The effects of test-oriented behaviour and cortisol reactivity to stress on cognitive test performance in preschool-aged children

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ABSTRACT

The effects of test-oriented behaviour and cortisol reactivity to stress on cognitive test performance in preschool-aged children

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The current study examined preschool-aged children's behavioural and cortisol responses to standardized cognitive testing and how these relate to their cognitive scores. Eighty-five Francophone children (45 boys) were administered the French edition of the Stanford-Binet IV (SB IV) and Peabody Picture Vocabulary Test Revised (EVIP) during two home visits. Two dimensions, Attentiveness/Compliance and Nervous/Anxious, were derived from examiner's ratings to describe behaviour during testing. Salivary cortisol samples were collected prior, during and after the SB IV on the first day of testing from 64 children (34 boys).

The two test behaviour factors were highly negatively correlated. Higher Attentiveness/Compliance and lower Nervous/Anxious scores were associated with higher SB IV and EVIP scores. Children who provided salivary samples performed higher on cognitive tests and showed more adaptive behaviour during testing. Path models showed that the initial cortisol sample was related to better Attentiveness/ Compliance, which in turn was related to higher SB IV composite scores and higher age. Once Attentiveness/Compliance was controlled for, older children, particularly boys showed lower SB IV scores. Hierarchical regressions showed that higher initial cortisol was related to higher SB IV performance for girls but lower initial cortisol was related to higher SB IV scores for boys. The implications of children's behaviours and cortisol reactivity during testing on validity of obtained cognitive scores are discussed.

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Table of Contents

List of Tables

List of Figures

List of Appendices

Introduction

The development of basic cognitive abilities is an integral part of every child's growth. Children need to develop attention, memory, quantitative reasoning, language, spatial reasoning and problem solving in order to become fully functional as adults. Cognitive abilities are developed through the process of learning and maintained through memory. Squire (1987) defined learning as the process of acquiring new information, and memory as the persistence of learning in a state that can be accessed at a later time. The preschool period (age 3 to 6 years of age) is characterized by rapid acquisition of cognitive skills and strategies. At the same time, the preschooler's brain is still undergoing neural development (Bjorklund, 2000). Within a few years preschool children have to build on the limited skills of a toddler in order to be ready for the transition into formal education which typically occurs around 6 to 7 years of age. Studies showed a wide variability in cognitive abilities in normally developing children. At the same time, studies documented consistent sex differences in certain cognitive abilities such as verbal, quantitative and spatial abilities (Halpern & LaMay, 2000).

Currently, cognitive abilities in children are assessed using standardized test batteries such as the WPSSI-III (Wechsler, 2002), WISC III (Wechsler, 1991), Stanford Binet IV (Thorndike, Hagen & Sattler, 1986), and Kaufman Assessment Battery for Children (Kaufman & Kaufman, 1983). Although the development of tests of cognitive ability began over 100 years ago with the work of Francis Galton (1869, 1883) and Binet and Simon (1905) (cited in Kaufman & Lichtenberger, 1999), researchers addressed the impact of test session behaviours only in the last 15 years. Recent studies suggested that children with inappropriate behaviour during testing score 7-10 points lower on global IQ than children with appropriate behaviours (Glutting, Youngstrom, Oakland & Watkins, 1996). Based on their finding that test session behaviour is more strongly related to scores on individual subtests than the composite IQ score, Konold, Maller, and Glutting (1998) argued that the test scores of children who are disruptive or inattentive may not be representative of their actual cognitive ability.

Furthermore, as suggested by a rapidly growing literature, children's behaviour styles including those during the assessment may be affected by their physiological reactivity to the novel test-taking experience. Studies focused on the mechanism of the hypothalamic-pituitary-adrenal (HPA) axis and its principal product, the hormone cortisol. Increased cortisol secretion during stressful events allows the organism to cope on a behavioural and physiological level (Sapolsky, 1992). Cortisol receptors are found throughout the human brain and bodily organ systems. Correspondingly, irregularities in cortisol secretion have been linked to a variety of emotional, behavioural and physiological disturbances (e.g., Granger, Weisz & Kauneckis, 1994; McBurnett, Lahey, Rathouz & Loeber, 2000). Furthermore, given the high cortisol receptor concentration in the hippocampus, an area important in learning and memory, cortisol levels directly influence cognitive abilities. Both under- and over-secretion of cortisol are linked to cognitive impairment (Lupien & McEwen, 1997) with the strongest effects emerging for verbal declarative memory in humans (Jameison & Dinan, 2001). While research on cortisol activity and behaviour styles in childhood and infancy is extensive (see work of Megan Gunnar) the issue of cortisol and cognitive abilities in childhood has been addressed by only a few researchers (Heffelfinger & Newcomer, 2001).

Consequently, the goal of the present study was to examine preschool-aged children's behavioural and cortisol responses to standardized cognitive testing and how these relate to their obtained cognitive scores. Given the documented sex differences in some cognitive abilities (Halpern & LaMay, 2000) and cortisol reactivity (Kirschbaum, Wuest & Hellhammer, 1992), analyses also examined whether the patterns of relationships among variables of interest differed in girls and boys.

