with the Munich and Los Angeles motivational findings. In Los Angeles high noise exposure in children was associated with reduced persistence on challenging puzzles in 2 cross-sectional studies (Cohen et al., 1980; Cohen et al., 1986) and in a longitudinal study (Cohen et al., 1981). In Munich children from noisy communities persisted less than children from quiet communities on an insoluble puzzle (Evans et al., 1995). Part of the reason for the lack of replication of these motivational findings may relate to the method of test administration. Even though the same line-tracing puzzles adapted from Glass and Singer's (1972) after-effects paradigm that were used in Munich were used in this study, the method of administration differed. The puzzles were administered in small groups in a class situation while in Munich the puzzles were individually administered. Recording the time and number of attempts each child made on the insoluble puzzle was less accurate in a class administered situation than in individual administration. This is supported by the fact that there was a significant difference in motivation level of the children according to which researcher was in charge of their group. Children in groups were also likely to be affected by the behaviour of the others and mirror each other in giving up. In addition, individual attention by an adult increases child motivation. There is likely to have been less individual attention in class administration of tests than in previous studies where tests were individually administered.

Due to these methodological issues of accuracy and peer group effects biasing the results, these data do not provide evidence that chronic aircraft noise exposure does not influence child motivation. Despite the methodological problems with measures of motivation, it is possible that the previous motivation findings were secondary to the cognitive results and that the performance task measured 'cognitive effort'. It is also possible that ‘task persistence’ as measured by the animal puzzles may assess a different aspect of motivation from learned helplessness, for example it may have measured incentive motivation.
It has been suggested that learned helplessness may become a generalised learned response that becomes manifest as low motivation during performance of all tasks regardless of the presence of noise (Cohen et al., 1980; Evans & Lepore, 1993; Evans et al., 1995). Attributional style and teacher rated learned helpless classroom motivation were measured for the first time in this study and yielded no evidence to support the learned helplessness hypothesis. The fact that no differences were found either on the teacher’s report of the children’s motivation or on attributional style by noise exposure does not support the learned helplessness hypothesis previously used to account for the effects of noise on motivation (Cohen et al., 1986). The strongest evidence that this theory does not account for the motivation is the test for an interaction in multiple regression (see motivation results section), which indicates that attributional style does not moderate the association between noise and motivation. The Munich child attributions for failure on the insoluble puzzle were assessed (Evans et al., 1995). In agreement with the results presented here, they also found no evidence of attributional style differences by noise (personal communication: Staffan Hygge). However, teachers may adjust their ratings to the school and their experience, so teachers in the high noise schools may have lower criteria. To test this accurately the same rater is required across the high and low noise schools.

3.3.5 Mental and physical health

Physical health symptoms (self-reported general health, headaches, tiredness and sleeping troubles) and mental health problems (high rates of anxiety and depression) were not associated with chronic aircraft noise exposure. These findings are not what was expected, according to exploratory hypothesis 4 “The prevalence of depression, anxiety, general psychological disturbance and health symptoms will be higher in high aircraft noise exposed schools than in low aircraft noise exposed schools”.

A consistent relationship between adult mental health and noise has not been found and still requires further understanding, which is also certainly the case for child mental health effects (Stansfeld & Haines, 1997). There are likely to be many factors influencing childhood anxiety and depression, especially stressful relationships with peers and adults. Nevertheless, it is possible that an extra stressor such as noise in combination with other factors may add to the harmful effects on health. Given the exploratory nature of this aspect of the research which attempted to examine subclinical mental health effects of noise in children for the first time, the result needs to be
clarified in further research. It is also possible that chronic noise exposure does not
directly affect anxiety and depression but affects other more stress-related aspects of
mental health (e.g. self-reported stress) which also need to be assessed.

3.3.6 Acute noise exposure and environmental factors
There was a clear distinction between high and low chronic aircraft noise exposed
schools in terms of acute noise aircraft noise exposure during testing. In fact, the
majority of testing periods in high noise schools occurred during times of high acute
noise exposure. This made it impossible in this study to distinguish chronic from acute
effects of aircraft noise. In these schools it seems to be a somewhat artificial distinction
in any case. Previous studies have conducted testing in controlled environments using a
sound proof trailer (Evans et al., 1995) or using headphones (Evans & Maxwell, 1997)
and have found reading deficits in school children. These results have been interpreted
to strongly suggest that chronic noise exposure is the cause of the noise related reading
deficits and acute aircraft interference does not seem to influence the reading results.

Unfortunately it was not possible to examine the moderating effect of home noise
exposures and length of time at the school to test hypothesis 8 “Chronic home aircraft
noise exposure and length of time in the school environment may moderate the
association between chronic aircraft noise exposure and cognitive performance”. In
further studies the sample should be selected in such a way that there is variability in
length of time exposed to acute noise at school and home noise exposure across the high
and low chronically exposed groups. The interesting relationship between multiple
environmental stressors (e.g home and school noise exposure) is important to
understand the relationship between human coping and adaptation to environmental
stressors. The issue of how long a child has to be exposed to chronic levels of aircraft
noise before impairments in reading and annoyance become manifest is critical for
public health intervention strategies. It must be cautioned that length of time at school
might not be a precise measure of duration of exposure to noise, because it is
confounded by exposure to noise at home and thus may not reflect real exposure levels
over time.

The results examining child environmental perceptions and attitudes reveal that chronic
exposure to noise at school was not associated with general environmental attitudes
(fear of aircraft, perception of an unsafe environment or a sense of reduced
environmental mastery). Child attitudes more specifically focused on classroom interference are mixed. Children in the noise exposed schools compared with the controls are more likely to agree that planes passing overhead make it hard for them to think. Both samples report the same level classroom interference by aircraft noise. In order to clarify this contradiction, questions about environmental perception need to be expanded and focused specifically on classroom interference.

3.3.7 Summary and further research
The results of this baseline study are not conclusive. Nevertheless, there is enough evidence to suggest that noise exposure may affect reading comprehension in children and certainly causes annoyance - although the consequence of this are uncertain. Household deprivation and main language spoken did not substantially confound the association between noise exposure and reading comprehension and annoyance. There was no evidence that the hypothesised psychological factors mediate the effect of noise on reading comprehension or annoyance. The following two studies in this thesis aim to clarify these findings.

Study 2 was the follow-up of this baseline study, which examined the effects of chronic exposure to noise on cognition and annoyance one year after the baseline study. The results in this study aimed to demonstrate whether these reading comprehension impairments and annoyance reactions persist over time and whether the size of the effect increases or decreases. Sustained attention was tested as a mediating factor to account for the noise related deficits in reading comprehension. Parental involvement in their child’s school work was measured to explore whether this factor that may account for the cognitive results. Self-reported stress was measured to gain further insight into the effects of chronic exposure to aircraft noise on child mental health and noise annoyance. Repeat measures of anxiety and depression were taken to replicate the previous results. Given there are methodological grounds for concern with the measures for motivation and long-term memory they were not be repeated at follow-up. Study 3 will addressed the potential confounding school effect. Multi-level modeling statistical techniques were used on a larger sample of schools to differentiate school effects from noise effects on cognition.
CHAPTER 4

STUDY 2: FOLLOW-UP

Introduction, Results & Discussion
4.1 Introduction

The cross-sectional results from the baseline study reported in Chapter 3 confirmed an association between aircraft noise exposure at school and impairments in reading comprehension and greater noise annoyance. These effects did not seem to be accounted for by anxiety, depression, motivation, or socio-economic factors. Further questions about the long term effects of noise and possible causal factors arose from the results of this baseline study. By conducting repeated measures on these children after one year, an impression of the long-term course of noise annoyance, cognitive impairments and adaptations to noise exposure could be obtained.

4.1.1 Objectives

The cognition and stress responses of children aged 9 - 12 years, first tested one year ago at baseline in 1996, and attending the same four schools in high noise areas, were compared with same four matched control schools exposed to lower levels of aircraft noise at follow-up in 1997.

This follow-up study has four main aims:

1) To examine whether the effects of aircraft noise exposure on: a) cognitive performance and b) annoyance can be replicated in the same sample of school children who were tested one year ago at baseline.

2) To examine how children adapt to aircraft noise over the one year period in terms of their reading comprehension and annoyance.

3) To examine the effects of chronic aircraft noise on sustained attention and self-reported stress.

4) To test whether sustained attention is a factor which mediates the association between noise exposure and reading impairment.
4.1.2 Child adaptation to noise exposure

Previous studies have attributed the cause of the adverse effects of environmental noise on child health to chronic noise exposure, rather than, to acute effects (Cohen et al., 1980; Evans et al., 1995; Evans & Maxwell, 1997; for a full discussion see Chapter 1). This raises the question: what is the effect of prolonged exposure to noise? This question requires an examination of the issue of adaptation. Adaptation and related terms such as habituation and desensitisation are defined differently according to discipline (for example, experimental, social and evolutionary psychology all use the term differently). For the purposes of this thesis adaptation will be defined broadly, as referring to the general process by which individuals cope with or get accustomed to a stressor (including environmental stressors such as noise exposure). Habituation will only be used in relation to the specific instance of physiological adaptation. It is still unknown whether prolonged chronic aircraft noise exposure results in increasing adverse effects, or whether the effects remain constant, or the effects lessen or disappear. It must be noted that adaptation in the context of this research does not refer to an adaptive behavioural coping response (e.g. move schools & wear ear protection), but rather to how the children's reading and annoyance (responses) are affected by continuing exposure to noise (stimuli). The way these responses are affected by continued exposure indicate how the children adapt to noise.

4.1.3 Adaptation and annoyance

There are few studies examining how children's annoyance adapts to continued noise exposure. Adults studies have found that noise annoyance responses vary over time in chronically noise exposed populations: in various studies noise annoyance diminishes over time (OPCS, 1971) or stays the same (Weinstein, 1980) or increases (Weinstein, 1978). Some argue that adaptation to noise in not a uniform phenomenon (Stansfeld, 1988). Others suggest that people appear to have much more difficulty in adjusting to noise than is commonly believed and that this is most apparent when people are asked directly about their attitudes and feelings with respect to noise (Cohen et al., 1986). Thus, it is difficult to produce a directional hypothesis about the effect of noise annoyance over time which justifies an exploratory hypothesis. The within-subjects annoyance analyses will provide a preliminary answer as to how child noise annoyance levels are affected by chronic aircraft noise exposure over the year.
4.1.4 Adaptation and child cognitive performance

There have only been two previous repeated measures studies that were able to examine adaptation (Los Angeles, Cohen et al., 1981; Munich, Evans et al., 1998; Hygge et al., 1996). The Munich study was designed to examine the effects of change in noise exposure on child health and performance (Hygge et al., 1996, Evans et al., 1998, the complete longitudinal results are as yet unpublished). While this study design allows the researchers to elegantly examine the causal role of aircraft noise exposure on child health, it is not the best design to examine adaptation. To test for adaptation, repeated measures of children's performance and health should be taken over time while the children are exposed to the same level of persistent aircraft noise.

Cohen and colleagues (1981) report a one year follow up of their 1980 sample of school children around Los Angeles Airport (Cohen et al., 1980). At follow-up in 1981, they were addressing whether children re-tested one year later continue to show baseline effects or whether they adapt to noise over the one year period. The follow-up sample was 163 (high noise sample = 83 and quiet sample = 80), and the response rate at 62% was poor. The low response rate was due to an attrition bias; the children in the noisy schools with the greatest impairments had migrated or refused to take part in the follow-up (Cohen et al., 1981, pp. 336-338). The cross-sectional results demonstrated that the noise effect on annoyance, selective attention during distraction and performance on a moderately difficult cognitive task were stable over time. They did not replicate the effect of aircraft noise on blood pressure, and motivation measured by rate of giving up on a difficult task, in the attrition sample. Unfortunately the within-subjects analyses were also difficult to interpret because of an attrition bias influencing the results (Cohen et al., 1981). In general, it was concluded that that the data could be interpreted to indicate some habituation of physiological stress response but show no signs of adaptation of cognitive and motivational effects over the one year period.

Some other studies have examined whether length of time exposed to aircraft noise provides any suggestive evidence to indicate adaptation to noise. Length of time exposure to the environmental noise source has been found to influence auditory distraction (Evans & Lepore, 1993), auditory discrimination (Cohen et al., 1973), reading (Cohen et al., 1973), attention (Cohen et al., 1980) and possibly school achievement results (Maser et al., 1978). These data suggest that the greater the length of time exposed to noise, the greater the cognitive impairment in children.
On the basis of these results it is expected in this study that the adverse effects in reading comprehension will increase over the year. The within-subjects analysis in this study will assess the extent to which noise exposure produces a delay in the progress of child reading comprehension.

The Los Angeles Study and the present study have a design problem in common that limits the interpretability of the within-subjects analyses, because it is unknown what the impact is of the previous experience of exposure to aircraft noise. Most of the children in the present follow-up study have been exposed to noise for four or five years already (baseline length of time at school data). It is possible that the children have already adapted to the noise exposure and the reading response will be constant between baseline and follow-up. Therefore taking repeated measures of performance and annoyance with a year interval between baseline and follow-up will not be able to detect whether adaptation has occurred previously. The issue of long-term adaptation to environmental stressors has only started to be addressed, and further repeated measures longitudinal research is still required to address that design problem. Even though this follow-up study is only one year after baseline, it will be able to provide an impression of what the long-term effects of chronic aircraft noise exposure might be like.

4.1.5 Sustained attention: a mechanism to account for cognitive noise effects

Attention is generally defined as the process of directing and focusing certain psychological resources, usually by voluntary control, to enhance information processing, performance and mental experience (Bernstein et al., 1988). Sustained attention is one process of selection of the attentional system within the brain. Sustained attention is broadly defined as a capacity to maintain performance over time, such as attending to an object, person, or task for a sustained period. It can be measured by tasks with irregular inter-stimulus intervals or continuous vigilance tests. In some studies examining the effect of noise on child attention main effects have been found (Hambrick-Dixon, 1986; Hambrick-Dixon, 1988; Karsdorff & Klappach, 1968; Kyzar, 1977; Moch-Sibony, 1984; Sanz et al., 1993); however, attention effects have not been entirely consistent (Evans et al., 1995). It is possible that aircraft noise has a main direct effect on sustained attention, and it is also possible that that sustained attention also acts as a mediating factor between noise exposure and cognitive impairments (see Chapter 1, section 2.2.1, for a detailed outline of this mechanism). By measuring
sustained attention, the attention mediation hypothesis can be directly tested in school children for the first time.

**4.1.6 Self-reported stress**

Research consistently shows that environmental stressors that are uncontrollable or unpredictable, like aircraft noise, cause greater stress in human beings than controllable and predictable stressors (Evans & Cohen, 1987). It has been proposed that chronic exposure to uncontrollable ambient stressors, such as noise, decreases expectancies for control and increase susceptibility to helplessness (Lepore & Evans, 1996). Learned helplessness is a very appealing theory (see Chapter 1), although there is little empirical evidence from the noise literature in general, let alone the child research, to support the key assumption of this theory that the children exposed to high levels of aircraft noise are, in fact, stressed (due to the uncontrollable nature of noise).

There are psychophysiological data to suggest that children chronically exposed to high levels of aircraft noise have higher levels of stress indicated by raised systolic and diastolic blood pressure (Cohen et al., 1980; Evans et al., 1995; Regecova & Kellerova, 1995) and catecholamine secretion (Evans et al., 1995). This general pattern of endocrine and cardiovascular responses to high levels of noise exposure can be interpreted as an indirect indication that noise exposure produces physiological stress responses. These psychophysiological data need to be supplemented by other more direct measures of self-reported stress to demonstrate that children chronically exposed to noise actually feel stressed. For the first time, self-reported stress will be measured in school children chronically exposed to aircraft noise. The possibility that the cognitive and annoyance noise effects could be mediated by self-reported stress will also be explored in the present research.

**4.1.7 Parental involvement in the child’s school work**

Parental involvement in school work has been shown to have beneficial effects on child performance (Masselam et al., 1990; Steinberg et al., 1992). Given that most of these children live in high aircraft noise exposed homes it is reasonable to assume that aircraft noise interferes with daily activities and communication in the home (Job, 1988), such that parents may be less likely to help at home with homework. Michelson (1968) found that a good study environment at home (quiet secluded place to study) buffers the effect of school noise exposure on children’s reading ability. As noise may have independent
effects on child performance and on the likelihood of parental assistance with school work, it is possible that parental help at home may influence the association between aircraft noise exposure and cognitive performance in children.

### 4.1.8 Specific hypotheses

It is hypothesised that:

1. Chronic aircraft noise exposure produces cognitive impairments in reading comprehension. *(Between subjects analysis)*

2. Chronic aircraft noise exposure produces a delay in the progress of reading comprehension over the period of a year. *(Within subjects analysis)*

3. Sustained attention mediates the noise effects on reading comprehension. *(Between subjects analysis)*

4. Chronic aircraft noise exposure produces cognitive impairments in sustained attention. *(Between subjects analysis)*

5. Chronic aircraft noise exposure in school children is associated with higher levels of noise annoyance. *(Between subjects analysis)*

6. The baseline psychological mediating results are replicated. Specifically:
   6.1 That depression, anxiety, self-reported stress and noise annoyance do not mediate the relationship between chronic aircraft noise exposure and cognitive performance.
   6.2 That depression, anxiety and self-reported stress do not mediate the relationship between chronic aircraft noise exposure and annoyance.

*The following hypotheses are exploratory* and are not based on strong predictions from previous research. It is hypothesised that:

7. Chronic aircraft noise exposure in school children will be associated with higher levels of self-reported stress than in children in schools exposed to lower levels of aircraft noise. *(Between subjects analysis)*

8. Parental interest in school work influences the effect of noise on cognitive performance. *(Between subjects analysis)*
4.2 Results

The results will be divided into 5 sections. Section 1 contains the background description of the sample and noise exposure levels. Section 2 contains the cross-sectional/between subjects results of the main noise effects in children. Section 3 contains the results of the within subjects analyses of noise effects in children over the period of a year. Section 4 contains the analyses to test the mediating factors that may influence the main noise effects in children. Section 5 contains a summary of the psychometric analyses.

4.2.1 Section I - Descriptive results

4.2.1.1 Response rate
The overall child response rate was 81% (n=275) of the baseline sample across the eight schools; 10% (n=35) of the original 340 sample declined to take part in 1997; 6% (n=19) of the original sample had moved; 3% (n=11) of the original sample were away at the time of testing. The socio-demographic characteristics of the declining sample and the sample that had moved were not significantly different to the participating sample in terms of sex, race, age and social class.

4.2.1.2 Socio-demographic characteristics of the sample
As before at baseline, the sample was well matched across noise levels for: class at school, sex, proportion of socio-economic groups, social class and level of deprivation (see Table 18 below). The sample was less well matched on main language spoken at home and race (see Table 18 below). The high noise school sample had a higher proportion of non-white and non-English as the main language spoken at home than the low noise schools. Chi-squared tests ($\chi^2$) were run to assess total differences between high and low noise exposed samples (see Table 18 below, data taken from the 1996 parent questionnaire).
Table 18.

The socio-demographic characteristics of the high and low noise child samples in 1997: frequencies and proportions. (Follow-up Study)

<table>
<thead>
<tr>
<th>Socio-Demographic Characteristic</th>
<th>High Noise N=148</th>
<th>Low Noise N=127</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 5</td>
<td>66 (45%)</td>
<td>55 (43%)</td>
</tr>
<tr>
<td>Year 6</td>
<td>82 (55%)</td>
<td>72 (57%)</td>
</tr>
<tr>
<td>Girls</td>
<td>74 (50%)</td>
<td>69 (54%)</td>
</tr>
<tr>
<td>Boys</td>
<td>74 (50%)</td>
<td>58 (46%)</td>
</tr>
<tr>
<td>White</td>
<td>49 (36%)</td>
<td>111 (89%)</td>
</tr>
<tr>
<td>Non-White</td>
<td>86 (64%)</td>
<td>14 (11%) *</td>
</tr>
<tr>
<td>English - Main Language Spoken at Home</td>
<td>90 (66%)</td>
<td>116 (94%)</td>
</tr>
<tr>
<td>Non-English</td>
<td>46 (34%)</td>
<td>8 (6%) *</td>
</tr>
<tr>
<td>Non-Manual Social Class (1,2,3N)</td>
<td>42 (47%)</td>
<td>49 (58%)</td>
</tr>
<tr>
<td>Manual Social Class (3M,4,5)</td>
<td>48 (53%)</td>
<td>36 (42%)</td>
</tr>
<tr>
<td>Professional Groups SEGs (1,2,3,4)</td>
<td>19 (21%)</td>
<td>22 (25%)</td>
</tr>
<tr>
<td>Other non-manual workers SEGs(5,6)</td>
<td>24 (26%)</td>
<td>30 (35%)</td>
</tr>
<tr>
<td>Skilled Manual Workers SEGs (8,9,12)</td>
<td>24 (26%)</td>
<td>25 (29%)</td>
</tr>
<tr>
<td>Semi-Skilled Manual Worker SEGs(7 &amp;10)</td>
<td>12 (14%)</td>
<td>8 (9%)</td>
</tr>
<tr>
<td>Unskilled SEG(11)</td>
<td>11 (12%)</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Others SEGs (13,14,15,16,17)</td>
<td>1 (1%)</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Not Deprived</td>
<td>68 (53%)</td>
<td>70 (63%)</td>
</tr>
<tr>
<td>Deprived</td>
<td>60 (47%)</td>
<td>41 (37%)</td>
</tr>
</tbody>
</table>

Note. Total percentages reported are of those known. Missing data are generally a small proportion of the sample, except in the case of social class, socio-economic group and deprivation.

* Chi-squared tests were only run on total rows, these items (χ2) p<0.05.

4.2.1.3 Noise exposure

Chronic Aircraft Noise Exposure At School

There is no reason to assume that the chronic levels of aircraft noise changed in the eight schools as there was no significant change in flight frequency at Heathrow Airport over the period of a year (Turner, 1997). See Table 8 in Chapter 3 for chronic aircraft noise levels at the 8 schools.

Home Aircraft Noise Exposure

Noise exposure at home was strongly associated with noise exposure at school according to local noise contours (1991 CAA noise contours). 80% of the children in high noise exposed schools lived in high noise exposed homes (>63 dBA Leq 16hr) and
87% of the children in low noise schools lived in low noise homes (<57 dBA Leq 16hr) (see Table 19 Below).

Table 19.
Proportion of high and low school noise samples in high, moderate and low aircraft noise exposed homes taken from the 1994 CAA noise contour maps for the 1997 sample. (Follow-up Study)

<table>
<thead>
<tr>
<th></th>
<th>High Noise School Sample*</th>
<th>Low Noise School sample*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Noise Home</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(greater than 63 dBA Leq 16 hr)</td>
<td>80 %</td>
<td>3 %</td>
</tr>
<tr>
<td>n=102</td>
<td>n=3</td>
<td></td>
</tr>
<tr>
<td><strong>Moderate Noise Home</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(in-between 57 - 63 dBA Leq 16 hr)</td>
<td>17 %</td>
<td>10 %</td>
</tr>
<tr>
<td>n=21</td>
<td>n=12</td>
<td></td>
</tr>
<tr>
<td><strong>Low Noise Home</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Less than 57 dB A Leq 16 hr)</td>
<td>3 %</td>
<td>87 %</td>
</tr>
<tr>
<td>n=4</td>
<td>n=102</td>
<td></td>
</tr>
</tbody>
</table>

* there were some missing data for home aircraft noise exposure

**Acute Noise**

The acute levels of noise interference at the time of testing by aircraft overflights and road and rail noise are displayed in Tables 20, 21, 22 below in single event noise exposure level (SEL dBA). Single event noise exposure level (SEL) is defined as a measure indicating the total energy of an event and is obtained by adding a time adjustment to the Leq value.

On day two of testing the schools chronically exposed to high aircraft noise had 3 aircraft overflights during the testing sessions (which lasted 5 hours and 38 minutes). On day two of testing the schools exposed to low aircraft noise had no aircraft overflights during the testing sessions (which lasted 3 hours and 56 minutes of noise measurement time).

On day three of testing the schools chronically exposed to high aircraft noise had 71 aircraft overflights during the testing sessions (which lasted 6 hours and 2 minutes).
On day three of testing the schools exposed to low aircraft noise had 28 aircraft overflight during the testing sessions (which lasted 4 hours and 39 minutes).

The schools chronically exposed to high aircraft noise had no acute rail noise exposure and had 13 road traffic events during the testing sessions on days 2 and 3. The schools exposed to low aircraft noise had 4 rail events and had 1 road traffic event during the testing sessions on days 2 and 3.

Table 20.
Acute aircraft noise levels at the time of testing on Day 2 by class in 1997. (Follow-up Study)

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean SEL dBA</th>
<th>Max SEL dBA</th>
<th>Min SEL dBA</th>
<th>Number of Events</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HIGH NOISE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedfont - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bedfont - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chatsworth - 5</td>
<td>65.7</td>
<td>68.3</td>
<td>61.9</td>
<td>3</td>
</tr>
<tr>
<td>Chatsworth - 6</td>
<td>65.7</td>
<td>68.3</td>
<td>61.9</td>
<td>3</td>
</tr>
<tr>
<td>Wellington - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wellington - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Springwell - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Springwell - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>LOW NOISE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hermitage - 5</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Hermitage - 6</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Strand on Green - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Strand on Green - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feltham Hill - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feltham Hill - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wood End - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wood End - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* equipment malfunction
Table 21.

*Acute aircraft noise levels at the time of testing on Day 3 by class in 1997.*

*(Follow-up Study)*

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean SEL</th>
<th>Max SEL</th>
<th>Min SEL</th>
<th>Number of Events</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dBA</td>
<td>dBA</td>
<td>dBA</td>
<td></td>
</tr>
<tr>
<td><strong>HIGH NOISE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedfont - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bedfont - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chatsworth -5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chatsworth - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wellington - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wellington - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Springwell Junior - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30*</td>
</tr>
<tr>
<td>Springwell Junior - 6</td>
<td>64.2</td>
<td>64.2</td>
<td>64.2</td>
<td>41*</td>
</tr>
<tr>
<td><strong>LOW NOISE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hermitage - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hermitage -6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Strand on Green - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14*</td>
</tr>
<tr>
<td>Strand on Green - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14*</td>
</tr>
<tr>
<td>Feltham Hill - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feltham Hill - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wood End -5</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wood End -6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* aircraft not measureable over room noise
Table 22.

Acute road traffic and rail noise levels (Mean SEL) and number of events on testing Day 2 and 3 by class. (Follow-up Study)

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean SEL</th>
<th>Mean SEL</th>
<th>Mean SEL</th>
<th>Mean SEL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dBA</td>
<td>DBA</td>
<td>dBA</td>
<td>DBA</td>
</tr>
<tr>
<td>Road Traffic</td>
<td>Day 2</td>
<td>Day 3</td>
<td>Day 2</td>
<td>Day 3</td>
</tr>
<tr>
<td>Traffic Noise</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIGH NOISE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedfont - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bedfont - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chatsworth -5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chatsworth -6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wellington - 5</td>
<td>64.5(8)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wellington - 6</td>
<td>62.1(5)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Springwell - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Springwell - 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LOW NOISE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hermitage - 5</td>
<td>*</td>
<td>0</td>
<td>*</td>
<td>0</td>
</tr>
<tr>
<td>Hermitage -6</td>
<td>*</td>
<td>0</td>
<td>*</td>
<td>0</td>
</tr>
<tr>
<td>Strand on Green - 5</td>
<td>0</td>
<td>0</td>
<td>62.8(1)</td>
<td>0(1)</td>
</tr>
<tr>
<td>Strand on Green - 6</td>
<td>0</td>
<td>0</td>
<td>68.3(1)</td>
<td>0(1)</td>
</tr>
<tr>
<td>Feltham Hill - 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feltham Hill - 6</td>
<td>63.7(1)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wood End -5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wood End -6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* equipment malfunction

Perception of noise exposure

Aircraft noise exposure at school was strongly associated with the perception of plane noise at school: 95% of the children in high noise schools agreed that they could hear plane noise at school, compared to 72% of the children in low noise schools ($\chi^2 (1,260)=31.51$, $p=0.00001$). Aircraft noise exposure at school was also associated with the perception of plane noise at home: 89% of the children in high noise schools agreed that they could hear plane noise at home, whereas 66% of the children in low noise schools agreed that they could hear plane noise at home ($\chi^2 (1,259)=20.75$, $p=0.00001$). The two groups did not differ in these attitudes towards aircraft noise: perception of safety of aircraft and fear response to aircraft.
4.2.2 Section II - Cross-sectional noise effects in children

This section is divided up into three parts: 1) Noise effects on cognitive performance; 2) Noise effects on stress responses and health and 3) Environmental perceptions and parental involvement in school work.

4.2.2.1 Noise effects on cognitive performance

Reading Comprehension
Chronic exposure to aircraft noise was not significantly related to reading comprehension in the analysis of the eight schools (see Table 23). However, in the 7 schools, children in the four high noise exposed schools had poorer reading comprehension than children in the three low noise schools after adjusting for age (HN mean=99.71 (CI:97.65-101.76), LN mean=105.19 (CI:102.66-107.71), F(1,214)=10.98, p=0.001, see Table 23) and after adjusting for age, deprivation and main language spoken (HN mean=100.84 (CI:98.14-103.11), LN mean=105.28 (CI:102.27-108.15), F(1,178)=5.00, p=0.027, see Table 23).

Long term memory
The high and low noise groups did not differ in recognition and recall (see Table 23).

Sustained Attention
Chronic exposure to high levels of aircraft noise was associated with poorer sustained attention on the Score task in the eight schools adjusted for age (HN mean=8.34 (CI:8.12-8.62), LN mean=8.94(CI:8.63-9.18), F(1,241)=10.85, p=0.001 see Table 23) and after adjustments for age, deprivation and main language spoken (HN mean=8.42 (CI:8.20-8.76), LN mean=9.01 (CI:8.70-9.29), F(1,201)=8.01, p=0.005 see Table 23). This sustained attention effect was also found in the analyses of the seven schools adjusted for age (HN mean=8.34 (CI:8.12-8.62), LN mean=8.86(CI:8.48-9.11), F(1,219)=6.89, p=0.009 see Table 23) and after adjustments for age, deprivation and main language spoken (HN mean=8.42 (CI:8.20-8.76), LN mean=8.91 (CI:8.54-9.23), F(1,183)=4.16, p=0.04 see Table 23). The two groups did not differ in performance on the sustained attention Code Transmissions task (see Table 23).
Table 23.
Cognitive outcome mean scores adjusted for a) age only and b) fully adjusted for age, deprivation and main language spoken in the 4 high-noise schools, the 4 low-noise schools and the 3 low-noise schools (excluding the procedural error school) at follow-up in 1997. (Follow-up Study)

<table>
<thead>
<tr>
<th>Cognition and Performance Outcome</th>
<th>Four High Noise Schools Mean</th>
<th>Four Low Noise Schools Mean</th>
<th>Three Low Noise Schools Mean</th>
<th>F statistic, degrees of freedom and p-value for 8 schools comparison</th>
<th>F statistic, degrees of freedom and p-value for 7 schools comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suffolk Reading Comprehension Scale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age adjusted</td>
<td>99.71</td>
<td>102.32</td>
<td>105.19*</td>
<td>F(1,236)=2.53, p=0.11</td>
<td>F(1,214)=10.98, p=0.001</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>100.84</td>
<td>102.19</td>
<td>105.28*</td>
<td>F(1,196)=0.45, p=0.50</td>
<td>F(1,178)=5.00, p=0.027</td>
</tr>
<tr>
<td>Long-term memory recall task</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age adjusted</td>
<td>2.88</td>
<td>2.98</td>
<td>3.22</td>
<td>F(1,219)=0.17, p=0.68</td>
<td>F(1,198)=1.89, p=0.17</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>3.09</td>
<td>3.02</td>
<td>3.24</td>
<td>F(1,184)=0.05, p=0.82</td>
<td>F(1,167)=0.32, p=0.57</td>
</tr>
<tr>
<td>Long-term memory recognition task</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age adjusted</td>
<td>4.36</td>
<td>4.14</td>
<td>4.28</td>
<td>F(1,219)=1.11, p=0.29</td>
<td>F(1,197)=0.10, p=0.75</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>4.45</td>
<td>4.09</td>
<td>4.22</td>
<td>F(1,184)=2.04, p=0.15</td>
<td>F(1,166)=0.62, p=0.43</td>
</tr>
<tr>
<td>Sustained Attention Score Task</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age adjusted</td>
<td>8.34</td>
<td>8.94*</td>
<td>8.86*</td>
<td>F(1,241)=10.85, p=0.001</td>
<td>F(1,219)=6.89, p=0.009</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>8.418</td>
<td>9.01*</td>
<td>8.91*</td>
<td>F(1,201)=8.01, p=0.005</td>
<td>F(1,183)=4.16, p=0.04</td>
</tr>
<tr>
<td>Sustained Attention Code Transmissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age adjusted</td>
<td>36.44</td>
<td>36.27</td>
<td>37.04</td>
<td>F(1,242)=0.05, p=0.83</td>
<td>F(1,220)=0.81, p=0.37</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>36.67</td>
<td>36.43</td>
<td>37.06</td>
<td>F(1,202)=0.07, p=0.79</td>
<td>F(1,184)=0.35, p=0.56</td>
</tr>
</tbody>
</table>

* P<0.05
4.2.2.2 Noise effects on stress responses and health

Annoyance for aircraft noise
Chronic exposure to aircraft noise was associated with higher levels of annoyance for aircraft noise in the analyses of the eight schools adjusted for age (HN mean=1.04 (CI:0.89-1.2), LN mean=0.52 (CI:0.35-0.69), F(1,249)=20.40, p=0.0001 see Table 24) and after adjustments for age, deprivation and main language spoken (HN mean=1.00 (CI: 0.82-1.17), LN mean=0.58 (CI:0.39-0.76), F(1,206)=9.75, p=0.002, see Table 24). This annoyance effect was also found in the analyses of the seven schools adjusted for age (HN mean=1.04 (CI:0.89-1.2), LN mean=0.54 (CI:0.34-0.73), F(1,225)=16.05, p=0.0001 see Table 24) and after adjustment for age, deprivation and main language (HN mean=1.00 (CI: 0.82-1.17), LN mean=0.56 (CI:0.35-0.78), F(1,188)=8.80, p=0.003, see Table 24).

Self-reported stress - perceived stress score
The perceived stress scale asks the children to rate how bad would they feel if each of the 20 stressful situations happened to them. Chronic exposure to aircraft noise was associated with higher levels of perceived stress in the analyses of the eight schools adjusted for age (HN mean=3.46 (CI:3.35-3.57), LN mean=3.22 (CI:3.12-3.33), F(1,219)=9.13, p=0.003, see Table 24) and after adjustments for age, deprivation and main language spoken (HN mean=3.5 (CI:3.38-3.62), LN mean=3.22 (CI:3.10-3.34) F(1,185)=9.57, p=0.002, see Table 24). This stress effect was also found in the analyses of the seven schools adjusted for age (HN mean=3.46 (CI:3.35-3.57), LN mean=3.19 (CI:3.07-3.31), F(1,196)=11.08, p=0.001, see Table 24) and after adjustment for age, deprivation and main language (HN mean=3.5 (CI:3.38-3.62), LN mean=3.20 (CI:3.06-3.33) F(1,168)=10.2, p=0.002, see Table 24).

Self-reported stress - Frequency Score
This frequency sub-scale asks the children to rate how often each of the 20 stressful situations happened to them. Chronic exposure to aircraft noise was associated with lower levels of stress as measured by the frequency score in the analyses of the eight school adjusted for age (F(1,219)=5.95, p=0.016, see Table 24). However this effect failed to remain significant after adjustment for age, deprivation and main language (F(1,185)=2.68, p=0.104, see Table 24). There was no difference between the two groups in the analyses of the seven schools (see Table 24).
Self-reported stress - Overall Stress Score
The two groups did not differ in levels of overall stress score in the analyses of the eight and the seven schools (see Table 24).

Depression and Anxiety
The two groups did not differ in levels of depression and anxiety in the analyses of the eight and the seven schools (see Table 24). The two groups did not differ in prevalence of cases of depression and anxiety as indicated by the clinically relevant cut-off scores for depression on the Child Depression Inventory and anxiety on the Child Manifest Anxiety Scale. No difference was found in the scores above the cut off for high levels of depression between the number of children in schools chronically exposed to high noise (15%) and the number of children chronically exposed to low noise (20%) ($\chi^2(1,256)= 1.23 \ p=0.26$). No difference was found in the scores above the cut off for high levels of anxiety between the number of children in schools chronically exposed to high noise (53%) and the number of children chronically exposed to low noise (48%) ($\chi^2(1,258)= 0.73 \ p=0.39$).

Health Symptoms
Aircraft noise exposure at school had no effect on child self reported general health, headaches or tiredness. More children exposed to low levels of noise reported that they often had sleeping troubles (23%) than children exposed to high levels of aircraft noise at school (13%), ($\chi^2(1,261) =9.16, \ p=0.01$).
Table 24.

Stress responses and health outcome mean scores adjusted for a) age only and b) fully adjusted for age, deprivation and main language spoken in the 4 high-noise schools, the 4 low-noise schools and the 3 low-noise schools (excluding the procedural error school) at follow-up in 1997. (Follow-up Study)

<table>
<thead>
<tr>
<th>Stress and Health Outcome</th>
<th>Four High Noise Schools Mean</th>
<th>Four Low Noise Schools Mean</th>
<th>Three Low Noise Schools Mean</th>
<th>F statistic, df, and p-value for 8 schools comparison</th>
<th>F statistic, df and p-value for 7 schools comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annoyance</td>
<td>1.04</td>
<td>0.52*</td>
<td>0.54*</td>
<td>F(1,249)=20.4, p=0.0001</td>
<td>F(1,225)=16.05, p=0.0001</td>
</tr>
<tr>
<td></td>
<td>fully adjusted</td>
<td>1.00</td>
<td>0.58*</td>
<td>F(1,206)=9.75, p=0.002</td>
<td>F(1,188)=8.8, p=0.003</td>
</tr>
<tr>
<td>Self-reported stress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived stress score</td>
<td>3.46</td>
<td>3.22*</td>
<td>3.19*</td>
<td>F(1,219)=9.13, p=0.003</td>
<td>F(1,196)=11.08, p=0.001</td>
</tr>
<tr>
<td></td>
<td>fully adjusted</td>
<td>3.50</td>
<td>3.22*</td>
<td>F(1,185)=9.57, p=0.002</td>
<td>F(1,168)=10.2, p=0.002</td>
</tr>
<tr>
<td>Self-reported stress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency score</td>
<td>1.87</td>
<td>2.00*</td>
<td>1.98</td>
<td>F(1,219)=5.95, p=0.016</td>
<td>F(1,196)=3.27, p=0.07</td>
</tr>
<tr>
<td></td>
<td>fully adjusted</td>
<td>1.88</td>
<td>1.99</td>
<td>F(1,185)=2.68, p=0.10</td>
<td>F(1,168)=0.94, p=0.33</td>
</tr>
<tr>
<td>Self-reported stress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total score</td>
<td>6.40</td>
<td>6.44</td>
<td>6.30</td>
<td>F(1,219)=0.02, p=0.88</td>
<td>F(1,196)=0.12, p=0.74</td>
</tr>
<tr>
<td></td>
<td>fully adjusted</td>
<td>6.52</td>
<td>6.37</td>
<td>F(1,185)=0.24, p=0.63</td>
<td>F(1,168)=1.06, p=0.31</td>
</tr>
<tr>
<td>Depression (CDI)</td>
<td>4.48</td>
<td>5.25</td>
<td>5.04</td>
<td>F(1,246)=2.06, p=0.15</td>
<td>F(1,222)=0.89, p=0.35</td>
</tr>
<tr>
<td></td>
<td>fully adjusted</td>
<td>4.50</td>
<td>4.86</td>
<td>F(1,203)=0.33, p=0.56</td>
<td>F(1,185)=0.01, p=0.92</td>
</tr>
<tr>
<td>Anxiety (CMAS)</td>
<td>11.38</td>
<td>11.90</td>
<td>11.45</td>
<td>F(1,248)=0.35, p=0.55</td>
<td>F(1,224)=0, p=0.97</td>
</tr>
<tr>
<td></td>
<td>fully adjusted</td>
<td>10.87</td>
<td>11.49</td>
<td>F(1,206)=0.36, p=0.55</td>
<td>F(1,188)=0.02, p=0.88</td>
</tr>
</tbody>
</table>

* P<0.05
4.2.2.3 Environmental perceptions and parental involvement in child school work

This follow-up study provided a further opportunity to collect more descriptive data of classroom noise interference in an expanded questionnaire (Bronzaft & MacCarthy, 1975). The results in this section are presented for the 8 schools only, because the sample from the procedural error school came from a control school and because it is unlikely that their lower ability would influence environmental perceptions.

Noise interfering in the classroom

On the whole there was no clear and consistent effect of children exposed to aircraft noise reporting that aircraft noise substantially interfered in the classroom compared with the control sample. A summary of the results are given below.

More children in the high noise exposed schools agreed that 'planes passing overhead make it hard for me to think' (45%) compared with the control group (28%) ($\chi^2(1,262) = 11.12$, p=0.01). The two groups did not differ on reported: 'easy to hear the teacher in the classroom', 'ease to be heard by the teacher', 'the level of noise in the classroom', and that 'classroom noise interfered with their school work'.

51% of the high noise sample and 57% of the low noise sample reported that there was too much noise in the classroom. The children in the schools exposed to high levels of noise who claimed that the classroom was too noisy were more likely to offer plane noise as the main source of noise (28%) than low noise children (8%) (see Table 25 below). The two groups did not differ on the other sources of classroom noise, such as 'playground noise' and 'other children', were evenly distributed amongst the high and low noise groups (see Table 25). 'Other children' was offered as the main source of noise interference by both groups.
Table 25.
The main source of noise interference offered by children in the 4 high and 4 low aircraft noise schools who responded that there was too much noise in the classroom. (Follow-up Study)

<table>
<thead>
<tr>
<th>Source of Noise</th>
<th>High noise sample who responded that there was too much noise in the classroom (N=76)</th>
<th>Low noise sample who responded that there was too much noise in the classroom (N=72)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rooms next door</td>
<td>12%</td>
<td>12%</td>
</tr>
<tr>
<td>Traffic in the street</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Planes</strong>*</td>
<td><strong>27%</strong></td>
<td><strong>8%</strong></td>
</tr>
<tr>
<td>Playground</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td>The Hallway</td>
<td>8%</td>
<td>15%</td>
</tr>
<tr>
<td>Other Children</td>
<td>38%</td>
<td>37%</td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
<td>11%</td>
</tr>
</tbody>
</table>

* Bold items signify items of interest

More children in the quiet control schools reported that they did not like their classroom (28%) than high noise children (10%) ($\chi^2(1,235) = 10.38, p=0.001$). Noise, crowding and unpleasant temperature were identified by both samples as the main problems with their classrooms (see Table 26)

Table 26.
The main classroom problem offered by children in the high and low aircraft noise schools who responded that they didn’t like their classroom. (Follow-up Study)

<table>
<thead>
<tr>
<th>Classroom Problem</th>
<th>High noise sample who responded that they didn’t like their classroom (n=15)</th>
<th>Low noise sample who responded that they didn’t like their classroom (n=35)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not enough light</td>
<td>20%</td>
<td>6%</td>
</tr>
<tr>
<td>Too cold or too warm</td>
<td>16%</td>
<td>21%</td>
</tr>
<tr>
<td>Too much noise</td>
<td>23%</td>
<td>30%</td>
</tr>
<tr>
<td>Too quiet</td>
<td>7%</td>
<td>3%</td>
</tr>
<tr>
<td>Too crowded</td>
<td>27%</td>
<td>25%</td>
</tr>
<tr>
<td>Other</td>
<td>7%</td>
<td>15%</td>
</tr>
</tbody>
</table>
**Other environmental factors apart from noise at school**

The high and low noise groups did not differ on perception of road traffic and air pollution at school. More children in the control schools reported that they could hear train noise at school (37%) than the children in the schools exposed to high levels of aircraft noise (16%) ($\chi^2(1,258)=17.18, p=0.0003$). More of the low noise sample reported that they found train noise at school ‘quite a bit’ or ‘very annoying’ (14%) than the high noise sample (3%) ($\chi^2(1,257)=18.29, p=0.0003$).

**Other environmental factors apart from noise at home**

More children in the control schools reported that their neighbourhood was not very friendly (16%) compared with the children in schools exposed to high levels of noise (7%) ($\chi^2(1,261)=7.15, p=0.02$). More children from the control schools reported that they could hear train noise at home (27%) than high noise exposed children (14%) ($\chi^2(1,259)=8.33, p=0.003$). There was no difference between the samples on how annoying they found the train noise at home. The high noise and control groups did not differ on perception of neighbourhood safety, road traffic, neighbour noise.

**Parental Involvement in School Work**

Parental help was measured by child report of: how much help the child got with home work, reading aloud to parents at home, having parents read aloud to children and general level of parental interest in children’s school work. There was a trend across the four questions, that assessed parental involvement in child school work, to indicate that the children in the high noise exposed schools had more parental involvement compared with the control sample. More children in the high noise schools reported that they had stories or other things read aloud to them at home at least once a week (38%) than the children in the low noise schools (23%) ($\chi^2(1,261)=8.5, p=0.01$). More children in the high noise schools reported that they read stories or other things read aloud at home at least once a week (64%) than the children in the low noise schools (46%) ($\chi^2(1,260)=9.95, p=0.006$). There was no difference between the high noise and low noise samples on general parental help with home work and parental interest in school work.

Parental involvement can not be tested as a potential moderating factor (Hypothesis 8) because the trend that, the children in the high noise exposed schools had more parental involvement compared with the control sample, does not suggest an interpretable
explanation for why the children chronically exposed to noise have poorer reading comprehension and sustained attention. The fact that there was more parental assistance given to the children in the high noise sample contradicts the basic assumption of this exploratory moderating hypothesis; namely that noise might have an independent effect on parents to make them less likely to help with homework. Therefore any moderating effect found could not be attributed to this hypothesis and it can not be tested. The potential moderating influence of parental help at home with school work still needs to be considered in further research of a larger sample of school children.
4.2.3 Section III - Within subjects analyses

Two statistical methods were used to assess the noise-effects over time. These two methods were: analyses of covariance adjusting for baseline performance (ANCOVA) and multiple analysis of variance (MANOVA). These two methods were used because they measure different aspects of adaptation to noise over time (for a full discussion see Chapter 2 - statistical procedures section).

4.2.3.1 Reading comprehension

Analyses of Covariance Adjusting for Baseline Performance

In the analyses with both the eight schools (HN mean=100.1 (CI:99.00-101.10), LN mean=101.9 (CI:100.63-103.00)) and seven schools (HN mean=100.1 (CI:99.00-101.10), LN mean=103.3 (CI:101.68-104.28)) after adjusting for baseline 1996 performance, performance in 1997 was significantly different between the high and low noise children (see Table 27 below). The age adjusted results indicate that high noise children progress at half the rate of low noise children. However, if further adjustments are made for age, main language spoken and deprivation the difference in reading comprehension performance in both the 7 and 8 schools fails to reach significance (see Table 27 below).
Table 27.

**ANCOVA models adjusting for baseline 1996 reading comprehension performance on reading comprehension performance at follow-up (1997)** adjusted for a) baseline performance and b) fully adjusted for baseline performance, age, deprivation and main language spoken in the 4 high-noise schools, the 4 low-noise schools and the 3 low-noise schools (excluding the procedural error school) in 1997. *(Follow-up Study)*

<table>
<thead>
<tr>
<th>Reading Comprehension at follow-up</th>
<th>Four High Noise Schools Mean</th>
<th>Four Low Noise Schools Mean</th>
<th>Three Low Noise Schools Mean</th>
<th>F statistic, degrees of freedom and p-value for 8 schools comparison</th>
<th>F statistic, degrees of freedom and p-value for 7 schools comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suffolk Reading Comprehension Score at follow-up</strong> adjusted for baseline performance</td>
<td>100.1</td>
<td>101.9*</td>
<td>103.3*</td>
<td>F(1,225)=4.57 p=0.03</td>
<td>F(1,204)=4.8 p=0.03</td>
</tr>
<tr>
<td><strong>Suffolk Reading Comprehension Score at follow-up</strong> fully adjusted</td>
<td>100.8</td>
<td>101.6</td>
<td>103.2</td>
<td>F(1,191)=0.8 p=0.37</td>
<td>F(1,173)=1.25 p=0.27</td>
</tr>
</tbody>
</table>

* p<0.05

The fully adjusted results indicate that this within-subjects noise effect might be confounded by main language spoken at home and deprivation. On the basis of this straightforward interpretation it could be proposed that; it is not the aircraft noise exposure, but the fact that the high noise children are a little more deprived and English is not spoken at home that causes the delay in progress. However in the seven and eight schools deprivation was not related to noise exposure and nor was main language spoken at home. This suggests that it may that the change in significance may not be due to the adjustment of these potential confounding factors and raises further questions. Is it main language spoken or is it deprivation that is causing the delay in progress effect? Is it an artifact of losing sample size? Can these effects be replicated in stratified samples?

Further analyses, adjusting for deprivation and main language separately, were conducted to address these questions. In analyses of the seven schools after an
adjustment for baseline reading comprehension and deprivation the main noise effect remains significant ($F(1,182)=3.93, p=0.049$). In an analyses of the seven schools after an adjustment for baseline reading comprehension and main language spoken the main noise effect fails to reach significance ($F(1,193)=2.18, p=0.142$). Therefore it would seem that the main language that is confounding the effect. This remains puzzling because main language spoken at home was not related to reading comprehension in these analyses.

To test whether the failure to reach significance after adjusting for main language was an artefact of losing sample size two further analyses were conducted. In an analyses of the seven schools after an adjustment for baseline reading comprehension in a reduced sample with exclusions made for the subjects with missing values for main language spoken the main noise effect fails to reach significance ($F(1,193)=3.41, p=0.06$, see Table 28). In an analyses of the seven schools after an adjustment for baseline reading comprehension in a reduced sample with exclusions made for the subjects with missing values for deprivation the main noise effect fails to reach significance ($F(1,173)=2.48, p=0.12$, see Table 28).

A close examination of the means presented in Table 28 below indicate that difference between the observed and the adjusted means vary slightly depending on the sample and the adjustments made. These results indicate that when reading comprehension is adjusted for deprivation and main language spoken there is a reduction in sample size, which may reduce the power of the ANCOVA to detect a significant delay in progress. However, there is some variation in the effect size with the full sample adjusted for baseline being 1.9 (first column) and this sample fully adjusted being 1.1 (last column), so adjustment partly influences the effect size. These data suggest that socio-demographic adjustment does partly influence the results. Therefore it is difficult to interpret whether the fully adjusted results indicate that this within-subjects noise effect is confounded by main language spoken at home and deprivation, because it is also influenced by reduction in sample size.

Finally, analyses were conducted in a stratified sample of English speakers only in the 7 schools to examine further whether the delay in progress effect can be replicated. In an analysis of the English speakers in the 7 schools after adjustments for baseline reading
comprehension the 1997 noise effect remains significant (High noise observed mean=100.1 and adjusted mean=101.8, Low noise observed mean=105.3, adjusted mean=103.6, F(1,169)=3.8, p=0.05).

Table 28.

Means of reading comprehension performance and effect size in 1997 in the 7 schools for: 1) the full sample adjusted for baseline reading comprehension, 2) the reduced sample with missing values taken out for main language spoken adjusted for baseline reading comprehension, 3) the reduced sample with missing values taken out for deprivation adjusted for baseline reading comprehension, 4) the full sample fully adjusted for baseline reading comprehension, deprivation, main language spoken and age. (Follow-up Study)

<table>
<thead>
<tr>
<th></th>
<th>Full Sample Adjusted for baseline reading comprehension</th>
<th>Reduced sample for Main language Spoken adjusted for baseline reading comprehension</th>
<th>Reduced sample for deprivation adjusted for baseline reading comprehension</th>
<th>Full sample fully adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High noise means</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>observed mean</td>
<td>obs: 99.50</td>
<td>obs: 99.80</td>
<td>obs: 99.84</td>
<td>obs: 99.80</td>
</tr>
<tr>
<td>adjusted mean</td>
<td>adj: 101.40</td>
<td>adj: 101.70</td>
<td>adj: 102.0</td>
<td>adj: 102.10</td>
</tr>
<tr>
<td><strong>Low noise means</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>observed mean</td>
<td>obs: 105.30</td>
<td>obs: 105.30</td>
<td>obs: 105.56</td>
<td>obs: 105.60</td>
</tr>
<tr>
<td>adjusted mean</td>
<td>adj: 103.30</td>
<td>adj: 103.30</td>
<td>adj: 103.40</td>
<td>adj: 103.20</td>
</tr>
<tr>
<td><strong>Effect Size after adjustment</strong></td>
<td>1.9</td>
<td>1.6</td>
<td>1.4</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>F, df, p-value</strong></td>
<td>F (1,204)=4.80, p=0.03</td>
<td>F(1,193)=3.41, p=0.06</td>
<td>F(1,173)=2.48, p=0.12</td>
<td>F (1,173)=1.14, p=0.27</td>
</tr>
</tbody>
</table>

Multiple Analyses of Variance: MANOVA

MANOVA assesses group differences over time. It produces three tests of differing levels of relevance, firstly a noise effect, a year effect and an interaction. The noise effect takes an average of performance over the two years and includes it in one analysis. The advantage of this test is that it doubles the scores entered into the analyses, hence increases the power of the tests for main noise effects. This is a more reliable measure of a total noise effect than the two cross-sectional comparisons. The interaction is a test of group adaptation to noise. The interaction test examines group differences for both time points, but is more likely to be confounded by other factors which makes any found effect directly attributable to noise. It is a cruder measure than
the ANCOVA and is of limited interest. As the year effect and interaction are of lesser importance the results will not be presented.

There was not a significant main noise effect in the 8 schools. In the analyses of the 7 schools there was a significant main noise effect adjusting for age (F(1,202)=10.24, p=0.002, Table 29). This effect remained significant after further adjustments for age, main language spoken and deprivation (F(1,169)=5.08, p=0.02, Table 29). Averaging over the two years the high noise children had significantly poorer reading comprehension performance than the low noise children, in the seven schools.

Table 29.
MANOVA main noise effect for reading comprehension performance averaged over baseline and follow-up adjusted for a) age and b) fully adjusted for age, deprivation and main language spoken in the 4 high-noise schools, the 4 low-noise schools and the 3 low-noise schools (excluding the procedural error school). (Follow-up Study)

<table>
<thead>
<tr>
<th>Reading Comprehension score averaged over baseline and follow-up</th>
<th>Four High Noise Schools Mean</th>
<th>Four Low Noise Schools Mean</th>
<th>Three Low Noise Schools Mean</th>
<th>F statistic, degrees of freedom and p-value for 8 schools comparison</th>
<th>F statistic, degrees of freedom and p-value for 7 schools comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Suffolk Reading Comprehension Score adjusted for age</td>
<td>98.86</td>
<td>101.10</td>
<td>103.78*</td>
<td>F(1,223)=1.95, p=0.16</td>
<td>F(1,202)=10.24, p=0.002</td>
</tr>
<tr>
<td>Average Suffolk Reading Comprehension Score fully adjusted</td>
<td>99.66</td>
<td>101.10</td>
<td>103.97*</td>
<td>F(1,187)=0.39, p=0.53</td>
<td>F(1,169)=5.08, p=0.02</td>
</tr>
</tbody>
</table>

* p<0.05
4.2.3.2 Noise annoyance for aircraft noise

**Analyses of Covariance Adjusting for Baseline Performance**

In the analyses of the 8 schools after adjusting for baseline noise annoyance (1996), noise annoyance in 1997 was significantly different between the high and low noise children (HN mean=0.92 (CI:0.79-1.08), LN mean=0.65 (CI:0.5-0.83), F(1,245)=5.42, p=0.02, See Table 30). This did not remain significant after further adjustment was made for age, deprivation and main language spoken.

In the analyses of the 7 schools after adjusting for baseline noise annoyance (1996), and after further adjustments for age, deprivation and main language spoken noise annoyance in 1997 was not significantly different between the high and low noise children (see Table 30).
Table 30.

ANOVA models adjusting for baseline noise annoyance (1996) on in noise annoyance at follow-up (1997) adjusted for a) baseline level and b) fully adjusted for baseline level, age, deprivation and main language spoken in the 4 high-noise schools, the 4 low-noise schools and the 3 low-noise schools (excluding the procedural error school) in 1997. (Follow-up Study)

<table>
<thead>
<tr>
<th>Aircraft Noise Annoyance at follow-up</th>
<th>Four High Noise Schools Mean</th>
<th>Four Low Noise Schools Mean</th>
<th>Three Low Noise Schools Mean</th>
<th>F statistic, degrees of freedom and p-value for 8 schools comparison</th>
<th>F statistic, degrees of freedom and p-value for 7 schools comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>adjusted for baseline performance</td>
<td>0.92</td>
<td>0.65*</td>
<td>0.68</td>
<td>F(1,245)=5.42, p=0.02</td>
<td>F(1,222)=3.35, p=0.069</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>0.88</td>
<td>0.69</td>
<td>0.69</td>
<td>F(1,204)=2.00, p=0.16</td>
<td>F(1,186)=1.68, p=0.197</td>
</tr>
</tbody>
</table>

Multiple Analyses of Variance: MANOVA

In the analyses of the 8 schools there was a significant main noise effect on annoyance adjusting for age (F(1,243)=36.76, p=0.0001, Table 31). This effects remained significant after further adjustments for age, main language spoken and deprivation (F(1,200)=17.69, p=0.0001, Table 31). In the analyses of the 7 schools there was a significant main noise effect adjusting for age (F(1,220)=31.19 p=0.0001, Table 31). This effects remained significant after further adjustments for age, main language spoken and deprivation (F(1,182)=14.39, p=0.0001, Table 31). Averaging over the two years children exposed to high levels of noise exposure had significantly higher noise annoyance levels than the children in schools exposed to lower levels of aircraft noise exposure.
Table 31. MANOVA main noise effect for noise annoyance averaged over baseline and follow-up adjusted for a) age and b) fully adjusted for age, deprivation and main language spoken in the 4 high-noise schools, the 4 low-noise schools and the 3 low-noise schools (excluding the procedural error school). (Follow-up Study)

<table>
<thead>
<tr>
<th>Noise annoyance score averaged over baseline and follow-up</th>
<th>Four High Noise Schools Mean</th>
<th>Four Low Noise Schools Mean</th>
<th>Three Low Noise Schools Mean</th>
<th>F statistic, degrees of freedom and p-value for 8 schools comparison</th>
<th>F statistic, degrees of freedom and p-value for 7 schools comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Noise Annoyance adjusted for age</td>
<td>1.57</td>
<td>0.72*</td>
<td>0.71*</td>
<td>F(1,243)=36.76 p=0.0001</td>
<td>F(1,220)=31.19 p=0.0001</td>
</tr>
<tr>
<td>Average Noise Annoyance fully adjusted</td>
<td>1.50</td>
<td>0.80*</td>
<td>0.79*</td>
<td>F(1,200)=17.69 p=0.0001</td>
<td>F(1,182)=14.39 p=0.0001</td>
</tr>
</tbody>
</table>

* P<0.05
4.2.4 Section IV - Mediating analyses

This section is divided into 2 sub-sections to examine the explanatory role of the hypothesised mediating factors on the significant relationships between noise and: 1) reading comprehension and 2) annoyance.

4.2.4.1 Psychological mediation of the association between noise exposure on reading comprehension effects.

Test of the Sustained Attention Mediation Hypothesis
The sustained attention (score task) was entered as covariate into an ANCOVA model to test whether it mediated the relationship between chronic noise exposure and reading comprehension (the Independent Variable school noise level: high or low and the Dependent Variable - reading comprehension score).

The result did not support hypothesis 3 because sustained attention as measured by performance on the score task did not explain the significant association between noise at school and reading comprehension (see Table 32 below). This is indicated by the fact that the significance level of the reading comprehension results was not altered by partialling out the effects of sustained attention. Nevertheless high levels of sustained attention were significantly correlated with higher reading comprehension (r=0.14, p=0.02, 8 schools).

The other psychological factors
The more exploratory mediators were tested by entering the perceived stress score, frequency stress score, depression (CDI), anxiety (CMAS), and aircraft noise annoyance separately as covariates in an ANCOVA model (with the Independent Variable school noise level: high or low and the Dependent Variable - reading comprehension score).

Adjusting for stress made the relationship between school noise exposure and reading comprehension significant in the eight schools. Adjusting for the frequency stress scale made the high noise mean change from 99.26 (observed) to 99.01 (adjusted) and the low noise mean from 102.93 (observed) to 103.09 (adjusted) and hence achieve significance (F(1,198)=5.04, p=0.026, see Table 32). Adjusting for perceived stress did not alter the significance level of the reading comprehension scores in the 8 schools.
In support of hypothesis 6.1, self-reported stress, anxiety, depression and aircraft noise annoyance did not explain the significant association between noise at school and reading comprehension in the seven schools (see Table 32 below). This is indicated by the fact that the significance level of the reading comprehension results was not altered by partialling out the effects of these psychological factors.

Nevertheless high perceived stress (r=-0.15, p =0.029 ) and anxiety( r = -0.14, p =0.029 ) were significantly correlated with lower reading comprehension in the eight schools. Frequency stress score, depression and aircraft noise annoyance were not significantly correlated with reading comprehension.

Table 32.

*The role of psychological mediating factors in the relationship between chronic noise exposure at school and reading comprehension. (Follow-up Study)*

<table>
<thead>
<tr>
<th>Covariate</th>
<th>8 schools</th>
<th>7 schools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F statistic, degrees of freedom, p-value</td>
<td>F statistic, degrees of freedom, p-value</td>
</tr>
<tr>
<td>Sustained Attention (score task)</td>
<td>F(1,224)=1.47, p=0.23</td>
<td>B=1.19, p=0.046</td>
</tr>
<tr>
<td></td>
<td>F(1,198)=5.04, p=0.026*</td>
<td>B= -2.64, p=0.21</td>
</tr>
<tr>
<td></td>
<td>F(1,118)=2.75, p=0.09</td>
<td>B= -2.78, p=0.07</td>
</tr>
<tr>
<td></td>
<td>F(1,223)=2.25, p=0.14</td>
<td>B= -0.26, p=0.03</td>
</tr>
<tr>
<td></td>
<td>F(1,225)=2.56, p=0.11</td>
<td>B= -0.11, p=0.58</td>
</tr>
<tr>
<td>Anxiety (CMAS)</td>
<td>F(1,223)=2.25, p=0.14</td>
<td>B= -0.26, p=0.03</td>
</tr>
<tr>
<td>Depression (CDI)</td>
<td>F(1,224)=2.60, p=0.11</td>
<td>B=0.45, p=0.64</td>
</tr>
</tbody>
</table>

*Change in significance level*
4.2.4.2 Psychological mediation of the association between noise exposure and annoyance

Child depression inventory score, child manifest anxiety score, perceived stress score, and frequency stress score were entered separately as covariates in an ANCOVA model (with the Independent Variable - school noise level: high or low, dependent variable - noise annoyance).

In support of hypothesis 6.2, none of these factors explained the significant association between noise exposure and annoyance (see Table 34 below). This is indicated by the fact that the significance level of annoyance results were not altered by partialling out the effects of depression, anxiety and stress.

Higher levels of anxiety (r=0.17, p=0.007) and higher levels of perceived stress (r=0.14, p=0.029), were significantly correlated with higher noise annoyance in the eight schools. Depression and the frequency of stressful events were not related to aircraft noise annoyance.

Table 33.

The role of psychological mediating factors in the relationship between chronic noise exposure at school and aircraft noise annoyance. (Follow-up Study)

<table>
<thead>
<tr>
<th>Covariate</th>
<th>8 schools F statistic, degrees of freedom, p-value</th>
<th>8 schools B, p-value</th>
<th>7 schools F statistic, degrees of freedom, p-value</th>
<th>7 schools B, p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression (CDI)</td>
<td>F(1,253)=21.24 p=0.0001</td>
<td>B=0.019 p=0.14</td>
<td>F(1,229)=16.79 p=0.0001</td>
<td>B=0.02 p=0.10</td>
</tr>
<tr>
<td>Anxiety (CMAS)</td>
<td>F(1,256)=21.31 p=0.0001</td>
<td>B=0.02 p=0.002</td>
<td>F(1,232)=16.64 p=0.0001</td>
<td>B=0.03 p=0.001</td>
</tr>
<tr>
<td>Perceived Stress Subscale</td>
<td>F(1,227)=11.06 p=0.001</td>
<td>B=0.16 p=0.11</td>
<td>F(1,204)=8.16 p=0.005</td>
<td>B=0.19 p=0.09</td>
</tr>
<tr>
<td>Frequency of Stressful events sub-scale</td>
<td>F(1,227)=14.18 p=0.0001</td>
<td>B=0.11 p=0.415</td>
<td>F(1,204)=11.50 p=0.001</td>
<td>B=0.12 p=0.38</td>
</tr>
</tbody>
</table>
4.2.5 Section V - Psychometric analyses

This section contains a summary of the full psychometric results that are reported in Appendix 15 for both the baseline and follow-up study. This section summarises the psychometric results for both the baseline and follow-up studies.

**Reliability - Stability**

Pearson’s correlations were taken on the scales that were used at both baseline and follow-up to test for stability over time. These correlations indicate that the subject ordering was consistent over time. The Suffolk reading scale had high stability. Depression (CDI), anxiety (CMAS) and noise annoyance had moderate stability. However, high levels of stability were not expected on these scales because of developmental influences on child depression, anxiety and annoyance over a period of a year. Long term memory recognition and recall had poor stability.

**Reliability - Internal consistency**

Cronbach alphas were taken on the depression, anxiety and stress psychological scales. These alphas indicate the internal consistency of the items within each scale. The Child Manifest Anxiety Scale (CMAS) and the Lewis Child Stress Scales had high internal consistency. The Child Depression Inventory (CDI) had poor internal consistency.

**Validity**

Validity is the extent to which a test measures the construct that it aims to measure. Concurrent validity is the extent to which a scale or test correlates with other related instruments. Concurrent validity is relevant for the present study, because it is a multivariate design of related but not identical variables. In order to determine whether the tests and scales have concurrent validity, assumptions about which scales should be related can be tested. It is to be expected that the cognitive measures (reading, memory & attention) would correlate positively with each other and that the mental health/affective measures (depression, anxiety, self-reported health, attributional style) would correlate positively with each other. The correlations of the measures at baseline and follow-up in Appendix 15 indicate that the cognitive and mental health measures used in this study have positive but sometimes weak concurrent validity.
Factor Analysis of the Stress Scale

A principal components factor analysis with varimax rotation was conducted on the 20 items of the 'feel bad' or 'perceived stress' scale on the sample from the 8 schools. The factor analysis yielded 6 factors with eigen values greater than 1.0. These 6 factors explained only 53% of the variance, with the first factor explaining 20% and the other 5 less than 10% each. The factor loadings greater than 0.30 reveal that this first factor might be measuring self-pressured stress, but this is not entirely clear (see Table A15.6 in Appendix 15)
4.3 Discussion

There were five main findings in this study. First, the associations between chronic aircraft noise exposure and reading comprehension and noise annoyance were replicated. Second, the within subjects analyses indicate that children's development in reading comprehension may be adversely affected by chronic aircraft noise exposure and that noise annoyance remained constant over a year with no strong evidence of adaptation. Third, the association between aircraft noise exposure and reading comprehension could not be accounted for by the sustained attention mediation hypothesis. Fourth, chronic aircraft noise exposure was associated with poorer sustained attention in children. Fifth, chronic aircraft noise exposure was associated with higher levels of self-reported perceived stress in children. Taken together these results provide further and stronger evidence that aircraft noise adversely affects the performance and health of school children and that these effects do not habituate over time. Further research is required to examine the long-term implications of these effects and the causal mechanisms and to test other related outcomes.

4.3.1 Reading comprehension

Confirming hypothesis 1 "chronic aircraft noise exposure produces cognitive impairments in reading comprehension", at follow-up, children in the four high noise schools had poorer reading comprehension compared with the children in the three control schools. This finding replicates the baseline results and demonstrates that noise effects on children's reading persist over time. The strongest evidence to support hypothesis 1 is demonstrated by the MANOVA main effect of noise on reading comprehension in the seven schools after adjustments for age, deprivation and main language spoken. This statistical test takes an average reading comprehension score over the two years, and therefore indicates a more reliable and robust effect than a single time cross-sectional analysis.

There was considerably less acute aircraft noise at follow-up testing compared with baseline testing, but the same reading effects were found in the same children. The fact that the main reading effect remained constant, despite marked variation in the acute noise interference at testing, provides further evidence that the cognitive impairments are due to chronic exposure. (This issue will be discussed further in the overall discussion Chapter 6.)
4.3.2 The effect of noise on reading over time

In partial support of hypothesis 2 "chronic aircraft noise exposure produces a delay in reading comprehension progress over the period of a year" there is some evidence that noise exposure can produce a delay in reading ability but it is difficult to be conclusive because the results may have been limited by sample size. After adjustment for baseline reading performance in both the seven and eight schools, a significant noise effect on reading remains at follow-up. This result indicates that further noise exposure over time is associated with an increase in the size of the reading impairments in the high noise exposed group compared with the control sample. This finding is not consistent with the follow-up study around Los Angeles Airport, where they found that cognitive effects did not show any signs of adaptation (Cohen et al., 1981). This result provides a more reliable examination of the within-subjects effect than the Los Angeles follow-up study because their longitudinal analyses were insensitive due to an attrition bias. The present within-subjects result demonstrates more reliably because of the high follow-up response rate (81%) that noise effects ‘increase’ over time, rather than remaining constant.

The inability to find an effect of noise exposure on reading progress after adjustments for deprivation and main language might to be due to a reduction in statistical power, because of a drop in sample size. The failure to find a significant noise effect after full adjustment was puzzling because neither deprivation nor main language spoken at home were related to noise exposure. In further analyses, deprivation and main language spoken at home were entered separately as covariates to examine which adjustment was responsible for the potential confounding. It seemed that adjustment for main language spoken, rather than household deprivation, was altering the significance of the effect. To test whether the failure to achieve a significant noise effect after adjustment for main language spoken at home was due to confounding or to a reduction in sample size, an analysis was conducted controlling for baseline reading in a reduced sample, with the reading scores taken out for the children with missing values for both deprivation and main language spoken. In this reduced sample the main effect found in the full sample is lost. This result suggests that regardless of whether main language spoken at home is, or is not, a confounding factor, the sample size is reduced to such an extent that when adjustments are made for language the ‘noise effect’ would be lost.
Also, when adjustment was made for baseline reading performance in the English speakers a significant noise effect on reading progress was still found. This result provides further evidence that chronic exposure to aircraft noise produces a delay in reading over the period of a year. There were not enough subjects with non-English as the main language spoken at home to conduct a stratified analysis.

The main finding that after adjustment for baseline performance there remains a significant noise effect on reading comprehension at follow-up provides stronger evidence than a cross-sectional comparison about the causal nature of noise on child cognition. This result is more informative and reliable because by adjusting for baseline performance, adjustment can be made for a range of individual differences that may be unrelated to noise and also affect cognitive performance. This analysis of covariance is a very sensitive statistical test of child development because the unit of analysis is at the child level and allows for tight controls over other potential influences on performance.

This within subjects reading finding is not conclusive, as there is still the possibility that socio-economic factors may confound the relationship because there are not enough socio-demographic data to test this reliably. As with most field studies, where sample sizes are not large enough, there is also the possibility of self-selection into the high and low noise areas biasing the results. In the case of this study it is possible that children with poorer performance tend to remain in the high noise exposed areas because their parents are less socially advantaged, hence less mobile. In addition, there is also the potential problem of when adjustment is made for baseline performance it also involves adjustment for previous noise exposure.

4.3.3 Factors mediating the reading effect

The results of this study do not support the sustained attention mediation hypothesis 3 "Sustained attention mediates the noise effects on reading comprehension" because sustained attention did not explain the significant association between aircraft noise at school and reading comprehension. The data from this study indicate that aircraft noise exposure is associated with both impaired reading comprehension and sustained attention and that sustained attention is positively correlated with reading comprehension; but that attention, as measured by the Score task, is not the mechanism by which noise exposure affects reading.
Attentional processes have been hypothesised as mediators in noise-related memory impairments more than reading effects. Adult noise studies on memory have been interpreted as indicative of attention narrowing or focusing on dominant stimuli (Cohen et al., 1986). Greater attention to more central cues could lead to poorer encoding of more peripheral material when greater processing demands are placed on memory than would be expected on a reading task. So it is possible that specific cognitive mechanisms may only apply to specific noise effects on child cognition. Further research should test and refine the other theories to account for these reading effects, especially testing psycholinguistic mechanisms where there is preliminary evidence of mediation such as speech perception (Evans & Maxwell, 1997) and auditory discrimination (Cohen et al., 1973).

As in the baseline study, at follow-up the association found between aircraft noise at school and reading comprehension could not be explained by psychological mediating factors (anxiety, depression, annoyance, and self-reported stress the feel-bad scale) which supported hypothesis 6.1 "That depression, anxiety, self-reported stress and noise annoyance do not mediate the relationship between chronic aircraft noise exposure and cognitive performance".

Unexpectedly, ‘frequency of stressful life events’ seemed to have influenced the association between noise and reading comprehension. In the eight schools, after adjusting for stressful life events, the difference in reading comprehension between the noise-exposed and control sample became significant. The children in the four low noise schools reported higher frequency of stressful life events than the children in the high noise schools. This difference was significant in the age adjusted model but once deprivation has been adjusted for difference became insignificant. This result is not surprising because it is intuitively reasonable that deprivation should be associated with higher levels of stressful events. So after adjustment for frequency of stressful life events in the eight schools the high noise reading comprehension mean is reduced (by .25) and the low noise mean is increased (by 0.16) and hence the adjusted difference became statistically significant. This result may be meaningful or it may simply be due to the higher prevalence of stressful life events of the children in the low noise schools. Adjustment for the ‘frequency of stressful life events’ did not affect the significant main reading comprehension effect in the seven schools, which indicates that it is not a mediating factor which can influence noise related reading effects.
Adjustment for self-reported stressful life events might be an important control factor in future research looking at school performance. Frequency of stressful life events might be a more sensitive indicator of deprivation in children than household data collected from parents because it is the child's perception of their own level of socio-emotional deprivation. The Lewis child stress scale (Lewis et al., 1984) operationalises stress from the child's perspective and includes situations that may make them feel bad, nervous, or worried such as conflicts with parents, self-image, self-esteem, peer group relationships and dislocations. If a child reports a high frequency of stressful life events this may indicate emotional deprivation. Child emotional deprivation and impaired social relations may be important by-products of parental material deprivation, and may have more influence on school performance than adult indices of material deprivation.

4.3.4 Sustained attention
Consistent with previous research (Hambrick-Dixon, 1986; Hambrick-Dixon, 1988; Karsdorff & Klappach, 1968; Kyzar, 1977; Moch-Sibony, 1984; Sanz et al., 1993); and hypothesis 4 “chronic aircraft noise exposure produces cognitive impairments in sustained attention”, children in high noise schools had poorer sustained attention than the children in the quiet control schools across both the seven and eight schools even after adjustment for age, deprivation and main language spoken at home. This main effect of noise on attention leads to further questions, about the direct and indirect effects of aircraft noise on child cognition that will be discussed in the overall discussion (Chapter 6). Further research should examine other cognitive performance outcomes, such as reasoning tasks and mathematics, to develop a clear profile of cognitive noise effects.

The attention effect was only found on the performance on the Score task and not in the Code Transmissions from the Tests of Every Day Attention for Children (TEACH; Manly et al., 1998). After testing it was discovered that Score, a task that varies inter-stimulus intervals, was a more reliable measure of sustained attention in a sample of non-clinical children than was Code Transmissions. Score is a test of sustained attention that is more reliable in school children in the general population. In adults, varying inter-stimulus intervals is a more sensitive way of measuring sustained attention than are vigilance tasks such as Code Transmissions (Fisk & Schneider, 1981; Manly & Robertson, 1997; Paus et al., 1988). Even though both tasks share common demands in
orienting attention, it is easier to tune out of a vigilance task such as Code Transmissions and still perform than an attention task like Score (Wilkins et al., 1987). The code transmissions test is not recommended for a non-clinical child sample to measure sub-clinical attention problems. Thus it is not surprising that a noise effect on child sustained attention was found on Score and not Code Transmissions.

The frequency of the scores for girls and boys for the whole sample on the SCORE task were very similar to the normative data (Manly et al., 1998). This indicates that despite the fact that the task was group administered, the results were valid. A closer examination of the frequency of scores for the high and low noise samples revealed that the high noise sample had a higher proportion of children with very low scores (5 or less) than the low noise sample. Within the high noise sample the girls had a higher prevalence of low scores compared with the normative data than the boys. This suggests that further research should examine the prevalence of potentially clinically relevant high levels of attentional problems in children chronically exposed to aircraft noise. Also there might be individual differences in how girls and boys are affected by chronic exposure to aircraft noise.

4.3.5 Annoyance

Confirming hypothesis 5 “chronic aircraft noise exposure in school children is associated with higher levels of noise annoyance”, and replicating the baseline results, at follow-up children in the high noise schools were found to have higher noise annoyance compared with the children in the control schools across the seven and eight schools. The strongest evidence to support hypothesis 5 is demonstrated by the MANOVA main effect of noise on noise annoyance in the seven and eight schools after adjustments for age, deprivation and main language spoken. Taking this MANOVA result together with the cross-sectional results at baseline and follow-up and previous research (Bronzaft & McCarthy, 1975; Evans et al., 1995), it is clear that the noise annoyance effect in children is reliable and robust.

As in the baseline study this association between noise at school and noise annoyance could not be explained by psychological mediating factors (anxiety, depression and self-reported stress) which supports hypothesis 6.2 “That depression, anxiety and self-reported stress do not mediate the relationship between chronic aircraft noise exposure and annoyance”. Higher levels of anxiety and perceived stress were positively
correlated with annoyance, whereas depression and frequency of stressful events were not correlated with noise annoyance. The fact that when adjustment is made for self-reported stress and it does not influence the association between noise and annoyance, indicates that noise annoyance is a different but related construct to stress. These results show that annoyance response is persistent over time and that it is a distinct, but related construct, to anxiety and self-reported stress.

4.3.6 Effect of noise on annoyance over time
The annoyance response remains constant over time and there is little evidence that the effect increases over time. This finding that noise annoyance, a stress response, remains persistent is in slight contradiction to the conclusions from the follow-up study around Los Angeles (Cohen et al., 1981) where the data were interpreted to indicate some habituation of physiological stress response. However, it is very possible that a self-reported stress response may be affected by chronic noise in a different way than a physiological stress response. It is also possible that response style to coping with environmental stress influences reports of self-reported stress, more than physiological responses. Future longitudinal research should measure both noise annoyance and physiological stress responses to examine adaptation or potentiation and the interaction between self-reported stress and biological stress markers. Adaptive behaviours may reduce the immediate stress response in the form of physiological adaptation, but the coping process itself may have adverse effects that might be measured through self-reported stress (Evans & Cohen, 1987).

4.3.7 Self-reported stress
Child self-reported stress was measured with the Lewis Child Stress Scale (Lewis et al., 1984) that consists of two sub-scales: the perceived stress scale and the frequency of stressful life events. Confirming exploratory hypothesis 7 "chronic aircraft noise exposure in school children will be associated with higher levels of self-reported stress than in children in schools exposed to lower levels of aircraft noise", children chronically exposed to high levels of aircraft noise had higher levels of perceived stress across the seven and eight schools, even after adjustment for age, deprivation and main language spoken. This finding indicates that the high noise children reported they would have felt more stressed than the control children if these stressful life events were to occur in their lives. Interestingly, the children across the two groups did not differ in terms of reporting actual stressful events. In fact the children exposed to high levels of
aircraft noise reported less stressful life events than the control sample. It is possible that this perceived stress scale also partly measures perceived coping ability or worrying and high scores predict sensitivity to stress.

These results show for the first time that children chronically exposed to aircraft noise do have higher levels of self-reported stress, which complements the previous psychophysiological data (catecholamine secretion and raised blood pressure, Cohen et al., 1980; Evans et al., 1995,1998). This result is important because it lends support to the underlying assumption that chronic exposure to aircraft noise is in fact stressful. This self-reported stress response needs to be refined by further measures, to ascertain what these children are stressed about - is it their environment?

One possible explanation of this stress effect maybe that it is partly mediated through annoyance. Noisy, overcrowded classrooms may contribute to increased aggression and annoyance in children who desire some quiet to work (Bronzaft & Dobrow, 1988). The annoyance produced by the high levels of aircraft noise may in turn effect stress levels. Understanding the nature of child stress responses to chronic exposure to environmental noise has increased in this repeated measures study. Consistent with the baseline results, levels of depression and anxiety did not differ between the two samples. These affective results taken together suggest that chronic exposure to aircraft noise produces an annoyance and general stress response rather than a sub-clinical mental health problems such as depression or anxiety. However, it is still unknown whether high levels of perceived stress in childhood lead to a higher risk of developing anxiety and depression in later life.

4.3.8 Child environmental perceptions and health

On the whole there was no clear and consistent effect of aircraft noise substantially interfering in the classroom for children exposed to aircraft noise compared with the control sample. This lack of a strong response in the classroom noise survey is interesting because children in high noise schools consistently and strongly report more noise annoyance. So if noise annoyance is not mainly a consequence of aircraft noise interfering in the classroom, what is causing the aircraft noise annoyance? Is it that aircraft noise interferes with more social activities in the playground? Or is it that noise is makes it harder for the children to work or think? The latter possibility is supported
by the fact that more children in the high aircraft noise exposed schools agreed that ‘planes passing overhead make it hard for me to think’ than the children in the control schools. The only other result that is worthy of note is that children in the high noise schools who felt that their classrooms were too noisy were more likely to offer aircraft noise as the main disturbing noise source than the children in the control schools who also claimed that their classrooms were too noisy. ‘Other children’ were offered as the main source of noise interference by both groups, which seems plausible.