Information-Processing Model of Cognitive Development

The information-processing approach to cognition emphasizes the need to process information in order to acquire, use or store it. According to the theoretical model of Atkinson and Shiffrin (1968) environmental input enters the sensory register, then is temporarily stored in short-term memory, and then moves to long-term memory. Each of these components fulfills a separate function: sensory registers (visual, auditory etc.) register input; short-term memory holds information long enough for evaluation or a behavioural response; and long-term memory acts as a relatively permanent store of knowledge and information processing strategies. Each of the three components is controlled by executive control processes and the interaction between sensory registers and short term memory is mediated by attention. Baddeley (1986) proposed the concept of working memory which includes the passive storage implicit in the notion of short term memory as well as the capacity to transform information.

Tulving (1985) proposed that information is represented in long-term memory as declarative and nondeclarative memory. Declarative memory can be stated verbally, be brought to mind as an image or proposition and at least in the adult human implies conscious awareness. Examples include recall and recognition of events, objects or places. Two subtypes of declarative memory are recognized. Episodic memory (also termed explicit) is the recall and recognition of personally experienced events. Semantic memory refers to knowledge of language, rules and concepts. In contrast, nondeclarative memory (also termed implicit) refers to a grouping of different subtypes of memory distinct from declarative memory. Nondeclarative memories are assumed to be unconscious and require multiple trials to acquire. Examples include priming, procedural memory, conditioning, and skilled motor learning. The distinction between declarative and nondeclarative memory was supported by studies of individuals with discrete brain lesions or neuroimaging studies of healthy individuals engaged in different memory tasks (Nelson & Carver, 1998).

Cognitive Development in Preschoolers

The information-processing model was applied to the study of cognitive development in children with the goal of finding age related differences. Perhaps the most important factor in engaging children in cognitive tasks is their developing attentive abilities. Sustained attention refers to the ability to focus on a given task. Preschoolers are much better at it than infants who habituate quickly (Berk, 1997). Observational studies showed that preschoolers' ability to engage in complex play allows them to become more attentive as the play session progressed (Berk, 1997). At the same time, their sustained attention span to a single task is relatively short. For example, the average time spent by a preschooler in a single activity during free play is about 7 minutes (Stodolsky, 1974). Another subtype of attention is selective attention - the ability to concentrate on relevant stimuli and ignore irrelevant stimuli. This ability increases sharply between ages 6 and 9 (Berk, 1997). Consequently, incidental learning (the learning of irrelevant stimuli) is better in younger children (Bjorklund, 2000). Another important ability is processing speed. Kail (1988, 1991, 1993) studied the performance of individuals, age 6 to 22, on basic cognitive tasks requiring processing speed such as visual search, mental rotation, mental addition, etc. He found that processing speed decreased with increasing age with a similar rate of change for all tasks. He also showed that given extensive practice, all participants' processing speed decreased but the relative age differences remained.

Studies of memory span suggested that capacity of the short-term memory increases with age. Dempster (1981) used the digit span task to show that 2-year-olds can hold 2 items in memory, 5 year olds - 4 items, 7 year olds - 5 items, and 9 year olds - 6 items. Other studies used working memory tasks which require manipulation of the to-be-remembered information (e.g. Siegel and Ryan, 1989) and found increasing working memory spans which were two items less than the child's short-term memory span. Bjorklund (2000) interpreted Kail's (1988, 1991, 1993) processing speed findings as indicating greater working memory capacity with increasing age. Studies of long-term memory showed that recognition is the simplest form of retrieval and is highly accurate by 4 years of age (Brown & Campione, 1972). In contrast, recall is harder as the to-be-remembered stimulus is not present. Thus, recall shows greater improvement with age due to child's increasing semantic knowledge base. Familiarity with a specific content area makes related information more meaningful so it is easier to store and retrieve (Carey, 1985; Chi, 1978). Also, younger children are poorer at free recall but do better in cued recall (Bjorklund, 2000). In contrast to declarative memory, nondeclarative memory tasks show little age variation (ViGiulio, Seidenberg, O'Leary & Raz, 1994).

An important factor in memory and other cognitive skills is the use of strategies, defined as goal-directed operations used to aid task performance (reviewed by Bjorklund, 2000). Studies showed that preschoolers typically do not spontaneously generate and use strategies to solve problems. Even if trained on a given strategy, they stop using it within a short time. However, preschoolers do use simpler memory and attentional strategies which increase in efficiency with age (Miller, 1990). For example, preschoolers show the beginnings of rehearsal but the rehearsal efforts have little impact on retention of information until age 6 (Berk, 1997). Another important factor in cognitive development is the child's use of language. Nelson (1993) argued that children's language serves a dual function of communication and mental representation of experience.