Aircraft noise at school had no effect on child self-reported general health, tiredness, and headaches. In addition, the two groups did not differ in prevalence of cases of high depression and anxiety as indicated by the clinically relevant cut-off scores on the Child Depression Inventory (CDI) and the Child Manifest Anxiety Scale (CMAS). One inexplicable result is that more children in the control sample reported having problems sleeping compared with the children exposed to high levels of aircraft noise at school. For more detailed, reliable and confirmatory health data it would be best to obtain further health information from general practitioners, school nurses, parents and teachers. Nevertheless, it would seem that aircraft noise at school has little effect on self-reported health. It is possible, however, that aircraft noise exposure has more subtle health effects in children and that certain children may be more vulnerable to physical health effects resulting from chronic exposure to aircraft noise, such as children with learning difficulties and existing health problems.

4.3.9 Psychometric analyses
The psychometric analyses indicate that the Suffolk reading scale, the noise annoyance question, the Lewis Child Stress Scale and the sustained attention Score task have good psychometric properties, which suggests that these measures were able provide valid and reliable significant results. The Suffolk Reading Scale had high stability and concurrent validity with the other cognitive outcomes. The noise annoyance question had moderate stability. The Lewis Child Stress Scale had positive internal consistency and concurrent validity with the other affective outcomes (depression & anxiety). The factor analysis of the Lewis Child Stress Scale indicates a one factor solution, but this is not strong as it only accounts for 20% of the variance. The Score task had high concurrent validity (correlated with reading comprehension). These psychometric results rule out the possibility that the significant noise effects were an artefact of poor measurement.
This repeated measures study was able to overcome common sampling biases of attrition and poor response rate that have reduced the strength of previous field research (Cohen et al., 1981; Tarnopolsky et al., 1980). The follow-up study around Los Angeles Airport (Cohen et al., 1981) had the problem that those least likely to adapt, the children with noise related impairments, had moved away from the noisy area and were not measured at follow-up. This sampling problem severely limits the interpretability of the Los Angeles follow-up results. In the present study the follow-up response rate of the total approached baseline sample was ninety percent and therefore there was little attrition.

A potential problem with collecting data from primary-aged children is that their understanding of the questions may be limited and their answers inconsistent. There is little evidence that the children in this study gave unreliable answers because when asked about the perception of plane and train noise at both school and home, which one would not expect to change over the year between baseline and follow-up, the child responses at baseline and follow-up were almost identical. This is a strong indication that the children reliably answered the questions.

The replication of the baseline reading comprehension and noise annoyance effect at follow-up could imply further validity of these effects. However, replications do not rule out the possibility that the same confounding factor operated at both baseline and follow-up. To overcome this potential problem replication should be sort in an independent sample. Issues of general reliability and validity will be discussed more fully in the overall discussion (Chapter 6).
4.3.10 Summary and further research

The results of this repeated measures study are not conclusive. Nevertheless, they provide stronger evidence than the baseline study to suggest that noise exposure affects child cognition and stress responses and that these effects do not habituate over a one year period. Chronic exposure to aircraft noise was consistently associated with high levels of annoyance. Against the background of previous studies, the reading findings suggest that noise exposure impairs reading comprehension. Moreover, this effect is not substantially confounded by social deprivation or main language spoken and nor is it mediated by sustained attention. These results do not support the sustained attention hypothesis previously used to account for the effects of noise on cognition in children. The within-subjects analyses indicate that children's development in reading comprehension may be adversely affected by chronic aircraft noise exposure (marginally significant). Noise annoyance remains constant over a year with no strong evidence of adaptation. Further research should look at the long-term implications of these effects and examine further underlying mechanisms.

The final study in this thesis, used a different analytical method and study design, aims to clarify these findings in three independent samples. Study 3 addressed the potential confounding school effect, by using multi-level modelling statistical techniques on a larger sample of schools to differentiate school effects from individual level noise effects on cognition. Noise effects were examined across a wider range of school performance measures than in the repeated measures study, to clarify and provide further understanding of the noise related cognitive impairments.
CHAPTER 5

National Standardised Scores (SATs) Study 3

Introduction, Methods Results & Discussion
5.1 Introduction

The results from the repeated measures classroom study suggest that aircraft noise exposure at school affects reading comprehension. However, it is possible that this relationship may be confounded by school quality (Cohen et al., 1980; Rutter, 1985). This means that the characteristics of individual schools may have a more powerful effect than noise exposure on reading comprehension and school performance generally. As the main objective of this thesis is to test whether cognitive effects previously found in children are attributable to noise, the potential confounding influence of a school effect needs to be empirically examined. In this final study, a dataset with a large sample of schools and individuals clustered within schools were obtained. This allowed for the data to be analysed at the school level as well as the individual level, taking account of the school effect.

The results of the repeated measures study also raise two further questions that need to be addressed. Firstly, there is the question of whether the aircraft noise exposure affects school performance uniformly or whether impairments are more likely to be found in language-based tasks. Generally, it has been assumed that language-based tasks (such as reading and comprehension) are more affected by noise exposure than non-language based tasks (mathematics and science). Whilst there is a growing number of studies to suggest that noise exposure does affect reading, there are few comparative data to suggest that noise exposure affects language-based tasks more than other cognitive tasks. In order to demonstrate that noise exposure affects language based tasks more than other cognitive outcomes, a comparative multivariate research design is required. This design will allow for testing the theories of noise induced cognitive impairments in children by making divergent predictions about the effects of noise on the performance outcomes.

Secondly, there is the unanswered question of whether cognitive noise effects are dose-response or threshold effects. To expand, this question suggests two possibilities: do the cognitive deficits increase monotonically as noise exposure increases (dose-response) or is there a sound pressure level above which cognitive effects become manifest and remain constant (threshold)? This is an important issue for designing interventions to ameliorate the adverse effects of noise exposure on child school
performance and for policy guidelines on noise exposure and school building regulation. In addition, being able to provide a more precise examination of the relationship between noise exposure and performance furthers understanding of how noise exposure affects health generally. In order to examine whether noise effects on performance are the result of a dose-response function or a threshold effect, a wider range of noise exposures is required.

In order to address these three issues of: a) school level effects, b) multiple outcomes and c) dose-response/threshold, an analysis was conducted for the first time using the National Standardised Scores (SATs) for Key Stage 2 in Mathematics, Science and English from the primary schools in three boroughs around Heathrow Airport. The main aim of this study is to examine the effects of chronic exposure to aircraft noise across a wide range of exposure levels on multiple school performance outcomes, accounting for individual level and school level factors. Unlike chapters 3 and 4 of last two studies, this Chapter 5 (SATs Study) will contain an introduction that focuses on the previous research evidence from studies using existing data sets of school performance and a brief discussion of the relationship between school quality, social deprivation and educational attainment. These introductory sections will lead into the research rationale and the specific hypotheses for this SATs study.

5.1.1 Research evidence

Earlier studies examining the association between chronic noise exposure at school and/or at home with standardised reading and other intellectual achievement tests have found preliminary evidence of a relationship between environmental noise exposure and school performance (Green et al., 1982; Lukas et al., 1981; Michelson, 1968, Bronzaft, 1981; Bronzaft & McCarthy, 1975; Cohen, 1973; Cohen et al., 1981; Evans et al., 1995). Michelson (1968) studied the effects of noise in the home environment on 710 scores for children in grades 1 to 5. He found that noise was associated with language and spelling difficulties and that it was not associated with mathematics achievements. Maser and colleagues (1978) found with 1, 917 children from grades 2, 5, 7 and 10 that noise was associated with reading and mathematics deficits in the 7th and 10th but had only marginal effects on 5th graders. The deficits increased as the students continued in the noisy schools, becoming statistically significant in the 7th grade. This result was interpreted to suggest that the longer the students had been attending the school, the stronger the deficits in performance. However, as ‘time attending the school’ was not
measured, the assumption that length of exposure contributed to impairments was not tested. Moreover it is also possible that school performance tests in the older grades are more discriminating and sensitive for children in the older grades than those in the younger grades. It is important to note that in these earlier studies, other differences between schools, such as teacher training or ability, racial composition, and social class of the student body, were not controlled for in the analyses. Thus it is possible that these factors may have acted as confounding factors masking or enhancing any noise effect on school performance.

Green and colleagues (1982), in the most comprehensive study to date analysing a large database of archival records of achievement tests, studied the school results from 362 of schools around John F Kennedy and La Guardia airports in New York City. The aggregate results of a nationally standardised test of reading ability, data on racial composition, socio-economic level and various educational factors were collected for each school, producing a data set of 8,240 grades from children in 2 – 6 years at school. The schools were geo-coded into five categories of aircraft noise bands and then the percent reading below grade level for each cluster of schools in the noise was calculated. They found a dose-response relationship that indicated that the percent reading below grade level increased as noise level increased. Specifically that 3.6 % of students in the noisiest schools read at least one year below grade level. The effects were stronger in the higher grades. In the light of this result, the present study also predicts a dose-response relationship between aircraft noise exposure and performance. A closer examination of these results reveals limitations that will be directly addressed in the SATs study.

First, the outcome performance measure was dichotomous, specifically being the percentage of students within each grade reading one or more years below grade level, or two or more years below grade level. This dichotomous variable is a crude measure, and weakens the findings. This result needs to be replicated with a sensitive continuous performance measure taken at the individual level. Second, this study is limited by the fact that the main performance results were the aggregate scores for schools, not scores at the individual level, which meant the data could not be analysed at both the school and individual level to adjust for school level differences. In this way the results were unable to be adjusted for a school effect by a cluster analysis which is the most appropriate statistical test for their dataset of individual pupils clustered within New
York City schools. Third, this study did not consider the possibility that other sources of environmental noise, such as rail or road noise, may influence the results.

To summarise, the previous studies have methodological and analytical flaws that limit their generalisability such as: no adjustments for potential confounding factors such as social class; exposure to other sources of environmental noise; limited examination of the effects of noise on multiple outcomes; and no assessment of school effects and different levels of noise on performance. These limitations will be considered in the research rationale and study design.

5.1.2 Inter-relationships between noise exposure, school quality, social deprivation and educational attainment

The theory that schools can promote the progress of pupils so as to overcome the influence of family, community and individual attributes, underpins British studies of school effectiveness (Mortimore & Whitty, 1997). Measures of added value have been developed as sophisticated ways of analysing potential school effects (Mortimore et al., 1994). There is a substantial body of research which shows that pupils from socially deprived areas have lower educational attainment than their counterparts from less disadvantaged areas (Higgs et al., 1997). Almost by definition, children from disadvantaged backgrounds are more likely than other children to live in a worse physical environment (Mortimore & Whitty, 1997). Thus there is a need to measure and adjust for the socio-economic characteristics of the local catchment area, as they may well confound the relationship between noise and educational attainment. There is a significant correlation between the free school meal ratio and a range of census indicators representative of socio-economic status, suggesting that, at least at the school level, free school meal ratios can act as a reliable proxy for social disadvantage (Williamson & Byrne 1977, Sammons et al., 1997).

School quality, social deprivation and noise exposure have complicated interrelationships and all these factors are related to school performance, which means that statistical treatment of social deprivation, or school quality as a confounding factor, may not adequately account for the pre-existing interrelationship between these factors. This relationship can be summarised as follows: poorer quality schools are more common in socially deprived areas, which are also more likely to be exposed to high levels of aircraft noise. Social deprivation, school quality and noise exposure are all
known to adversely influence school performance. Thus adjustment for either school quality or social deprivation might involve an over adjustment for noise exposure, because this statistical method does not take into account the broader ecological context in which environmental stressors, such as noise exposure, exist (Cohen et al., 1986). This possibility will be considered when interpreting the results of the multilevel models where adjustments will be made for socio-economic status.

5.1.3 Research rationale

In response to the questions outlined above and the methodological and analytical refinements suggested from the limitations of previous research, the specific aim of this study is to examine the effect of chronic exposure to aircraft noise on a range of school performance outcomes in Mathematics, English (reading, writing, spelling and handwriting) and Science in 11 year old children. The analysis will be at the school and individual level using a nationally standardized performance outcome scale (SATs) that is more sensitive than previously used dichotomous outcomes. The analysis will extend and refine the previous research, because the data will be analysed at both the school and individual level, controlling for reliable socio-demographic factors (sex, free school meal ratio, main language spoken at home), environmental factors (road and rail noise exposure near schools), and school factors (type of school).
5.1.4 Specific hypotheses

It is hypothesised that:

1) Chronic exposure to aircraft noise at school is associated with poorer performance in English after adjustment for school effects. Noise effects will be larger for the reading performance than for spelling, writing and handwriting performance.

2) Chronic exposure to aircraft noise at school is not associated with poorer performance on the control outcomes, of Mathematics and Science after adjustment for school effects.

*The following hypothesis is exploratory* and is not based on strong predictions from previous research. It is hypothesised that:

3) The effects of noise on performance are a dose-response function such that: the impairments in school performance will monotonically increase as noise exposure levels rise.
5.2 Methods

5.2.1 Design

The analyses involved cross-sectional comparisons between aircraft noise exposure and school performance in a sample of students using the 1996 and 1997 results of National Standardised Scores (SATs) for Key Stage 2 in Mathematics, Science and English. The analysis used Multilevel modelling to take account of the hierarchical or clustered sample design (pupils within schools) and to allow adjustment for both pupil and school level factors. Adjustments were made for socio-economic, environmental and school quality factors. The study included 128 government, grant maintained and church primary schools in three boroughs around Heathrow Airport. Schools were assigned aircraft noise exposure level from the 1994 Civil Aviation Authority aircraft noise contour maps.

5.2.2 Sample

The sample were approximately 11,000 children in year 6 (approximately 11 years old), the final year of primary school, who completed the Key Stage 2 SATs examinations in 1996 and 1997 from 128 primary government, grant maintained and church schools in the boroughs of Hillingdon, Hounslow and Windsor & Maidenhead. These areas were chosen because they surround Heathrow Airport, and within each area schools are exposed to a large range of aircraft noise exposure. In the analyses the following numbers of pupils were included: 10,998 scores for English (10,957 for spelling; 10,957 for handwriting; 10,957 for writing; 10,957 for reading); 11,105 scores for Mathematics; 11,163 for Science. The numbers differ slightly as some test results were missing or invalid for a very small number of pupils.

Table 34 below summarises the variables used in the SATs study. These factors will be fully described in the sections that follow.
Table 34.
A summary of the variables and precise outcomes in the analyses. (SATs Study)

<table>
<thead>
<tr>
<th>School Level Factors</th>
<th>Individual Level Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft noise exposure</td>
<td>English performance score</td>
</tr>
<tr>
<td>Road noise exposure</td>
<td>English sub-tests: spelling, handwriting, writing, reading</td>
</tr>
<tr>
<td>Rail noise exposure</td>
<td>Mathematics performance score</td>
</tr>
<tr>
<td>Level of existing sound insulation in the school</td>
<td>Science performance score</td>
</tr>
<tr>
<td>Percentage of pupils eligible for a free school meal</td>
<td>Sex</td>
</tr>
<tr>
<td>Percentage of pupils statemented with special needs</td>
<td>Year in terms of 1996 or 1997</td>
</tr>
<tr>
<td>Percentage of pupils with English as a second language</td>
<td>Date of birth (only for 1997 sample)</td>
</tr>
</tbody>
</table>

5.2.3 Noise exposure estimation

Aircraft

The key exposure examined in this study was aircraft noise (air noise, rather than ground noise) from the aircraft taking off from and landing at Heathrow Airport. Schools were chosen within the published 1994 Civil Aviation Authority dBA Leq, 16hr (92 days) contour maps indicating the average continuous equivalent sound level of aircraft noise within a particular area for 16 hour daily periods during June 15 to September 15. Each school was classified into one of 8 noise exposure levels depending on which noise contour band the school was sited: 1 = >54, 2 = 54>57, 3 = 57 >60, 4 = 60>63, 5 = 63 >66, 6 = 66 >69, 7 = 69>72, 8 = <72. This variable was used for the dose response analysis.

For the purposes of threshold analyses: High noise schools were classified as: greater than 63 dBA Leq contour. Moderate noise exposed schools were classified as: 57>63 57 dBA Leq contour. Low noise schools were classified as: less than 57 dBA Leq contour. These cut points for the high, medium and low noise exposure categories were selected because: a) they were the selection criteria for the repeated measures study and b) also to have a reasonable spread of schools across the three categories it was necessary to choose these cut off scores.
**Road**

The distance from each school to the closest roads was measured as a crude proxy for road traffic noise exposure. These distances were measured using Geographical Information Systems (GIS) software. A distance in metres was calculated for each school for the: a) distance to the nearest A-road, b) distance to the nearest B-road and c) motorway. The accuracy of the road data was at two levels for the London borough of Hounslow: 1:10 000 (Meridian) and for the boroughs of Hillingdon, Windsor & Maidenhead: 1: 500 000 (Barts).

**Rail**

The distance from each school to the closest overland railway line was measured as a proxy for rail traffic noise exposure. These distances were measured using national ordnance survey maps of Hillingdon, Hounslow and Windsor and Maidenhead. The distances were measured in kilometers as the crow flies from each school to the nearest railway line, either by marking a piece of paper with the two points and then transferring it to the scale on the map or by using a pedometer which records the distance on a dial. The measurements were then converted into meters from the rail track for each school.

**5.2.4 Performance data and other school statistics**

**School Performance**

Since 1995, standardised performance tests (SATs) of national curriculum assessments for Key Stage 2 are taken by all British School children when they are in year 6 and aged approximately 11 years old. These examinations are nationally standardised and marked externally for English, Mathematics and Science. School averages are public, but individual grades are available on request from the Department For Education and Employment (DfEE). The school and individual level scores were obtained in ASCII format from the Department for Education and Employment (DfEE). Individual level raw scores were not available for the 1995 examinations and so they were not included in this study.

The examinations involve each child completing two exams for Mathematics (which produces one total score), two for Science (which produces one total score), and four exams for English (spelling, handwriting, writing and reading). Individual final raw scores that range from 0 to 100 are calculated by averaging performance across exams.
for each of Mathematics, Science and English. The raw scores are then grouped into levels from key stage 1 to 6 and the published results are based on these levels. These grouped scores were not used in the present analyses because the raw scores are more a more sensitive indicator of performance.

The 5 dependent variables used for English were: total raw score for English, and the separate scores for spelling (test 1); handwriting (test 2); writing (test 3); reading (test 4).

The 1 dependent variable used for Mathematics was: total raw score for mathematics.

The 1 dependent variable used for Science was: total score for science

Other pupil level data
Individual date of births of the 1997 sample were obtained from the local education authorities. Sex and class of each individual child were obtained in ASCII format in from the Department For Education and Employment (DfEE). The variables used for demographic adjustment at the pupil level are: sex and class at school for each child and age for 1997 sample only.

Social Deprivation
At the school level, ‘percentage of pupils eligible for free school meals’ was used as a measure for social deprivation. Family on social security benefit is the criteria for entitlement for free school meal. Previous research in Britain suggests that ‘percentage of pupils eligible for free school meals’ is a reliable indicator of social disadvantage for the precise catchment of pupils attending the school because there is a significant correlation between the free meal ratio and a range of census indicators representative of social economic status (Williamson & Byrne, 1977).

There are problems with using 1991 Census data, especially small area statistics, as a crude proxy of school catchment deprivation because the significance of relationship between the census variables will decline as the latter increasingly comes out of date and if the catchment area changes. The last national census was in 1991 which makes it five to six year out of date for the Key Stage 2 SATs results used in this study. Percentage of pupils entitled to free school meal within each school was obtained from the local education authorities. Unfortunately individual level data on eligibility for free school meal was not available. If this data had been available and linked to individual
performance adjustment for social deprivation would have been more accurate. Despite the lack of this individual data, it was felt that a school level adjustment for deprivation would be sufficient. Adjustment at the school level was made for: percentage of pupils entitled to a free school meal.

**Main language spoken at home**
Percentage of children who have English as a second language were obtained in ASCII format in from the Department For Education and Employment (DfEE) from the 1996 and 1997 school census data. To be consistent with the repeated measures study main language spoken at home was used instead of ethnicity in the analyses.

**School Characteristics**
Percentage of children who are statemented as having special needs were obtained in ASCII format from the Department For Education and Employment (DfEE) from the 1996 and 1997 school census data. Statemented as having a special need is a formal document drawn up by the local education authority in accordance with the 1996 Education Act. The special need can either be a behavioural problem, a learning difficulty or a learning disability and is assessed by a multi-disciplinary team. This document lists the child’s special educational needs and the special educational provision that will be necessary to meet those needs. 2.9% of all school children in England are statemented as having a special need (School Census 1998, DfEE). There are different levels of statementing, that reflect differing levels of child educational need. The data received from the DfEE, indicates if a child was statemented as having any level of need.

Type of school, classified as either: government, grant-maintained, church or special were obtained in ASCII format in from the DfEE.

The 2 variables used for school characteristics at school level are: percentage of pupils statemented as having special needs in the school and type of school.

**School Sound Insulation**
Each of schools was classified into the extent to which they were sound insulated as being: 1) Completely double glazed/sound insulated; 2) Partially double glazed/sound insulated; 3) Not at all sound insulated. These data were collected from the local authority property division within Education departments or by telephone survey of the schools.
5.2.5 Statistical procedures

The analysis used multilevel modelling (Goldstein, 1995) for the following reasons. The SATs data is hierarchical with pupils clustered within schools. Using multilevel terminology, there are two levels of units. The level 1 units are pupils who are clustered within the level 2 school units. Multilevel modelling makes best (or statistically efficient) use of this data rather than having to choose whether to analyse at the individual or school level neither of which is satisfactory (Thompson et al., 1997). The multilevel method produces correct standard errors and significance tests as the analysis takes account of the clustered nature of the data. If an individual level regression analysis was carried out, the standard errors of the regression coefficients would be underestimated in situations where there is clustering. Another advantage is that both variables at the school level (e.g. type of school) and the pupil level (e.g. age) can be included in the same model. Finally, one can see whether noise effects ‘explain’ any of the variation in SATs scores between schools.

The multilevel models were fitted to the data using the statistical package, MIn, which was written by statisticians from the Institute of Education, University of London. All the datasets were transferred into SPSS files; any recoding of variables and merging of datasets was done in SPSS, then text files were output to be read into MIn. There was a small amount of missing data.

Then models including the possible explanatory variables were fitted. The output from these analyses is in two parts: i) fixed coefficients for each of the explanatory variables in the model ii) random parameters which describe the unexplained variability in SATs scores after taking account of the explanatory variables (Section 2 Results). The fixed coefficients, with the most important being the coefficient for noise level are interpreted just as in ordinary multiple regression. This noise co-efficient as well as the mean scores are useful as a guides to the importance of the effects. There are two random parameters, one for the level 2 (school) variation and one for the level 1 (pupil) variation. These can be compared across models containing different explanatory variables to see whether these variables ‘explain’ any of the variability in SATs scores between schools or pupils. For example, if including the percentage eligible for free school meals in the model results in a reduction in the unexplained variation at the school level, this indicates that deprivation accounts for some of the between school variation.
The statistical significance of a fixed coefficient can be judged by dividing the estimate by the standard error and it being greater than 2. An alternative way to assess statistical significance is to compare the goodness of fit of two alternative models and to test whether the improvement in fit is statistically significant. This second method has been used to produce the significance levels given in the text for the statistically significant associations.

To explore whether the effects of noise on performance are a dose-response function there will be an analysis in Section 2 of the multi-level modelling of the performance data using the noise band contours 1 - 8. These analyses will assess if the impairments in school performance are associated with a monotonic increase in noise exposure. To assess whether a threshold effect there will be an analysis in Section 3 of the results that applies the unadjusted and fully adjusted multi-level models to the performance data using the noise categories low, medium and high. This threshold analysis will test whether above a certain broadly defined noise exposure level there is a marked decrease in performance.

**Multi-Level Models and results presentation**

Results from two models, summarised below, will be presented for both the dose-response and threshold analyses. The first model will estimate the association between noise and SATs scores after adjustment for sex, year of testing and type of school. In the text this is referred to as the ‘unadjusted model’. The second model will adjust additionally for the percentage of pupils eligible for a free school meal, a measure of social deprivation. In the text this is referred to as the ‘adjusted model’.

For further information to interpret the multi-level modelling, the raw means and standard deviations, unadjusted for any factor will be presented in tables with the unadjusted noise co-efficients and standard errors displayed as a footnote to these tables (that is a test for a noise performance effect without any statistical adjustment).
Model 1 – Unadjusted for Social Deprivation
Independent Variable - Aircraft Noise level
Dependent Variables - SATs performance individual scores
3 Fixed coefficients: sex (male, female), year (1996,1997), type of school (government, grant maintained and church)

Model 2 – Adjusted for Social Deprivation
Independent Variable - Aircraft Noise level
Dependent Variables - SATs performance individual scores
3 Fixed coefficients: sex (male, female), year (1996,1997), type of school (government, grant maintained and church), percentage eligible for free school meals

As was planned, preliminary analyses were conducted including ‘English as a second language’ and ‘percentage of children statemented with special needs’ in the fully adjusted model. These analyses revealed that adjustment for these factors were no longer significant after adjustment for percent eligible for free school meals. Thus, they were not included in the final model because they did not add any further information and because including more fixed co-efficients involves losing additional degrees of statistical freedom.
5.3 Results

The results will be presented in three sections. Section 1 contains the descriptive results. Section 2 contains the results from the multi-level models for English, Mathematics and Science for the noise trends testing for a dose response function across 8 noise contour bands. Section 3 contains the unadjusted and adjusted multi-level models testing for a threshold effect by modelling the effects of noise on performance across the low, medium and high categories.

5.3.1 Section I - Description of the schools

Table 35 gives a description of the schools in terms of school borough, type of school and sound insulation. The majority of the schools exposed to high levels of aircraft noise (n=17) were situated in the London Borough of Hounslow. The majority of the schools exposed to low levels of aircraft noise situated in the London Borough of Hillingdon (n=51). The majority of schools exposed to moderate levels of aircraft noise were situated in Hounslow. Schools in Windsor and Maidenhead were mainly exposed to moderate levels (n=16) of aircraft noise or low levels (n=10) of aircraft noise.

The majority of schools exposed to high levels (79%) and moderate levels (69%) of aircraft noise were government schools. There were less government schools (57%) and more church schools (26%) in the sample of low noise exposed schools than the high and moderate noise exposed schools.

The extent of sound insulation in the schools was roughly equivalent across the noise categories. It is interesting to note that schools exposed to high levels of aircraft noise were less likely to be sound insulated (partial or complete) with 41% not being insulated at all, compared to the moderate noise schools (19% not insulated at all) and the low noise schools (12% not insulated at all).

For a description of the schools in terms of exposure to road and rail noise, see Table 36 below. The schools exposed to high levels of aircraft noise are situated closer to A-roads, B-roads and motorways than the schools exposed to low and moderate levels of aircraft noise.
When adjustment was made for A-road, B-road and rail noise exposure in the multi-level models, they did not influence the size of the effect and so were not included in the fully adjusted model. If adjustment is made for proximity to motorway, then the magnitude of the noise effect is reduced for Mathematics (from -0.73 to -0.47) and for Reading (from -0.42 to -0.2) and it is no longer significant. However, it is difficult to interpret this result because the variable for distance to motorway is crude, it probably does not indicate exact noise exposure. Road traffic noise contour data do not exist for the areas around Heathrow Airport. In addition, airports tend to be placed near motorways for transporting goods, so exposure to high levels of both noise is most probably highly correlated. Nonetheless, this result is interesting and justifies the ‘non exposure to other sources of environmental noise’ being a criterion for school selection in the repeated measures study. As it is difficult to interpret and it is a minor aspect of this SATs study motorway exposure will not be addressed further.

Table 35.

A description of the low, moderate and high aircraft noise exposed schools in terms of school borough, type of school, sound insulation. (SATs Study)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Low Noise</th>
<th>Moderate Noise</th>
<th>High Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt; 57</td>
<td>57&gt;63</td>
<td>63&gt;72</td>
</tr>
<tr>
<td>Total=128</td>
<td>N= 61</td>
<td>N= 48</td>
<td>N= 19</td>
</tr>
<tr>
<td>Borough</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hillingdon</td>
<td>84% (n=51)</td>
<td>4% (n=2)</td>
<td>5% (n=1)</td>
</tr>
<tr>
<td>Hounslow</td>
<td>0% (n=0)</td>
<td>63% (n=30)</td>
<td>90% (n=17)</td>
</tr>
<tr>
<td>Windsor &amp; Maidenhead</td>
<td>16% (n=10)</td>
<td>33% (n=16)</td>
<td>5% (n=1)</td>
</tr>
<tr>
<td>Type of School</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government</td>
<td>57% (n=35)</td>
<td>69% (n=33)</td>
<td>79% (n=15)</td>
</tr>
<tr>
<td>Church</td>
<td>26% (n=16)</td>
<td>29% (n=14)</td>
<td>16% (n=3)</td>
</tr>
<tr>
<td>Grant Maintained</td>
<td>12% (n=7)</td>
<td>0% (n=0)</td>
<td>0% (n=0)</td>
</tr>
<tr>
<td>Special</td>
<td>5% (n=3)</td>
<td>2% (n=1)</td>
<td>5% (n=1)</td>
</tr>
<tr>
<td>Sound Insulation *</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>12% (n=7)</td>
<td>19% (n=9)</td>
<td>41% (n=7)</td>
</tr>
<tr>
<td>Partial</td>
<td>58% (n=35)</td>
<td>24% (n=11)</td>
<td>29.5% (n=5)</td>
</tr>
<tr>
<td>Complete</td>
<td>30% (n=18)</td>
<td>57% (n=27)</td>
<td>29.5% (n=5)</td>
</tr>
</tbody>
</table>

* 4 schools have missing data for sound insulation
Table 36.

Mean Measured distance from roads and railway in metres for the schools and number of schools within each noise category: low, moderate and high aircraft noise bands. (SATs Study)

<table>
<thead>
<tr>
<th>Type of Road</th>
<th>Low Noise *</th>
<th>Moderate Noise *</th>
<th>High Noise *</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;57 metres</td>
<td>57&gt;63 metres</td>
<td>&lt;63 metres</td>
</tr>
<tr>
<td></td>
<td>No of schools</td>
<td>No of schools</td>
<td>No of schools</td>
</tr>
<tr>
<td>A-Road</td>
<td>606</td>
<td>450</td>
<td>268</td>
</tr>
<tr>
<td></td>
<td>n=52</td>
<td>n=31</td>
<td>n=15</td>
</tr>
<tr>
<td>B-Road</td>
<td>1077</td>
<td>880</td>
<td>974</td>
</tr>
<tr>
<td></td>
<td>n=52</td>
<td>n=31</td>
<td>n=15</td>
</tr>
<tr>
<td>Motorway</td>
<td>3847</td>
<td>1930</td>
<td>1595</td>
</tr>
<tr>
<td></td>
<td>n=52</td>
<td>n=31</td>
<td>n=15</td>
</tr>
<tr>
<td>Above ground</td>
<td>1338</td>
<td>840</td>
<td>1292</td>
</tr>
<tr>
<td>railroad</td>
<td>n=60</td>
<td>n=47</td>
<td>n=19</td>
</tr>
</tbody>
</table>

Note: There are some missing data for distance from roads and railways for some of the schools, due to the inaccessibility of the specific Ordinance Survey Maps and software required to take the measurements.
5.3.2 Section II - Noise effects on English, mathematics and science: dose-response trends across contour bands adjusted and unadjusted multi-level models

**English**
Noise level is not associated with performance in English in both the unadjusted and adjusted model (see Table 37 for means and Table 38 for modelling). The Table of means indicate that the trend across these raw mean scores, not adjusted for any factor is a statistically significant (noise coefficient= -0.70 standard error=0.34).

**Reading**
A closer analysis of the subscales of the four English tests show that aircraft noise exposure affects performance on the reading test (test 4) more than the other subclasses: spelling (test1), handwriting (test2), writing (test3) (see see Table 39 for means and Table 40 for modelling). As noise levels increase by contour band, performance drops by 0.42 of a mark (p=0.025). After adjustment for percentage of pupils eligible for free school meals the effect is lost on the reading test (test4).

**Mathematics**
Noise level is significantly related to mathematical performance before adjustment for percentage of pupils eligible for free school meals (see Table 37 for means and Table 38 for modelling). As noise levels increase by contour band, performance drops by 0.73 of a mark (p=0.014). After adjustment for percentage of pupils eligible for free school meals the association becomes statistically insignificant.

**Science**
Noise level is not associated with performance in Science in both the unadjusted and adjusted model (see Table 37 for means and Table 38 for modelling).

**The relationship between noise exposure and the adjusted factors in the model**
Sex significantly affects the relationship between noise and English and Mathematics. Girls perform better in English than boys (6 points higher). Boys perform better in Mathematics than girls (1.3 points higher). These sex differences are unaffected by adjustment for social class. Type of school significantly affects the association between
noise exposure and SATs performance: with church schools performing better than government schools for English, Mathematics and Science.

For all analyses the between school variability is significant and so is the pupil level variability. As free school meal eligibility is measured at the school level, when adjustment is made for the ratio, it does not affect the variability within performance at the individual level. After adjustment for percentage of pupils eligible for free school meals the effects of noise on English and Mathematics is no longer significant and the variability between schools drops, but is still significant. This suggests that between school variability is not solely explained by social class.
Table 37.
The unadjusted raw performance outcomes means and standard deviations for SATs scores for English, Mathematics and Science across the noise contours (dBA Leq). (SATs Study)

<table>
<thead>
<tr>
<th>Performance indicator</th>
<th>Noise contour band</th>
<th>Noise contour band</th>
<th>Noise contour band</th>
<th>Noise contour band</th>
<th>Noise contour band</th>
<th>Noise contour band</th>
<th>Noise contour band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>&lt;54</td>
<td>54 &gt;57</td>
<td>57&gt;60</td>
<td>60&gt;63</td>
<td>63&gt;66</td>
<td>66&gt;69</td>
<td>69&gt;72</td>
</tr>
<tr>
<td>SD</td>
<td>(16)</td>
<td>(16)</td>
<td>(16.6)</td>
<td>(16.4)</td>
<td>(15.8)</td>
<td>(15)</td>
<td>(16.4)</td>
</tr>
</tbody>
</table>

- English: 60.4 (16) 56.2 (16) 59.2 (16.6) 56.2 (16.4) 60.3 (15.8) 55.9 (15) 53.9 (16.4)
- Mathematics: 46.4 (15.4) 43.8 (13.7) 44.8 (15.7) 45.0 (14.9) 43.8 (15.4) 43.1 (15.3) 35.6 (13.6)
- Science: 49 (12.7) 46.4 (11.2) 48.9 (13.1) 48.6 (13.6) 48.6 (13.1) 46.5 (13.6) 42.7 (12.3)

Note: The test for a noise effect for performance unadjusted for any factor noise coefficients and standard errors are as follows: English -0.7(0.34); Mathematics -0.81(0.32); Science -0.46(0.31). The effect is statistically significant for English and Mathematics.

Table 38.
The multi-level models for the performance outcomes of English, Mathematics and Science unadjusted and fully adjusted: Estimates and (standard errors). (SATs Study)

<table>
<thead>
<tr>
<th>Fixed Coefficients</th>
<th>English Model 1 Unadjusted n=10998</th>
<th>English Model 2 Adjusted</th>
<th>Mathematics Model 1 Unadjusted n=11105</th>
<th>Mathematics Model 2 Adjusted</th>
<th>Science Model 1 Unadjusted n=11163</th>
<th>Science Model 2 Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>56.88 (1.07)</td>
<td>60.09 (1.00)</td>
<td>45.29 (1.03)</td>
<td>48.09 (1.02)</td>
<td>49 (1.0)</td>
<td>50.06 (1.07)</td>
</tr>
<tr>
<td>Noise Level</td>
<td>-0.54 (0.31)</td>
<td>0.12 (0.27)</td>
<td>-0.73 (0.30)*</td>
<td>-0.15 (0.28)</td>
<td>-0.44 (0.30)</td>
<td>-0.22 (0.30)</td>
</tr>
<tr>
<td>Sex (F vs M)</td>
<td>5.84 (0.28)</td>
<td>5.86 (0.28)</td>
<td>-1.28 (0.27)</td>
<td>-1.27 (0.27)</td>
<td>0.03 (0.22)</td>
<td>0.04 (0.23)</td>
</tr>
<tr>
<td>Year (97 vs 96)</td>
<td>1.24 (2.19)</td>
<td>-1.72 (0.28)</td>
<td>2.49 (0.27)</td>
<td>2.37 (0.27)</td>
<td>-0.11 (0.23)</td>
<td>-0.16 (0.23)</td>
</tr>
<tr>
<td>Church vs Gov</td>
<td>6.77 (1.15)</td>
<td>4.44 (0.99)</td>
<td>5.55 (1.11)</td>
<td>3.49 (1.02)</td>
<td>4.21 (1.08)</td>
<td>3.43 (1.08)</td>
</tr>
<tr>
<td>GM vs Gov</td>
<td>1.24 (2.19)</td>
<td>0.61 (1.76)</td>
<td>-0.67 (2.11)</td>
<td>-1.27 (1.81)</td>
<td>-1.97 (2.08)</td>
<td>-2.20 (1.96)</td>
</tr>
<tr>
<td>%eligible</td>
<td>-</td>
<td>-0.22 (0.03)</td>
<td>-</td>
<td>-0.19 (0.03)</td>
<td>-</td>
<td>-0.07 (0.03)</td>
</tr>
</tbody>
</table>

Random Parameters

| Level 2: (school)  | 26.95 (3.84)                      | 16.47 (2.48)             | 25.10 (3.57)                          | 17.74 (2.6)                    | 24.94 (3.44)                     | 21.87 (3.04)             |
| Level 1: (pupil)   | 218.2 (2.96)                      | 218.7 (2.96)             | 203.6 (2.75)                          | 203.9 (2.8)                    | 140.9 (1.90)                     | 141 (1.90)               |

* p=0.014
Table 39.
The unadjusted raw performance outcomes means and standard deviations for SATs scores for the English sub-tests: spelling, handwriting, writing and reading across the noise contours (dBALeq). (SATs Study)

<table>
<thead>
<tr>
<th>Performanceindicator</th>
<th>Noise contourband</th>
<th>Noise contourband</th>
<th>Noise contourband</th>
<th>Noise contourband</th>
<th>Noise contourband</th>
<th>Noise contourband</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>&lt;54</td>
<td>54&gt;57</td>
<td>57&gt;60</td>
<td>60&gt;63</td>
<td>63&gt;66</td>
<td>66&gt;69</td>
</tr>
<tr>
<td>SD</td>
<td>(6.6)</td>
<td>(6.4)</td>
<td>(6.4)</td>
<td>(6.6)</td>
<td>(6.8)</td>
<td>(6.7)</td>
</tr>
<tr>
<td>Spelling</td>
<td>(2.7)</td>
<td>(2.8)</td>
<td>(2.8)</td>
<td>(2.7)</td>
<td>(2.7)</td>
<td>(2.6)</td>
</tr>
<tr>
<td>English (T1)</td>
<td>(3.8)</td>
<td>(3.4)</td>
<td>(3.6)</td>
<td>(3.6)</td>
<td>(3.9)</td>
<td>(3.5)</td>
</tr>
<tr>
<td>Handwriting</td>
<td>(0.9)</td>
<td>(0.9)</td>
<td>(0.9)</td>
<td>(0.8)</td>
<td>(0.9)</td>
<td>(0.9)</td>
</tr>
<tr>
<td>English (T2)</td>
<td>(21.6)</td>
<td>(20.9)</td>
<td>(21.3)</td>
<td>(20.2)</td>
<td>(22.0)</td>
<td>(20.5)</td>
</tr>
<tr>
<td>Writing</td>
<td>(4.9)</td>
<td>(5.2)</td>
<td>(5.0)</td>
<td>(5.2)</td>
<td>(4.7)</td>
<td>(4.8)</td>
</tr>
<tr>
<td>English (T3)</td>
<td>(28.5)</td>
<td>(26.0)</td>
<td>(27.9)</td>
<td>(26.5)</td>
<td>(27.7)</td>
<td>(25.2)</td>
</tr>
<tr>
<td>Reading</td>
<td>(9.8)</td>
<td>(9.5)</td>
<td>(10.3)</td>
<td>(9.8)</td>
<td>(10.0)</td>
<td>(9.4)</td>
</tr>
</tbody>
</table>

Note: The test for a noise effect for reading performance unadjusted for any factor noise co-efficients and standard errors is -0.52 (0.21). The effect is statistically significant for reading and not for any of the other tests.
Table 40.

The multi-level models for the performance outcomes for SATs scores for the English subtests: unadjusted and fully adjusted: spelling, handwriting, writing and reading

Estimates and (standard errors). (SATs Study)

<table>
<thead>
<tr>
<th>Fixed Coefficients</th>
<th>English Test 1 Spelling</th>
<th>English Test 2 Handwriting</th>
<th>English Test 3 Writing</th>
<th>English Test 4 Reading</th>
<th>English Test 4 Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1 unadjusted n=10,957</td>
<td>Model 1 unadjusted n=10,957</td>
<td>Model 1 unadjusted n=10,957</td>
<td>Model 1 unadjusted n=10,957</td>
<td>Model 2 adjusted n=10,957</td>
</tr>
<tr>
<td>Intercept</td>
<td>6.07(0.15)</td>
<td>3.6(0.06)</td>
<td>19.72(0.3)</td>
<td>27.64(0.6)</td>
<td>29.8(0.58)</td>
</tr>
<tr>
<td>Noise Level</td>
<td>-0.02(0.04)</td>
<td>-0.01(0.02)</td>
<td>-0.09(0.10)</td>
<td>-0.42(0.19)*</td>
<td>0.03(0.16)</td>
</tr>
<tr>
<td>Sex (FvsM)</td>
<td>0.7(0.05)</td>
<td>0.3(0.02)</td>
<td>2(0.08)</td>
<td>2.81(0.18)</td>
<td>2.82(0.18)</td>
</tr>
<tr>
<td>Year (97v96)</td>
<td>-0.09(0.04)</td>
<td>-0.2(0.02)</td>
<td>1.0(0.09)</td>
<td>-2.43(0.18)</td>
<td>-2.5(0.18)</td>
</tr>
<tr>
<td>Church</td>
<td>0.8(0.16)</td>
<td>0.13(0.07)</td>
<td>1.6(0.4)</td>
<td>4.2(0.7)</td>
<td>2.6(0.58)</td>
</tr>
<tr>
<td>GM</td>
<td>0.06(0.31)</td>
<td>0.04(0.12)</td>
<td>0.4(0.6)</td>
<td>0.7(1.3)</td>
<td>0.25(1.02)</td>
</tr>
<tr>
<td>%eligfsm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-1.15(0.02)</td>
</tr>
</tbody>
</table>

**Random Parameters**

| Level 2: (school) | 0.52(0.08) | 0.09(0.01) | 2.63(0.37) | 9.54(1.4) | 5.42(0.84) |
| Level 1: (pupil) | 6.6(0.09)  | 0.64(0.000) | 20.35(0.28) | 83.61(1.2) | 83.75(1.14) |

*p=0.025. Note. As the unadjusted models for tests 1 to 3 (spelling, handwriting and writing) were not significant fully adjusted models are not presented.
5.3.3 Section III - Threshold analyses

There was no evidence of a threshold effect in the comparisons across SATs performance for English, Mathematics and Science between medium and low noise exposed schools and also between high and low noise exposed schools (see Table 41 for means and Table 42 for modelling). For the purposes of threshold analyses: High noise schools were classified as: greater than 63 dBA Leq contour. Moderate noise exposed schools were classified as: 57>63 dBA Leq contour. Low noise schools were classified as: less than 57 dBA Leq contour.

Table 41.

The unadjusted raw performance outcomes means and standard deviations scores for English, Mathematics and Science across low, medium and high aircraft exposed schools. (SATs Study)

<table>
<thead>
<tr>
<th>Performance indicator</th>
<th>Low Noise Category</th>
<th>Medium Noise Category</th>
<th>High Noise Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;57 dBA Leq</td>
<td>57&gt;63 dBA Leq</td>
<td>63&gt; dBA Leq</td>
</tr>
<tr>
<td>English</td>
<td>60.1 (16.1)</td>
<td>58.7 (16.5)</td>
<td>55.5 (15.3)</td>
</tr>
<tr>
<td>Mathematics</td>
<td>46.2 (15.3)</td>
<td>44.7 (15.5)</td>
<td>41.5 (15.2)</td>
</tr>
<tr>
<td>Science</td>
<td>48.8 (12.6)</td>
<td>48.8 (13.2)</td>
<td>45.7 (13.4)</td>
</tr>
</tbody>
</table>

Note: The test for a noise effect on performance between the high and low noise groups unadjusted for any factor noise co-efficients and standard errors are as follows: English -4.05(2.33); Mathematics -4.43(2.19); Science -2.98(2.07). The difference between high and low noise is statistically significant for English and Mathematics.
Table 42.

**Threshold multi-level models for the performance outcomes of English, Mathematics and Science unadjusted and fully adjusted: Estimates and (standard errors) between high, medium and low noise exposed groups. (SATs Study)**

<table>
<thead>
<tr>
<th>Fixed Coefficients</th>
<th>English Model 1 unadjusted</th>
<th>English Model 2 Adjusted</th>
<th>Mathematics Model 1 unadjusted</th>
<th>Mathematics Model 2 Adjusted</th>
<th>Science Model 1 unadjusted</th>
<th>Science Model 2 adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>56.2(0.87)</td>
<td>60.11(0.9)</td>
<td>44.3(0.84)</td>
<td>47.8</td>
<td>48.19(0.82)</td>
<td>49.7 (1.0)</td>
</tr>
<tr>
<td>Noise Level Med Vs low</td>
<td>-1.14 (1.06)</td>
<td>0.87 (0.90)</td>
<td>-1.43(1.03)</td>
<td>0.38(0.92)</td>
<td>-0.36(1.01)</td>
<td>0.42 (0.9)</td>
</tr>
<tr>
<td>Noise Level Hi Vs low</td>
<td>-2.89 (2.07)</td>
<td>-0.38(1.69)</td>
<td>-3.67(2.01)</td>
<td>-1.44(1.74)</td>
<td>-2.55(1.97)</td>
<td>-1.60(1.9)</td>
</tr>
<tr>
<td>Sex (F vs M)</td>
<td>5.84(0.28)</td>
<td>5.86(0.28)</td>
<td>-1.28(0.27)</td>
<td>-1.27(0.27)</td>
<td>0.03(0.23)</td>
<td>0.04(0.23)</td>
</tr>
<tr>
<td>Year (97 vs 96)</td>
<td>-1.58(0.28)</td>
<td>-1.73(0.28)</td>
<td>2.49(0.27)</td>
<td>2.36(0.27)</td>
<td>-0.11(0.23)</td>
<td>-0.17(0.23)</td>
</tr>
<tr>
<td>Church</td>
<td>6.28(1.13)</td>
<td>4.32(1.1)</td>
<td>5.64(1.11)</td>
<td>3.37(1.02)</td>
<td>4.25(1.08)</td>
<td>3.29(1.08)</td>
</tr>
<tr>
<td>GM</td>
<td>1.38(2.2)</td>
<td>0.85(1.75)</td>
<td>-0.41(2.14)</td>
<td>-1.01(1.80)</td>
<td>-1.60(2.10)</td>
<td>-1.89(1.95)</td>
</tr>
<tr>
<td>%eligfsm</td>
<td>-</td>
<td>-0.22(0.03)</td>
<td>-</td>
<td>-0.2(0.03)</td>
<td>-</td>
<td>-0.08(0.03)</td>
</tr>
</tbody>
</table>

**Random Parameters**

| Level 2: (school) | 27.05(3.85)               | 16.25(2.47)             | 25.42(3.61)                  | 17.46(2.59)                   | 25 (3.44)                 | 21.3 (2.99)              |
| Level 1: (pupil)  | 218.2(2.96)               | 218.7(3.1)              | 203.6(2.75)                  | 203.9(2.75)                   | 140.9(1.90)               | 141.1(1.90)              |
5.4 Discussion

There were four main findings in this study. First, as predicted, chronic exposure to aircraft noise was significantly related to poorer reading performance and was not associated with the control English performance outcomes, spelling, writing and handwriting. Second, chronic exposure to aircraft noise at school was significantly related to poorer performance on a nationally standardised test of Mathematics after adjustment for school effects. Third, after adjustment for socio-economic status, measured by free school meal ratio, the association between high noise exposure and poorer performance on the SATs tests is reduced and is no longer statistically significant. Fourth, the effects of noise on school performance seem more likely to be a dose response function than a threshold effect. Taken together these results suggest that chronic exposure to aircraft noise is associated with school performance in reading and mathematics in a dose-response function after adjustment for school effects, but that this association is influenced by socio-economic factors. The complex interrelationship between school performance, environmental stressors such as noise exposure and socio-economic status needs to be theoretically considered and empirically examined in the future.

5.4.1 English - reading effect

The results confirm Hypothesis 1 that “Chronic exposure to aircraft noise at school is associated with poorer performance in English after adjustment for school effects. Noise effects will be larger for the reading performance than for spelling, writing and handwriting performance”. Chronic exposure to aircraft noise was significantly associated with poorer reading performance and was not associated with spelling, writing and handwriting. These English results are entirely consistent with previous research and theory. This result corroborates the reading comprehension result from repeated measures study in this thesis (Chapters 3 and 4) and reading results from previous research (Green et al., 1982; Lukas et al., 1981; Michelson, 1968, Bronzaft, 1981; Bronzaft & McCarthy, 1975; Cohen, 1973; Cohen et al., 1981; Evans et al., 1995).

The previous theory into noise related reading deficits is supported by the fact that there was divergent performance across the different sub-tests of the English test. Within the English sub-tests there is an effect of noise on reading and there no association between
noise and the three others, spelling, writing and handwriting. This result provides empirical support for the theory that tasks with a high component of language comprehension dependent on listening and comprehension are more affected by noise exposure than other tasks which are less language-based such as spelling, handwriting and writing. The reason that there was not a statistically significant association between the composite English score and noise exposure was because there was not an association between noise and performance on three of the sub-scales (spelling, writing and handwriting) that form part of the composite score. These divergent results across the English sub-tests, provide only suggestive evidence that chronic exposure to aircraft noise affects language-based tasks more that other cognitive tasks, because of the significant noise effect on mathematical performance (a control outcome). These results can be interpreted to indicate that noise exposure does not exclusively affect language and comprehension based tasks such as reading. Moreover, Hypothesis 1 was not entirely confirmed because after adjustment for socio-economic factors (measured as the free school meal ratio), the associations between noise and reading were lost. These two issues will be discussed in the sections below.

5.4.2 Control outcomes: mathematics and science
The results provide contradictory evidence for exploratory Hypothesis 2 “Chronic exposure to aircraft noise at school is not associated with poorer performance on the control outcomes of mathematics and science after adjustment for school effects”. This hypothesis is not supported because a significant association was found between chronic noise exposure and poorer performance in mathematics and there was no noise effect for science performance. These results could be interpreted to indicate that: a) noise does not effect school performance and that this positive result on a control outcome suggests that the noise result is artifactual or b) noise genuinely effects mathematical performance and it is not a control outcome.

5.4.3 Mathematics
Previous research examining the effects of noise exposure on mathematical ability have yielded equivocal results. Six previous studies (Cohen et al., 1980, 1981, 1986, Green et al., 1982; Lukas et al., 1981; Michelson, 1968; Maser et al., 1978) have examined the association between chronic aircraft noise and mathematical performance: two studies found an effect of noise exposure on Mathematical performance (Lukas et al.; Masser 1978) and the other four found no effect (Cohen et al., 1980, 1981, 1986.; Michelson,
These studies were conducted in the 1960s, 1970s and early 1980s when scientists were exploring the possibility that noise affects school performance. Interestingly mathematics has not been included in later research because of the dominant theory that noise exposure affects language-based tasks such as reading more than other cognitive tasks. This SATs study is the first time mathematical performance has been tested as a control outcome and it was unexpectedly found to be associated with noise exposure. The pattern of results across the performance outcomes showing that the strongest association between noise and performance is for mathematics compared with English and reading, is also unexpected.

There is no current theory to explain why noise exposure might affect mathematical ability because it has been assumed by researchers that high levels of noise exposure do not have an effect on mathematics. The results from this study, which indicate noise exposure is related to impairments in mathematics, compel researchers to consider that a wider range of performance outcomes are affected by chronic exposure to aircraft noise. There are at least two possible interpretations of this result. The first interpretation is that the finding of a noise effect on a control outcome could be interpreted as suggesting that a third unmeasured or poorly measured factor is confounding the relationship between reading and noise exposure. This interpretation is possible, but an unmeasured confounding factor is unlikely because all the other reasonable potential confounding factors such as school effect and main language spoken at home are controlled for in the reading analysis. In addition, if it was the case that there was an unmeasured factor accounting for the English and the mathematical results, then why did it not influence performance on the science test? Socio-economic status, measured as free school meals, affects both the reading and mathematics results and is a likely contributing factor.

The second interpretation is that mathematical ability is genuinely affected by exposure to noise, that is to say that it is a real effect. It could be that that noise exposure influences both reading and mathematics through different mechanisms. It is possible to speculate that an effect of noise on mathematical ability might be due to another mechanism apart from the psycholinguistic mechanisms thought to underlie the previously found reading and memory deficits. The two tests of mathematics for SATs at Key stage 2 level examine these mathematical subjects: number, algebra, space, shape, measures and the handling of data. They contain a range of question styles
including both contextualised questions and questions that appear in a mathematical context only. Unfortunately with the DfEE data it is not possible to distinguish which test measured which component of mathematical ability. Some of these domains of mathematical subject would involve the examination of complex cognitive tasks. So it could be the case that this mathematics result is a real effect then it could be because of the complex nature of cognitive functions that the SATs mathematics test measures.

5.4.4 Science
Exploratory hypothesis 2 was supported with the negative result for science. Chronic exposure to aircraft noise was not associated with performance on the SATs Science test. This test examines these scientific subjects: life processes, living things, materials and their properties and physical processes. The science tests contain a range of styles, such as multiple choice, short answer and longer responses. This is the first time performance in science has been studied in relation to noise exposure and no association was found. This negative result needs to be replicated before any strong conclusions can be drawn about whether science performance is influenced by chronic exposure to aircraft noise.

In sum, it is difficult to interpret the results from the cognitive control outcomes because they are contradictory. Even though it is possible that noise exposure genuinely effects mathematical ability, there is little theory to suggest a plausible explanation. Future laboratory and field research is required to confirm or disprove that the positive mathematics and the negative science effects are real.

5.4.5 Summary of main effects: nature of noise performance effects
For the moment, if it is accepted that the results of this study are due to noise exposure and not to a confounding factor, then the nature of performance noise effects in children can be briefly discussed. This pattern of results of SATs performance has implications for the assumption that complex tasks that involve central processing demands and language comprehension are more affected by noise exposure than are simple tasks (Cohen et al., 1986; Evans et al., 1995; Evans and Lepore, 1993; Hygge, 1994). In fact the results do not support this assumption in both respects, namely: a) that noise exclusively affects language-based tasks and b) that noise is more likely to affect complex tasks than simple tasks. The strongest noise effect found in this study was for mathematics, which provides evidence against the assumption that noise does not
exclusively affect language-based tasks. The suggestion that noise adversely affects mathematical performance because Mathematics is a complex task is also not entirely clear, because of the negative science result. The science test contains complex tasks that require a level of language comprehension. This suggests that this notion of ‘complex cognitive tasks’ needs to be refined to identify precisely what ‘complex’ cognitive tasks are adversely effected by noise exposure. For example, are cognitive tasks that require high attentional demands at the learning and performance testing stages more affected by noise exposure than simple tasks? The nature of noise effects will be discussed in more detail the overall discussion Chapter 6.

5.4.6 Adjustment for school effects
The English, mathematics and reading results discussed in the previous sections have been adjusted for the influence of school level factors. This means that the fact that individuals are clustered within schools has been taken into statistical consideration in the multi-level modelling. It is important to note that this SATs study using a sample of 128 schools and approximately 11,000 individual scores per outcome, provides evidence for the first time that noise is found to affect reading and mathematical performance after adjustments have been made for school level factors. However future field research still needs to consider the influence of a school effect, because the results indicate that the between school level variability is high and because reliable measures of other school level factors such as quality of teaching could be included. Future planned studies need to sample a large enough number of schools so that school level effects can be adjusted for accordingly using multi-level modelling statistical techniques.

5.4.7 Adjustment for socio-economic status
The association between high noise exposure and poorer performance on the SATs tests is significantly reduced and is no longer statistically significant after adjustment for socio-economic status, measured by free school meal ratio at the school level. It would have been more sensitive to supplement this school level adjustment with an adjustment for deprivation at the individual level and link it directly to performance. This is because other research has suggested that deprivation has separate effects at both the school and individual level. That is, being at a school in a deprived area can influence performance irrespective of individual deprivation level. This is called a context effect (Morris et al., 1996).
This alteration in the association between noise exposure and SATs performance could be for several reasons. There are at least two possible interpretations of this effect of socio-economic status on SATs performance. The obvious interpretation is that socio-economic status confounds the association between noise and school performance, and completely explains the noise effect. However, on the other hand, adjustment for socio-economic status might constitute an over adjustment for noise exposure and leads to the suggestion that both factors influence school performance.

The first interpretation of the fully adjusted multi-level models is that socio-economic status is a factor that confounds the association between noise and school performance. This implies that the effects of noise exposure could be a marker for a socio-economic effect on performance. Adjustment for free school meals is an adjustment for parental employment status, which is known to be a reliable indicator of household socio-economic status and social class (Sammons et al., 1997; Williamson & Byrne, 1977). Both parental social class and socio-economic status are factors that undoubtedly play some role in predicting child school performance (Higgs et al., 1997; Morris et al., 1996). The specific issue about the potential influence of socio-economic status on child performance is: to understand to what extent does noise exposure adversely affect performance taking into account the influence of social class on performance. The results from the fully adjusted multi-level models indicate that socio-economic factors have greater influence over school performance than chronic exposure to aircraft noise.

In the introduction to this study this issue of a complicated inter-relationship between social deprivation and environmental stress was raised. It was questioned whether statistical adjustment for socio-economic status is the most appropriate way to detect an independent noise effect because it is plausible that adjustment for socio-economic status might constitute an overadjustment for noise exposure. This statistical method might be an 'overadjustment' because it does not take adequate account of the naturalistic context in which environmental stressors such as noise exposure normally occur (Cohen et al., 1986, see Figure 9 below).
5.4.8 Interrelationships between noise exposure, social deprivation, and performance

The fully adjusted multi-level models are difficult to interpret and to draw strong conclusions from about the interrelationship between noise exposure, school performance and socio-economic status. The conclusion that noise exposure has no effect whatsoever on reading and mathematics can not be drawn from these results because of the effect found in the unadjusted models has been found in previous research. Nonetheless, on the other hand, to conclude that the fully adjusted models constitute a gross statistical over adjustment that masks a noise effect, may also not be correct. These SATs results suggest that it is possible that the noise related performance effects are not independent from the effects of social disadvantage on performance. That is to say, that both noise exposure and social class are inter-related and they combine together to influence performance. The nature of the pathways between social class, noise and performance are unknown and need further theoretical consideration and empirical examination.

5.4.9 Dose-response versus threshold effects

Hypothesis 3 was “The effects of noise on performance are a dose-response function such that: the impairments in school performance will monotonically increase as noise exposure levels rise”. The investigation of exploratory Hypothesis 3 yielded the
following results: the unadjusted reading and mathematics effects across the noise contours demonstrate a significant dose-response function. There was no evidence of a threshold effect in the comparisons across SATs performance for English, mathematics and science between medium and low noise exposed schools and also between high and low noise exposed schools. In addition, the mean scores for reading and mathematics performance across the eight aircraft noise contour bands, indicate a decline in performance as aircraft noise exposure increases. Taken together these results suggested that: the effects of noise on school performance seem more likely to be a dose-response function than a threshold effect.

Nonetheless, it is unexpected and curious that a comparison between the high and low noise schools in the threshold tests were not significant for English and mathematics and science. For the purposes of threshold analyses, high noise schools were classified as: greater than 63 dBA Leq contour and low noise schools were classified as less than 57 dBA Leq contour. This result is not consistent with the repeated measures study and with previous studies comparing performance between high and low noise exposed schools. However, it is possible that the number of schools in the high noise group (N=19) did not yield enough power to detect a noise effect across the groups in multi-level models 1 and 2 (NB: the completely unadjusted analysis for reading, English and mathematics demonstrated a statistically significant difference in performance between high and low noise schools see footnote to Table 41). Because of this unexpected finding, it must be tentatively concluded that: the effects of noise on school performance seem more likely to be a dose-response function than a threshold effect. Another reason for caution with this conclusion is that it could be argued that there is a threshold effect, but it does not correspond with the cut points in dBA Leq that were chosen to classify the schools into low, medium and high exposure.

5.4.10 Strengths and limitations of this study

Despite the fact that the results from the SATs study are difficult to interpret, there are methodological and analytical innovations and design strengths that directly address the limitations of the methods used in previous studies. This is the first time such an analysis has been conducted in the United Kingdom combining SATs results, CAA aircraft noise contours and multi-level modelling. The multi-level modelling statistical method was more effective than any other method of analysis used in previous studies
to examine individual level school performance in relation to aircraft noise exposure adjusting for school level factors. The SATs data also provided more sensitive outcomes than the New York City study (Green et al., 1982), because the London data provided a continuous outcome variable whereas the New York data were dichotomous. The design of the study using control outcomes (science and mathematics) could be useful in future research for interpreting whether a third unmeasured factor is confounding the relationship between school performance and noise exposure. This is because it might reasonably be expected that an unknown confounding factors affects school performance in science and mathematics as well as English. This design allowed previous theory to be empirically examined because divergent predictions about the association between noise exposure and performance could be generated and tested. The SATs data are nationally standardised and normed, so they are reliable, and the multi-level modelling analyses are the most valid analyses considering that the data is clustered.

One possible limitation of this study is that: it could be argued that the proposed study confounds chronic and acute effects because it relies on archival records of achievement tests, where noise exposure at the time of testing is unknown. However, results from previous research in controlled testing environments (Evans et al., 1995; Evans & Maxwell, 1997) and in naturalistic settings in the field such as the repeated measures study suggest that impairments in school achievement are probably caused by chronic and not acute exposure. In addition, results from the repeated measures study in this thesis strongly suggest that acute noise interference does not influence the reading results. The intention to control for other environmental factors such as road and rail noise exposure is a design strength, but unfortunately the environmental measures based on distance from roads and railways lines used in the SATs study were crude. Ideally measures of sound pressure levels for road and rail noise exposure to each of the schools would be the most effective way of dealing with other sources of environmental noise. However, noise contour maps do not exist at this time for road and rail noise exposure in Hounslow, Hillingdon, Windsor and Maidenhead, in the same way as they exist for aircraft noise exposure. It must be noted that it is contentious how reliably these CAA contours estimate actual exposure level because they are formulated on average aircraft noise exposure over a 16-hour period (Porter et al., 1998).
Another limitation was that with the DfEE data set it was not possible to link performance scores to eligibility for free school at the individual level. It would have been better to have individual level data on whether each child was eligible for a free school meal and on main language spoken at home and to have this data from the School Census linked to the Key Stage 2 SATs results. This would have enabled the socio-economic adjustment to have been more accurate at the individual level than the analysis that was conducted, which adjusted for the school average of percentage of children eligible for a free school meal. Adjustment for baseline performance at the time of entry to school would be beneficial but this is not possible, because children are not routinely tested with a nationally standardised battery of cognitive tests at time of entry of school on performance.

5.4.11 Summary, conclusion and future research

The results from this study are difficult to interpret because they provide an unexpected pattern of performance results. A further complication is that socio-economic adjustment has a very powerful effect on the association between noise exposure and performance. On one hand, the reading and English results are consistent with previous research and theory. However, on the other hand, the unexpected association between noise exposure and mathematics result is puzzling and difficult to interpret whether it is a real effect. These results suggest that it is still an open issue as to whether chronic aircraft noise exposure effects language-based tasks exclusively because aircraft noise had the strongest effect on mathematical performance. The models fully adjusted for socio-economic status provide limited information about the interrelationship between noise exposure, school performance and socio-economic status. The results from both the unadjusted and fully adjusted models suggest that both noise exposure and socio-economic status are interrelated and combine to influence performance. The dose-response and threshold analyses indicate that the effects of noise on school performance seem more likely to be a dose-response function than a threshold effect.

Given the complex nature of the results, it is difficult to draw strong conclusions from the SATs study. Taken together, these results suggest that chronic exposure to aircraft noise is associated with school performance in reading and mathematics in a dose-response function after adjustment for school effects, but that this association is influenced by socio-economic factors. As a priority, future research ought to address
the main question that these results beg: to understand to what extent does noise exposure adversely effect child school performance over and above the influence of socio-economic status on performance? Consideration of individual differences between children need to be considered as factors in future research examining noise performance effects. Given the powerful sex and type-of-school effects on performance it is possible that the effect of noise exposure on school performance could be moderated by these factors. Future research should be conducted concurrently with detailed theoretical consideration of the nature of the pathways between socio-economic status, noise exposure and performance.
CHAPTER 6

Overall discussion
**Introduction**

The studies in this thesis examined the effects of chronic exposure to aircraft noise on primary aged school children’s cognition, motivation and mental health. “The main objective of this thesis is to test whether the cognitive effects previously found in children are attributable to noise and to test possible mechanisms” (Chapter 1, for the specific aims see Table 43 below). This objective may seem, at first glance quite a straightforward matter, as for example a person not familiar with the topic might think that it was obvious and intuitive that children exposed to an aircraft overflight every ninety seconds would have impaired learning and raised stress. The challenging aspect of investigating noise effects in children is to determine precisely and quantify what cognitive processes are impaired and stress responses, such as annoyance, that are evoked in children in response to high levels of chronic aircraft noise exposure. This research endeavour is complicated because other factors such as language and deprivation could potentially confound the association between noise and health and further complexity arises because the inter-relationships between the effects (cognitive functions and stress responses can covary).

In the discussion sections of Chapters 3, 4 and 5 the results of the repeated measures and multi-level modelling studies were described in detail, compared with other relevant research, and also briefly discussed in terms of their implications for the subsequent study in the thesis. The aim of this final chapter is to further interpret and synthesise these findings by relating the results to the overall objective of the thesis and to the wider context of child noise research and theory. The discussion will firstly consider the most important results from the repeated measures and SATs studies. Consideration will be given to how the results impact upon the existing theories to account for how noise exposure affects child health and the general models of environmental stress. Methodological implications and limitations that arose from these studies will be discussed in detail. Finally a set of conclusions and recommendations will be drawn in the light of the strengths and limitations of the results and the previous research. This overall discussion can be distinguished from the discussion in the previous chapters because it extends and synthesises the implications of the results for theory and the next steps for future research.
6.1 Summary of key findings

The specific aims of the thesis were outlined in Chapter 1, and for easy reference they are presented below in Table 43. The results of this thesis do address the issues and achieve the specific established aims, apart from the final aim, set out in the first chapter. The main cognitive and stress response effects tested aims 1 and 4. Testing the sustained attention hypothesis tested aim 2. The design of the repeated measures study, which allowed for an examination of how children adapted to aircraft noise, meant that aim 3 could be tested. The results are best synthesised and discussed in three main areas: cognition, stress responses and adaptation. The main findings are summarised below.

Cognition and motivation (relate to thesis aims 1 & 2)
Chronic exposure to aircraft noise was associated with impaired cognition and sustained attention in school children. Specifically, children chronically exposed to aircraft noise had poorer reading comprehension and sustained attention after adjustment for potential confounding factors. The association between aircraft noise exposure and reading comprehension could not be accounted for by the sustained attention mediation hypothesis. Children chronically exposed to aircraft noise had poorer performance on nationally standardised tests (SATs) of reading and mathematics but this result may have been at least partially explained by socio-economic confounding factors. Chronic exposure to noise was not associated with deficits in motivation.

Stress Responses (relate to thesis aims 1 & 4)
Chronic aircraft noise exposure was strongly associated with higher levels of noise annoyance and was also associated with self-reported perceived stress in children. Chronic exposure to noise was not associated with raised anxiety and depression. Anxiety and depression did not mediate the association between noise exposure and cognitive impairment and noise annoyance.

Adaptation (relate to thesis aim 3)
The within subjects analyses from the repeated measures study indicate that children's development in reading comprehension may be adversely affected by chronic aircraft noise exposure and that noise annoyance remains constant over a year with no strong evidence of adaptation.
Table 43.

Main objective and specific aims of the thesis taken from Chapter 1.

(Chapter 6 overall discussion)

The studies in this thesis aim to examine the effect of chronic exposure to aircraft noise on primary aged school children’s cognition, motivation and health. **The main objective of this thesis is to test whether the cognitive effects previously found in children are attributable to noise and to test possible mechanisms.**

The specific aims are:

1) To test whether chronic high levels of aircraft noise exposure in children are associated with **a) cognitive impairments** (in reading, memory, sustained attention, and school performance); **b) deficits in motivation** (behavioural performance task, attributional style, teacher rating); **c) noise annoyance** after adjustment for potential confounding factors (social deprivation, main language spoken at home, age and school effectiveness).

2) To test sustained attention as a mechanism to account for the effect of noise on cognition.

3) To examine how children adapt to aircraft noise over a one year period.

4) To assess whether there is any evidence that chronic noise exposure affects other health outcomes apart from noise annoyance: **a) child stress responses** (self-reported stress) and sub-clinical mental health (anxiety, depression, deviant behaviour) and **b) whether these psychological factors mediate the association between noise exposure and cognitive impairment and noise annoyance.**

5) To test whether environmental factors (length of time exposed to aircraft noise at school and home noise exposure) influence the relationship between aircraft noise and impairment of child health.

*NB:* Aim 5 could not be addressed here. The reasons have been outlined in the discussion of Chapter 3 – The baseline study.
6.2 Aircraft noise and child cognitive performance

In this section the nature of the cognitive noise effects and the mechanisms and theories to account for these effects will be addressed. The assumptions underlying the general position that noise exposure affects language-based cognitive tasks and complex rather than simple cognitive tasks will be appraised. Then the assumptions of the theoretical position 'cognitive coping strategies theory' will be questioned, followed by a discussion of the evidence for specific mechanisms to account for the cognitive noise effects.

6.2.1 Nature of the cognitive noise effects

By briefly describing the profile of the cognitive noise effects found in this study and in previous research it is possible to conjecture about the nature of the cognitive impairments associated with chronic aircraft noise exposure. In the present studies aircraft noise affected child reading comprehension, sustained attention and nationally standardised tests (SATs) of reading and mathematics. Apart from the mathematics result, these findings are consistent with the previous research, where noise has also been found to influence other cognitive functions: speech perception (Evans & Maxwell, 1997), auditory discrimination (Cohen et al., 1973; Cohen et al., 1980; Deutsch, 1964; Moch-Sibony, 1984) and long-term memory and complex memory tasks (Evans et al., 1995; Hygge et al., 1996). However, chronic exposure to environmental noise does not effect all cognitive tasks uniformly. Noise exposure has not largely been associated with these cognitive processes: mathematics (Evans & Lepore, 1993); short term memory or simple memory tasks (Hambrick-Dixon, 1986; Evans et al., 1995; Hygge et al., 1996); and sound perception (Evans & Maxwell, 1997). This pattern of findings from previous research and from the studies in this thesis beg the following two questions:

1) Is there something common to the cognitive processes that are affected by noise exposure that can distinguish them from the unaffected cognitive outcomes?

2) And if so, is it possible to comment on the nature of noise related cognitive deficits?
Smith and Broadbent (1992) argue that ‘noise has a definite effect on performance but that the precise nature of the effect depends on the type of noise and the task being performed’. Despite the obvious complicated relationship between noise exposure and performance put forward by Smith and Broadbent (1992), there are two assumptions about the nature of child cognitive noise effects that researchers broadly agree on. Generally, it has been argued that complex tasks that involve central processing demands and language comprehension are more affected by noise exposure than simple tasks (Cohen et al., 1986; Evans et al., 1995; Evans & Lepore, 1993; Hygge, 1994).

There are two distinct aspects of this formulation, namely that chronic noise exposure affects: a) language-based cognitive tasks and b) complex rather than simple tasks. The rationale for both of these aspects is distinct and requires exposition because they are based on assumptions for which there is little empirical evidence.

**Assumption 1: noise exposure affects language-based tasks**

There is little comparative data to suggest that chronic noise exposure affects language-based tasks more than other cognitive tasks. The emphasis on the main effects of noise on language-based tasks is probably because of the psycholinguistic theory of mechanisms to account for cognitive noise effects and the measures selected in the previous research. Initially, the reason researchers predominantly studied the effects of chronic aircraft noise exposure on child reading as opposed to performance in other areas such as mathematics or science, was that noise exposure was known to interfere with auditory discrimination and attention, two cognitive processes that are known to be important in reading acquisition. A further reason why reading and language-based tasks continued to be included in studies was that researchers could replicate previous research to obtain positive results. The previous reading results and psycholinguistic theories do not preclude the possibility that chronic noise exposure could also affect other aspects of cognitive performance, which might be mediated through non-psycholinguistic mechanisms.

In order to demonstrate that noise exposure affects language-based tasks more than other cognitive outcomes, multivariate research designs are required, such as the SATs study reported in Chapter 5. The design of the SATs study allowed for the testing of this assumption that ‘noise exposure affects language-based cognitive tasks’ in children by making divergent predictions about the effects of noise on the performance outcomes. To test this, it was hypothesised (hypothesis 1) that noise effects would be
larger for the English reading performance than spelling, writing and handwriting performance. In addition, exploratory hypothesis 2 of the SATs study was ‘to explore whether chronic exposure to aircraft noise at school is not associated with poorer performance on the control outcomes mathematics and science’.

The results of the SATs study do not support the assumption that noise exposure affects language-based tasks tasks exclusively, because chronic exposure to aircraft noise was significantly associated with poorer mathematical performance (a control outcome) as well as English performance. An alternative interpretation of these mixed results could be that because noise effects in the SATs study are non-specific. This suggests that neither the mathematics nor the reading results are due to noise exposure at all. However, even if these results from the SATs study are real, they still only demonstrate that chronic noise exposure is correlated with both language and non-language based tasks. These SATs results suggest that it might not be the case that chronic aircraft noise exposure effects language-based tasks exclusively because aircraft noise had the strongest effect on mathematical performance.

The SATs result for the English tests demonstrated that chronic exposure to aircraft noise was significantly related to poorer reading performance and was not associated with the control English outcomes: spelling, writing and handwriting. The results of the SATs study suggest that it is possible that the effects of noise on language-based tasks might be more domain specific (reading based) than has been previously accepted. This result coupled with the mathematics result can be interpreted in a way that leads to the refinement of this broad assumption that noise exclusively affects language-based tasks. Specifically, it could be argued that within language-based tasks, noise effects are more pronounced in tasks that are heavily reliant on reading comprehension. Moreover, because of the mathematics result, it can not be assumed that noise exclusively affects language based tasks.

A more informative and elegant way to test the assumption that noise exposure affects language tasks more than other cognitive tasks is through an experimental design where level of language skills required is manipulated while keeping the complexity of the task constant. For example long-term memory could be tested using three types of stimuli: visual, language based and auditory respectively. Another way to test this assumption is to design a stimulus set, where mathematical problems are presented in
sentences. These experiments could test more effectively than a cross-sectional study precisely what types of cognitive tasks are detrimentally affected by chronic exposure to aircraft noise. If it was confirmed in future research that the reading noise effect is independent from the mathematics noise effect, then separate mechanisms to account for these impairments would have to be hypothesised and tested.

Assumption 2: noise exposure effects complex rather than simple cognitive tasks
In contrast to the first assumption about the nature of cognitive noise effects, there is more empirical evidence to support the second assumption that chronic aircraft noise affects complex cognitive tasks more than simple tasks. There is correlational evidence from child field studies such as the Munich Airport Study, where chronic noise exposure had a significant effect on complex tasks (long-term memory recall and reading) and not simple tasks (recognition and working memory). However, stronger and more convincing evidence comes from experimental laboratory studies in adults (reviewed by Smith & Jones, 1992) and children (Enmarker et al., 1998; Hygge, 1994; Meis et al., 1998). The general finding is that when simple and complex tasks are tested under quiet and noisy conditions, only performance on the complex tasks was affected by noise exposure.

The repeated measures and SATs studies were not designed to directly test this suggestion that noise exposure affects child performance on complex cognitive tasks more than on simple tasks. The effects of noise on complex cognitive tasks have been attributed to increased arousal and decreased attention through distraction and decreased focusing on stimuli peripheral to the task, as well as altering choice of task strategy (Stansfeld & Haines, 1997). Because complex tasks require more attention than simple tasks, researchers argue that noise affects performance on complex tasks more than simple tasks. These mechanisms of attention and arousal still need to be confirmed in children, because in the present repeated measures study there was no evidence that the effect of noise on reading was mediated by the effects of noise on sustained attention. The result of this sustained attention mediation analysis compels researchers to re-examine previous theory and to generate mechanisms to account for these cognitive effects on complex tasks.
6.2.2 Theory of mechanisms to account for these cognitive effects

**The theoretical perspective - cognitive coping strategies**

The main theoretical focus of this thesis stemmed from the psychological theory of environmental stress called the cognitive coping strategies theory (Cohen *et al.*, 1986; Evans & Cohen, 1987). According to this theory, cognitive performance is affected by an environmental stressor to the extent that cognitive coping strategies are required for task completion. This theory is outlined below in Figure 10. The basic idea of the theory is that following chronic exposure to an environmental stressor (predictor variable), children develop a generalised cognitive response of constantly tuning out. This generalised response results in cognitive coping strategies such as reduced attention and tuning out from auditory stimuli. If these strategies are habitually employed even in the absence of the environmental stressor, then efforts to complete tasks under chronic environmental stress may cause long-term deficits in reading and memory (see Figure 10 below; for a more detailed discussion of this theory see Chapter 1).

This theory and hypotheses were adopted over other psychological models of environmental stress presented in Chapter 1, namely the arousal, information overload, and loss of control models, because the explanatory power of these other three models is low in accounting for noise related cognitive impairments. The two classic psychological models of information overload and arousal are not entirely relevant to the subject of this thesis because they do not adequately predict what kinds of psychological deficits are likely to be produced by exposure to environmental stress. The third ‘loss of control’ model has mainly been used to explain some of the detrimental motivational consequences of chronic noise exposure, and again is not relevant to the results of this thesis. The major strength of the 'cognitive coping strategies' model is that it provides testable predictions for main effects and mechanisms to account for the cognitive effects of noise exposure in children.
It would not be appropriate to apply the results in this thesis as a test of the cognitive coping strategies model of environmental stress. This is because it is difficult to comment on whether the results found in this thesis are generalisable to all environmental stressors or if they are only specific to noise exposure. However, it is relevant to theoretically address the assumptions of this model and examine the evidence for the hypothesised cognitive coping mechanisms.

**The assumptions of the cognitive coping strategies theory**

This theory posits that the detrimental effects of environmental stressors are often attributable to the cost of coping rather than to direct effects of stressors on performance and behaviour. The first assumption of this theory that noise is an ‘environmental stressor’ will be dealt with in the stress section below. The second assumption of this theory is that cognitive coping mechanisms are the result of an over-generalised response that the children learn to ‘tune-out’ in the presence of noise (see second step in
the diagram above). This second step on the pathway was put into the model because the earlier research confirmed an auditory distraction effect (Cohen et al., 1973; Cohen et al., 1980; Hambrick-Dixon, 1986; Heft, 1979; Moch-Sibony, 1984) and this effect has been recently replicated in the Munich Airport Study (Evans et al., 1995). It has also been argued that this tuning out response is supported by the findings that children exposed to noise have deficits in attention, auditory discrimination and speech perception (Cohen et al., 1973; Moch-Sibony, 1984; Evans et al., 1995). So there is evidence for the first step on the pathway that noise exposure is linked to the generalised response of tuning out.

One problem with this second assumption of the cognitive coping strategies theory, is that it has not been demonstrated that each of the hypothesised cognitive coping mechanisms stem from the same over generalised tuning out response. That is to say that the second step on the pathway has not been confirmed. This is illustrated in Figure 10 by the three arrows linking the generalised response (tuning out) to the three hypothesised cognitive coping mechanisms (sustained attention, auditory discrimination and speech perception), these links have not been proven. The implication of this is that, it is possible that noise exposure may directly impact on sustained attention, auditory discrimination and speech perception. This could be illustrated on Figure 10 by editing the second step on the pathway of generalised response (tuning out) and linking the arrows directly to the predictor variable (noise). This assumption of the theoretical pathway between the generalised response of constant tuning out and the mechanisms needs to be empirically confirmed.

Another problem with the cognitive coping strategies theory is that all the possible consequences of constant tuning out have not been explored. It can also be speculated whether constant tuning out is detrimental to other cognitive processes and behaviour. For example, children may cope with high levels of noise in the environment by reduced communication and interacting less with other children, which could be another form of tuning out. This social withdrawal, if it becomes habitual, could escalate into impaired communication and social skills. This reduction in social communication could in turn could be a potential mediating factor between noise exposure and impaired cognitive performance, especially reading skills that are reliant on good oral and aural communication. Another interesting aspect to explore in further research, is that some of the coping responses that children might employ to combat chronic aircraft noise
exposure might not necessarily be detrimental, and could in fact be protective factors. Initially, these coping mechanisms might be best identified by qualitative methods, through in-depth interviews with school children. The identification of protective factors would also be useful for future intervention studies and educational and public health policy (see Section 8 at the end of this chapter for a summary of future research ideas).

**The evidence for specific mechanism to account for the cognitive noise effects**

One of the attractive features of the cognitive coping strategies theory is that it provides testable predictions for main effects and mechanisms, but there is little research that has directly tested the hypothesised mechanisms (for a fuller discussion of this point see Chapter 1). The theoretical understanding of child noise effects is limited, because very few studies have actually tested the mediating role of a hypothesised factor. The relationship between cognitive main effects and cognitive mechanisms is complex, because these factors tend to be interrelated (Evans & Lepore, 1993). Moreover, it is plausible that there is more than one mediating construct between noise and reading. So it is possible that noise could impair attention and speech perception, and heighten arousal and that all of these could have distinct impacts on child cognition.