Neural Development in Preschoolers

Recently, the field of cognitive neuroscience endeavored to connect our knowledge of cognitive and neural development. The brain continues to mature after birth with a rapid formation of new synapses (synaptogenesis) and the peak number of synapses is attained by 24 months (Huttenlocher, 1994). The ensuing process of selective cell death is mediated by sensory and motor experience where only the synapses activated by experience survive. These changes occur at different rates in different areas of the brain. After the first year of life, the brain metabolism rate increases sharply and peaks at age 4 to 5 at approximately 150% of the adult rate (Chugani, Phelps & Mazziota, 1987, cited in Bjorklund, 2000) possibly reflecting the rapid learning and high numbers of neurons and synapses (Bjorklund, 2000). The process of myelination, where the neural axons are surrounded by myelin to allow faster signal transmission, continues into adolescence and adulthood. Age differences in processing speed are probably related to myelination (Bjorklund, 2000). Nelson (1995) proposed that more mature forms of declarative memory which depend on the hippocampus and surrounding structures in the medial temporal lobe likely do not develop until close to 1 year of age and undergo considerable refinement until age four. The development of explicit memory throughout the preschool period is facilitated by the emergence of prefrontal functions such as the use of strategies to help remember things, multitasking, and metamemory (awareness that things can be forgotten) (Nelson & Carver, 1998).

Sex Differences in Children's Cognitive Abilities

In addition to neural development, studies suggested the importance of sex in assessment of developing cognitive abilities. In general, studies showed no sex differences on measures of overall cognitive ability. However, standardized intelligence tests were constructed in such a way that no sex differences emerge on the composite scores (reviewed by Halpern & LaMay, 2000). Consequently, it is more valid to examine sex differences on tasks and tests which target more specific cognitive abilities.

This line of research found that girls scored higher on measures of verbal fluency (Haden, Haine, & Fivush, 1997), and rate of vocabulary growth during toddler years (Huttenlocher, Haight, Bryk, Seltzer & Lyons, 1991). Furthermore, rates of dyslexia (Skinner & Shelton, 1985) and stuttering (Vanderberg, 1987, cited in Lips, 1997) are much higher in boys than girls. Studies of mathematical ability showed girls to have an advantage in basic arithmetic (Feingold, 1993). In contrast, boys tended to score higher on tests of mathematical problem solving, particularly in samples selected for high mathematical ability (Brody, 1992). Studies of memory showed a female advantage in verbal declarative (Geffen, Moar, O'Hanlon, Clark & Geffen, 1990; Kimura & Clarke, 2002), short-term (Jensen, 1998) and episodic memory (Herlitz, Nilsson & Baeckman, 1997). The strongest sex differences emerged in spatial abilities with a male advantage in spatial perception and mental rotation of figures. However, no sex differences were apparent in spatial visualization (Voyer, Voyer & Bryden, 1995).

Sex differences in verbal ability (Huttenlocher et al., 1991) and spatial ability (Robinson, Abbott, Berninger & Busse, 1996) were observed in toddlers and preschool children. Consequently, it is important to consider the moderating role of sex when assessing young children's cognitive abilities.

Test Session Behaviours

The goal of standardized cognitive testing is to obtain an index of the child's cognitive ability which is comparable to the child's peers of the same age. However, the child's test score is not solely determined by cognitive ability. The child's attitude and behavioural response to a standardized test are likely to influence the obtained test scores (Glutting & McDermott, 1988; Sattler, 1988, 1992, 2001; Watson, 1951). Thus, behavioural observation of young children during testing is crucial as inattention, self-regulation difficulties and noncompliance are normative in this population. Also, preschool children undergo rapid but uneven changes in social, emotional, cognitive and linguistic domains during the preschool period (Campbell, 1994). Consequently, they exhibit a wide range of individual differences in behaviour which need to be taken into account when interpreting standardized test scores. Test behaviour observations fulfill three specific purposes: (1) Help determine whether a child's responses to a given item or subtest are interpretable; (2) Verify proper testing procedures by ensuring that the child is comfortable, motivated and aware of expectations; (3) Provide samples of behaviour that may be generalizable to settings outside the test session (Glutting, Oakland & McDermott, 1989). The first two points serve as validity cross-checks of formal test scores. The third point is controversial (Glutting et al., 1989) but its discussion is outside the scope of this thesis.

Most clinicians appreciate the need for behavioural observation, but they tend to disagree on which behaviours they deem important. Also, they differ in the level of detail which they provide in their descriptions. Sattler's (1992) exhaustive Behaviour and Attitude Checklist included 41 items which describe the child's attitude towards the examiner, test situation, and self; work habits; and reaction to test items, failure, and praise. Caldwell (1951) and Kaufman and Lichtenberger (2000) considered similar test observations. Thorndike et al. (1986) developed the 15 item Stanford Binet Observation Schedule (SBOS) for use with the Stanford Binet IV Intelligence Scale. The SBOS emphasized five behavioural domains: Attention, Reactions During Test Performance, Emotional Independence, Problem-Solving Behaviour and Independence of Examiner Support. However, some of these assessment measures were simply lists of undifferentiated behaviours (e.g., Caldwell, 1951; Kaufman & Lichtenberger, 2000), whereas, others were based on rationally derived behaviour domains (e.g., Sattler, 1992; Thorndike et al., 1986). They also tended to focus on negative behaviours and overlooked adaptive behaviour, and most importantly, lacked empirical evidence for association with test scores (Glutting, Oakland & Konold, 1994).

Only three studies considered this topic in a preschool sample. Glutting and McDermott (1988) conducted a principal components analysis of the SBOS items based on a sample of 155 kindergarten children. They extracted two factors which they named

Self-Confidence and Task-Attentiveness. However, they did not examine the relationship between the two test behaviour factors and the children's cognitive scores. Campbell, Pierce, March, Ewing and Szumowski (1994) designed a child observation measure tapping activity, attention, cooperation, affect, sociability and task involvement. They observed the behaviour of 4-year-old boys identified as active, inattentive and impulsive and control boys during the Stanford Binet (Form L-M). Their principal components analysis indicated two factors: Overactivity/Inattention (e.g., restlessness, attempts to distract the tester) and Noncompliance/Negative Affect (e.g., low involvement, irritability). Like Glutting and McDermott (1988), Campbell et al. (1994) did not report the relationship between the behaviour factors and the SB test scores. Speltz, DeKlyen, Calderon, Greenberg and Fisher (1999) used Campbell et al.'s rating scale to examine a group of preschool boys with and without early onset conduct problems. Speltz et al. (1999) expected the behavioural ratings to load on three factors: Attention, Compliance and Affect. However, these were not supported by a confirmatory factor analysis and all ratings were summed to give an index of Disruptive Behaviour. Boys with conduct problems had higher rates of Disruptive Behaviour and lower scores on measures of verbal ability, visual-motor ability and executive function than controls. Only the group differences in verbal ability remained significant after controlling for disruptive behaviour, suggesting that lower scores on the other two cognitive tests were due to maladaptive behaviour only.

In a study with older, normally developing children (age 7 to 14), Glutting et al. (1989) conducted a principal components analysis on items developed by Caldwell (1951). They extracted 3 factors: Task Attentiveness, Task Confidence and Cooperative

Disposition. The three factors had moderate correlations with the WISC-R Performance and Verbal IQ scores, low correlations with the California Achievement Test (CAT) mathematics scale and no relationship with the CAT reading scale. Lynam, Moffitt and Stouthamer-Loeber (1993) administered the WISC-R short version to 13-year-old boys with three levels of delinquency (none, moderate and serious). A global index of test motivation was developed based on videotape codings for boredom (e.g., yawning) and impatience-impersistence (e.g., giving up quickly). Test motivation was moderately related to overall and verbal IQ but less so with performance IQ.

Glutting et al. (1996) conducted a metanalysis of six studies and found the average coefficient between children's inappropriate test behaviours and IQs obtained during same test session to be -0.34. However, the test session behaviour measures included lacked developmental norms and thus neglected the issue of age-related differences in behaviour (Oakland & Glutting, 1997). Glutting and Oakland (1993) (cited in Oakland & Glutting, 1997) developed the Guide to the Assessment of Test Session Behaviour (GATSB), a structured 29-item behaviour rating scale for observing 6 to 16-year-olds. The GATSB had three levels of age norms and was co-normed with the WISC-III and the WIAT. GATSB items loaded on three factors: Avoidance, Uncooperative Mood and Attention. The factors correlated appreciably, mean $r = 0.59$ (Konold et al., 1998), suggesting they tapped overlapping dimensions of behaviour. Glutting et al. (1996) reported that the Avoidance Scale had the highest correlations (-0.23 to -0.39) with WISC III scales and indices, then Uncooperative Mood, followed by Inattentiveness in a normative sample. Similar results were reported in a referred sample. Furthermore, children with inappropriate behaviours as measured by GATSB scored 7-10 points lower on full scale IQ than children with appropriate behaviours. Daleiden, Drabman, and Benton (2002) replicated the relationship between the three GATSB factors and WISC III indices in a referred sample. However, GATSB factor scores were not consistently related to tests of visual memory and learning.

A few studies examined differences in test behaviour related to sex, race and socioeconomic status (SES). Oakland and Glutting (1990) used Caldwell's (1951) rating scale to assess children's (age 7 to 14) behaviour during the WISC-R. They found that that among children with similar full scale IQs, Anglo examiners observed higher rates of attention, cooperation and self-confidence in Black and Mexican American children (compared with Anglo children) and in lower SES children (compared with middle SES). No sex differences were found. A follow-up study using the GATSB ratings and the WISC III found no sex and SES effects (Glutting et al., 1994). However, Anglo examiners tended to rate test behaviour of Latino children as better than Anglo children but only when the children's IQs were below average. In summary, studies suggested that test behaviour observation scales such as the GATSB showed little test bias regarding to sex, SES, and race. However, no study to date has addressed these demographic variables when examining test behaviours in preschool children.