A strength of the repeated measures study was that the sustained attention mediation hypothesis was directly tested for the first time. It was concluded that chronic aircraft noise exposure influences attention, but that impairments in attention do not, in turn, cause reading impairments. It is possible that attentional processes act as mediators in noise-related memory impairments more than reading effects, but this needs to be tested (for full argument see Chapter 4 discussion). To speculate, it is possible that specific cognitive mechanisms may only apply to specific noise effects on child cognition. The most theoretically plausible mechanisms to account for reading deficits in Diagram 7 are the psycholinguistic mediators, because they have been shown to be robust in accounting for reading acquisition (Evans & Maxwell, 1997). Furthermore, there is preliminary empirical evidence to support these psycholinguistic hypotheses (Cohen et al., 1973; Evans & Maxwell, 1997). Two studies have conducted appropriate analysis for the mediating role of psycholinguistic processes, auditory discrimination (Cohen et al., 1973) and speech perception (Evans & Maxwell, 1997). Focusing on the underlying mechanisms not only furthers theoretical knowledge of noise effects, but could also be used as a point of intervention (e.g. educational interventions). This may be necessary
in instances where it is difficult to alter the predictor variable, when these are environmental stressors such as aircraft noise exposure.

Testing the potential mediating role of depression, anxiety, annoyance and perceived stress in the association between chronic aircraft noise exposure and reading was a more exploratory component of the research in this thesis. These psychological factors did not mediate the relationship between chronic aircraft noise exposure and cognitive performance. For quite some time researchers have speculated that annoyance mediates the cognitive impairments. The results from the repeated measures study indicate that chronic aircraft noise exposure has independent effects on both reading and annoyance and that annoyance does not mediate the reading effect. However, these results do not definitively address the complex question of the nature of the association between the stress responses and the cognitive processes. The psychophysiological data from the Munich Airport Study will be analysed in relation to the cognitive data to address this question more fully (Hygge, 1998).
6.3 Aircraft noise and child stress responses

In this section the nature of the noise induced stress responses, and the mechanisms and theories to account for these effects will be addressed. Discussion will firstly focus on the definition of annoyance and its behavioural correlates. Then the first assumption of theories of environmental stress, that noise exposure is an environmental stressor, will be examined. And finally, the question of whether environmental stress results from noise exposure per se, or whether it is the result of perceived noise will be raised.

6.3.1 Nature of the noise induced stress responses

In contrast to the cognitive effects of noise exposure in children, there is much less research into the stress responses found in children and most of it has focused on physiological stress responses. Previous research has left aside the issue of the possible interdependence of the cognitive and stress systems, so the research in this thesis has considered them independently. As the research is very much at the exploratory stage, multiple self-report affective measures were administered in the repeated measures study to broadly explore what aspects of stress responses were affected by aircraft noise exposure. The rationale was to explore the speculation that one reason why adult mental health effects are slight and equivocal is because sub-clinical effects in anxiety, depression, health functioning, quality of life and self-reported stress maybe more likely to be the result of noise exposure than clinical illness (Stansfeld & Haines, 1997).

The profile of children’s stress responses to chronic exposure to aircraft noise has been clarified with the present studies. In the repeated measures study chronic exposure to aircraft noise was associated with noise annoyance and perceived stress. The negative results from the repeated measures study are also informative because they support the speculation that self-reported stress is more likely to be affected by noise exposure than is clinical illness. In the repeated measures study high levels of aircraft noise were not associated with children experiencing specific psychological disorders such as anxiety and depression nor were they associated with experiencing higher frequencies of stressful life events. These results are consistent with the results from previous research examining noise effects on child psychological health (Evans et al., 1995; Nurmi & von Wright, 1983; Poustka et al., 1992) .
Psychological disorder was not related to noise exposure in children (Nurmi & von Wright, 1983; Poustka et al., 1992). Self-reported stress responses from the Munich Airport study were measured with two outcomes: noise annoyance and quality of life. Quality of life was measured with the Kindl Scale (Bullinger et al., 1994) that has four domains: physical, psychological, social and functional daily life. A close examination of the Munich Airport results reveals a pattern that is similar to the results found around Heathrow Airport, specifically that there was a significant relationship between aircraft noise exposure and noise annoyance. There was a significant relationship between noise exposure and the psychological sub-scale of the Kindl, that measures a similar construct as the self reported stress scale used in the repeated measures study. However the Munich Airport Study results are not entirely consistent with the repeated measures study because there was no association with the other sub-scales of the Kindl, physical, social and functional.

To summarise, by using the results in this thesis and those from previous research, we can conjecture about the nature of child stress responses associated with chronic aircraft noise exposure. The pattern of positive and negative results found in the repeated measures study partly confirms this suspicion in the sense that stress responses that indicate impaired well-being were found, but they were not found uniformly across all the psychological outcomes. Chronic noise exposure seemed to affect more generalised stress outcomes that incorporate irritability and perception of coping than actual specific mental health problems such as anxiety and depression. Noise annoyance was the most consistent result in the repeated measures study and warrants further discussion.

**Noise annoyance**

The noise annoyance response is the most well documented and widespread finding in the adult literature in relation to environmental noise. For the first time the standardised annoyance question (Fields et al., 1997) was used with children and confirmed the adult research. Only twice before has child noise annoyance been reported (Bronzaft & McCarthy, 1975; Evans et al., 1995), but these data were not collected with a standardised measures, which makes generalisability uncertain. Even though raised noise annoyance was associated with raised depression, anxiety and perceived stress, none of those factors could account for the association between noise and annoyance. This result demonstrates that noise annoyance is not merely the same response as perceived stress, depression, and anxiety, but rather it is a distinct construct.
The link between noise exposure and noise annoyance seems to be clear, whereas the perceived stress finding needs to be replicated and thought needs to be given to what is the precise aspect of perceived stress that could be affected by chronic exposure to aircraft noise.

Noise annoyance is generally thought to be a form of mild anger and fear that is related to a belief that one is being harmed in a way that could be avoided (Cohen & Weinstein, 1981). In adults, noise annoyance is commonly precipitated by the interference of noise in daily activities (Job, 1988). It is possible that this ‘interference in daily activities’ is the underlying mechanism of noise annoyance. Contrary to the adult findings, at both baseline and follow-up the children did not report, on the questionnaire adapted from Bronzaft & McCarthy (1975), that aircraft interference in the classroom overly obstructed or interfered with activities. A reason for this curious disassociation between noise annoyance and reporting of interference with activities is that: ‘noise annoyance’ may mean something different to children than adults. As children’s classroom activities are constantly interrupted by other aspects of school life apart from aircraft noise, it might be hard for them to distinguish between the all the sources of noise interference. One way forward to examine the question of ‘what is it about aircraft noise that children find annoying?’ is by qualitative interviews with children.

In the introductory Chapter 1 the issue of behavioural correlates of noise annoyance was raised. Specifically the question was asked: does noise annoyance lead to more disruptive behaviour in the classroom? However, there was little evidence from the results of the Modified Rutter Parent Questionnaire (see Appendix 14 for the complete results of this questionnaire) and the Student Behaviour Checklist completed by the teachers that annoyance had behavioural consequences, such as conduct problems, less manifestations of prosocial behaviour (e.g. helpful if someone is hurt), or poor motivation to work in the classroom. (It must be noted that these teacher and parent reports could be strengthened by direct observation of independent researchers as validation.) Leaving aside possible reporting biases, the results of the repeated measures study which were consistent across parents and teachers suggest that noise annoyance may not be a severe enough response to provoke child behavioural consequences. Annoyance may be manifest in other ways, because there are suggestions from previous studies that noise annoyance could be associated with physiological stress such as raised blood pressure (Evans et al., 1995; 1998) and
catecholamine secretion (Evans et al., 1995; 1998). However, whether it is the noise exposure that leads directly to the physiological stress or that it is mediated by noise annoyance, or vice versa, remains unknown.

6.3.2 Theory of mechanisms to account for these stress responses

There has not been any theory positing a precise underlying mechanism to account for how noise affects child stress responses. The theories to account for adult noise annoyance could be applied to children. In adults, these psychological effects have been attributed as stress responses resulting from the general arousing properties of noise. This speculation has been based on the previous psychophysiological data. Children chronically exposed to noise have consistently been shown to have higher levels of physiological stress such as systolic and diastolic blood pressure (Cohen et al., 1980; Evans et al., 1995; Evans et al., 1998; Regecova & Kellerova, 1995) and catecholamine secretion (Evans et al., 1995; Evans et al., 1998); however, no association was found with cortisol level (Evans et al., 1995; Evans et al., 1998).

It is difficult to interpret precisely what aspects, if any, of affective stress response these psychophysiological markers indicate. A cautious interpretation would be that raised blood pressure and catecholamine secretion suggested heightened sympathetic arousal. To interpret the physiological data correctly and test this hypothesis would be to conduct a pathway analysis, for example, using the Munich Airport Study data. In the absence of any evidence to support this pathway, at this stage it is important to go back and examine the first principle of environmental stress theory.

Theories of environmental stress

Most psychological theories of environmental stress adopt a relational interactive definition of stress. Stress is defined as a relational concept signifying an imbalance between environmental demands, individual and social resources to cope with those demands, and the individual’s appraisal of that relationship (Lepore & Evans, 1996). Stress occurs when a situation has been appraised as demanding with the potential of exceeding coping resources. Taking this definition further, it could be argued that the objective environmental conditions are only important to the extent that they influence the individual’s perception of the environment as stressful. On the other hand are some environmental conditions stressful regardless of an individual’s perception?
Assumption: Notion of noise as an environmental stressor

The first assumption of the ‘cognitive coping strategies model’ and for all environmental stress theories applied to noise research is that people living in noisy environments do perceive noise as a threat and also find it stressful. This position is based on the evidence of psychophysiological human response, which has been interpreted to suggest that noise exposure has arousing properties. This argument is flawed by circular reasoning, as the outcome (raised blood pressure and catecholamine secretion) is seen to not only to be caused by the predictor (noise exposure), but also to define the nature of the predictor noise as an environmental stressor. Thus it is not valid to use the psychophysiological data as evidence to support either the second link in the argument that noise is arousing or the third link that the state of psychophysiological arousal in turn implies that noise is an environmental stressor.

‘Noise as an environmental stressor’ is an important conceptual issue, especially for children, because they have very little perception of and control over threatening situations. This assumption of ‘perceived threat’ needs to be tested by measuring the way children appraise the threat of aircraft noise in their home and school environments. From the results of the Lewis Child Stress Scale in the follow up study (Chapter 4) it is known that children exposed to high levels of aircraft noise report that they would be more stressed if they were confronted with adverse life events. A difficult issue to deal with when measuring child appraisal of the threat, is whether the children attribute their stress to the environmental conditions or whether they are generally stressed due to other circumstances. Even once it is known whether children perceive chronic noise exposure as stressful, the independent issue of whether noise exposure can cause stress responses is still not answered, even if children don’t appraise noise as an environmental stressor.

Biological and psychological competing theories of stress

To answer this question is to take a position on either the biological or psychological theories of stress that have been debated over the last forty years. The psychological perspective on environmental stress emphasises the person’s perception of the stressor and evaluation of the potential threat posed by the stressors (Cohen et al., 1995). According to this psychological perspective, the stress responses outcomes (e.g noise annoyance) and cognitive impairments (e.g reading comprehension) are the result of the
sound pressure level being perceived as 'threatening'. The biological perspective of environmental stress focuses on the activation of the physiological systems that are particularly responsive to physical and psychological threats. So from this perspective exposure to noise is enough to activate the psychophysiological systems to prepare the person to combat the environmental stressor. From this perspective, the stress responses outcomes and cognitive impairments are the result of the sound pressure level that makes the child become physiologically prepared (Cohen et al., 1986; Halpern, 1995). Therefore, it is possible to be exposed to high levels of sound exposure, but not perceive it as threatening and still be adversely affected.

As with most theoretical debates, biological and psychological models are sometimes presented as a false dichotomy for the sake of argument, and biological and psychological models are not necessarily mutually exclusive in the case of environmental stress. For example the heuristic model of stress process (Cohen et al., 1995) was designed to illustrate the potential integration of the environmental, psychological and biological approaches. Another integration of these perspectives is to argue that 'perceived threat' moderates the association between noise exposure and stress responses. The moderating relationship would be that children who perceive noise as threatening are more likely to suffer the adverse consequences of exposure to high levels of sound pressure level. It is also possible that perception of threat affects health, independently of actual noise exposure. To develop the intricacies of these theoretical positions is beyond the scope of this thesis, but what is more relevant is to outline ways which the predictions derived from these theories can be empirically tested.

One question of interest is whether noise effects found in children result from actual or perceived noise exposure levels. The first step to answer this question is to obtain reliable measures of: noise exposure, perceived noise exposure, perceived threat of chronic exposure to aircraft noise and the stress and cognitive outcomes. In the repeated measures study, physical measures of the environment sound levels and corresponding perceived measures of noise exposure were taken as well as a question asking whether the children felt afraid of the aircraft noise. Unfortunately, comment could not be made on the empirical relationships found between noise, perceived noise exposure and sense of fear and stress responses because of the lack of variability in the child responses to perceived noise and fear of aircraft noise. Most children exposed to
high levels of noise also perceived that they were exposed to high levels of noise. Similarly, aircraft noise exposure did not elicit a fear response in most children.

**Noise and environmental stress theory**

The rationale for collecting these measures is applicable to other sources of environmental stress, because they allow for testing perceived versus actual measures of environmental conditions and human health and performance outcomes (Cohen *et al.*, 1986). Noise pollution is a particularly functional example of an environmental stressor to examine these theories because of the precision of measurement that can be achieved. Objective measurement of noise pollution as a chronic environmental stressor can be precise (Lepore, 1995) and there are WHO guidelines (Berglund & Lindvall, 1995) as to what sound pressure levels result in serious annoyance (although there is large individual variability in reaction to noise). Noise research can take environmental theory forward by using both the objective measurements of a quantifiable environmental stressor and individual measures of perceived threat to test the first assumption that the 'perceived threat' is, in fact, a prerequisite to experiencing environmental stressors. Another related and interesting question is that of adaptation: does the perceived stress of an environmental condition alter over time, for example does it become less stressful after continued exposure?
6.4 Child adaptation to chronic aircraft noise exposure

In order to answer the question of whether the effects of noise are reduced after continued exposure, adaptation and empirical evidence from repeated measures studies need to be discussed. Adaptation refers to the general process by which individuals get accustomed to an environmental stressor. The issue of long-term adaptation to chronic environmental stressors has only started to be addressed empirically and has implications for interventions. Acute noise effects may decrease rapidly in the laboratory (Glass & Singer, 1972; Kryter, 1970), but it is worth emphasising that surveys from community noise research (Jonsson & Sorenson, 1973; Weinstein, 1978) demonstrate that people appear to have much more difficulty in adjusting to chronic noise than is commonly believed. Intervention strategies and public policy should not be based on laboratory studies, because it is questionable whether the performance and stress results generalise to chronic environmental exposure in the community nor should intervention strategies be based on common beliefs.

To test for adaptation, repeated measures of children’s performance and health should be taken over time while the children are exposed to the same level of persistent aircraft noise. In the absence of repeated measures data, other studies (e.g., Cohen et al., 1980; Green et al., 1982; Michelson, 1968) have tried to comment on adaptation by obtaining a record of how long the subjects have been exposed to the noise. This design is not as informative as a repeated measures design, because baseline measures are required to look at length of time exposed and concomitant changes in performance and annoyance within the same sample. Also another potential problem in interpreting the results from the study conducted by Green and colleagues (1982) is that cognitive performance was compared across children aged seven to twelve, and it is questionable that the cognitive outcomes used over the age range operationalised the same construct. Measurement of the change in the size of the effect in the same individuals is required while exposure to noise pollution remains constant over time.

In addition, careful examination of self-selection bias is necessary to address the possibility that there is something unique to people who choose to live longer in high noise exposure, such as low socio-economic status and noise insensitivity. The repeated measures study in this thesis is the first time data like these have been reliably collected.
in children and it can therefore provide an empirical basis on which researchers can estimate the long-term effects of chronic exposure to noise.

The within-subjects results in the repeated measures study demonstrate more reliably than the Los Angeles Airport Study (Cohen et al., 1980) that the effect of noise on reading increases over time. This means that the further year of being exposed to high levels of aircraft noise made the difference in reading scores compared with the control sample significantly increase. The results also demonstrate that the difference in noise annoyance remains the same, and do not indicate adaptation. These results are consistent with the emerging evidence to suggest that people do not psychologically habituate to other chronic stressors such as: marital stress and chronic physical disability (Lepore, 1995). However, not all studies are consistent with this position because adult studies have found that noise annoyance responses vary over time, which suggests that adaptation to noise is not a uniform phenomenon (Stansfeld, 1988). Therefore, the repeated measures results are not conclusive and need replication, but if it is confirmed that children do not adapt to aircraft noise, then the implications need to be considered.

Future research needs to study a large group of children, who will be followed up over time with multiple repeated measures, whilst the exposure to aircraft noise remains at a constant sound pressure level. Other potentially confounding factors also need to be kept constant over the time period, as much as is practically possible, such as home exposure level and school attending and other environmental conditions. The cognitive measures and stress responses need to be repeated and kept comparable over time and take into consideration maturation effects. This study design would allow for the results to answer other questions apart from adaptation such as: whether there are any more sensitive periods of development and the related issue of for how long an individual has to be exposed to aircraft noise before the effects become manifest. If well-designed longitudinal community-based research confirms that children do not psychologically adapt to chronic aircraft noise exposure then there are implications for public health and educational policy. The practical implications are that intervention strategies and public policy would be required to reduce the cognitive impairments and stress responses (these will be outlined in more detail in the final section of this chapter).
This section on adaptation to chronic aircraft noise exposure raised questions that need to be answered. It is, however, important not to overlook the significant contribution of the previous research that has examined noise effects over time (Cohen et al., 1981; Evans et al., 1998). In particular, the Munich Airport Study (Evans et al., 1998) allows for an examination of how adaptation to aircraft noise affects the physiological and psychological indicators independently, but also more interestingly how physiological adaptation influences psychological functioning and adaptation. The previous intervention and repeated measures studies, because of their designs, have provided the strongest evidence that cognitive impairments and stress responses are in fact attributable to chronic noise exposure.
6.5 Strength of the evidence

The theme of 'strength of the evidence' has been continually raised throughout this thesis, when interpreting the previous research and designing the present studies. This is especially relevant for field noise research where an almost inexhaustible list of factors that influence child cognition can be generated such as: diet, social class, language proficiency, number of siblings, quality of school, peer group influences, parental support, etc. (Sammons et al., 1994). It is known that people who reside in high noise exposed areas also tend to have higher levels of deprivation, exemplified by more run-down housing, lower standard schools in which to educate their children, and possibly less of a sense of community etc. Thus, there could be a pre-existing relationship between noise and these other potentially confounding factors which could make one of these aspects of deprivation, school quality, and home life and not 'noise exposure' the cause of the cognitive impairments and stress responses.

Bearing this in mind, careful consideration was given to the design and methodological and statistical refinements that could strengthen the studies in this thesis, within the logistical constraints in terms of time and resources of conducting field research. In relation to design: repeated measures were taken on the same sample and a large number of scores were entered into a multi-level model. In relation to methodology: the schools were carefully matched, and measures were taken of deprivation and main language spoken at home. In relation to statistical refinements: measures and adjustments were made for potential confounding factors, multi-level modelling analyses were conducted at both the school and individual level, and psychometric analyses were conducted to test for reliability and validity. The success of these refinements will be evaluated in more detail in the discussion of methodological issues (section 6.5.1), reliability, and validity (section 6.5.2), and finally in the strengths and limitations of the research (section 6.5.3).
6.5.1 Methodological issues

In the introductory chapter of this thesis a distinction was made between the conceptual and practical methodological issues. Conceptual methodological issues influence the study design and the practical matters inform research methods and data analysis. The discussion contained in Chapters 3, 4 and 5 focused on the more practical points and suggestions made for specific refinements, such as the method of testing for long-term memory and motivation. The discussion that follows will selectively address these conceptual issues that have arisen from the studies: confounding, sample selection, acute and chronic noise effects, and noise exposure measurement.

Issue 1- Confounding

It was concluded in the repeated measures study that “although deprivation and main language spoken at home may have had a small confounding effect on the association between noise exposure and reading comprehension, they did not explain the association”. The small confounding effect refers to the non-significant change in size of effect after adjustment for deprivation and main language spoken at home between the high and low noise groups. However, adjustment for those two factors did not significantly alter the size of the effect of the age-adjusted effects. But more importantly, the fact that the age-adjusted and fully adjusted means hardly varied at all is more significant evidence that deprivation and main language spoken at home did not explain the association between noise and cognitive impairments. Unfortunately, it is difficult to comment on the within subjects analyses because of sample size reduction, and a full adjustment may have lost the statistical power to detect a significant difference, as was the case in the follow-up study (for full argument see Chapter 4). Obviously, these within subjects analyses need replication.

It is possible that main language spoken did not influence the association between noise and cognitive performance because the measure used in the repeated measures and SATs studies of ‘non-English spoken at home’ was not the most sensitive measure to detect the influence of language on reading performance. The best way to measure language proficiency is to assess fluency of English. This fluency assessment requires individual testing by an educational psychologist which was not logistically possible in these studies. The insensitivity of measuring ‘main language spoken at home’ is because language spoken is also highly related to cultural factors and sometimes having two
main languages (bi-lingualism) confers an added advantage to a child’s school performance (Bialystok & Majumder, 1998; Garcia et al., 1998).

The result from the repeated measures study indicating that deprivation may not have confounded the association between noise exposure and cognitive performance, is in contradiction of the results from the SATs study. In the SATs study when adjustment was made at the school level for percentage of students eligible for a free school meal, as a proxy measure for deprivation, the trend of increased noise exposure being associated with poorer performance disappeared (for full arguments about the interpretation of the SATs results see Chapter 5). The problems associated with the statistical method of adjustment will be addressed in more detail below.

**Statistical method of adjustment for dealing with confounding factors**

The statistical method of adjusting for potential environmental and social confounding factors is widely used in epidemiological environmental research that is focusing on examining the effects of one specific stressor, such as noise, air pollution, or crowding in isolation. This method does not take adequate account of the naturalistic context in which environmental stressors normally occur (Cohen et al., 1986). Being exposed to high levels of aircraft noise is one among several adverse environmental conditions more likely to affect deprived households and communities of ethnic minorities. Deprivation-related characteristics of households and individuals generate social and financial stressors that are, in themselves, also stressful and that could have multiplicative effects when they coexist with environmental stressors (Evans et al., 1999 *in press*). There is preliminary evidence to suggest that social stressors when coupled with environmental stressors have multiplicative consequences for child well-being (Evans & Saegert, in press). On the basis of this preliminary evidence from the Bronx in New York City, it could be argued that adjusting out ‘deprivation’ underestimates the real impact on aircraft noise on child cognition and health.

An interesting question for future research would be to assess whether there is any evidence that children from areas of high social disadvantage are more affected by chronic noise exposure than children from areas of low social disadvantage. Children with high levels of social disadvantage are an obvious group at risk from the effects of chronic aircraft noise exposure. Social disadvantage is associated with low school achievement (Mortimore & Whitty, 1997). The effects of additional adverse
environmental conditions such as noise may have a cumulative effect on low school achievement in children from socially disadvantaged backgrounds. Therefore, children from disadvantaged backgrounds may be more vulnerable to the effects of chronic noise exposure than more advantaged children.

Another possible problem with the statistical method of adjustment for dealing with confounding factors is the ‘partialling fallacy’ (Halpern, 1995). That is if the influence of a variable strongly associated with noise exposure is statistically controlled for (such as deprivation or main language spoken at home), then the effect size explained by noise exposure on the outcome (e.g., reading) will appear to be sharply reduced or even eliminated. This statistical method does not allow for the conceptually plausible possibility that that noise exposure may have been a significant mediator of the control variable’s influence (Halpern, 1995). That is to say that the main predictor variable is social deprivation and that noise exposure, as a part of socially deprived environment, might be part of the reason why deprivation affects reading comprehension. One solution to this problem of statistical adjustment and a way of testing the hypothesis that children with high social disadvantage are more vulnerable to the effects of noise exposure is to perform stratified analyses in samples stratified by deprivation levels.

**Measurement of potential confounding factors**

Another precaution taken in research to make sure of accounting for the effect of potential confounding factors is to measure them reliably. The SATs result, indicating that deprivation confounded the association between noise exposure and cognitive performance, is contrary to the results from the repeated measures study. In the SATs study the socio-economic adjustment was made at the school level and not at the individual level. When statistical adjustment was made for deprivation in the repeated measures study it was done so with a sensitive measure of deprivation collected at the individual level. This striking difference in how deprivation influenced noise effects in the both studies might be explained by the speculation that adjustment for school level socio-economic status (i.e. a school attracts low SES catchment that in turn influences individual performance of all students) is different to the individual level adjustment (actual individual deprivation) measure. Future research should include both measures of school and individual level deprivation.
Previous research has used single item scales that are limited to take account of the potential confounding associated with socio-economic status at the individual level such as parental income or social class (Cohen et al., 1980, 1981; Evans et al., 1995, 1998; Evans & Maxwell, 1997). In the repeated measures study, household deprivation was measured in a more reliable way than in any previous study using the Townsend Scale (Townsend et al., 1989). This scale is a more reliable indicator of child disadvantage because it combines social class with other indicators of disadvantage such as overcrowding and possession of household amenities (Bartley et al., 1994). The results from the Lewis Child Stress Scale (Chapter 4) suggest that a sensitive indicator of child deprivation might be stressful events, because they could allow us to assess of form of emotional deprivation. Emotional deprivation as a likely by-product of material or economic deprivation might have a more powerful influence over child stress and performance than economic deprivation on its own (Bifulco & Moran, 1998).

The discussion above has focused on how researchers can control for the impact of confounding factors on performance by considering measuring the potential factors and the statistical methods to adequately adjust for their contributing influence on the outcome. Another way to deal with confounding factors is to refine the method of sample selection.

**Issue 2 - sample selection**

Previous studies, all with small samples of school children, have not given attention to sample selection and matching as a method of addressing confounding factors (Bronzaft & McCarthy, 1975; Evans et al., 1995; Evans & Maxwell, 1997). Confounding factors were considered in the design of the repeated measures study (Chapters 3 & 4), by utilising a refined method of selecting and matching the schools. The high noise schools were selected first, and then they were matched with the control schools by obtaining census data and school data from the local authorities and from site visits on a *a priori* matching criteria (see Methods Chapter 2). Both the high and low noise exposed schools were selected from the same boroughs around Heathrow Airport in order to minimise the physical and social environmental differences between the two areas other than noise.

The next steps for further refinement are for a larger sample to be selected that is well controlled at both the school and the individual level. By substantially increasing the
number of schools and children, future studies will be able to increase the statistical power of the analyses. This will markedly improve the precision of the estimates of the noise effects and will allow for reliable adjustment of potential confounding factors. Moreover, a large sample will allow for analyses to be conducted within stratified ethnic and social class groups of children. A further issue is how randomly the control schools can be matched to the high noise schools in practice when the number of suitable schools is limited.

**Issue 3 - acute and chronic noise effects**

In the 1960s and 1970s the answer to the question of whether the performance effects of noise were attributable to chronic noise exposure or acute interference at the time of testing was unknown. The results from later studies in the 1980s and 1990s, in which cognitive tests were conducted in controlled quiet conditions (e.g., a sound-proof trailer (Cohen et al., 1980 Evans et al., 1995) or using headphones (Evans & Maxwell, 1997), strongly suggest that chronic noise exposure was the cause of the noise related reading deficits and that acute aircraft interference did not seem to influence the reading results. These are strong data indeed and provide a substantive and conclusive answer to the question of chronic versus acute noise effects. The results from the repeated measures study entirely support this position, because the noise effects found at baseline, when there was considerable acute noise interference, were replicated at follow-up when acute interference was negligible. However, it may also be the case that acute noise at the time of testing increases the likelihood of even poorer reading performance, and thus it may act as a moderating factor in the association between chronic aircraft noise exposure and cognitive impairments.

The way to test the contribution of acute noise exposure on the association between chronic noise exposure and cognitive performance would be to manipulate testing conditions using a repeated measures experimental design in the field. This would require a within subjects cross-over experimental design using two samples of children chronically exposed to high and low levels of experimental noise. There would be two groups of school children: 1) chronically exposed to high levels of aircraft noise at school and 2) a control group chronically exposed to low levels of aircraft noise at school. They would complete the same cognitive tasks twice in two experimental conditions. One experimental condition is quiet with the children instructed to wear headphones, and the other is the noisy condition without headphones. The comparison
between the performance of the high noise group across the two experimental conditions is the test for acute noise interference as a moderating factor.

**Issue 4 - noise measurement**

Acute noise effects raise the issue of how adequately noise exposure is measured in environmental research. Generally, it is agreed that greater attention should be paid to the need for standardisation of measures of noise exposure (Porter et al., 1998). Without going into too much acoustical detail, as it is outside the scope of this thesis, it should be noted that choosing schools using the latest published Civil Aviation Authority dBA Leq contour maps is controversial. It is contentious how reliably these CAA contours estimate actual exposure level because they are formulated on average aircraft noise exposure over a 16-hour period (Turner, 1997). The measurement of outside levels of acute aircraft noise exposure during testing at both the noise exposed and control schools could be refined by obtaining hourly values of Laeq, together with values, for each hour of other parameters such as Lmax, L10, and L90. More work is required to characterise the noise exposure experienced in the schools and the setting of environmental noise standards and regulations in relation to non-auditory health effects (Porter et al., 1998).
6.5.2 Validity and reliability
Psychometric analyses have been neglected in previous noise research and there is a need for a more thorough assessment of reliability and validity of the outcome measures. The issue of trying to obtain valid and reliable data has been a consistent theme throughout this thesis, as evident by: the psychometric review upon which the measures were selected (Chapter 2); the procedures adopted to attain reliable results with a child sample (Chapter 2); the statistical procedures (Chapter 2), and especially the comprehensive psychometric analyses (see Chapter 2 and Appendix 15 for the complete analyses and Chapter 4 for detailed discussion). It is important to assess the reliability and validity of the data, in order to comment on the strength of the evidence of the results presented in this thesis.

Generally, it can be concluded from these psychometric analyses that the measures, apart from long-term memory, were reliable in terms of stability and internal consistency. Also, both the cognitive and mental health measures had consistent concurrent validity respectively. Even though the results from the child environment section were mixed they are useful when considering the validity and reliability of this study. The pattern of child responses in the health and environment section across baseline and follow-up clearly demonstrate that the children understood the questions and gave reliable answers. The higher response rates both at baseline (77%) and follow-up (81%) than is usual in field research, reduced the likelihood of potential sampling biases. The original sample was representative of the schools selected and the fact that attrition did not affect the reliability of the follow-up data. To overcome this problem, taking into consideration the cluster design a substantially larger number of children would be required, which was beyond the practical scope of this study. Taking these psychometric analyses all together it can be concluded that the most of the results in this thesis were reasonably reliable and valid.
6.5.3 Strengths and limitations of the research

To summarise the previous discussion, the main strengths of the studies in this thesis are as follows: 1) there was a theoretical base and rationale for these studies; 2) a hypothesised mediating factor was directly tested; 3) potential confounding factors were well measured and were taken into consideration by appropriate statistical analyses and the method of sample selection; 4) the sample size, although not ideal, was the largest to date examining noise effects on child health; and 5) finally multi-level modelling techniques were applied for the first time to address school level factors.

Although these studies have clearly identifiable strengths, inevitably there are also certain weaknesses. There are three limitations with the design of the repeated measures study. Firstly, in order to give a more comprehensive answer to the question of adaptation, it would be necessary to collect multiple repeated measures over a larger period of time. By conducting more than one follow-up study, it would be possible to examine how the size of the noise effects change over time. This study design could test whether when an individual is exposed to noise for more time, the size of the noise effects increases in a dose-response function, or whether after a certain period of time that an individual is exposed to noise the size of the effects remains constant, indicating a threshold effect. Also by allowing more time to pass than one year between follow-up data collections, the study would become genuinely longitudinal. Secondly, a larger study of more schools would have given greater control over the possible confounding of school effects. By conducting the study on a larger number of schools, the data could be analysed at the school level as well as the individual level, taking the clustering of the pupils in classes, and therefore school effects, into account. Thirdly, the repeated measures and the SATs studies are observational, because the predictor variable ‘aircraft noise exposure’ was not manipulated. Therefore, a self selection factor or environmental or social factors co-existent with noise cannot be totally eliminated as accounts of the results. On the other hand, it is impossible to manipulate environmental aircraft noise exposure in community field studies, without the occurrence of a natural experiment or construction intervention.

There are two limitations of the methodology of the repeated measures study. First, group administered classroom testing was advantageous in the sense that it allowed for more data to be collected in the limited time that was available. However, individual
assessments would have afforded greater experimental control over the cognitive and motivation tests and would possibly have allowed for other measures that require individual testing such as blood pressure. Second, even though only an extremely small proportion of the sample had hearing problems (4.3% (n=12) had mild hearing problems, 0.4% (n=1) had a moderate problem and none had a severe problem) as reported by the children’s parents, it would have been more accurate to have pre-screened each child individually for hearing loss.

The SATs study was limited by the crudeness of the school level data that was available from the local authorities and DfEE, but hopefully these data will be refined centrally for future research. Specifically it would have been better to have individual level data on whether each child was eligible for a free school meal and what was the main language spoken at home, and to have this data from the School Census linked to the Key Stage 2 SATs results. This would have enabled the socio-economic adjustment to have been more accurate at the individual level than the analysis that was conducted, which adjusted for the school average of percentage of children eligible for a free school meal. Key Stage 1 SATs examinations are taken when the children are seven years old. At this stage, these data are not available for research and they are not linked to Key Stage 2. Moreover, the Key Stage 1 exams are not nationally standardised, which means that it is not possible to compare results across schools. In future, if these problems are dealt with, Key Stage 1 data could be used to adjust for baseline performance on Key Stage 2 performance.
6.6 General conclusions to be drawn from the thesis

To conclude, the central question of this thesis concerns the extent to which the cognitive and stress effects associated with noise are indeed attributable to noise. Considering the results of the three studies, the data do suggest that chronic aircraft noise exposure is a likely contributing factor that leads to impaired cognition and raised stress responses in children. In comparison to the stronger evidence to confirm the existence of noise effects that comes from intervention studies (Bronzaft, 1981) and natural experiments (Evans et al., 1995; Evans et al., 1998) where changes in noise exposure are shown to be accompanied by changes in health function and cognition, causal inferences can not be drawn from the studies in this thesis due to their cross-sectional and limited follow-up designs. Against the back-drop of those previous intervention studies and considering the design and methodological refinements employed in the studies in this thesis, further more specific conclusions can be drawn.

Considering the strengths and limitations of the research, the following five specific conclusions have been drawn from the studies in this thesis:

1) High levels of chronic aircraft noise exposure in children were associated with cognitive impairments in reading comprehension and sustained attention.

2) Sustained attention did not act as a mediating factor to account for the association between noise exposure and impaired reading comprehension.

3) High levels of chronic noise exposure were associated with raised noise annoyance and perceived stress.

4) It is possible that these cognitive effects and stress responses do not lessen with continued exposure to high level of aircraft noise.

5) It needs to be clarified that these cognitive and stress effects found in children were not partly influenced by school level factors, main language spoken at home, or household deprivation.
6.7 Implications and the need for further research

In view of the potential importance of these results and conclusions on children’s education and health, future research must give policy makers clearer guidance on whether these effects are related to noise exposure and must suggest viable and proven interventions. The results from this thesis suggest a need for further research and, if the effects of noise are confirmed, then interventions to reduce the level of aircraft noise in schools around Heathrow Airport should become a priority. Also if these results are confirmed they will allow researchers to draw conclusions about the nature of children’s cognitive processes and stress responses. For example, inferences could be drawn about the role of impaired speech perception on reading performance generally and about child coping strategies when confronted with chronic stress.

Future Research

Throughout this final Chapter 6 many suggestions for future research have been put forward, including field, qualitative, laboratory, and experimental studies. As a great deal of unanswered questions remain about the nature and cause of noise effects in children, these suggestions for future research need to be prioritised. Firstly, a large scale confirmatory study is required because previous field studies including those in this thesis (Cohen et al., 1980; Evans et al., 1995, Evans & Maxwell, 1997) have not been of sufficient size to account adequately for potential confounding factors in the relationship between noise and cognitive impairments.

Secondly, if noise effects are confirmed, then the next stage for research would be to design and assess interventions such as sound insulation of schools. Improved sound insulation would help to reduce aircraft noise exposure in classrooms. It may be that outside sound pressure levels in the playground affect play and relaxation which, in turn, influence social skills and learning. However, we still can not tell how much aircraft noise exposure at home and in the school environment outside the classroom, may contribute to the cognitive performance difficulties. Hence, sound insulation at school may not be a sufficient intervention alone to prevent further negative health effects in school children exposed to aircraft noise. It may be necessary to reduce overall levels of aircraft noise exposure to reduce the cognitive performance difficulties in children. Another point of intervention could be the identification of protective
factors such as extra classes in cognitive subjects that are known to be affected by aircraft noise and the establishment of quiet study areas either at home or in the schools.

Thirdly, studies need to examine the possibility that some children may be more vulnerable to the effect of noise than others. It has been argued that there are certain groups of the adult population who may be more vulnerable to the mental health effects of aircraft noise, such as those with higher levels of noise sensitivity and pre-existing mental health problems (Stansfeld et al., 1985; Stansfeld, 1992). Extrapolating from this idea, it may be hypothesised that children with high anxiety and depression may also be more vulnerable to the effects of chronic aircraft noise exposure. The issue of children from deprived homes and lower social class as another high risk group has been raised previously. To speculate, other high risk groups of children could include those with long-term illnesses, physical handicaps, learning difficulties, and special reading needs. If these speculations were confirmed then obviously these children should be given priority for interventions. And finally all future research should be designed to test theoretical positions and hypothesised mechanisms to account for noise related cognitive impairments and stress responses.

Policy Implications
From a policy point of view these data are suggestive and not conclusive. In the 1990s there was an emerging trend that psychological perspectives on environmental risk management are in demand because of the increasing behavioural dimensions of environmental policy (Vaughan, 1993). School inspectors dating back to the Wilson Committee Report in 1963 have consistently commented on the unsatisfactory nature of school environments exposed to aircraft noise around Heathrow Airport. If these results are confirmed in further research around Heathrow Airport there are implications for interventions for improving school environments and future transport developments. Since research at other airports shows the same trend in results, it may be wise to apply the precautionary principle of environmental law for improving the school environment around airports and transport developments. If the level of noise remains consistent, or if there is an increase in noise levels in schools, then more children will be taught in a disadvantaged learning environment that could have negative consequences for cognitive development and well-being.


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Appendix 1: The extent to which the selected schools were matched
Appendix 1: The extent to which the selected schools were matched

Table A1.1.