Konold et al. (1998) noted that studies which simply consider the correlation between test session behaviours and test scores are unable to distinguish between two possibilities: (1) Test session behaviours influence performance on the subtests which are used to measure intelligence; or (2) Test session behaviours are directly related to the global construct of intelligence. The authors tested both models using structural equation modelling (SEM) and found that test behaviours (as measured by GATSB) were more strongly related to individual WISC III subtests than to the full scale IQ score, thereby supporting the first hypothesis.

Konold et al. (1998) provided strong empirical evidence to support the systematic observation of children's behaviours during cognitive assessment. If a child's behaviour interferes with the goals of assessment, the child's scores may not provide an accurate reflection of his or her true abilities (Konold et al., 1998). However, as mentioned above, studies of preschool children are lacking. Studies which used a heterogeneous sample had the benefit of providing a wide range of behaviours. But, the factor structure may be different in normative and clinical samples, particularly when the clinical sample includes children with externalizing problems. Furthermore, the inconsistencies across studies in number and interpretation of extracted factors may in fact reflect a difficulty in operationally defining independent behaviours. Young children's behavioural response to the novel situation of cognitive testing may not be differentiated enough to be described by more than one or two dimensions. The reviewed studies suggested the importance of concentration and compliance or the ability of the child to focus on the task demands and cooperate with examiner's instructions. However, these may not necessarily be independent dimensions as they are both dependent on the child's ability to comply with the demands of the testing situation.

Cortisol

The hypothalamic-pituitary-adrenal (HPA) axis refers to a chain of neuroendocrine changes which begins in the brain. First, the hypothalamus secretes the corticotropin releasing hormone (CRH) which leads the anterior pituitary to secrete the adrenocorticotropic hormone (ACTH). ACTH prompts the adrenal glands (located on top of the kidneys) to release the glucocorticoid hormone, cortisol. Studies of healthy adults and children demonstrated a diurnal secretion pattern where cortisol levels peak shortly after awakening (Pruessner et al., 1997) and decline across the waking day (Kiess et al., 1995; Sapolsky, 1992). When an individual is exposed to a stressful event, salivary cortisol levels peak within 10 to 30 minutes of exposure (Kirschbaum & Hellhammer, 2000) and decrease once the stressor abates. A negative feedback loop prompts the hypothalamus and the anterior pituitary to cease releasing their respective hormones. The increased cortisol secretion in times of stress serves adaptive functions: (1) mobilizes energy stores; (2) coordinates the behavioural response to threat; and (3) suppresses pain perception and inflammation (Sapolsky, 1992). These functions are facilitated by the proliferation of cortisol receptors throughout the bodily organ systems. Also, cortisol receptors are found in many brain regions (e.g., prefrontal cortex, hypothalamus, hippocampus and amygdala) which are involved in emotion regulation, learning and memory (Sapolsky, Krey & McEwen, 1986).

Studies showed a large range of individual variability in cortisol diurnal patterns (Stone et al., 2001) and stress responses, both in timing and absolute levels of cortisol secreted (Negrao, Deuster, Godl, Singh & Chrousos, 2000). The relationship between sex and cortisol profiles was not well examined by existing research. Most studies failed to report the evidence for or against sex differences in cortisol profiles. Some studies reported that adult males produce higher cortisol responses to psychosocial (Kirschbaum, Wust & Hellhammer, 1992; Kirschbaum, Kudielka, Gaab, Schommer, & Hellhammer, 1999; Kudielka, Hellhammer, & Kirschbaum, 2000) and cognitive stressors (Seeman, Singer, Wilkinson, & McEwen, 2001) than adult women. Klimes-Dougan, Hastings, Granger, Usher, and Zahn-Waxler (2001) found higher basal cortisol levels at midday and late afternoon in female adolescents compared to male adolescents.

Research showed that both high and low extremes in cortisol profiles are associated with maladaptive functioning. Although vital to cope with stress in the short-term, chronic elevations in cortisol are detrimental to the organism. Animal and human studies showed that cortisol overproduction due to chronic stress leads to stunted growth and impairments in the immune, reproductive and gastrointestinal systems (Sapolsky, 1992) as well as emotional and cognitive disturbances (see discussion below). More recently, decreased morning cortisol levels were identified as potential indices of risk (Gunnar & Vazquez, 2001). Flattened circadian rhythm was found in institutionalized orphans (Carlson & Earls, 1997) as well as physically (Cicchetti & Rogosch, 2001) and sexually abused children (King, Mandansky, King, Fletcher, & Brewer, 2001). Similarly, Hart, Gunnar, and Cicchetti (1995) found maltreated children to have decreased cortisol reactivity to social conflict. Other environmental factors such as lower SES are linked to chronic stress due to violent neighbourhoods, poverty etc. (Seccombe, 2000). Lupien, King, Meaney and McEwen (2001) found higher cortisol levels in younger children (age 10 and below) who came from lower SES background than in those from high SES. Similarly, children living in households with weak and sporadic caretaking or with non-biological relatives are more likely to show extreme basal cortisol (both high and low). Family conflicts are also associated with temporary increases in child's cortisol (Flinn & England, 1997). In summary, abnormalities in diurnal and stress response cortisol appear to be associated with adverse experiences as well as maladaptive physiological and psychological functioning.

The recent expansion of research into cortisol activity in humans was facilitated by methodological advances. In earlier studies, cortisol levels were measured using blood samples and cortisol metabolites in urine. However, even a simple venipuncture is stressful to an individual, particularly a young child, thus it evokes the HPA stress response. Urinary cortisol concentrations reflect the cumulative HPA function over a period of time (Schulz, Halpern, Newcorn, Sharma & Gabriel, 1997) and may be difficult to collect at specific time intervals. Thus, the development of reliable and non-invasive methods of measuring cortisol in saliva samples was instrumental to stress reactivity research. Salivary cortisol levels are highly correlated with plasma concentrations and are independent of saliva flow rate (Kirschbaum & Hellhammer, 1994).

Cortisol and Cognition

Animal and human studies showed that the hippocampus contains the highest concentrations of specific glucocorticoid receptors within the brain (Sapolsky, 1996). Elevated glucocorticoids compromise hippocampal function by: (1) decreasing signal conduction within hippocampal neurons in response to excitatory signals; (2) decreasing compensatory responses of surviving hippocampal neurons leading to decreased synaptic plasticity; and (3) compromising the survival of hippocampal pyramidal cells leading to atrophy (Lupien, Nair et al., 1999). Studies linked cortisol abnormalities to cognitive abilities mediated by the hippocampus in very different populations. Animal models showed that adrenal glucocorticoid levels are positively related to the magnitude of hippocampal neuronal loss and spatial memory impairments in the elderly rat (Issa, Rowe, Gauthier, & Meaney, 1990; Landfield, Waymire, & Lynch, 1978). Furthermore, rodents adrenalectomized at midlife with low-level corticosterone replacement showed reduced neuronal loss and better cognitive functioning when compared with intact control animals (Landfield, Baskin, & Pitler, 1981).

Human studies began with the observation of 'steroid psychosis'. Patients treated with glucocorticoid medication developed reversible euphoric, depressive and psychotic symptoms (Ling, Perry & Tsuang, 1981) as well as deficits in memory, attention, concentration, and logical thinking (Varney, Alexander, & MacIndoe, 1984). Subsequent studies looked at hypercorticolism related to illness such as Cushing's Disease (CD), Depression and Post-Traumatic Stress Disorder (PTSD). Patients with CD scored lower on global indices of intelligence, verbal ability, and memory than controls but not on tasks measuring attention and working memory (Starkman, Giordani, Berent, Schork & Schteingart, 2001). Depressed patients with high cortisol scored lower on tests of cognitive abstracting ability (Rubinow, Post, Savard, & Gold, 1984). Adults with PTSD present with a range of memory impairments including deficits in declarative, non-declarative, short-term, and long-term memory (Bremner, 1999). The severity of hypercorticolism correlated with decreases in hippocampal volume in CD (Starkman, Gebarski, Berent, & Schteingart, 1992) and PTSD (reviewed by Sapolsky, 1996).

Research also examined the aging population who show decreases in fluid intelligence, recall memory, and processing speed with increasing age (Kaufman & Lichtenberger, 1999). Lupien et al. (1994) followed healthy elderly participants over a 4 year period. They found impaired declarative memory and selective attention only in those individuals whose cortisol increased to a high level. Participants whose cortisol levels decreased performed as well as young controls. However, differences in cortisol levels were not related to short term memory, long term memory, divided attention, implicit memory, and verbal fluency. Lupien et al. (1997) found that elderly participants who showed increased cortisol in anticipation of a public speaking task, had more impaired declarative memory afterwards.

Although the clinical and aging studies supported the association between cortisol and cognitive impairment, their results are not generalizable to healthy non-elderly populations. These studies were confounded by other psychological and physiological processes including medication effects that are specific to the given population. Methodological issues included small sample sizes and non-random treatment assignment designs which preclude causal inferences. For example, decreases in hippocampal volume seen in patients with PTSD and depression may be a predisposing factor for the disorder rather than a consequence (Sapolsky, 1996). Also, studies differed in criteria for matching control individuals. Some studies matched the psychiatric and the control group on overall IQ indices or the vocabulary subtest; whereas, others included these measures in the test battery comparing the two groups. Only Wolkowitz et al. (1990) consistently applied the same measure of cognition to different populations (depressed and healthy) and used different chemical compounds to elicit high cortisol levels in the healthy participants. Individuals with high cortisol levels showed more errors of commission on declarative verbal memory tasks but similar rates of omission errors as controls. The authors concluded that elevated cortisol impairs selective attention.