First Pair: Bedfont Junior (high noise) and Strand-on-the-Green (low noise).
(Appendix 1)

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<th>The matching criteria</th>
<th>High Noise</th>
<th>Low Noise</th>
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<td>Strand on the Green Junior</td>
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<td></td>
<td>Hounslow</td>
<td>Hounslow</td>
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<td>Ward: East Bedfont</td>
<td>NOISE 66 - 69</td>
<td>Ward: Gunnersbury</td>
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</tbody>
</table>

dBA Leq taken from the 1991 CAA noise contours 16 hour outdoor

<table>
<thead>
<tr>
<th>DOUBLE GLAZING</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Sources of Environmental Noise</td>
<td>Some of traffic at peak time but generally quite</td>
</tr>
<tr>
<td></td>
<td>No road traffic, close to a railway line. When the school was approached they claimed that the trains didn’t interfere with the teaching</td>
</tr>
</tbody>
</table>

Socio Economic Groups (SEG)
1 - Professional and Managerial (SEGs 1,2,3,4,13)
2 - Other non-Manual (SEGs 5,6)
3 - Skilled Manual (SEGs 8,9,12,14)
4 - Semi-skilled manual (SEGs 7,10,15)
5 - Unskilled (11)
6 - Others (SEG 16,17)

<table>
<thead>
<tr>
<th>Unemployment</th>
<th>Male - 8.7 %</th>
<th>Male - 12.9 %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female 6.6 %</td>
<td>Female - 8.9 %</td>
</tr>
</tbody>
</table>

Ethnic Groups in the School Ward

<table>
<thead>
<tr>
<th>Percentage of the main ethnic groups out of all residents in the ward</th>
<th>White</th>
<th>White</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Indian</td>
<td>4.9%</td>
<td>3. Indian</td>
</tr>
<tr>
<td>2. 6.7%</td>
<td>3.0%</td>
<td>2. Born in Ireland</td>
</tr>
<tr>
<td>3. Born in Ireland</td>
<td>2.0%</td>
<td>5. Black African</td>
</tr>
<tr>
<td>4. Other Asian</td>
<td>1.2%</td>
<td>6. Black</td>
</tr>
<tr>
<td>80 % White</td>
<td>84 % white</td>
<td></td>
</tr>
</tbody>
</table>

Ethnic Groups in the School Percentage of white children in the school on the basis of school survey
Table A1.2.
Second Pair: Chatsworth Junior (high noise) and Hermitage Primary School (Low Noise). (Appendix 1)

<table>
<thead>
<tr>
<th>The matching criteria</th>
<th>High Noise</th>
<th>Low Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chatsworth Junior</td>
<td>Hermitage Junior</td>
</tr>
<tr>
<td></td>
<td>Hounslow</td>
<td>Hillingdon</td>
</tr>
<tr>
<td></td>
<td>Ward: Hounslow South</td>
<td>Ward: Uxbridge North</td>
</tr>
<tr>
<td>NOISE</td>
<td>63 – 66</td>
<td>&lt; 57 Leq</td>
</tr>
</tbody>
</table>

- dBA Leq taken form the 1991 CAA noise contours 16 hour outdoor
- DOUBLE GLAZING No. No
- Other Sources of Environmental Noise
  - Busy in the mornings but not so much road traffic
  - Quiet inside buildings even though it is set back off a busy road
- Socio Economic Groups (SEG)
  1 - Professional and Managerial (SEGs 1,2,3,4,13)
  2 - Other non-Manual (SEGs 5,6)
  3 - Skilled Manual (SEGs 8,9,12,14)
  4 - Semi-skilled manual (SEGs 7,10,15)
  5 - Unskilled (11)
  6 - Others (SEG 16,17)

<table>
<thead>
<tr>
<th>Socio Economic Groups (SEG)</th>
<th>High Noise</th>
<th>Low Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Professional and Managerial</td>
<td>1 - 21.8 %</td>
<td>1 - 31.5 %</td>
</tr>
<tr>
<td>(SEGs 1,2,3,4,13)</td>
<td>2 - 41.6 %</td>
<td>2 - 38.8 %</td>
</tr>
<tr>
<td>2 - Other non-Manual (SEGs 5,6)</td>
<td>3 - 12.0 %</td>
<td>3 - 14.4 %</td>
</tr>
<tr>
<td>3 - Skilled Manual (SEGs 8,9,12,14)</td>
<td>4 - 19.6 %</td>
<td>4 - 9.7 %</td>
</tr>
<tr>
<td>4 - Semi-skilled manual (SEGs 7,10,15)</td>
<td>5 - 3.2 %</td>
<td>5 - 2.7 %</td>
</tr>
</tbody>
</table>

- Unemployment
  - Unemployed percentage of males and females aged 16 - 59 who are classified as economically inactive
  - male: 7.1 %
  - female: 5.3 %
  - male: 4.9 %
  - female: 4.1 %

- Ethnic Groups in the School Ward
  1. White - 74.3 %
  2. Indian - 15.8 %
  3. Born in Ireland - 4.2 %
  4. Pakistani - 2.6 %

- Ethnic Groups in the School
  Percentage of white children in the school on the basis of school survey
  White - 39 %
  White - 67 %
Table A1.3.

*Third Pair: Springwell Junior was matched with Feltham Hill Junior School in Hounslow as the low noise school. (Appendix 1)*

<table>
<thead>
<tr>
<th>The matching criteria</th>
<th>High Noise</th>
<th>Low Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Springwell Junior</td>
<td>Feltham Hill Junior School</td>
</tr>
<tr>
<td>Ward</td>
<td>Heston Central</td>
<td>Feltham South</td>
</tr>
<tr>
<td><strong>NOISE</strong></td>
<td>63 - 66</td>
<td>&lt;57 Leq</td>
</tr>
<tr>
<td>dB a Leq taken from the 1991 CAA noise contours 16 hour outdoor</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DOUBLE GLAZING</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Other Sources of Environmental Noise</strong></td>
<td>On a busy road but the school has double glazing which makes the traffic noise in the classrooms inaudible</td>
<td></td>
</tr>
<tr>
<td><strong>Socio Economic Groups (SEG)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - Professional and Managerial (SEGs 1,2,3,4,13)</td>
<td>1 - 24.1 %</td>
<td>1 - 18.2 %</td>
</tr>
<tr>
<td>2 - Other non-Manual (SEGs 5,6)</td>
<td>2 - 38.0 %</td>
<td>2 - 40.7 %</td>
</tr>
<tr>
<td>3 - Skilled Manual (SEGs 8,9,12,14)</td>
<td>3 - 15.6 %</td>
<td>3 - 12.4 %</td>
</tr>
<tr>
<td>4 - Semi-skilled manual (SEGs 7,10,15)</td>
<td>4 - 15.7 %</td>
<td>4 - 21.1 %</td>
</tr>
<tr>
<td>5 - Unskilled (11)</td>
<td>5 - 4.3 %</td>
<td>5 - 5.3 %</td>
</tr>
<tr>
<td>6 - Others (SEG 16,17)</td>
<td>6 - 2.5 %</td>
<td>6 - 2.4 %</td>
</tr>
<tr>
<td>* These data come from the full small area 100 % census sample.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Unemployment</strong></td>
<td>Male: 9 %</td>
<td>Male: 8 %</td>
</tr>
<tr>
<td></td>
<td>Female: 7 %</td>
<td>Female: 5 %</td>
</tr>
<tr>
<td>Unemployed percentage of males and females aged 16 - 59 who are classified as economically inactive</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ethnic Groups in the School Ward</strong></td>
<td>White: 55.7 %</td>
<td>White: 92.7 %</td>
</tr>
<tr>
<td>Indian</td>
<td>30 %</td>
<td>Indian: 2.8 %</td>
</tr>
<tr>
<td>Pakistani</td>
<td>5 %</td>
<td></td>
</tr>
<tr>
<td>Percentage of the main ethnic groups out of all residents in the ward</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ethnic Groups in the School</strong></td>
<td>Indian: 62 %</td>
<td>No figures available</td>
</tr>
<tr>
<td>Percentage of white children in the school on the basis of school survey</td>
<td>Indian: 62 %</td>
<td>No figures available</td>
</tr>
<tr>
<td>White</td>
<td>16 %</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>14 %</td>
<td></td>
</tr>
</tbody>
</table>
**Table A1.4.**  
*Fourth Pair: Wellington Primary School (High Noise) and Wood End Park Junior School (Low Noise). (Appendix 1)*

<table>
<thead>
<tr>
<th>The matching criteria</th>
<th>High Noise</th>
<th>Low Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wellington Primary School</td>
<td>Wood End Park Junior School</td>
</tr>
<tr>
<td></td>
<td>Ward: Hounslow Heath</td>
<td>Ward: Wood End</td>
</tr>
<tr>
<td><strong>NOISE</strong></td>
<td>63 - 66 Leq</td>
<td>&lt;57 Leq</td>
</tr>
<tr>
<td></td>
<td><strong>dBA Leq taken from the 1991 CAA noise contours 16 hour outdoor</strong></td>
<td></td>
</tr>
<tr>
<td><strong>DOUBLE GLAZING</strong></td>
<td>No</td>
<td>20% double glazed</td>
</tr>
<tr>
<td><strong>Other Sources of Environmental Noise</strong></td>
<td>No effect in the classrooms even though it's on a reasonably busy road</td>
<td>no</td>
</tr>
<tr>
<td><strong>Socio Economic Groups (SEG)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - Professional and Managerial (SEGs 1,2,3,4,13)</td>
<td>1 - 15.3%</td>
<td>1 - 16.2%</td>
</tr>
<tr>
<td>2 - Other non-Manual (SEGs 5,6)</td>
<td>2 - 34.6%</td>
<td>2 - 30.1%</td>
</tr>
<tr>
<td>3 - Skilled Manual (SEGs 8,9,12,14)</td>
<td>3 - 21.5%</td>
<td>3 - 25.4%</td>
</tr>
<tr>
<td>4 - Semi-skilled manual (SEGs 7,10,15)</td>
<td>4 - 15.8%</td>
<td>4 - 18.4%</td>
</tr>
<tr>
<td>5 - Unskilled (11)</td>
<td>5 - 6.1%</td>
<td>5 - 8.0%</td>
</tr>
<tr>
<td>6 - Others (SEG 16,17)</td>
<td>6 - 6.8%</td>
<td>6 - 2.0%</td>
</tr>
<tr>
<td><strong>Unemployment</strong></td>
<td>male: 12.0%</td>
<td>male: 9.9%</td>
</tr>
<tr>
<td></td>
<td>female: 9.4%</td>
<td>female: 5.3%</td>
</tr>
<tr>
<td>Unemployed percentage of males and females aged 16 - 59 who are classified as economically inactive</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ethnic Groups in the School Ward</strong></td>
<td>White: 49.8%</td>
<td>white: 83.8%</td>
</tr>
<tr>
<td></td>
<td>Indian: 35.6%</td>
<td>Indian: 9.1%</td>
</tr>
<tr>
<td></td>
<td>Pakistani: 5.8%</td>
<td>Black Caribbean: 2.0%</td>
</tr>
<tr>
<td></td>
<td>Born in Ireland: 3.7%</td>
<td>Other Asian: 3.1%</td>
</tr>
<tr>
<td><strong>Percentage of the main ethnic groups out of all residents in the ward</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ethnic Groups in the School</strong></td>
<td>White: 39%</td>
<td>White: 68%</td>
</tr>
<tr>
<td>Percentage of white children in the school on the basis of school survey</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 2: Pilot Study
Appendix 2: Pilot Study

The test procedure and materials were piloted on an 8 year old sample. The aims of the pilot study were:

1) to examine whether testing affected mood.

2) to test for child compliance with and comprehension of the tasks.

3) to compare two long term memory tasks.

4) to time how long the tasks would take.

5) to collect feedback in a sample of school children.

Methods

The pilot study was conducted at Gillespie Road Primary School in Highbury in February 1996. The sample was 10 ethnically and academically mixed Year 5 students. The students were seen on two mornings 10 days apart.

Materials (For a detailed description of these measures see Chapter 2)

The following tests were carried out:
The children were given two reading passages taken from child education literature: one was modelled directly on the Munich Study, a difficult passage about Egyptians (Allan, 1993) and an easier passage Our Friend The Dolphin (Hunt, 1985). Two corresponding long term memory comprehension tests were administered. They each contained 6 simple multi-choice questions and 3 complex questions. The Suffolk Reading Scale (Hagley, 1987) was also administered. Short term memory was measured with a 6 trial of a digit serial recall task. Anxiety was measured with the Child Manifest Anxiety Scale (Reynolds & Richmond, 1978). Depression was measured with the short version of the Child Depression Inventory (Kovacs & Beck, 1977). Optimism Bias was measured using an adapted scale from (Haines & Job; 1994). Social desirability was measured using 7 items from the Child Manifest Anxiety Scale (Reynolds & Richmond, 1978). Attributional style was measured with a short version of the Child Attributional
Style Questionnaire (Kaslow & Nolen-Hoeksema, 1991). The subjects were given the Bond Lader Mood Scale (Bond & Lader, 1974).

Results and Discussion

The children could understand the Bond Lader Scale a visual analog of mood. After probing it was discovered that the students could reliably record their current mood. Testing altered the children’s mood, because the children reported a more depressed mood on the Bond Lader Scale after testing. On the basis of this finding mood was measured in the main study.

The children could understand the instructions of the Suffolk Reading Scale and effectively complete the items. A good range of scores was found indicating that the scale was sensitive.

Our Friend The Dolphin long term memory passage was selected for the main study because it was short and because there was a reasonable range of scores. The Egyptian passage was too difficult and the pilot results showed a floor effect. The instructions of the complex questions were reworded to included ‘write as much as you can remember from the passage you read last week’ to increase the response rate.

The short term memory results indicated that the digit serial recall task was a sensitive measure and that the instructions were understood. Procedurally, the researchers would have to check that the children didn’t cheat by writing down the numbers while the trials were being read out.

The psychological scales were understood by the sample. The subject of these scales was changed from the first person to the second for clarity when reading these scales out aloud to the children. The optimism bias question was edited from the main study to reduce testing time. The children did not find any test item upsetting. The overall testing time was satisfactory.

On the basis of the piloting of the motivation task the following changes were made: the instructions were made more explicit and a demonstration was included, the children needed to be constantly reminded to note the number of attempts they made.
General procedural changes that were made following the pilot study were that:
1) another researcher would be required to help with the testing;
2) the researchers would have to check that the children didn’t copy each other’s answers;
3) where possible scales should be read out loud so that the children all answer each item at the same time and so that the testing takes less time.
Appendix 3: Day 1 Child Questionnaire – baseline
CONFIDENTIAL

Information Sheet - for School Children

Title: The School Environment and Health Study

* We are inviting you and your parents to take part in a study to look at the effects of the environment on the health of parents and children. It means that you and your parents will fill in some short forms. You will also be asked to do short written tests and activities in the classroom with the rest of your class.

* The reason we are carrying out this study is to look at how your surroundings affect your health and performance at school. Our findings may be very important in showing the effect of the school environment on children.

* All your answers will be kept completely confidential, which means that your parents or school teachers cannot read your answers.

* You do not have to take part in this study if you do not want to. If you decide to take part you may say you don’t want to go on with it at any time without having to give a reason. If you don’t want to answer any particular question on any form you can leave it blank.

Investigators:

Dr. Stephen Stansfeld, Department of Epidemiology and Public Health, University College London.
Ms Mary Haines, Department of Epidemiology and Public Health, University College London.
Professor Birgitta Berglund, Department of Psychology, University of Stockholm.
Dr. Soames Job, Department of Psychology, University of Sydney.
Background Information

What is your full name (first name and last name):

______________________________________________________________

Are you?  □ a girl or □ a boy

What are all the languages spoken in your home? (Please tick ALL the languages that are spoken)

□ English  □ Punjabi  □ Urdu  □ Chinese  □ Hindi  □ Gujarati  □ Cantonese

Others: ____________________________________________________________

What is the main language spoken in your home? (Please tick Only ONE BOX)

□ English  □ Punjabi  □ Urdu  □ Chinese  □ Hindi  □ Gujarati  □ Cantonese

Others: ____________________________________________________________

Which category best describes you?

□ Asian: Bangladeshi
□ Asian: Indian
□ Asian: Pakistani
□ Asian: Chinese
□ Asian: Other

□ Black: African
□ Black: Caribbean
□ Black: British
□ Black: Other

□ White

□ Other: __________________________________________________________
Our friend, the dolphin

A woman was once thrown into the sea when the yacht she was on exploded. After a short time, three dolphins swam up to her. One of them kept the woman afloat. The other two circled round and round to protect her from sharks. The dolphins steered the woman to a large marker in the sea. As soon as the woman had climbed safely on to it the dolphins left her. After the woman had been rescued, it was found that she had drifted for over 200 miles. The dolphins had stayed with her for the entire distance.

Recently a dolphin kept trying to jump on to a Russian fishing boat. At last the puzzled fishermen pulled the dolphin on board. They found that it had a large bleeding gash on its side. The dolphin quietly allowed the ship's doctors to stitch up the wound. Once this was done the dolphin was put back in the sea where it swam off.

The dolphin is a very intelligent creature. Its brain compares with that of a man. The lifespan of a dolphin is about 30 years. This is enough to gain a large store of knowledge. Dolphins appear to have a language. They talk to each other using a range of clicks and whistles. They also have an amazing sense of hearing. They send out sounds and can tell from their echo the size of objects as far away as a quarter of a mile.
More than 2,000 years ago there was a great war between Athens and Sparta.

One day a boy ran into the camp of Lysander, the great Spartan general.

The boy had run for many days with a message from Lysander's spies.

'I...I was given a tunic, a belt, and some sandals,' stammered the boy. 'And I was told to run to you. But I was not told what the message was.'

Lysander asked, 'Were you stopped by the enemy?'

'Yes, many times, sir,' replied the boy. 'But I could tell them nothing so they let me go.'

Lysander asked the boy to give him the belt which had on it a jumble of letters.

Lysander carefully wound the belt round his stick so that the edges touched.

When he had done this a message could be seen.

It said that his friends, the Persians, were turning against him.

Thanks to the secret message, Lysander was ready to beat his new enemy.

It is quite easy to make your own secret code like the one used by Lysander. Use a tin can or a cardboard tube. Wind a narrow strip of paper evenly round it and fasten the ends with sticky tape. Write your message in big letters straight down the tube. Then unwind the paper and write a jumble of odd letters all over the rest of it.

The message can only be read if the person you send it to winds it round a cylinder of exactly the same thickness as the one you used.
Appendix 4: Day 2 Child Questionnaire - baseline
CONFIDENTIAL

The School Environment and Health Study

School Children’s Consent Form

I have listened to the explanation about the health and environment study. All my questions about the study have been answered. I feel that I know about what is being asked of me. I understand that I am free to withdraw at any time from the study and that I don’t have to answer any question that I don’t want to.

I will give honest and accurate answers knowing full well that they will be kept confidential.

I agree to take part in the study (Please sign)

______________________________
(Signature)

______________________________
(Please Print Name)
Our friend, the dolphin

Section 1

Instructions: Out of the three choices given circle the answer that is correct. Only one answer is correct in each question.

For example:

The capital city of England is ?

(a) New York
(b) Paris
(c) London

1. The woman was thrown into the sea from what kind of boat ?

(a) Yacht
(b) Ferry
(c) Battleship

2. What did the dolphins protect the woman from ?

(a) Her enemies
(b) Sharks
(c) Sea monsters

3. What was wrong with the dolphin who the Russian fishermen found ?

(a) The dolphin was cut
(b) The dolphin was hungry
(c) The dolphin was tired
4. What did the Russian's finally do with the dolphin?

(a) Took it back to Russia.
(b) Sold the dolphin
(c) Put the dolphin back into the sea.

5. The dolphin's brain was compared to?

(a) A whale’s brain
(b) A human being’s brain
(c) An elephant’s brain

6. Dolphin's talk to each other by?

(a) Waving their fins
(b) Clicks and whistles
(c) Splashes and jumps
Section 2

Instructions: Please answer these questions with as much information as you can remember from the passage you read last week.

1. What two great dangers was the woman who was thrown into the sea in?

2. What puzzled the Russian fishermen about the dolphin's behaviour?

3. What facts do you remember about dolphins?
Top Secret

Section I

Instructions: Out of the three choices given circle the answer that is correct. Only one answer is correct in each question.

For example:

The capital city of England is?

(a) New York
(b) Paris
(c) London

**--------------------------------**

1. Who was the great war 2000 years ago between?

   (a) Athens & Sparta
   (b) Rome & Athens
   (c) Sparta & Rome

2. Who did Lysander fight for?

   (a) Rome
   (b) Sparta
   (c) Athens

3. What was the boy given to take to Lysander?

   (a) A weapon, clothes and sandals
   (b) A message, food and drink
   (c) A tunic, belt and sandals
4. Why did Lysander’s enemies let the boy go when they stopped him?

(a) Because they didn’t suspect a child
(b) Because they only wanted to catch Lysander
(c) Because the boy could tell them nothing

5. Who sent the boy to Lysander?

(a) Lysander’s spies
(b) The Persians
(c) Lysander’s superiors

6. Which one of these things did you read about to make your own secret code?

(a) a piece of string
(b) a tin can
(c) a stick
Section 2

Instructions: Please answer these questions with as much information as you can remember from the passage you read last week.

1. How did Lysander finally read the message?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. What did Lysander learn from the message?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

3. What do you remember about ways of making your own secret code?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Complete the sentence activity

Instructions
Please choose which word fits best into the sentence. Look at each of the five words underneath the sentence. Sometimes more than one word will fit into the sentence. Decide which one fits best. Circle the word that fits in best.

You may find some items more difficult than others. If you are not sure circle the one that you think fits best. Only miss out a sentence if you really can not do it.

Practice Items

1. You drink from a ____________.
    bean        bus        cup        hop        tack

2. You ____________ water to make tea.
    boil        milk        fill        paint        match

3. A monkey is an ____________.
    envelope    octopus    excuse    apron    animal

4. The arithmetic problem was ____________ to solve.
    divided    definite    difficult    squared    physical

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Please circle the word which fits best into the sentence.

1. Dogs like to ________________.
   - get
   - run
   - ball
   - fur
   - toy

2. A kitten is a baby ________________.
   - dog
   - fox
   - bird
   - fish
   - cat

3. The old ________________ gave the girl her shoe.
   - more
   - magic
   - can
   - main
   - pan

4. We buy sweets in a ________________.
   - shop
   - house
   - church
   - garden
   - money

5. A ________________ tells us the time.
   - clay
   - minute
   - clock
   - could
   - witch

6. The birthday ________________ has six candles on it.
   - take
   - cake
   - kite
   - cup
   - bake

7. The car went along the ________________.
   - sweet
   - steer
   - steep
   - street
   - sheep

8. ________________ live in houses.
   - door
   - people
   - pipe
   - deer
   - roof
10. The __________ is in the trap.

house  home  mouse  must  miss

11. It was __________ dark under the trees.

over  every  very  ever  any

12. I __________ draw a rabbit.

will  well  tell  ran  want

13. Apples, plums, bananas and lemons are all __________.

fast  fear  fruit  fair  fret

14. A pen and paper are used for __________.

laughing  running  making  chalking  writing

15. Seven is __________ than three.

much  many  most  number  more

16. Boys and girls draw __________.

paint  waters  picnics  paper  pictures

17. A knife and fork are used for __________.

jumping  eating  sleeping  walking  talking
racing
dancing
hitting
thinking
working

19. He ran home ____________ to show his mother the letter.

quick
quickly
quite
slow
quiet

20. A ____________ has four sides.

signal
silver
square
sister
skirt

21. The hottest season of the year is ____________.

holiday
winter
summer
sunshine
weather

22. Clowns make me ____________.

sneeze
climb
grasp
laugh
leaf

23. You can ____________ a pencil with a knife.

sharpen
shoot
shine
sheep
shake

24. Hockey, tennis, cricket and ____________ are played with a ball.

goat
golf
gold
goal
gore

25. The horse ____________ to the pond.

work
walked
worked
walk
picked

26. When it is very cold the puddles ____________ over.

slide
hard
solid
freeze
fence
28. Footballers often wear striped ____________.

shaves  shines  shirts  ships  shoots

29. ____________ is made from clay and fired in a kiln.

poster  porter  pottery  pancake  postage

30. Apples are harvested in ____________.

basket  rosy  autumn  sunny  pears

31. A hedgehog is a small mammal which ____________ for the winter.

migrates  vacates  emigrates  hibernates  separates

32. The fuel most cars use is ____________.

petrol  oil  anti-freeze  electricity  paraffin

33. A clarinet is a musical ____________.

instruction  note  instrument  character  experiment

34. Many servants were needed to ____________ a splendid feast.

propel  prepare  prevent  pretend  protect

35. A ____________ is used to define the meanings of words.

dictaphone  dictator  dictionary  directory  diversion
37. Long journeys may ________ using maps.

invite involve invent invalid interrupt

38. Many people find that watching fish is very ________.

artful angling swimming successful relaxing

39. Dolphins are said to be ________ creatures.

internal interrupted inescapable intelligent insulting

40. The boy observed his ________ in the shop window.

spectacle opposition mirage imprint reflection

41. This machine ________ the picture on to the screen.

injects subjects rejects objects projects

42. The audience began to ________ the talented violinist.

appeal applaud apply appear appoint

43. The solution was ________ with water.

diluted explored permitted obstructed varied

44. It is unusual for snow to fall in the ________.

tropics daylight fields ocean arctic
out further excavations.

archivists architects archaeologists archdeacons artichokes

46. The ______________ caused a delay in the traffic.

diversion subversion conversion inversion reversion

47. Food is ______________ for survival.

eternal fatal immortal vital person

48. His name was ______________ on the silver trophy.

inscribed subscribed described transcribed prescribed

49. The ______________ collected and stored the water for the city.

reservation resonance reservoir restoration radiation

50. The musician’s lecture was ______________ and the audience was bored.

uninspired refreshing madrigal symphonic engaging

51. Although unremunerated the ______________ position provided valuable experience for the young adolescent.

tentacle temporary terminate testimony tertiary

52. A puncture to the car tyre made it impossible to ______________.

reinflate infatuate remunerate repatriate reimburse
resulted in a tragic accident.

irrefutable irritable infernal irresponsible irresistible

54. The doctor was correct in his ____________.

hospital ambulance pulse temperature diagnosis

55. A man-made fiber like nylon is called ____________.

artificial natural superior elastic analysis

56. To produce the ____________ pieces of material were glued to a board.

drawing collage sculpture column lithograph

57. His literary composition received wide acclaim as a ____________ of modern satire.

masterly motivation masterpiece mystery massacre

58. One thief was caught but his ____________ got away.

accomplishment accomplice appearance attendance combatant

59. The prevailing ____________ conditions caused the meteorologist to predict that a typhoon was imminent.

autistic atmospheric migratory auspicious typhoid

60. The two scientists decided that their chances of success would be enhanced if they worked in ____________.

collaboration collation obligation allegiance partiality
navigable transmarine rocky cruising gigantic

62. Biologists may be impressed by the infinite ____________ of nature.

volume classification botany voracity variety

63. The ____________ of a circle passes through its centre.

diameter area volume circumference perimeter

64. He spoke so softly that he was ____________ at the back of the room.

incredible indigenous inaudible indivisible intentional

65. In recent times great ____________ has been placed on town planning.

notice emphasis competition energy enjoyment

66. Prior to the commencement of the gruelling ____________ each competitor had been issued with an identification number.

dispatch imprisonment positioning arrangements marathon

67. The ____________ force acting on an object is called its weight.

fractional gravitational metricated strongest weaker

68. It was common before Victorian times for drinking water to be ____________ by domestic waste and industrial effluent.

diseased purified consumed contaminated filtered
freightage  frippery  fraudulent  fragmental  fraternisation

70. The comedians in pantomime usually behave in a ____________ manner.

lubricant  profligate  ludicrous  stupendous  serene
Complete the sentence activity

Instructions
Please choose which word fits best into the sentence. Look at each of the five words underneath the sentence. Sometimes more than one word will fit into the sentence. Decide which one fits best. Circle the word that fits in best.

You may find some items more difficult than others. If you are not sure circle the one that you think fits best. Only miss out a sentence if you really can not do it.

Practice Items

1. You drink from a ________________ .

bean bus cup hop tack

2. You ________________ water to make tea .

boil milk fill paint match

3. A monkey is an ________________ .

envelope octopus excuse apron animal

4. The arithmetic problem was ________________ to solve .

divided definite difficult squared physical

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Please circle the word which fits best into the sentence.

1. A ___________ can swim.

fun        fish        fast        five        roof

2. One, two, three, four, ____________ .

face        five        fight        fig        fan

3. He ____________ into the water.

says        wants        jumps        sweets        some

4. The dog wants ____________ go home.

no           to           go           in           on

5. Peter likes to ____________ apples.

drink        ate           eat           sweet        sour

6. A clock tells us the ____________ .

table        take         time         train         total

7. The rabbits jump on the ____________ grass.

gate         grate         grin         green         grape

8. In a park children play on ____________ .

swim         sweets        square        swings        stable
9. Here is a penny ______________ you.

fur of off fir for

10. My little brother is _____________ some sweets.

writing riding sister smaller eating

11. Children like to ______________ television.

play write draw want watch

12. We _____________ four and five to make nine.

add ask about away after

13. The ______________ flew above the houses until it saw the church.

boy sky beard bird cloud

14. We lit the bonfire at ________________

match night count today flame

15. A frying pan is used for ________________.

washing running sawing talking cooking

16. Tom ______________ shopping to buy a birthday present.

when were where what went
17. The milkman drove down the ____________.

robe road door milk read

18. We sometimes dream when we are ____________.

asleep along away aware afraid

19. We listen to the ____________.

radiator radius radio radish radian

20. The colours of the handles were ____________ and green.

wood red round smooth rod

21. She spilt the milk and had to wipe the ____________.

flour floor flood roof flower

22. A lighthouse ____________ ships at sea.

rocks storm warns warts weighs

23. A deciduous tree loses its ____________ every winter.

roots loaves leaves leaf branches

24. The drum is one of the oldest ____________ instruments.

medical mathematical musical marginal material

25. Sheep are tended by a ____________.

cowman sherpa shadow shepherd shrew
26. He made a ______________ pile of logs.

beg fire flames high hot

27. Houses are ______________ with materials like brick, wood and stone.

blunt brought blown bolt built

28. Chairs, tables and bookcases are all items of ______________ .

crockery cutlery furniture pottery clothing

29. Length is ______________ with a ruler.

measured mean calculated shortened extended

30. Chess is a game that is played on a ______________ .

beard board bread daub broad

31. The farmer ______________ his field into eight equal parts.

destroyed engaged diverted divided employed

32. A dinosaur is a ______________ creature.

prepare present prediction professor prehistoric

33. The ______________ was locked up in his cell.

pensioner policeman caller prisoner judge
34. In hockey we have two types of players, _______________ and defenders

attakers     attenders     antagonists     assassins     assessors

35. A _______________ is a person who repairs vehicles.

mechanic       carpenter       conductor       lawyer       electrician

36. Switzerland is a _______________ country.

momentous     monitorial    muffled       muscular     mountainous

37. The church was _______________ with shiny holly.

destroyed     delivered    coloured    decorated    cultivated

38. Science is a subject which involves _______________ work.

solution     acid        exotic       liquid     experimental

39. The festive occasion ended with a _______________ firework display.

speculation    spectacular    classified    perpetual    spectacle

40. Conditions for slaves on board the slave ships were very _______________.

commodious     cramped     carefree       colourful    creditable

41. Sponges _______________ moisture rapidly.

abstract     absorb    exact        examine    abandon
42. The silence was ____________ by the noisy aircraft

shouted  shadowed  shuttered  shattered  sheltered

43. Glass is an example of a ____________ substance.

experience  transport  invertebrate  inscrutable  transparent

44. Some children in Third World Countries have to work in ____________ conditions.

democratic  appalling  applauding  civilian  technical

45. There were plans for the ____________ of the children of London at the outbreak of war.

acceleration  evacuation  assassination  undulation  exaggeration

46. The physics teacher repeatedly drew attention to the complicated ____________ in order to clarify the theorem.

diaphragm  denominator  diagram  diatom  diatonic

47. The rebels wanted to overthrow the government by starting a ____________.

revolver  recycle  revulsion  redemption  revolution

48. The ____________ designed a magnificent palace.

artisan  artifact  artillery  architect  article

49. The ____________ of Charles I ended when he was beheaded.

throne  reign  crown  rain  rein
50. Wind, rain, ice and snow cause ____________ of rocks.

erosion temperature humidity weather barrier

51. They made camp in a meadow of long grass and the starving pony ate ____________.

reasonably resonantly revengefully rascally ravenously

52. The Trades Description Act ____________ the use of misleading or exaggerated claims in advertising.

proceeds prevaricated prohibits proficient proliferates

53. He refused to eat the ____________ he was offered because he was a vegetarian.

vision cauliflower cabbage venison version

54. The victim needed a powerful ____________ to combat the poison.

aspirin disinfectant antidote dispersant character

55. Many people need to ____________ to work each day by public transport.

conform compute compete constitute commute

56. The engagement ring was ____________ with diamonds.

engaged encrusted enforced enlisted enraged
57. The doctor recommended two weeks' ______________ after the illness.

confidence conclusion confusion convulsion convalescence

58. The funeral cortege ______________ at a stately pace through the solemn and saddened crowds.

processed prohibited prolific promoted propagated

59. Chemical compounds are made up of tiny particles called ______________.

solvents genes molecules solids germs

60. Music is a subject which involves practical, theoretical and ______________ work.

microscopical automatic aural inaudible inaugural

61. During harsh winters when villages were isolated, basic ______________ such as milk and bread were unobtainable.

commodious contrary commodities conclusion conflict

62. Some workshop operations are particularly ______________ and special safety precautions should be observed.

lubricated mechanical powerful hazardous engineered

63. The boiling liquid gave off a ______________ odour.

pungent penitent plaintive plutocratic proletarian
64. The heroic explorers whose purpose was to proceed to possibly the most inhospitable region on earth speculated on the ________ prospect of traversing the antarctic polar terrain.

transcendental  daunting  continental  speculative  meteoric

65. The democratic government decided on a ________ to ascertain the national will on the highly controversial subject.

referendum  referral  constituency  refractory  refectory

66. Anthropologists question if the recent upsurge of terrorist violence is a new social ________.

phenomenon  phlegm  photology  phrenology  chronology

67. The sails of the windmill should be balanced with precision if they are to revolve without ________ vibration.

excessive  grinding  circular  equivalent  fricative

68. The International Airline had a moral ________ to compensate the passenger for the loss of his luggage during transit.

oblige  obligation  oblation  objection  obturation

69. Primitive man believed in supernatural causes of ________ events such as eclipses and earthquakes.

inexplicable  inadvertent  interior  incurious  inexorable

70. The old lady ________ the youth for not offering her his seat on the bus.

repented  rebuked  retracted  repaired  resprayed
Appendix 5: Day 3 Child Questionnaire – baseline
What I think and feel

Instructions: I will read each item to you. Think carefully about whether the item is true about yourself. Tick the YES box if you think that the statement is true about yourself. Tick the NO box if you think that the statement is not true about yourself.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1. You have trouble making up your mind.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>2. You get nervous when things do not go the right way for you.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>3. Others seem to do things easier than you can.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>4. You like everyone you know.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>5. Often you have trouble getting your breath.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>6. You worry a lot of the time.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>7. You are afraid of a lot of things.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>8. You are always kind.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>9. You get angry easily.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>10. You worry what your parents will say to you.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>11. You feel that others do not like the way you do things.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>12. You always have good manners.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>13. It is hard for you to sleep at night.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>14. You worry about what other people think about you.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>15. You feel alone even when there are people with you.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>16. You are always good.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>17. Often you feel sick in your stomach.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>18. Your feelings get hurt easily.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>19. Your hands feel sweaty.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>20. You are always nice to everyone.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>21. You are tired a lot.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>22. You worry about what is going to happen.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>23. Other children are happier than you.</td>
<td>□ - YES</td>
<td>□ - NO</td>
</tr>
<tr>
<td>24. You tell the truth every single time.</td>
<td>□ - YES</td>
<td>□ - NO</td>
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<td></td>
</tr>
<tr>
<td>25. You have bad dreams.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>26. Your feelings get hurt easily when you are told off.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>27. You feel that someone will tell you that you do things the wrong way.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>28. You never get angry.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>29. You wake up scared some of the time.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>30. You worry when you go to bed at night.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>31. It is hard for you to keep your mind on your school work.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>32. You never say things that you shouldn't.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>33. You fidget in your seat a lot.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>34. You are nervous.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>35. A lot of people are against you.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>36. You never lie.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>37. You often worry about something bad happening to you.</td>
<td>YES</td>
<td>NO</td>
</tr>
</tbody>
</table>
Instructions: Here are some situations. I want you to try really hard to imagine that these situations just happened to you. After each situation is presented, two possible reasons for why the situation might have happened are given. I want you to choose the most likely reason to explain why the situation happened to you.

Sometimes both of the reasons may sound true, and sometimes both may sound false, and, you may never have been in some of these situations. But even so, I want you to pick the reason that seems to explain why the situation happened to you.

There are no right and no wrong answers, so always pick the reason that seems most likely to you.

Tick either ‘A’ or ‘B’ for each question. I will read along with you.

Do you have any questions before we begin?
1. You get an ‘A’ on a test
   □ A. I am smart
   □ B. I am good in the subject that the test was in.

2. Some kids that you know say that they do not like you.
   □ A. Once in a while people are mean to me.
   □ B. Once in a while I am mean to other people.

3. A good friend tells you that he hates you.
   □ A. My friend was in a bad mood that day.
   □ B. I wasn’t nice to my friend that day.

4. A person steals money from you.
   □ A. That person is not honest.
   □ B. Many people are not honest.

5. Your parents tell you that something that you make is very good.
   □ A. I am good at making some things.
   □ B. My parents like somethings I make.

6. You break a glass.
   □ A. I am not careful enough.
   □ B. Sometimes I am not careful enough.

7. You do a project with a group of kids and it turns out badly.
   □ A. I don’t work well with the people in that particular group.
   □ B. I never work well with groups.

8. You make a new friend.
   □ A. I am a nice person.
   □ B. The people that I meet are nice.
9. You have been getting along well with your family.
   □ A. I am usually easy to get along with when I am with my family.
   □ B. Once in a while I am easy to get along with when I am with my family.

10. You get a bad mark in school.
    □ A. I am not a good student.
    □ B. Teachers give hard tests.

11. You walk into a door and get a bloody nose.
    □ A. I wasn’t looking where I was going.
    □ B. I have been careless lately.

12. You have a messy room.
    □ A. I did not clean my room that day.
    □ B. I usually do not clean my room.

13. Your mother makes you your favourite dinner.
    □ A. There are a few things that my mother will do to please me.
    □ B. My mother usually likes to please me.

14. A team that you are on loses a game.
    □ A. The team members don’t help each other when they play together.
    □ B. That day the team members didn’t help each other.

15. You do not get your chores done at home.
    □ A. I was lazy that day.
    □ B. Many days I am lazy.

16. You go to an amusement park and you have a good time.
    □ A. I usually enjoy myself at amusement parks.
    □ B. I usually enjoy myself in many activities.
17. You go to a friend’s party and you have fun.
   □ A. Your friend usually gives good parties.
   □ B. Your friend gave a good party that day.

18. You have a substitute/supply teacher and she likes you.
   □ A. I was well behaved during class that day.
   □ B. I am almost always well behaved during class.

19. You make your friends happy.
   □ A. I am usually a fun person to be with.
   □ B. Sometimes I am a fun person to be with.

20. You put a hard puzzle together.
   □ A. I am good at putting puzzles together.
   □ B. I am good at doing many things.

21. You try out for a sports team and do not make it.
   □ A. I am not good at sports
   □ B. The other kids who tried out are very good at sports.

22. You fail a test
   □ A. All tests are hard.
   □ B. Only some tests are hard.

23. You hit a home run in a ball game.
   □ A. I swung the bat just right.
   □ B. The bowler threw an easy ball.

24. You do the best in your class on a project.
   □ A. The other kids in my class did not work hard on their projects.
   □ B. I worked hard on the project.
Instructions: People sometimes have different feelings and ideas. This questionnaire lists the feelings and ideas in groups. From each group pick ONE sentence that describes you best over the past two weeks. After you pick up a sentence from the first group, go on to the next group. **THERE IS NO RIGHT OR WRONG ANSWER**. Just pick the sentences that best describe the way you have been recently. **Tick the box** next to the sentence that you pick.  
**All Your Replies Will Be Confidential**

1.  
☐ I am sad once in a while.  
☐ I am quite often sad.  
☐ I am sad all the time.  

2.  
☐ Nothing will ever work out for me.  
☐ I am not sure if things will work out for me.  
☐ Things will work out for me OK.  

3.  
☐ I do most things OK.  
☐ I do many things wrong.  
☐ I do everything wrong.  

4.  
☐ I have fun in many things  
☐ I have fun in some things  
☐ Nothing is fun at all.  

5.  
☐ I am bad all the time.  
☐ I am quite often bad.  
☐ I am bad once in a while.  

6.  
☐ I think about bad things happening to me once in a while.  
☐ I worry that bad things will happen to me.  
☐ I am sure that terrible things will happen to me.
7. □ I hate myself.
   □ I do not hate myself.
   □ I like myself.

8. □ All bad things are my fault.
   □ Many bad things are my fault.
   □ Bad things are not usually my fault.

9. □ I do not think about killing myself.
   □ I think about killing myself but I would not do it.
   □ I want to kill myself.

10. □ I feel like crying every day.
    □ I quite often feel like crying.
    □ I feel like crying once in a while.

11. □ Things bother me all the time.
    □ Things quite often bother me.
    □ Things bother me once in a while.

12. □ I like being with people.
    □ I quite often do not like being with people.
    □ I do not want to be with people at all.

13. □ I cannot make up my mind about things.
    □ It is hard to make up my mind about things.
    □ I make up my mind about things easily.

14. □ I look OK.
    □ There are some bad things about my looks.
    □ I look ugly.
Instructions
Write the numbers you heard in the order that you heard them in the boxes.
PLEASE DO NOT GUESS

Practice 1

Practice 2

Set 1

Set 2

Set 3

Set 4

Set 5

Set 6
Health and Environment
We are interested in your health and what you think about the area surrounding your home and school. Please answer by placing a tick in the box. Please only tick one box for each question.

Section 1: Your Health
1. In general, would you say your health is
   - Very Good
   - Good
   - Fair
   - Poor

2. Have you had headaches in the last 2 weeks?
   - often
   - sometimes
   - never

3. Have you felt tired in the last 2 weeks?
   - often
   - sometimes
   - never

4. Have you had trouble sleeping in the last 2 weeks?
   - often
   - sometimes
   - never

Section 2: Your Environment
5. How clean do you think the air is around your school (for instance in the playground)?
   - very clean
   - clean
   - not very clean

6. How safe do you feel in the area where you live?
   - very safe
   - safe
   - not very safe

7. How friendly do you feel the area where you live is?
   - very friendly
   - friendly
   - not very friendly

8. If there was something in your environment or immediate surroundings that bothered or annoyed you, do you feel that you could do something to change it?
   - very much
   - quite a bit
   - a little
   - not at all

9. Do you hear Plane Noise around your home?
   - yes
   - no

10. When you are at home, does the noise from the planes bother or annoy you?
    - very much
    - quite a bit
    - a little
    - not at all
I’d like to ask you questions about the area around your school and then about the area around your home. Try to think about them separately. Please tick only one box for each question.