In general, studies with healthy non-elderly adults showed an inverted U-shaped relationship between cortisol levels and cognition, analogous to the Yerkes and Dodson (1908) arousal and performance curve (Lupien & McEwen, 1997). Thus, it appears that both too low and too high cortisol levels are associated with cognitive impairment whereas moderate cortisol is associated with optimal performance on cognitive tasks. Most studies compared performance on tasks that are known to be mediated by the hippocampus such as verbal declarative memory and those that are not such as nondeclarative verbal memory. This line of research showed that high cortisol levels were related to impaired verbal declarative memory as measured by delayed recall of word lists (Kirschbaum, Wolf, May, Wippich & Hellhammer, 1996; Newcomer, Craft, Hershey, Askins & Bardgett, 1994; Newcomer et al., 1999) although one study showed enhanced verbal declarative memory (Domes, Heinrichs, Reichwald & Hautzinger, 2002) and some studies showed no significant effects (Bohnen, Houx, Nicolson, & Jolles, 1990; Lupien, Gillin, & Hauger, 1999). Correspondingly, Lupien et al. (2002) found that pharmacologically decreased cortisol was related to impaired verbal declarative memory. Also, most studies found no relationship between cortisol and nondeclarative verbal memory as measured by word stem completion tasks (Domes et al., 2002; Kirschbaum et al., 1996) although Lupien et al. (2002) found that low cortisol levels were associated with faster reaction time on these tasks.

Studies of performance on short-term memory tasks (immediate recall of word lists) showed both deleterious effects (Brandenberger, Follenius, Wittersheim & Salame, 1980; Vedhara, Hyde, Gilchrist, Tytherleigh & Plummer, 2000) and facilitative effects (Beckwith, Petros, Scaglione & Nelson, 1985; Wittersheim, Brandenberger & Follenius, 1985) of increased cortisol. The work of Beckwith et al. (1985) suggested the differential effects of practice not taken into account by most studies. Lupien, Gillin et al. (1999) found an inverted U-curve relationship between cortisol dosage and performance on working memory tasks but Vedhara et al. (2002) did not replicate it in a study of cortisol levels induced by university examination stress.

Other studies examined the relationship between cortisol and subtypes of attention. Bohnen et al. (1990) found deficits in divided attention in participants with a high cortisol response. Vedhara et al. (2000) found impaired divided and selective attention in participants with low cortisol responses. Born, Kern, Fehm-Wolfsdorf and Fehm (1987) found an association between elevated cortisol and evoked-related potentials related to arousal. In contrast, studies found no relationship between cortisol and measures of sustained attention (Lupien et al., 1999; Newcomer et al., 1999) and selective attention (Born et al., 1987; Newcomer et al., 1999). Some studies examined cognitive abilities rarely included in others. Kirschbaum et al. (1996) found elevated cortisol to be related to deficits in spatial reasoning and memory, but this was not replicated by Newcomer et al. (1999). Newcomer et al. (1999) also examined verbal executive function measured by verbal fluency and found no effects.

The inconsistent findings regarding cortisol and distinct cognitive abilities may be in part attributed to methodological differences which make generalizations across studies difficult. Pharmacological methods of inducing decreased or elevated cortisol ranged from single to multiple doses administered to the participant over several days. Studies relied on different compounds such as dexamethasone which are not necessarily equivalent to high basal cortisol levels (Lupien & McEwen, 1997; Wolkowitz et al., 1990). Even the use of exogenously administered cortisol (hydrocortisone) may induce other physiological effects such as changes in other hormones (Mendl, 1999). Other studies attempted to 'naturally' induce secretion of cortisol through a variety of 'stressful' experiences such as prolonged mental effort or public speaking and mental arithmetic (Trier Social Stress Test; Kirschbaum, Pirke & Hellhammer, 1993). These manipulations were not always successful as some participants show elevated cortisol in response to simply being present in the laboratory (Domes et al., 2000) and performing cognitive tasks (Brandenberger et al., 1980). Only one study (Kirschbaum et al., 1996) included both pharmacological and psychosocial stressors and consistently found high cortisol levels to be associated with impaired declarative memory but these results should be replicated in future studies.

Furthermore, researchers differed in their approach to cognitive testing – some focused on very specific abilities and used tests that are presumed to tap only those while others use extensive test batteries. Many of the specific cognitive tests used lacked normative data. On the other hand, many of the standardized measures such as the WAIS III (Wechsler, 1997) and WMS III (Wechsler, 1997) subtests tap into multiple cognitive functions based on many brain regions. Most studies did not consider reaction time data (Lupien et al., 2002). Also, only a few studies (e.g., Newcomer et al., 1999) explicitly discussed whether their observed cognitive deficits were clinically significant in addition to being statistically significant. Additionally, the majority of studies focused on the effects of elevated cortisol on cognition while the issue of hypocorticolism has been addressed only recently and requires deeper investigation.

Finally, many studies did not adequately address the issue of sex differences. Many studies studied one sex exclusively (e.g., Domes et al., 2002; Lupien et al., 2002) or the sample size was too small to examine sex differences (e.g., Kirschbaum et al., 1996). Wolf, Schommer, Helhammer, McEwen and Kirschbaum (2001) reported a significant relationship between cortisol increase due to the Trier Social Stress Test and impaired verbal declarative memory in adult men but not in women. The authors proposed the role of sex hormones or developmentally programmed sex differences as possible explanations. Additionally, as reviewed above, studies of cognitive development suggested some sex differences but it is unknown how these interact with cortisol levels.