Section 3- The area around your school

Now please think about the area around your home

1. Do you hear Road Traffic Noise around your school?
   □ yes □ no

2. Do you hear Train Noise around your school?
   □ yes □ no

3. Do you hear Plane Noise around your school?
   □ yes □ no

4. When you are at school, does the noise from the planes bother or annoy you?
   □ very much □ quite a bit □ a little □ not at all

5. When you are at school, does the noise from the trains bother or annoy you?
   □ very much □ quite a bit □ a little □ not at all

6. When you are at school, does the noise from road traffic bother or annoy you?
   □ very much □ quite a bit □ a little □ not at all

Section 4: The Area Around Your Home

Now please think about the area around your home

1. Do you hear Road Traffic Noise around your home?
   □ yes □ no

2. Do you hear Train Noise around your home?
   □ yes □ no

3. Do you hear your Neighbours Noise around your home?
   □ yes □ no

4. When you are at home, does the noise from the trains bother or annoy you?
   □ very much □ quite a bit □ a little □ not at all

5. When you are at home, does the noise from road traffic bother or annoy you?
   □ very much □ quite a bit □ a little □ not at all

6. When you are at home, does the noise from your neighbour’s bother or annoy you?
   □ very much □ quite a bit □ a little □ not at all
Section 5

I want to know what you think about noise. Here I have some statements that I want your opinion about. Please place a tick in the box that is your answer.

1. I get annoyed when I hear loud noise
   - agree strongly
   - agree
   - disagree
   - disagree strongly

2. I get used to most noises easily
   - agree strongly
   - agree
   - disagree
   - disagree strongly

3. I am sensitive to noise
   - agree strongly
   - agree
   - disagree
   - disagree strongly

Section 6

I want to know what you think about noise in your classroom. Here I have some statements that I want your opinion about. Please place a tick in the box that is your answer.

1. It is easy to hear the teacher in the classroom
   - agree strongly
   - agree
   - disagree
   - disagree strongly

2. There is too much noise in the classroom
   - agree strongly
   - agree
   - disagree
   - disagree strongly

3. Noise makes it hard for me to work
   - agree strongly
   - agree
   - disagree
   - disagree strongly

4. Planes passing overhead make it hard for me to think
   - agree strongly
   - agree
   - disagree
   - disagree strongly

5. Do the planes ever seem to you to fly too low for safety?
   - often
   - sometimes
   - never

6. How do you feel when the planes fly over you?
   - excited and interested
   - frightened or worried
   - no feelings
Place your pen at home. You have to make a path back to home stopping at each animal ONCE before returning home. You must follow the following two rules.

Rule 1: You only stop at each animal once
Rule 2: You can not go back along any line again or lift up your pen.

As you work through this puzzle tick the number of attempts that you have made in the boxes below. Raise your hand when you think that you’ve finished the task.

IMPORTANT: This is not a competition or a test - work at YOUR OWN PACE PLEASE
Place your pen at home. You have to make a path back to home stopping at each food ONCE before returning home. You must follow the following two rules.

Rule 1: You only stop at each food once

Rule 2: You can not go back along any line again or lift up your pen.

As you work through this puzzle tick the number of attempts that you have made in the boxes below. Raise your hand when you think that you’ve finished the task or when you want to move on to the second task.

IMPORTANT: This is not a competition or a test - work at YOUR OWN PACE PLEASE

Tick the box each time you make an attempt to solve the puzzle:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
</table>
Appendix 6: Day 1 Child Questionnaire - follow-up
CONFIDENTIAL

Information Sheet - for School Children

Title: The Schools Environment and Health Study

* We are inviting you and your parents to continue with your participation in The Schools Environment and Health Study. You will also be asked to do some activities in the classroom with the rest of your class.

* The reason we are carrying out this study is to look at how your surroundings affect your health and performance at school. Our findings maybe very important in showing the effect of the school environment on children.

* All your answers will be kept completely confidential, which means that your parents or school teachers cannot read your answers.

* You do not have to take part in this study if you do not want to. If you decide to take part you may say you don’t want to go on with it at any time without having to give a reason. If you don’t want to answer any particular question on any form you can leave it blank.

Investigators:

Dr. Stephen Stansfeld, Department of Epidemiology and Public Health, University College London.
Ms Mary Haines, Department of Epidemiology and Public Health, University College London.
Top secret

More than 2,000 years ago there was a great war between Athens and Sparta.
One day a boy ran into the camp of Lysander, the great Spartan general.
The boy had run for many days with a message from Lysander’s spies.
‘I . . . I was given a tunic, a belt, and some sandals,’ stammered the boy. ‘And I was told to run to you. But I was not told what the message was.’
Lysander asked, ‘Were you stopped by the enemy?’
‘Yes, many times, sir,’ replied the boy. ‘But I could tell them nothing so they let me go.’
Lysander asked the boy to give him the belt which had on it a jumble of letters.
Lysander carefully wound the belt round his stick so that the edges touched.
When he had done this a message could be seen. It said that his friends, the Persians, were turning against him.
Thanks to the secret message, Lysander was ready to beat his new enemy.

It is quite easy to make your own secret code like the one used by Lysander. Use a tin can or a cardboard tube. Wind a narrow strip of paper evenly round it and fasten the ends with sticky tape. Write your message in big letters straight down the tube. Then unwind the paper and write a jumble of odd letters all over the rest of it.
The message can only be read if the person you send it to winds it round a cylinder of exactly the same thickness as the one you used.
Our friend, the dolphin

A woman was once thrown into the sea when the yacht she was on exploded. After a short time, three dolphins swam up to her. One of them kept the woman afloat. The other two circled round and round to protect her from sharks. The dolphins steered the woman to a large marker in the sea. As soon as the woman had climbed safely on to it the dolphins left her. After the woman had been rescued, it was found that she had drifted for over 200 miles. The dolphins had stayed with her for the entire distance.

* * *

Recently a dolphin kept trying to jump on to a Russian fishing boat. At last the puzzled fishermen pulled the dolphin on board. They found that it had a large bleeding gash on its side. The dolphin quietly allowed the ship's doctors to stitch up the wound. Once this was done the dolphin was put back in the sea where it swam off.

The dolphin is a very intelligent creature. Its brain compares with that of a man. The lifespan of a dolphin is about 30 years. This is enough to gain a large store of knowledge. Dolphins appear to have a language. They talk to each other using a range of clicks and whistles. They also have an amazing sense of hearing. They send out sounds and can tell from their echo the size of objects as far away as a quarter of a mile.
Appendix 7: Day 2 Child Questionnaire - follow-up
CONFIDENTIAL

The School Environment and Health Study

School Children's Consent Form

I have listened to the explanation about the health and environment study. All my questions about the study have been answered. I feel that I know about what is being asked of me. I understand that I am free to withdraw at any time from the study and that I don't have to answer any question that I don't want to.

I will give honest and accurate answers knowing full well that they will be kept confidential.

I agree to take part in the study (Please sign)

______________________________
(Signature)

______________________________
(Please Print Name)

Date of Birth: ____________________________

Code: ____________________________
Top Secret

Section 1

Instructions: Out of the three choices given circle the answer that is correct. Only one answer is correct in each question.

For example:

The capital city of England is?

(a) New York

(b) Paris

(c) London

*******************************************************************************

1. Who was the great war 2000 years ago between?

(a) Athens & Sparta

(b) Rome & Athens

(c) Sparta & Rome

2. Who did Lysander fight for?

(a) Rome

(b) Sparta

(c) Athens

3. What was the boy given to take to Lysander?

(a) A weapon, clothes and sandals

(b) A message, food and drink

(c) A tunic, belt and sandals
4. Why did Lysander’s enemies let the boy go when they stopped him?

(a) Because they didn’t suspect a child
(b) Because they only wanted to catch Lysander
(c) Because the boy could tell them nothing

5. Who sent the boy to Lysander?

(a) Lysander’s spies
(b) The Persians
(c) Lysander’s superiors

6. Which one of these things did you read about to make your own secret code?

(a) a piece of string
(b) a tin can
(c) a stick
Section 2

Instructions: Please answer these questions with as much information as you can remember from the passage you read last week.

1. How did Lysander finally read the message?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. What did Lysander learn from the message?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

3. What do you remember about ways of making your own secret code?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Complete the sentence activity

Instructions
Please choose which word fits best into the sentence. Look at each of the five words underneath the sentence. Sometimes more than one word will fit into the sentence. Decide which one fits best. Circle the word that fits in best.

You may find some items more difficult than others. If you are not sure circle the one that you think fits best. Only miss out a sentence if you really can not do it.

Practice Items

1. You drink from a ____________.
   bean    bus    cup    hop    tack

2. You ____________ water to make tea.
   boil    milk    fill    paint    match

3. A monkey is an ____________.
   envelope  octopus  excuse  apron  animal

4. The arithmetic problem was ____________ to solve.
   divided  definite  difficult  squared  physical
Please circle the word which fits best into the sentence.

1. Dogs like to ____________ .
   get    run    ball    fur    toy

2. A kitten is a baby ____________ .
   dog    fox    bird    fish    cat

3. The old ____________ gave the girl her shoe.
   more    magic    can    man    pan

4. We buy sweets in a ____________ .
   shop    house    church    garden    money

5. A ____________ tells us the time .
   clay    minute    clock    could    witch

6. The birthday ____________ has six candles on it.
   take    cake    kite    cup    bake

7. The car went along the ____________ .
   sweet    steer    steep    street    sheep

8. ____________ live in houses.
   door    people    pipe    deer    roof
10. The ____________ is in the trap.

11. It was ____________ dark under the trees.

12. I ____________ draw a rabbit.

13. Apples, plums, bananas and lemons are all ____________ .

14. A pen and paper are used for ____________ .

15. Seven is ____________ than three.

16. Boys and girls draw ____________ .

17. A knife and fork are used for ____________ .
18. When you are ____________, you run as fast as you can.

racing  dancing  hitting  thinking  working

19. He ran home ____________ to show his mother the letter.

quick  quickly  quite  slow  quiet

20. A _______________ has four sides.

signal  silver  square  sister  skirt

21. The hottest season of the year is ________________.

holiday  winter  summer  sunshine  weather

22. Clowns make me ________________.

sneeze  climb  grasp  laugh  leaf

23. You can ________________ a pencil with a knife.

sharpen  shoot  shine  sheep  shake

24. Hockey, tennis, cricket and ________________ are played with a ball.

goat  golf  gold  goal  gore

25. The horse ________________ to the pond.

work  walked  worked  walk  picked

26. When it is very cold the puddles ________________ over.

slide  hard  solid  freeze  fence
thirsty  thrifty  thirty  thin  hungry

28. Footballers often wear striped ____________.

shaves  shines  shirts  ships  shoots

29. ____________ is made from clay and fired in a kiln.

poster  porter  pottery  pancake  postage

30. Apples are harvested in ____________.

basket  rosy  autumn  sunny  pears

31. A hedgehog is a small mammal which ____________ for the winter.

migrates  vacates  emigrates  hibernates  separates

32. The fuel most cars use is ____________.

petrol  oil  anti-freeze  electricity  paraffin

33. A clarinet is a musical ____________.

instruction  note  instrument  character  experiment

34. Many servants were needed to ____________ a splendid feast.

propel  prepare  prevent  pretend  protect

35. A ____________ is used to define the meanings of words.

dictaphone  dictator  dictionary  directory  diversion
30. A quarter is a _____________.

traction fiction tension fraction suction

37. Long journeys may ______________ using maps.

invite involve invent invalid interrupt

38. Many people find that watching fish is very ________________.

artful angling swimming successful relaxing

39. Dolphins are said to be ______________ creatures.

internal interrupted inescapable intelligent insulting

40. The boy observed his ______________ in the shop window.

spectacle opposition mirage imprint reflection

41. This machine ______________ the picture on to the screen.

injects subjects rejects objects projects

42. The audience began to ______________ the talented violinist.

appeal applaud apply appear appoint

43. The solution was ______________ with water.

diluted explored permitted obstructed varied

44. It is unusual for snow to fall in the ______________.

tropics daylight fields ocean arctic
46. The ____________ caused a delay in the traffic.

diversion   subversion   conversion   inversion   reversion

47. Food is _____________ for survival.

eternal   fatal   immortal   vital   person

48. His name was ____________ on the silver trophy.

inscribed   subscribed   described   transcribed   prescribed

49. The ____________ collected and stored the water for the city.

reservation   resonance   reservoir   restoration   radiation

50. The musician’s lecture was _____________ and the audience was bored.

uninspired   refreshing   madrigal   symphonic   engaging

51. Although unremunerated the ____________ position provided valuable experience for the young adolescent.

tentacle   temporary   terminate   testimony   tertiary

52. A puncture to the car tyre made it impossible to ____________.

reinflate   infatuate   remunerate   repatriate   reimburse
53. His ___________ behaviour in driving whilst under the influence of alcohol resulted in a tragic accident.

irrefutable       irritable       infernal       irresponsible       irresistible

54. The doctor was correct in his ________________.

hospital         ambulance        pulse         temperature        diagnosis

55. A man-made fiber like nylon is called ________________.

artificial       natural          superior       elastic           analysis

56. To produce the ______________ pieces of material were glued to a board.

drawing          collage          sculpture       column           lithograph

57. His literary composition received wide acclaim as a ______________ of modern satire.

masterly         motivation       masterpiece     mystery          massacre

58. One thief was caught but his ______________ got away.

accomplishment   accomplice       appearance      attendance        combatant

59. The prevailing ______________ conditions caused the meteorologist to predict that a typhoon was imminent.

autistic          atmospheric     migratory      auspicious       typhoid

60. The two scientists decided that their chances of success would be enhanced if they worked in ________________.

collaboration    collation        obligation      allegiance        partiality
61. The transmarine liner in hazardous conditions disastrously collided with a __________ iceberg.

navigable  transmarine  rocky  cruising  gigantic

62. Biologists may be impressed by the infinite __________ of nature.

volume  classification  botany  voracity  variety

63. The __________ of a circle passes through its centre.

diameter  area  volume  circumference  perimeter

64. He spoke so softly that he was __________ at the back of the room.

incredible  indigenous  inaudible  indivisible  intentional

65. In recent times great __________ has been placed on town planning.

notice  emphasis  competition  energy  enjoyment

66. Prior to the commencement of the gruelling __________ each competitor had been issued with an identification number.

dispatch  imprisonment  positioning  arrangements  marathon

67. The __________ force acting on an object is called its weight.

fractional  gravitational  metricated  strongest  weaker

68. It was common before Victorian times for drinking water to be __________ by domestic waste and industrial effluent.

diseased  purified  consumed  contaminated  filtered
69. During occupation ______________ with the enemy was actively discouraged by the officers.

freightage frippery fraudulent fragmental fraternisation

70. The comedians in pantomime usually behave in a ______________ manner.

lubricant profligate ludicrous stupendous serene
Our friend, the dolphin

Section 1

Instructions: Out of the three choices given circle the answer that is correct. Only one answer is correct in each question.

For example:

The capital city of England is?
(a) New York
(b) Paris
(c) London

1. The woman was thrown into the sea from what kind of boat?
(a) Yacht
(b) Ferry
(c) Battleship

2. What did the dolphins protect the woman from?
(a) Her enemies
(b) Sharks
(c) Sea monsters

3. What was wrong with the dolphin who the Russian fishermen found?
(a) The dolphin was cut
(b) The dolphin was hungry
(c) The dolphin was tired
4. What did the Russian’s finally do with the dolphin?

(a) Took it back to Russia.
(b) Sold the dolphin
(c) Put the dolphin back into the sea.

5. The dolphin’s brain was compared to?

(a) A whale’s brain
(b) A human being’s brain
(c) An elephant’s brain

6. Dolphin’s talk to each other by?

(a) Waving their fins
(b) Clicks and whistles
(c) Splashes and jumps
Section 2

Instructions: Please answer these questions with as much information as you can remember from the passage you read last week.

1. What two great dangers was the woman who was thrown into the sea in?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. What puzzled the Russian fishermen about the dolphin's behaviour?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

3. What facts do you remember about dolphins?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Complete the sentence activity

Instructions
Please choose which word fits best into the sentence. Look at each of the five words underneath the sentence. Sometimes more than one word will fit into the sentence. Decide which one fits best. Circle the word that fits in best.

You may find some items more difficult than others. If you are not sure circle the one that you think fits best. Only miss out a sentence if you really can not do it.

Practice Items

1. You drink from a _____________.

   bean        bus        cup        hop        tack

2. You _____________ water to make tea.

   boil        milk        fill        paint        match

3. A monkey is an _____________.

   envelope    octopus    excuse    apron    animal

4. The arithmetic problem was _____________ to solve.

   divided    definite    difficult    squared    physical
Please circle the word which fits best into the sentence.

1. A _____________ can swim.
   fun       fish     fast     five     roof

2. One, two, three, four, ________________.
   face      five     fight    fig      fan

3. He _______________ into the water.
   says      wants    jumps    sweets   some

4. The dog wants _______________ go home.
   no        to       go       in      on

5. Peter likes to _______________ apples.
   drink     ate      eat      sweet    sour

6. A clock tells us the ________________.
   table     take     time     train    total

7. The rabbits jump on the ________________ grass.
   gate      grate    grin     green    grape

8. In a park children play on ________________.
   swim      sweets    square    swings   stable
9. Here is a penny ______________ you.

furfur offfirsfor

10. My little brother is _____________ some sweets.

writingriding sis tersmaller eating

11. Children like to ______________ television.

play writ edraw want watch

12. We ______________ four and five to make nine.

add ask about away after

13. The _____________ flew above the houses until it saw the church.

boy sky beard bird cloud

14. We lit the bonfire at ______________ .

matchnight count today flame

15. A frying pan is used for ______________ .

washing running sawing talking cooking

16. Tom ______________ shopping to buy a birthday present.

when were where what went
17. The milkman drove down the _______.

robe  road  door  milk  read

18. We sometimes dream when we are ________.

asleep  along  away  aware  afraid

19. We listen to the ________.

radiator  radius  radio  radish  radian

20. The colours of the handles were ________ and green.

wood  red  round  smooth  rod

21. She spilt the milk and had to wipe the ________.

flour  floor  flood  roof  flower

22. A lighthouse ________ ships at sea.

rocks  storm  warns  warts  weighs

23. A deciduous tree loses its ________ every winter.

roots  loaves  leaves  leaf  branches

24. The drum is one of the oldest ________ instruments.

medical  mathematical  musical  marginal  material

25. Sheep are tended by a ________.

cowman  sherpa  shadow  shepherd  shrew
26. He made a ___________ pile of logs.

beg fire flames high hot

27. Houses are ___________ with materials like brick, wood and stone.

blunt brought blown bolt built

28. Chairs, tables and bookcases are all items of ____________.

crockery cutlery furniture pottery clothing

29. Length is ____________ with a ruler.

measured mean calculated shortened extended

30. Chess is a game that is played on a ____________.

beard board bread daub broad

31. The farmer ____________ his field into eight equal parts.

destroyed engaged diverted divided employed

32. A dinosaur is a ____________ creature.

prepare present prediction professor prehistoric

33. The ____________ was locked up in his cell.

pensioner policeman caller prisoner judge
34. In hockey we have two types of players, ___________ and defenders.

attackers    attenders    antagonists    assassins    assessors

35. A _____________ is a person who repairs vehicles.

mechanic    carpenter    conductor    lawyer    electrician

36. Switzerland is a _____________ country.

momentous    monitorial    muffled    muscular    mountainous

37. The church was _____________ with shiny holly.

destroyed    delivered    coloured    decorated    cultivated

38. Science is a subject which involves _____________ work.

solution    acid    exotic    liquid    experimental

39. The festive occasion ended with a _____________ firework display.

speculation    spectacular    classified    perpetual    spectacle

40. Conditions for slaves on board the slave ships were very _____________.

commodious    cramped    carefree    colourful    creditable

41. Sponges _____________ moisture rapidly.

abstract    absorb    exact    examine    abandon
42. The silence was ______________ by the noisy aircraft

shouted   shadowed   shuttered   shattered   sheltered

43. Glass is an example of a ______________ substance.

experience   transport   invertebrate   inscrutable   transparent

44. Some children in Third World Countries have to work in ______________ conditions.

democratic   appalling   applauding   civilian   technical

45. There were plans for the ______________ of the children of London at the outbreak of war.

acceleration   evacuation   assassination   undulation   exaggeration

46. The physics teacher repeatedly drew attention to the complicated ______________ in order to clarify the theorem.

diaphragm   denominator   diagram   diatom   diatonic

47. The rebels wanted to overthrow the government by starting a ______________.

revolver   recycle   revulsion   redemption   revolution

48. The ______________ designed a magnificent palace.

artisan   artifact   artillery   architect   article

49. The ______________ of Charles I ended when he was beheaded.

throne   reign   crown   rain   rein
50. Wind, rain, ice and snow cause ______________ of rocks.

erosion temperature humidity weather barrier

51. They made camp in a meadow of long grass and the starving pony ate ______________.

reasonably resonantly revengefully rascally ravenously

52. The Trades Description Act ______________ the use of misleading or exaggerated claims in advertising.

proceeds prevaricated prohibits proficient proliferates

53. He refused to eat the ______________ he was offered because he was a vegetarian.

vision cauliflower cabbage venison version

54. The victim needed a powerful ______________ to combat the poison.

aspirin disinfectant antidote dispersant character

55. Many people need to ______________ to work each day by public transport.

conform compute compete constitute commute

56. The engagement ring was ______________ with diamonds.

engaged encrusted enforced enlisted enraged
57. The doctor recommended two weeks' _____________ after the illness.

confidence  conclusion  confusion  convulsion  convalescence

58. The funeral cortege _____________ at a stately pace through the solemn and saddened crowds.

processed  prohibited  prolific  promoted  propagated

59. Chemical compounds are made up of tiny particles called _____________.

solvents  genes  molecules  solids  germs

60. Music is a subject which involves practical, theoretical and _____________.

work.

microscopical  automatic  aural  inaudible  inaugural

61. During harsh winters when villages were isolated, basic ____________ such as milk and bread were unobtainable.

commodious  contrary  commodities  conclusion  conflict

62. Some workshop operations are particularly ____________ and special safety precautions should be observed.

lubricated  mechanical  powerful  hazardous  engineered

63. The boiling liquid gave off a ____________ odour.

pungent  penitent  plaintive  plutocratic  proletarian
64. The heroic explorers whose purpose was to proceed to possibly the most inhospitable region on earth speculated on the ____________ prospect of traversing the antarctic polar terrain.

transcendental  daunting  continental  speculative  meteoric

65. The democratic government decided on a ____________ to ascertain the national will on the highly controversial subject.

referendum  referral  constituency  refractory  refectory

66. Anthropologists question if the recent upsurge of terrorist violence is a new social ____________.

phenomenon  phlegm  photology  phrenology  chronology

67. The sails of the windmill should be balanced with precision if they are to revolve without ____________ vibration.

excessive  grinding  circular  equivalent  fricative

68. The International Airline had a moral ____________ to compensate the passenger for the loss of his luggage during transit.

oblige  obligation  obliteratıon  objecıon  obturation

69. Primitive man believed in supernatural causes of ____________ events such as eclipses and earthquakes.

inexplicable  inadvertent  interior  incurious  inexorable

70. The old lady ____________ the youth for not offering her his seat on the bus.

repented  rebuked  retracted  repaired  resprayed
Appendix 8: Day 3 Child Questionnaire - follow-up
The following is a list of things that some children say make them feel bad, or nervous, or make them worry. For each, tick the box showing how you would feel if this happened to you.

<table>
<thead>
<tr>
<th></th>
<th>Not Bad</th>
<th>A Little Bad</th>
<th>Pretty Bad</th>
<th>Very Bad</th>
<th>Terrible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Having your parents separate</td>
<td>☐</td>
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<td>☒</td>
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<td>5. Feeling sick</td>
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<td>11. Changing schools</td>
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<td>13. Not being able to dress the way you want to</td>
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and if so how often. For each, tick the box showing how often this has happened to you.

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<thead>
<tr>
<th></th>
<th>Never</th>
<th>Once or Twice</th>
<th>Sometimes</th>
<th>Often</th>
<th>All The Time</th>
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<tbody>
<tr>
<td>1. Having your parents separate</td>
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Instructions: People sometimes have different feelings and ideas. This questionnaire lists the feelings and ideas in groups. From each group pick ONE sentence that describes you best over the past two weeks. After you pick up a sentence from the first group, go on to the next group. THERE IS NO RIGHT OR WRONG ANSWER. Just pick the sentences that best describe the way you have been recently. Tick the box next to the sentence that you pick.

All Your Replies Will Be Confidential

1.
☐ I am sad once in a while.
☐ I am quite often sad.
☐ I am sad all the time.

2.
☐ Nothing will ever work out for me.
☐ I am not sure if things will work out for me.
☐ Things will work out for me OK.

3.
☐ I do most things OK.
☐ I do many things wrong.
☐ I do everything wrong.

4.
☐ I have fun in many things.
☐ I have fun in some things.
☐ Nothing is fun at all.

5.
☐ I am bad all the time.
☐ I am quite often bad.
☐ I am bad once in a while.

6.
☐ I think about bad things happening to me once in a while.
☐ I worry that bad things will happen to me.
☐ I am sure that terrible things will happen to me.
7. □ I hate myself.
   □ I do not hate myself.
   □ I like myself.

8. □ All bad things are my fault.
   □ Many bad things are my fault.
   □ Bad things are not usually my fault.

9. □ I do not think about killing myself.
   □ I think about killing myself but I would not do it.
   □ I want to kill myself.

10. □ I feel like crying every day.
    □ I quite often feel like crying.
    □ I feel like crying once in a while.

11. □ Things bother me all the time.
    □ Things quite often bother me.
    □ Things bother me once in a while.

12. □ I like being with people.
    □ I quite often do not like being with people.
    □ I do not want to be with people at all.

13. □ I cannot make up my mind about things.
    □ It is hard to make up my mind about things.
    □ I make up my mind about things easily.

14. □ I look OK.
    □ There are some bad things about my looks.
    □ I look ugly.
### What I think and feel

**Instructions:** I will read each item to you. Think carefully about whether the item is true about yourself. Tick the YES box if you think that the statement is true about yourself. Tick the NO box if you think that the statement is not true about yourself.

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<tbody>
<tr>
<td>1. You have trouble making up your mind.</td>
<td>YES</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>2. You get nervous when things do not go the right way for you.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>3. Others seem to do things easier than you can.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>4. You like everyone you know.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>5. Often you have trouble getting your breath.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>6. You worry a lot of the time.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>7. You are afraid of a lot of things.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>8. You are always kind.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>9. You get angry easily.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>10. You worry what your parents will say to you.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>11. You feel that others do not like the way you do things.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>12. You always have good manners.</td>
<td>YES</td>
<td>NO</td>
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<tr>
<td>13. It is hard for you to sleep at night.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<td>14. You worry about what other people think about you.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<td>15. You feel alone even when there are people with you.</td>
<td>YES</td>
<td>NO</td>
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<td>16. You are always good.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>17. Often you feel sick in your stomach.</td>
<td>YES</td>
<td>NO</td>
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<tr>
<td>18. Your feelings get hurt easily.</td>
<td>YES</td>
<td>NO</td>
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<td>19. Your hands feel sweaty.</td>
<td>YES</td>
<td>NO</td>
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<td>20. You are always nice to everyone.</td>
<td>YES</td>
<td>NO</td>
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<td>21. You are tired a lot.</td>
<td>YES</td>
<td>NO</td>
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<td>22. You worry about what is going to happen.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>23. Other children are happier than you.</td>
<td>YES</td>
<td>NO</td>
<td></td>
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<tr>
<td>24. You tell the truth every single time.</td>
<td>YES</td>
<td>NO</td>
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<td>25.</td>
<td>You have bad dreams.</td>
<td>□ - YES □ - NO</td>
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<td>26.</td>
<td>Your feelings get hurt easily when you are told off.</td>
<td>□ - YES □ - NO</td>
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<td>27.</td>
<td>You feel that someone will tell you that you do things the wrong way.</td>
<td>□ - YES □ - NO</td>
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<td>28.</td>
<td>You never get angry.</td>
<td>□ - YES □ - NO</td>
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<td>29.</td>
<td>You wake up scared some of the time.</td>
<td>□ - YES □ - NO</td>
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<td>30.</td>
<td>You worry when you go to bed at night.</td>
<td>□ - YES □ - NO</td>
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<tr>
<td>31.</td>
<td>It is hard for you to keep your mind on your school work.</td>
<td>□ - YES □ - NO</td>
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<td>32.</td>
<td>You never say things that you shouldn't.</td>
<td>□ - YES □ - NO</td>
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<td>33.</td>
<td>You fidget in your seat a lot.</td>
<td>□ - YES □ - NO</td>
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<td>34.</td>
<td>You are nervous.</td>
<td>□ - YES □ - NO</td>
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<td>35.</td>
<td>A lot of people are against you.</td>
<td>□ - YES □ - NO</td>
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<td>36.</td>
<td>You never lie.</td>
<td>□ - YES □ - NO</td>
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<tr>
<td>37.</td>
<td>You often worry about something bad happening to you.</td>
<td>□ - YES □ - NO</td>
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</table>
We are interested in your health and what you think about the area surrounding your school and home. Please answer by placing a tick in the box. Please only tick one box for each question.

Section 1: Your Health

1. In general, would you say your health is
   - Very Good
   - Good
   - Fair
   - Poor

2. Have you had headaches in the last 2 weeks?
   - Often
   - Sometimes
   - Never

3. Have you felt tired in the last 2 weeks?
   - Often
   - Sometimes
   - Never

4. Have you had trouble sleeping in the last 2 weeks?
   - Often
   - Sometimes
   - Never

Section 2: Your Environment

5. How clean do you think the air is around your school (for instance in the playground)?
   - Very clean
   - Clean
   - Not very clean

6. How safe do you feel in the area where you live?
   - Very safe
   - Safe
   - Not very safe

7. How friendly do you feel the area where you live is?
   - Very friendly
   - Friendly
   - Not very friendly

8. Do you hear plane noise around your home?
   - Yes
   - No

9. When you are at home, does the noise from the planes bother or annoy you?
   - Very much
   - Quite a bit
   - A little
   - Not at all

10. How much help do you get with your homework at home?
    - A lot
    - Quite a bit
    - A little
    - None at all

11. Do you have stories or other things read aloud to you at home?
    - More than once a week
    - Once a week
    - Never

12. Do you read aloud to your parents or other adults at home?
    - More than once a week
    - Once a week
    - Never
I'd like to ask you questions about the area around your school and then about the area around your home. Try to think about them separately. Please tick only one box for each question.

Now please think about the area around your school

13. Do you hear road traffic noise around your school?
   - yes  - no

14. Do you hear train noise around your school?
   - yes  - no

15. Do you hear plane noise around your school?
   - yes  - no

16. When you are at school, does the noise from the planes bother or annoy you?
   - very much  - quite a bit  - a little  - not at all

17. When you are at school, does the noise from the trains bother or annoy you?
   - very much  - quite a bit  - a little  - not at all

18. When you are at school, does the noise from road traffic bother or annoy you?
   - very much  - quite a bit  - a little  - not at all

Now please think about the area around your home

19. Do you hear road traffic noise around your home?
   - yes  - no

20. Do you hear train noise around your home?
    - yes  - no

21. Do you hear your neighbour's noise around your home?
    - yes  - no

22. When you are at home, does the noise from trains bother or annoy you?
    - very much  - quite a bit  - a little  - not at all

23. When you are at home, does the noise from road traffic bother or annoy you?
    - very much  - quite a bit  - a little  - not at all

24. When you are at home, does the noise from your neighbour's bother or annoy you?
    - very much  - quite a bit  - a little  - not at all
I want to know what you think about noise in your classroom. Please tick only one box for each question.

25. It is easy to hear the teacher in your classroom? □-yes □-no

26. It is easy for the teacher to hear you in your classroom? □-yes □-no

27. Is there too much noise in your classroom? □-yes □-no

28. If you think there is too much noise in your classroom, what kind of noise is it?
   a) Is it noise from rooms next door? □-yes □-no
   b) Is it noise from traffic in the street? □-yes □-no
   c) Is it noise from the planes? □-yes □-no
   d) Is it noise from the playground? □-yes □-no
   e) Is it noise from the hallway? □-yes □-no
   f) Is it noise from other children in the room? □-yes □-no
   g) Is there any other kind of noise? Write it down here ______________________

29. If you think there is too much noise, does the noise make it hard for you to do your work? □-yes □-no

30. Planes passing overhead make it hard for me to think
□-agree strongly □-agree □-disagree □-disagree strongly

31. Do you like your classroom? □-yes □-no

32. If you don’t like your classroom, what don’t you like about it?
□ - Not enough light
□ - Too cold or too warm
□ - Too much noise
□ - Too quiet
□ - Too crowded
□ - If you have any other reason write it here _______________________
33. How noisy is your classroom?

- very noisy
- noisy
- not very noisy
- not noisy at all

34. Do the planes ever seem to you to fly too low for safety?

- often
- sometimes
- never

35. How do you feel when the planes fly over you?

- excited and interested
- frightened or worried
- no feelings

36. How interested are your parents/carers in your school work? (e.g. do your parents/carers visit the school often, care about what secondary school you will go to, expect you to do well at school and ask for your marks) Are your parents/carers?

- very much interested
- quite a bit interested
- a little interested
- not at all interested
Numbers Activity

Activity 1: Code Transmission

On the tape there is going to be a very long list of numbers between 1 and 9. You have to find certain numbers in the list, like a code. The code is that you have to listen out for two 5's in a row. A 5 on its own is no good. It has to be two 5's in a row. When you hear two 5's in a row you have to write down the number that came just before. Write the number down in the boxes below, if you did not hear the number that came before the two 5's in a row mark the box with an X and move onto the next box.

Practice

The Activity
Activity 2: Score

INSTRUCTIONS: Count how many sounds you hear in each game, as if you were keeping score by counting the number of 'scoring sounds' in a computer game. Do not count the siren sounds that signal the beginning and end of each game. Write the number down in the box beside the game number.

<table>
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<th>PRACTICE 1</th>
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<tbody>
<tr>
<td>PRACTICE 2</td>
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<tr>
<td>GAME 1</td>
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<td>GAME 9</td>
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<td>GAME 10</td>
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Appendix 9: Long term-memory scoring manual
Our friend, the dolphin

1. What two great dangers was the woman who was thrown into the sea in?

Correct answer

a) The yacht exploded (she could have been burned by the explosion)
b) She was thrown into the sea
c) Sharks
d) Drowning (sinking, she was a long way from land)
e) The dolphins saved her. The dolphins steered the woman to a large marker in the sea. She drifted for over 200 miles.

Scoring (A part of an alternative can also give points)
1 p = One alternative.
2 p = Two alternatives
3 p = Two alternatives a-d and something from alternative e.

2. What puzzled the Russian fishermen about the dolphin's behaviour?

Correct answer

a) That the dolphin tried to jump on to the boat (the dolphin was "talking" and trying to tell something)
b) The dolphin quietly allowed the ships' doctor to stitch up the wound (human like behaviour)
c) The fishermen pulled the dolphin on board and found that it had a large bleeding gash on its side.

Scoring (A part of an alternative can also give points)
1 p = One alternative a-c
2 p = Two alternatives a-c
3 p = Three alternatives a-c
3. What facts do you remember about dolphins?

Correct answer:

a) The dolphin is very intelligent, they can gain a large store of knowledge. (they are also very friendly).

b) Its brain compares with that of a man

c) The lifespan of a dolphin is about 30 years

d) They talk to each other using a range of clicks and whistles

e) They have an amazing sense of hearing

f) They send out sounds and can tell from their echo the size of objects as far away as a quarter of a mile

Scoring (A part of an alternative can also give points)

1 p = One alternative a-f

2 p = Two alternatives a-f

3 p = Three or more alternatives a-f
1. How did Lysander finally read the message?

**Correct answer:**

a) He could read the message by the boys belt

b) Lysander wound the belt, with the jumble of letters, round his stick (he could read the code by the boys belt)

c) Lysander wound the belt so that the edges touched

**Scoring** (A part of an alternative can also give points)

1 p = Alternative a

2 p = Alternative a and b or alternative b

3 p = Alternative b and c

2. What did Lysander learn from the message?

**Correct answer:**

a) That his friends were against him

b) That his friends, the Persians, were against him

c) That he should be ready to fight against a new enemy

**Scoring** (A part of an alternative can also give points)

1 p = Alternative a

2 p = Alternative b or alternative a and c

3 p = Alternative b and c
3. What do you remember about ways of making your own secret code?

**Correct answer:**

a) Use a tin can or a cardboard tube.

b) Wind a narrow strip of paper evenly round it and fasten the ends with sticky tape.

c) Write your message in big letters straight down the tube.

d) Then unwind the paper and write a jumble of odd letters all over the rest of it.

e) The message can only be read if the person you send it to winds it round a cylinder of exactly the same thickness as the one you used.

**Scoring** *(A part of an alternative can also give points)*

1 p = One alternative

2 p = Two alternatives

3 p = Three alternatives
CONFIDENTIAL

Teacher Questionnaire

Student's name_________________________________________________________

Your name_____________________________________________________________

1. What are the last assessed National Curriculum Level Scores for this student in:

   English:_____________________________________________________________

   Mathematics:_________________________________________________________

   Science:_____________________________________________________________

2. Does this child have a hearing problem? □ No □ Yes * if so what type and to what extent

3. Does this child have a reading problem? □ No □ Yes * if so what type and to what extent

4. Does this child have a learning problem? □ No □ Yes * if so what type and to what extent

5. Does this child have a fine motor skills problem? □ No □ Yes * if so what type and to what extent

Head of Department and Professor of Epidemiology and Public Health Professor M.G. Marmot
Professor of Dental Public Health Professor A. Sheehan
Below is a list of items that describe some children's behaviour in school. Please consider the behaviour of the child named above over the last 2-3 months. For each item, circle the number that indicates how true that description is of the child. Please read the items carefully, as they ask about several different aspects of the child's behaviour.

<table>
<thead>
<tr>
<th>Item Description</th>
<th>not at all</th>
<th>not true</th>
<th>some times true</th>
<th>true</th>
<th>very true</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefers to do easy problems rather than hard ones.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Expresses enthusiasm about his/her work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>When s/he encounters an obstacle in his/her work s/he works to overcome it.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Takes little independent initiative; you must help him/her to get started and keep going on an assignment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>In general, s/he expects to do well on school (rather than expecting to do poorly and expressing surprise at each success).</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>When s/he fails one part of a task, s/he looks discouraged - says s/he is certain to fail at the entire task.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Tries hard to finish assignments, even when they are difficult</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Makes negative or degrading comments about his/her ability when s/he performs poorly.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Gives up when you correct him/her or find a mistake in his/her work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>In general, attempts to do her/his work thoroughly and well, rather than just trying to get by.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>If asked why s/he received a poor grade, s/he is likely to say something about trying harder (e.g., “I didn’t concentrate enough that time”).</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>After failing a few problems on an academic task, s/he continues to do poorly on remaining problems even though they are within his/her ability range.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Prefers new and challenging problems over easy problems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Asks for help from aides, other students, or yourself on academic tasks more than is necessary.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>When you point out a mistake s/he “takes it in stride” tries to correct the error, and continues to work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Can see that s/he is proud when s/he receives a good grade or when his/her work is praised.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>When s/he begins a difficult problem, his/her attempts are half-hearted.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Does not respond with enthusiasm and pride when asked how s/he is doing on an academic task.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>When s/he does badly on one part of a task, s/he still expects to perform well on the rest of the task.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Says things like ‘I can’t do it’ and when s/he has trouble with his/her work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>When given a good grade, s/he does not believe s/he really can do that subject - says for example, that you were being nice, the problems were just easy, or s/he was lucky.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>When experiencing difficulty s/he persists for a while before asking for help.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>When s/he encounters an obstacle in school work s/he gets discouraged and stops trying. S/he is easily frustrated.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>When s/he received a poor grade, says s/he will try harder in that subject the next time.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix 11: Parent Questionnaire
Confidential

The Schools Environment and Health Study Parent Questionnaire

Your name: ____________________________________________

Your child’s Name: _____________________________________

Relationship to your child: ________________________________

Date: _________________________________________________

Please answer these questions in the order they come on this form.

Thank you
Section 1 Your Child’s Health

This section concerns the health of your child taking part in the study.

Question 1

Please tick either yes or no for each of these three questions and answer the follow on question if you answer yes

1. Does your child have a hearing problem?
   - No
   - Yes
   → What type and to what extent?

2. Does your child have a learning difficulty?
   - No
   - Yes
   → What type and to what extent?

3. Does your child take any medication?
   - No
   - Yes
   → What type and how frequently?

4. How would you rate the health of your child? (please tick one box)
   - Excellent
   - Very Good
   - Good
   - Fair
   - Poor
The following questions on health problems and habits asks about various kinds of behaviour that many children show at some time. Please give answers according to the way your child has been during the PAST 12 MONTHS

**Health Problems**

Below is a list of minor health problems which most children have at some time. Please tell us how often each of these happens with your child by ticking the correct column.

<table>
<thead>
<tr>
<th>Minor Health Problem</th>
<th>Never</th>
<th>Occasionally but not as often as once per week</th>
<th>At least once per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complains of headaches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has stomach-ache or vomiting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asthma or attacks of wheezing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wets the bed or pants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>soils or loses control of bowels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has temper tantrums(that is, complete loss of temper with shouting, angry movements, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Had tears on arrival at school or refused to go into the building</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truants from school</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Habits**

Please place a tick in the box by the correct answer

1. Does he/she stammer or stutter?
   - [ ] No
   - [ ] Yes - mildly
   - [ ] Yes - severely

2. Is there any difficulty with speech other than stammering or stuttering?
   - [ ] No
   - [ ] Yes - mildly
   - [ ] Yes - severely

If YES, please describe the difficulty:

________________________________________________________________________

________________________________________________________________________
3. Does he/she ever steal things? (please tick one box)

- [□] No
- [□] Yes - occasionally
- [□] Yes - frequently

If 'YES' (occasionally or frequently) does it involve (please tick one box)

- [□] minor pilfering of pens, sweets, toys, small sums of money, etc.
- [□] stealing of big things
- [□] both minor pilfering and stealing of big things.

Is stealing done (please tick one box)

- [□] in the home
- [□] elsewhere
- [□] both in the home and elsewhere

4. Is there any eating difficulty?

- [□] No
- [□] Yes - mild
- [□] Yes - severe

If YES is it

- [□] faddiness
- [□] not eating enough
- [□] eating too much
- [□] other, please describe:

5. Is there any sleeping difficulty?

- [□] No
- [□] Yes - mild
- [□] Yes - severe

If YES is it

- [□] getting off to sleep
- [□] waking during the night
- [□] waking early in the morning
- [□] other, please describe:

Question 5: Strengths and Difficulties Questionnaire
For each item, please mark the box for NOT TRUE, SOMEWHAT TRUE or CERTAINLY TRUE. It would help us if you answered all items as best you can even if you are not absolutely certain or the items seems daft! Please give your answers on the basis of the child’s behaviour over the last six months or this school year.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>NOT TRUE</th>
<th>SOMEWHAT TRUE</th>
<th>CERTAINLY TRUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Considerate of other people’s feelings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restless, overactive, cannot stay still for long</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often complains of headaches, stomach-aches or sickness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shares readily with other children (treats, toys, pencils etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often has temper tantrums or hot tempers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rather solitary, tends to play alone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generally obedient, usually does what adults request</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Many worries, often seems worried</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helpful if someone is hurt, upset or feeling ill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constantly fidgeting or squirming</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has at least one good friend</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often fights with other children or bullies them</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often unhappy, down-hearted or tearful</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generally liked by other children</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easily distracted, concentration wanders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nervous or clingy in new situations, easily loses confidence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kind to younger children</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often lies or cheats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picked on or bullied by other children</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often volunteers to help others (parents, teachers, other children)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinks things out before acting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steals from home, school or elsewhere</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gets on better with adults than with other children</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Many fears, easily scared</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sees tasks through to the end, good attention span</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section 2 Your Health

This section deals with your own health

Question 1

1. In general, would you say your health is: (please tick one box)

☐ Excellent  ☐ Very Good  ☐ Good  ☐ Fair  ☐ Poor

Question 2

We would like to know if you have had any medical complaints, and how your health has been in general over the past few weeks. Please answer these questions simply by indicating the answer which you think most nearly applies to you. Remember we want to know about your present and recent complaints, not those you had in the past.

It is important that you try to answer ALL the questions. (please tick ONE box in the row that corresponds to your answer)

HAVE YOU RECENTLY

<table>
<thead>
<tr>
<th>Question</th>
<th>Better than usual</th>
<th>Same as usual</th>
<th>Less than usual</th>
<th>Much less than usual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Been able to concentrate on whatever you’re doing?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Lost much sleep over worry?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Felt that you are playing a useful part in things?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Felt capable of making decisions about things?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Felt constantly under strain?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Felt you couldn’t overcome your difficulties?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Been able to enjoy your normal day-to-day activities?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Been able to face up to your problems?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Been feeling unhappy and depressed?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Been losing confidence in yourself?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Been thinking of yourself as a worthless person?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Been feeling reasonably happy, all things considered?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
Please answer the following questions about members of your immediate family living inside your home (please tick ONE box in the row that corresponds to your answer)

<table>
<thead>
<tr>
<th>Questions</th>
<th>A great deal</th>
<th>Quite a lot</th>
<th>A little</th>
<th>Not at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much do you think that members of your family really care about you?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>How much do they understand the way you feel about things?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>How much can you rely on them for help if you have a serious problem?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>How much can you be open with them if you need to talk about your worries?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Please answer the following questions about members of your immediate family living inside your home

<table>
<thead>
<tr>
<th>Question</th>
<th>Often</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do members of your family make too many demands on you?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>How often do they criticise you?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>How often do they let you down when they are counting on them?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>How often do they get on your nerves?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

**Question 4**

Please answer each of the following questions by ticking the yes or no column beside each question.

Do not think too long about the exact meaning of the questions

<table>
<thead>
<tr>
<th>Question</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your mood often go up and down?</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Are you a talkative person?</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Do you ever feel 'just miserable' for no reason?</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Are you rather lively?</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Are you an irritable person?</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Do you enjoy meeting new people?</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Are you feelings easily hurt?</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Can you usually let yourself go and enjoy yourself at a lively party?</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Do you often feel 'fed-up'?</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Do you usually take the initiative in making new friends?</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
1. At home, I feel I have control over what happens in most situations (please tick one box)

- Strongly disagree
- Moderately disagree
- Slightly disagree
- Slightly agree
- Moderately agree
- Strongly agree

2. At work, I feel I have control over what happens in most situations (please tick one box)

- Strongly disagree
- Moderately disagree
- Slightly disagree
- Slightly agree
- Moderately agree
- Strongly agree

**Question 6**

Please indicate the degree to which each of the following statements is TRUE OF YOU in general: (please tick ONE box in the row that corresponds to your answer)

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>A little bit</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sudden loud noises really bother me</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I hate to be too hot or too cold</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am quick to sense the hunger contractions in my stomach</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have a low tolerance for pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section 3 Environmental Issues

This section deals with the area surrounding your home.

Question 1
a) We are interested in your opinions of the area surrounding your home. Thinking of all aspects of the area in which you live, how satisfied are you with this area as a place to live in? (please tick one box)

Very Satisfied □
Fairly Satisfied □
Rather Dissatisfied □
Very Dissatisfied □
No Feelings Either Way □

b) When you are at home are you ever bothered by: (please tick either yes or no)

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fumes, smoke or unpleasant smells from outside</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Traffic congestion</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Dust and dirt from outside</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Lack of local parks or open spaces</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Litter/rubbish in the street</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

c). How safe do you feel in area where you live?
□ very safe □ safe □ not very safe

d). How friendly do you feel the area where you live is?
□ very friendly □ friendly □ not very friendly
Question 2
a) Thinking back over the last week which kinds of noise do you hear around your home?
(please tick either yes or no)

<table>
<thead>
<tr>
<th>Type of Noise</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>road traffic noise</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>neighbours's noise</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>aircraft noise</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>train noise</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

b) Which is the loudest noise source you hear in your dwelling?

____________________________________________________

(c). How loud is this noise source? (please tick ONE box)

not at all noisy  □
somewhat noisy   □
rather noisy     □
very noisy       □

d). How annoying is this noise for you? (please tick ONE box)

not at all annoying □
a little annoying  □
moderately annoying □
very much annoying □

Question 3
How annoyed or bothered are you by the following noises? (please tick ONE box in each row)

<table>
<thead>
<tr>
<th>Type of Noise</th>
<th>not at all annoyed</th>
<th>a little annoyed</th>
<th>moderately annoyed</th>
<th>very much annoyed</th>
</tr>
</thead>
<tbody>
<tr>
<td>road traffic noise</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>neighbours's noise</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>aircraft noise</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>train noise</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
**Question 4**

The following questions are about your reaction to noise. (please tick ONE box in each row)

<table>
<thead>
<tr>
<th></th>
<th>agree strongly</th>
<th>agree</th>
<th>agree mildly</th>
<th>disagree mildly</th>
<th>disagree</th>
<th>disagree strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-one should mind much if someone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>turns up his/her stereo full-blast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>once in a while</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am easily awakened by noise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I get annoyed when my neighbours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>are noisy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I get used to most noises without</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>much difficulty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes noises get on my nerves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and get me irritated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Even music I normally like will</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bother me if I’m trying to</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>concentrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I find it hard to relax in a place</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>that’s noisy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I’m good at concentrating no matter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>what is going on around me.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I get angry with people who make</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>noise that keeps me from falling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>asleep or getting work done.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am sensitive to noise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Question 5**

Please tell me whether or not you find the following activities at home are disturbed by noise from aircraft. Do you find that the aircraft noise in this neighbourhood disturbs or interferes with .....? (please tick either yes or no)

<table>
<thead>
<tr>
<th>Activity</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talking on the telephone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conversation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listening to TV, radio or music</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleeping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Getting children to sleep</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relaxing indoors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relaxing outdoors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading or studying</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entertaining</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household activities (cooking, cleaning)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Having meals</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Question 6:

1. Have you ever made a complaint or protest about aircraft noise?

☐ Yes  ☐ No

2. Have you ever done anything to lessen the impact of the noise? (Please tick either yes or no)

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double glazing of your windows</td>
<td>☐</td>
</tr>
<tr>
<td>Sign a petition</td>
<td>☐</td>
</tr>
<tr>
<td>Complain to local officials</td>
<td>☐</td>
</tr>
<tr>
<td>Complain to your member of parliament</td>
<td>☐</td>
</tr>
<tr>
<td>Write a letter to a newspaper</td>
<td>☐</td>
</tr>
<tr>
<td>Attend a meeting of neighbours</td>
<td>☐</td>
</tr>
<tr>
<td>Become a member of a protest group</td>
<td>☐</td>
</tr>
<tr>
<td>Take some kind of legal action</td>
<td>☐</td>
</tr>
</tbody>
</table>

Question 7

1. Do the planes ever seem to you to fly too low for safety when they pass by your home? (Please tick your answer)

Often ☐ sometimes ☐ never ☐

2. How do you feel when the planes fly over you? (please tick your answer)

excited and interested ☐

frightened or worried ☐

no feelings either way ☐
Section 4 Background Information

We need to collect this background information for statistical purposes.

1. What is your age group? (please tick the box)
   - [ ] 18 - 29 years
   - [ ] 30 - 39 years
   - [ ] 40 - 49 years
   - [ ] 50 - 59 years
   - [ ] 60 - 69 years
   - [ ] Over 70 years

2. Are you?  [ ] male  [ ] female

3. Would you describe yourself as?
   - [ ] Asian: Bangladeshi
   - [ ] Asian: Indian
   - [ ] Asian: Pakistani
   - [ ] Asian: Chinese
   - [ ] Asian: Other
   - [ ] Black: African
   - [ ] Black: Caribbean
   - [ ] Black: British
   - [ ] Black: Other
   - [ ] White

4. What languages are spoken in your home?

5. What is the main language spoken in your home?

6. How many years have you spent in formal full-time education?  [ ] Please enter in this box the number of years that you have spent in education from when you began school NB: not preschool.

What is the highest qualification you have obtained?
7. What is your current marital status? (tick the box which is your answer)

☐ Never Married  ☐ Divorced
☐ Separated      ☐ Widowed
☐ Married        ☐ Living as married

8. What is your current employment status?

☐ Full time  ☐ Part time
☐ Casual     ☐ In training
☐ Home duties ☐ Unemployed

9. What is your occupation?


10. What is your partner’s occupation?


11. Are you the main wage earner in your household?  ☐ YES  ☐ NO

12. What do you estimate the total household income was in the last year before tax?

☐ No income  ☐ Less than £4 000
☐ £4 000 - £11 000 ☐ £11 000 - £21 000
☐ £21 000 - £45 000 ☐ £45 000 +

13. How many years have you been living at your current address?

☐ Less than one year  ☐ 1 - 2 years
☐ 3 - 5 years         ☐ 6 - 10 years
☐ More than 10 years  ☐ All of your life
14. Is the accommodation in which you live owned or rented?

☐ Owned  ☐ Rented from the local authority

☐ Rented privately, unfurnished  ☐ Rented privately, furnished

15. How many people live in your household?  ☐ Number in Household

16. Which of the following descriptions applies to your home?

☐ Detached house  ☐ Semi-detached house

☐ Terraced house (including end terrace)  ☐ Flat with exclusive use of facilities e.g. bathroom/kitchen

☐ Flat with shared use of facilities  ☐ Rooms/bedsit

☐ Mobile home or caravan  ☐ Bungalow

17. Does your home suffer from any of the following problems?

☐ Damp  ☐ Mould

☐ Cold  ☐ Traffic Vibration

☐ Noise  ☐ Dust

18. How many rooms do you have in your present accommodation (not including kitchen and bathroom) for the sole use of your household?  ☐ Number of Rooms

Thank you very much
Appendix 12: 1997 National Standardised Scores for the Outlier Class
Appendix 12 - 1997 National Standardised Scores for the Outlier Class

Corroborative independent evidence about the outlier class was obtained using the results from the National Standardised Scores (SATS). SATS are conducted three times in a child's school career. These tests are referred to as: Key Stage 1 (age 7, year 2), Key Stage 2 (age 11, year 6) and Key Stage 3 (age 13, year 8). The baseline study was conducted in 1996 when the outlier class was in year 5. The 1996 Key Stage 2 results are those for the children in year 6 in 1996, which was not the class sampled. The 1997 Key Stage 2 results were those of the children we sampled in the outlier class, when they were in year 6. As national tests are not carried out in years 4 and 5, but in year 6, the outlier class was not nationally tested until they were a year older and became year 6 in 1997. The criteria for achieving an acceptable standard in Key Stage 2 tests is a performance of level 4 or above. Two comparisons using the 1997 Key Stage 2 results will be presented. First the performance of the outlier class was compared with the performance of the rest of the year within Wood End Park Junior (class comparison). Second, the performance of Wood End Park Junior has been compared with the other low noise schools (school comparison).

1) Class Comparison

For English, Mathematics and Science there was a smaller proportion of children in the outlier class achieving level 4 or above compared with the rest of the year in that school (this difference is only statistically significant for Science see Table A12.1 below). The differences in English are most relevant to our reading comprehension results. In English 18% of the outlier class achieved level 4 or above compared with 33% of the rest of the year. Taking the English, Science and Mathematics results together they suggest that the outlier class performs at a lower rate than the other two classes in that year and thus may not be representative of the whole year.
Table A12.1.

Class Comparison within Wood End Park Junior: Percentage of the outlier class achieving level 4 or above for English, Mathematics and Science compared with the rest of the year for the 1997 Key Stage 2 1997 results. (Appendix 12)

<table>
<thead>
<tr>
<th>Subject</th>
<th>% of the outlier class achieved level 4 or above</th>
<th>% of the rest of the year achieved level 4 or above</th>
<th>Chi-Squared Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=23</td>
<td>n=77</td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>18 %</td>
<td>33 %</td>
<td>Chi-Square (1,98)=1.78, p=0.18</td>
</tr>
<tr>
<td>Mathematics</td>
<td>35 %</td>
<td>45 %</td>
<td>Chi-Square (1,100)=0.82, p=0.36</td>
</tr>
<tr>
<td>Science</td>
<td>39 %</td>
<td>63 %</td>
<td>Chi-Square (1,98)=3.98, p=0.04</td>
</tr>
</tbody>
</table>

2) School Comparison

The key stage 2 results also provide independent evidence that Wood End Park Junior school is an outlier and not well matched to the other low noise schools. Wood End Park Junior's English performance in the Key Stage 2 results for 1997 were much lower than any of the other 7 schools studied (see Table A12.2 below). Wood End Park Junior had the poorest English performance in the 1997 Key Stage 2 results in the borough of Hillingdon (School League Tables, Department for Education and Employment). Moreover the schools English performance dropped from 47 % achieving 4 or above in 1996 to 29 % in 1997. This comparison between school performance in 1996 with school performance in 1997 provides further evidence that the year sampled in the repeated measures study was not representative of the school as a whole. Wood End Park Junior is the only school sampled whose performance in English dropped between 1996 and 1997 (see Table A12.2 below).
Table A12.2.
Percentage of children achieving level 4 or above in English in the Key Stage 2 results for 1996 and 1997 for the 8 schools in The Schools Environment and Health Study. (Appendix 12)

<table>
<thead>
<tr>
<th>School</th>
<th>1996 Key Stage 2 English Results</th>
<th>1997 Key Stage 2 English Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HIGH NOISE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedfont Junior</td>
<td>38 %</td>
<td>62 %</td>
</tr>
<tr>
<td>Chatsworth Junior</td>
<td>48 %</td>
<td>61 %</td>
</tr>
<tr>
<td>Wellington Primary</td>
<td>51 %</td>
<td>51 %</td>
</tr>
<tr>
<td>Springwell Junior</td>
<td>72 %</td>
<td>84 %</td>
</tr>
<tr>
<td><strong>LOW NOISE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hermitage Junior</td>
<td>41 %</td>
<td>88 %</td>
</tr>
<tr>
<td>Strand on the Green</td>
<td>73 %</td>
<td>83 %</td>
</tr>
<tr>
<td>Feltham Hill Junior</td>
<td>42 %</td>
<td>55 %</td>
</tr>
<tr>
<td><strong>Wood End Park Junior</strong></td>
<td>47 %</td>
<td>29 %</td>
</tr>
</tbody>
</table>
Appendix 13: Threats to Validity
Appendix 13: Threats to Validity

The following threats to validity were addressed prior to the data analysis: floor/ceiling effects, question and version effects, social desirability and patterns of missing data at both baseline and follow-up.

**Threats to Validity at Baseline**

**Floor/Ceiling Effects**
The main dependent variables were examined for floor and ceiling effects. All the scales were normally distributed.

**Question order and version effects**
There were no question order effects for the three versions of the Day 3 questionnaire. This means that the ordering of the The Child Depression Inventory (F=.4042, df 1,313, p=.5254) or The Child Attributional Style Questionnaire (F=0.2941, df=1,314, p=.5880) or The Child Manifest Anxiety Scale (F=0.0049, df 1, 314, p=0.9441) did not affect responding. There was no difference in mean group performance on version A & B of the Suffolk Reading Scale ((F=0.0050, df 1,292, p=.9435). There was a version effect on long term memory task. The Dolphin passage was significantly easier than the Top Secret passage. Version effect on long term memory task the Dolphin passage was significantly easier than the Top Secret passage. This was the case for both the recognition (F(1,277)=90.17, p=0.0001, Dolphin mean: 4.74, Top Secret mean: 3.15) and recall (F(1, 277)=34.32, p=0.0001, Dolphin mean:2.42 , Top Secret mean:1.30 )

**Social Desirability**
The was a significant social desirability effect. The children in the high noise schools had higher scores on the lie scale than the children from the low noise schools. This was be taken into consideration when interpreting the psychological results.

**Missing Data**
Patterns of missing data were examined. The proportion of non-response for the sociodemographic questions was even across the 2 noise exposure groups.
Threats to Validity Follow-up

Floor/Ceiling Effects
The main dependent variables were examined for floor and ceiling effects. These tasks and scales were normally distributed: Suffolk reading scale, long term memory, the lewis Child Stress Scale, CDI and CMAS.

The distribution on these scales demonstrates possible ceiling or floor effects: score and code transmissions may have a ceiling effects. A cut-point analysis was performed on these scales to address this potential bias. Noise annoyance for aircraft noise at school may have a floor effect. This distribution is to be expected.

Question order and version effects
There were no question order effects for the three versions of the Day 3 questionnaire. This means that the ordering of the stress (total score $F(1,236)=0.55, p=0.58$) CDI ($F(1,257)=0.46, p=0.633$) or CMAS ($F(1,257)=0.24, p=0.784$) scales did not affect responding. There was no difference in mean group performance on version A & B of the Suffolk Reading Scale ($F(1,253)=0.02, p=0.87$). A version effect was found again on the long term memory task. The Dolphin passage was significantly easier than the Top Secret passage. This was the case for both the recognition ($F(1,166)=143, p=0.0001$, Dolphin mean: 5.42, Top Secret mean: 3.32) and recall ($F(1,237)=26.24, p=0.0001$, Dolphin mean: 3.43, Top Secret mean: 2.2)

Social Desirability
There was a significant social desirability effect. The children in the low noise schools had higher scores on the lie scale than the children from the high noise schools. This results is the opposite of the 1996 results. This was be taken into consideration when interpreting the psychological results.

Missing Data
Patterns of missing data were examined. The proportion of non-response for the sociodemographic questions was even across the 2 noise exposure groups.
Value Substitutions on the Psychological Scales

If a participant had many items missing on the CDI, CMAS, or Lewis Child Stress Scale then this is will contribute to lower total scores on these scales. Lower scores on these scales indicate lower anxiety, depression and stress. These results may be misleading. Participants with an anxiety score with 4 or more missing values were excluded from the analysis. Participants with a depression score with 2 or more missing values were excluded from the analysis.

Dealing with the missing values for the Lewis Child Stress Scale is more complicated, due to the nature of the 2 sub-scales that are multiplied to create an overall stress total score. For the feel bad sub-scale, the total mean average score across the sub-scale items for each child was substituted for the missing value because the item to total reliability coefficient alpha was $r=0.78$. For the frequency of bad events sub-scale, the total mean average score across the sub-scale items for each child was substituted for the missing value because the item to total reliability coefficient alpha was $r=0.72$. All missing were replaced with these substitutions. Any subject with 4 or more missing values was excluded from the analysis.
Value Substitutions on the Psychological Scales
If a participant had many items missing on the CDI, CMAS, or Lewis Child Stress Scale then this is will contribute to lower total scores on these scales. Lower scores on these scales indicate lower anxiety, depression and stress. These results may be misleading. Participants with an anxiety score with 4 or more missing values were excluded from the analysis. Participants with a depression score with 2 or more missing values were excluded from the analysis.

Dealing with the missing values for the Lewis Child Stress Scale is more complicated, due to the nature of the 2 sub-scales that are multiplied to create an overall stress total score. For the feel bad sub-scale, the total mean average score across the sub-scale items for each child was substituted for the missing value because the item to total reliability coefficient alpha was $r=0.78$. For the frequency of bad events sub-scale, the total mean average score across the sub-scale items for each child was substituted for the missing value because the item to total reliability coefficient alpha was $r=0.72$. All missing were replaced with these substitutions. Any subject with 4 or more missing values was excluded from the analysis.
Appendix 14: The Complete Modified Rutter Parent Questionnaire Results

Prevalence of Child's Health symptoms and Habits

Aircraft noise exposure at school did not affect the level of parent's reporting the following symptoms or habits in their children: headaches, stomach aches, asthma, bed wetting, soiling, temper tantrums, truanting, stuttering, other speech disorders, eating difficulty, sleeping difficulty, tears on arrival to school, and stealing.

Children in low noise schools had higher rates of tears on arrival to school (10 % occasionally) compared with children in high noise schools (2 %) ($\chi^2(2,276)=6.87, p=.032$). Children in low noise schools had higher rates of stealing (12 % occasionally) compared with children in high noise schools (3 %) ($\chi^2(2,281)=10.07, p=.0065$).

Level of psychological disturbance

Aircraft noise exposure at school did not affect the level of prosocial behaviour, hyperactivity, emotional disorder, conduct disorder, peer problems and total deviance score (see Table A14.1).
Table A14.1
Mental health outcomes from the modified rutter parent questionnaire sub scale mean scores adjusted for a) age only and b) adjusted for age, deprivation and main language spoken in the 4 high-noise schools, the 4 low-noise schools and the 3 low-noise schools (excluding the procedural error school). (Appendix 14)

<table>
<thead>
<tr>
<th>Mental Health Outcome from the Modified Rutter Parent Questionnaire</th>
<th>Four High Noise Schools Mean</th>
<th>Four Low Noise Schools Mean</th>
<th>Three Low Noise Schools Mean</th>
<th>F statistic, degrees of freedom and p-value for 8 schools comparison</th>
<th>F statistic, degrees of freedom and p-value for 7 schools comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prosocial behaviour score age adjusted</td>
<td>8.18</td>
<td>8.2</td>
<td>8.15</td>
<td>F(1,278)=0.01, p=0.935</td>
<td>F(1,255)=0.02, p=0.888</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>8.22</td>
<td>8.11</td>
<td>8.02</td>
<td>F(1,260)=0.21, p=0.65</td>
<td>F(1,238)=1.02, p=0.314</td>
</tr>
<tr>
<td>Hyperactivity score age adjusted</td>
<td>3.47</td>
<td>3.43</td>
<td>3.34</td>
<td>F(1,279)=0.02, p=0.9</td>
<td>F(1,256)=0.19, p=0.663</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>3.44</td>
<td>3.49</td>
<td>3.38</td>
<td>F(1,261)=0.03, p=0.871</td>
<td>F(1,239)=0.09, p=0.764</td>
</tr>
<tr>
<td>Emotional symptoms score age adjusted</td>
<td>2.00</td>
<td>2.2</td>
<td>2.16</td>
<td>F(1,279)=0.76, p=0.384</td>
<td>F(1,256)=0.36, p=0.549</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>1.95</td>
<td>2.13</td>
<td>2.02</td>
<td>F(1,261)=0.48, p=0.491</td>
<td>F(1,239)=0.00, p=0.971</td>
</tr>
<tr>
<td>Conduct problems score age adjusted</td>
<td>1.43</td>
<td>1.47</td>
<td>1.35</td>
<td>F(1,279)=0.04, p=0.84</td>
<td>F(1,256)=0.17, p=0.682</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>1.5</td>
<td>1.42</td>
<td>1.27</td>
<td>F(1,261)=0.09, p=0.769</td>
<td>F(1,239)=1.35, p=0.246</td>
</tr>
<tr>
<td>Peer problems score age adjusted</td>
<td>1.94</td>
<td>1.75</td>
<td>1.65</td>
<td>F(1,278)=0.83, p=0.364</td>
<td>F(1,255)=1.95, p=0.164</td>
</tr>
<tr>
<td>fully adjusted</td>
<td>1.89</td>
<td>1.82</td>
<td>1.68</td>
<td>F(1,260)=0.11, p=0.736</td>
<td>F(1,238)=1.09, p=0.238</td>
</tr>
</tbody>
</table>

Prevalence of Potential Psychiatric Casesness
Psychiatric caseness on the Strengths and Difficulties Questionnaire is indicated by established cut off scores were taken from Goodman (1997) See Table A14.2.
Table A14.2.
The cut off scores for psychiatric caseness for the Strengths and Difficulties Questionnaire. (Appendix 14)

<table>
<thead>
<tr>
<th>Scale</th>
<th>Healthy range of scores</th>
<th>Potentially unhealthy range of scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prosocial behaviour score</td>
<td>6 - 10</td>
<td>0 - 5</td>
</tr>
<tr>
<td>Hyperactivity score</td>
<td>0 - 5</td>
<td>6 - 10</td>
</tr>
<tr>
<td>Emotional symptoms score</td>
<td>0 - 3</td>
<td>4 - 10</td>
</tr>
<tr>
<td>Conduct problems score</td>
<td>0 - 2</td>
<td>3 - 10</td>
</tr>
<tr>
<td>Peer problems score</td>
<td>0 - 2</td>
<td>3 - 10</td>
</tr>
<tr>
<td>Total deviance score</td>
<td>0 - 13</td>
<td>14 - 40</td>
</tr>
</tbody>
</table>

Across the 8 schools noise level did not affect the level of psychiatric caseness on the following sub-scales of the Strengths and Difficulties Questionnaire: prosocial, hyperactivity, emotional symptoms, conduct problems and peer problems. Aircraft noise exposure at school did not affect the level of psychiatric caseness on the total deviance scale (see Table A14.3).

Table A14.3
The proportion of the high and low noise sample with scores indicating psychiatric caseness on the sub-scales of the Strengths and Difficulties Questionnaire in the 8 schools. (Appendix 14)

<table>
<thead>
<tr>
<th>Mental Health Outcome from the Modified Rutter Parent Questionnaire</th>
<th>High noise % with psychiatric caseness</th>
<th>Low noise % with psychiatric caseness</th>
<th>Chi-Square Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prosocial behaviour score</td>
<td>8.5 %</td>
<td>12.2%</td>
<td>$\chi^2 (1,279)=1.04$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>p=0.3</td>
</tr>
<tr>
<td>Hyperactivity score</td>
<td>18.3 %</td>
<td>20.9%</td>
<td>$\chi^2 (1,280)=0.29$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>p=0.59</td>
</tr>
<tr>
<td>Emotional symptoms score</td>
<td>21.1%</td>
<td>22.3%</td>
<td>$\chi^2 (1,280)=0.06$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>p=0.81</td>
</tr>
<tr>
<td>Conduct problems score</td>
<td>20.4%</td>
<td>21.6%</td>
<td>$\chi^2 (1,280)=0.06$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>p=0.81</td>
</tr>
<tr>
<td>Peer problems score</td>
<td>31.2%</td>
<td>30.2%</td>
<td>$\chi^2 (1,279)=0.03$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>p=0.86</td>
</tr>
<tr>
<td>Total deviance score</td>
<td>18.3%</td>
<td>21.6%</td>
<td>$\chi^2 (1,280)=0.47$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>p=0.49</td>
</tr>
</tbody>
</table>

To summarise, there are no consistent findings of the parent reports of child mental health to show a strong main effect.
Appendix 15: The Psychometric Analyses
Appendix 15: The Psychometric Analyses

This appendix is referred to in Chapter 4 in the results and discussion section, although the results apply to both baseline and follow-up studies (Chapters 3 & 4).

1) Reliability - Stability
Pearson’s correlations were taken on the scales that were used in both 1996 and 1997 to test for stability (see Table A15.1 below). In this way, performance in 1996 was correlated with performance in 1997. These correlations indicate the extent to which scores were consistent over time, which is slightly different to test-retest reliability. The Suffolk reading scale had high stability. Depression (CDI), anxiety (CMAS) and noise annoyance had moderate stability. Long term memory recognition and recall had poor stability.

Table A15.1.
The Stability of scores in 1996 correlated with scores in 1997 for the 8 schools.
(Appendix 15)

<table>
<thead>
<tr>
<th>Scale</th>
<th>Correlation coefficient (r)</th>
<th>number in sample (n)</th>
<th>p-value (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suffolk standardised reading</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>score</td>
<td>r=0.87</td>
<td>n=225</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.0001</td>
<td></td>
</tr>
<tr>
<td>Long term memory Recognition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task</td>
<td>r= -0.17</td>
<td>n=200</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.013</td>
<td></td>
</tr>
<tr>
<td>Long term memory recall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>r=0.28</td>
<td>n=197</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.0001</td>
<td></td>
</tr>
<tr>
<td>Child Depression Inventory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDI</td>
<td>r=0.55</td>
<td>n=244</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.0001</td>
<td></td>
</tr>
<tr>
<td>Child Manifest Anxiety Scale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMAS</td>
<td>r=0.67</td>
<td>n=246</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.0001</td>
<td></td>
</tr>
<tr>
<td>Noise annoyance for aircraft</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>noise at school</td>
<td>r=0.43</td>
<td>n=246</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.0001</td>
<td></td>
</tr>
<tr>
<td>Noise annoyance for aircraft</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>noise at home</td>
<td>r=0.399</td>
<td>n=248</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=0.0001</td>
<td></td>
</tr>
</tbody>
</table>
2) Reliability - Internal consistency

Cronbach alpha coefficients were calculated for the following scales. The Child Depression Inventory (CDI) at baseline alpha= -0.1; CDI at follow-up alpha=0.04, The Child Manifest Anxiety Scale (CMAS) at baseline alpha=0.88; CMAS at follow-up; The Lewis Child stress scale (feel bad items) alpha=0.9.

3) Validity

Validity is the extent to which a test measures what it is supposed to measure. Concurrent validity is the extent to which a scale or test correlates with other instruments that measure similar constructs. Concurrent validity is more relevant for the present study, with a multi-variate design of related but not indentical variables. In order to determine whether the tests and scales were valid, assumptions about which scales should be related can be assessed. It is to be expected that the cognitive measures (reading, memory & attention) would correlate positively with each other and that the mental health measures (depression, anxiety, self-reported stress, attributional style) would correlate positively with each other.

Concurrent Validity of the Cognitive Measures

As expected at baseline the cognitive measures were significantly and positively related to each other (see Table A15.2 below).

Table A15.2.

Concurrent validity of the cognitive measures at baseline for the 8 schools: Pearson correlation coefficients, number of subjects, and two-tailed significance level.

(Appendix 15)

<table>
<thead>
<tr>
<th></th>
<th>reading comprehension</th>
<th>long-term memory recognition</th>
<th>long-term memory recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>reading</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>comprehension</td>
<td>reading comprehension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>long-term</td>
<td>r=0.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>memory</td>
<td>n=277</td>
<td></td>
<td></td>
</tr>
<tr>
<td>recognition</td>
<td>p=0.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>long-term</td>
<td>r=0.51</td>
<td>r=0.48</td>
<td></td>
</tr>
<tr>
<td>memory</td>
<td>n=270</td>
<td>n=269</td>
<td></td>
</tr>
<tr>
<td>recall</td>
<td>p=0.0001</td>
<td>p=0.0001</td>
<td></td>
</tr>
<tr>
<td>short-term</td>
<td>r=0.27</td>
<td>r=0.12</td>
<td>r=0.2</td>
</tr>
<tr>
<td>memory</td>
<td>n=260</td>
<td>n=245</td>
<td>n=238</td>
</tr>
<tr>
<td></td>
<td>p=0.0001</td>
<td>p=0.057</td>
<td>p=0.002</td>
</tr>
</tbody>
</table>
This was replicated at follow-up. The cognitive measures were significantly and positively related to each other except sustained attention was not related to long-term memory (see Table A15.3 below)

**Table A15.3.**

*Concurrent validity of the cognitive measures at follow-up: Pearson correlation coefficients, number of subjects, and two-tailed significance level. (Appendix 15)*

<table>
<thead>
<tr>
<th></th>
<th>reading comprehension</th>
<th>long-term memory recognition</th>
<th>long-term memory recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>reading comprehension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>long-term memory</td>
<td>r=0.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>memory</td>
<td>n=219</td>
<td></td>
<td></td>
</tr>
<tr>
<td>recognition</td>
<td>p=0.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>long-term memory</td>
<td>r=0.52</td>
<td>r=0.48</td>
<td></td>
</tr>
<tr>
<td>memory</td>
<td>n=219</td>
<td>n=219</td>
<td></td>
</tr>
<tr>
<td>recall</td>
<td>p=0.0001</td>
<td>p=0.0001</td>
<td></td>
</tr>
<tr>
<td>sustained attention (Score)</td>
<td>r=0.15</td>
<td>r=0.06</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>n=225</td>
<td>n=211</td>
<td>n=211</td>
</tr>
<tr>
<td></td>
<td>p=0.02</td>
<td>p=0.4</td>
<td>p=0.37</td>
</tr>
</tbody>
</table>

**Concurrent Validity of the Mental Health Measures**

As expected at baseline the mental health measures were signficanlty and positively related to each other (see Table A15.4 below). Even though the correlations between anxiety and depression with attributional style was negative they indicate a positive association because the lower the score on the CASQ the higher the depressive attributional style.

**Table A15.4.**

*Concurrent validity of the mental health measures at baseline: Pearson correlation coefficients, number of subjects, and two-tailed significance level. (Appendix 15)*

<table>
<thead>
<tr>
<th></th>
<th>Depression (CDI)</th>
<th>Anxiety (CMAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression (CDI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anxiety (CMAS)</td>
<td>r=0.64</td>
<td>r=0.39</td>
</tr>
<tr>
<td></td>
<td>n=314</td>
<td>n=315</td>
</tr>
<tr>
<td></td>
<td>p=0.0001</td>
<td>p=0.0001</td>
</tr>
<tr>
<td>Attributional Style (CASQ)</td>
<td>r= -0.49</td>
<td>r= -0.39</td>
</tr>
<tr>
<td></td>
<td>n=314</td>
<td>n=315</td>
</tr>
<tr>
<td></td>
<td>p=0.0001</td>
<td>p=0.0001</td>
</tr>
</tbody>
</table>
This was replicated at follow-up, as the mental health measures were significantly and positively related to each other (see Table A15.5 below).

**Table A15.5.**

*Concurrent validity of the mental health measures at follow-up: Pearson correlation coefficients, number of subjects, and two-tailed significance level. (Appendix 15)*

<table>
<thead>
<tr>
<th></th>
<th>Depression (CDI)</th>
<th>Anxiety (CMAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression (CDI)</td>
<td>r=0.69</td>
<td></td>
</tr>
<tr>
<td>Anxiety (CMAS)</td>
<td>n=253</td>
<td>n=227</td>
</tr>
<tr>
<td></td>
<td>p=0.0001</td>
<td>p=0.004</td>
</tr>
</tbody>
</table>

Taken together these correlations indicate that the cognitive and mental health measures used in this study had positive but sometimes weak concurrent validity.

To assess whether a test can accurately discriminate between persons with a disorder and those without, the test’s sensitivity, specificity need to be assessed. Sensitivity is the proportion of persons with a particular disorder who are correctly identified. Specificity refers to the proportion of individuals without a disorder correctly classified by the test. Discriminant validity could not be assessed in this study because there were no other assessments of cognition and mental health in this sample, measuring identical constructs.

4) **Factor Analysis of the Stress Scale**

A principal components factor analysis with varimax rotation was conducted on the 20 items of the feel bad scale on the sample from the 8 schools. The factor analysis yielded 6 factors with eigen values greater than 1.0. These 6 factors explained only 53% of the variance, with the first factor explaining 20% and the other five factors less than 10% each. The results for the first three factors in the principal components factor analysis are presented in Table A15.6 below. The factor loadings greater than 0.30 reveal that factor 1 maybe measuring self-pressured stress, but this is not entirely clear. Then a 3 factor solution was examined by a principal components factor analysis with varimax rotation constrained by extracting 3 factors. A 3 factor solution was examined because
the Lewis et al. 1984 found a three factor solution. The 3 factor solution was not confirmed.

### Table A15.6.

**Rotated Factor Structure of the Stress Scale. (Appendix 15)**

<table>
<thead>
<tr>
<th>Item on the Stress Scale</th>
<th>Factor One</th>
<th>Factor Two</th>
<th>Factor Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Having your parents separate</td>
<td>-0.1</td>
<td>0.12</td>
<td>0.71*</td>
</tr>
<tr>
<td>2. Being pressured to try something new</td>
<td>.75*</td>
<td>-.18</td>
<td>-.17</td>
</tr>
<tr>
<td>3. Having your parents argue in front of you</td>
<td>0.43*</td>
<td>-0.02</td>
<td>0.38*</td>
</tr>
<tr>
<td>4. Not spending enough time with your parents</td>
<td>0.06</td>
<td>0.03</td>
<td>0.67*</td>
</tr>
<tr>
<td>5. Feeling sick</td>
<td>0.13</td>
<td>0.11</td>
<td>-0.06</td>
</tr>
<tr>
<td>6. Fighting with your parents about house rules</td>
<td>0.35*</td>
<td>-0.06</td>
<td>0.56*</td>
</tr>
<tr>
<td>7. Not having homework done on time</td>
<td>0.53*</td>
<td>0.24</td>
<td>.08</td>
</tr>
<tr>
<td>8. Moving from one place to another</td>
<td>0.06</td>
<td>0.13</td>
<td>0.16</td>
</tr>
<tr>
<td>9. Not getting along with your teacher</td>
<td>0.58*</td>
<td>.30*</td>
<td>.13</td>
</tr>
<tr>
<td>10. Being overweight or bigger than others</td>
<td>0.25</td>
<td>0.63*</td>
<td>0.03</td>
</tr>
<tr>
<td>11. Changing schools</td>
<td>0.11</td>
<td>0.05</td>
<td>0.09</td>
</tr>
<tr>
<td>12. Not having enough money to spend</td>
<td>-0.14</td>
<td>0.31</td>
<td>-0.13</td>
</tr>
<tr>
<td>13. Not being able to dress the way you want to</td>
<td>0.16</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>14. Feeling left out of a group</td>
<td>0.49*</td>
<td>0.31*</td>
<td>0.18</td>
</tr>
<tr>
<td>15. Having nothing to do</td>
<td>0.01</td>
<td>0.54*</td>
<td>0.03</td>
</tr>
<tr>
<td>16. Pressured to get good marks at school</td>
<td>-0.03</td>
<td>0.24</td>
<td>0.22</td>
</tr>
<tr>
<td>17. Not being good enough at sports</td>
<td>0.00</td>
<td>0.69*</td>
<td>0.13</td>
</tr>
<tr>
<td>18. Being late for school</td>
<td>.6*</td>
<td>.17</td>
<td>-0.4</td>
</tr>
<tr>
<td>19. Feeling like your body is changing</td>
<td>0.13</td>
<td>0.41*</td>
<td>0.16</td>
</tr>
<tr>
<td>20. Being smaller than others your age</td>
<td>0.21</td>
<td>0.63*</td>
<td>-0.12</td>
</tr>
</tbody>
</table>

* items loading 0.30 or greater on a factor