Cortisol and Cognition in Children

Recently, researchers recognized the need to study glucocorticoid effects on cognition in preschool children (Bremner, 1999; Hellfinger & Newcomer, 2001). As reviewed above, the brain, including the hippocampus, continues to develop during this period and damage during different developmental stages may have different effects (Bremner, 1999). Also, it is difficult to generalize adult findings to child populations since abilities such as verbal declarative memory may still be developing in the young child.

Clinical studies of children with hypercorticolism are rare as depressed children and adolescents do not show it (Kaufman, Martin, King & Charney, 2001; Puig-Antichet al., 1989). Bender, Lerner and Kollasch (1988) investigated the relationship between low and high doses of corticosteroid treatment given to severely asthmatic children (age 8 to 16 years). At high doses, children exhibited impairments in long term verbal memory but no differences were found on measures of sustained attention. Findings of decreased verbal memory due to high doses of steroids were replicated by Bender, Lerner and Poland (1991). As reviewed above, results of clinical studies are difficult to generalize to non-clinical populations. However, administration of cortisol and other corticosteroid compounds would be unethical in healthy child populations.

Heffelfinger, Luby, Mrakotsky and Newcomer (cited in Heffelfinger & Newcomer, 2001) reported a study with preschool children which resembled the results of adult studies. Higher cortisol responses to mild psychological stress were related to impaired pre- and post-stress declarative memory tested by immediate and delayed recall. The high responders also had lower scores on verbal factual knowledge. Davis, Bruce and Gunnar (2001) examined 6-year-olds' performance on the Go/No-go task which taps the ability to inhibit a previously rewarded response and a selective attention task. They found that more accurate performance on both tasks was associated with higher cortisol levels at home and in the laboratory. However, these cortisol levels may not have been high enough to impair cognition (Davis et al., 2001). In contrast, Lupien et al. (2001) found no direct relationship between cortisol levels and cognitive abilities (declarative and nondeclarative memory, sustained attention, and verbal fluency) assessed in a group format in 6 to 16 year olds.

Interestingly, Tennes and Kreye (1985) found that children's overall intelligence mediated their cortisol response to normal classroom routine and academic testing. Using measures of urinary cortisol, the authors found that on non-test days, children of average intelligence showed increased cortisol than children of high or low intelligence. On test-days, children of average and high intelligence showed higher cortisol levels than children of low intelligence. Surprisingly, there was no relationship between cortisol levels and self-reported test anxiety. These results are difficult to interpret, given that an increase in cortisol may be indicative of arousal (an adaptive response) or stress (a maladaptive response).

Cortisol and Behaviour Styles in Children

In general, studies pointed to an association between cortisol profiles and maladaptive and adaptive behaviour, in both clinical and normative populations. However, the findings of associations between specific behaviour styles and specific HPA activity (e.g. cortisol hyper- or hypocorticolism) were inconsistent. Research with antisocial adult males found that decreased cortisol levels correlate with severity of aggression (Virkkunen, 1985). However, studies of cortisol levels in aggressive children and adolescents produced mixed results. Some reported decreased baseline cortisol (McBurnett, Lahey, Rathouz & Loeber, 2000; Pajer, Gardner, Rubin, Perel & Neal, 2002), others found no differences in baseline but a decreased stress response (van Goozen et al., 2000); still others found no differences in either baseline or stress response (Klimes-Dougan et al., 2001; Scerbo & Kolko, 1994). In normative samples, observed hostility towards teacher and peers in second grade children was negatively associated with urinary cortisol (Tennes & Kreye, 1985; Tennes, Kreye, Avitable, & Wells, 1986).

Similarly, mixed associations have been found between HPA activity and behavioural inhibition. Temperamentally shy children tend to delay approaching novel social situations, remain close to their mothers and show negative affect (Kagan, Reznik, & Snidman, 1987, 1988; Schmidt et al., 1997). They are more likely to develop anxiety disorders (Hirshfeld et al., 1992). Some studies showed that behavioural inhibition in preschoolers and toddlers was associated with elevated morning cortisol levels (Kagan et al., 1987, 1988, Schmidt et al., 1997). Others failed to find this association (de Hann, Gunnar, Tout, Hart & Stansbury, 1998; Davies, Donzella, Krueger, & Gunnar, 1999; Schmidt, Fox, Schulkin & Gold, 1999). Furthermore, Sanchez-Martin et al. (2001) found a curvilinear relationship where both low and high cortisol levels were associated with social isolation in preschool. Gunnar, Tout, de Haan, Pierce, and Stansbury (1997) showed that socially solitary preschoolers with high negative affect had elevated cortisol levels several weeks after beginning a new school but not necessarily immediately after. In a referred sample of children and adolescents, Granger et al. (1994) found that a cortisol increase in response to a conflict-oriented discussion with a parent was related to social withdrawal, social anxiety and social difficulties, as well as inhibited behaviour during the task. The high cortisol responders also perceived themselves and other children as having less personal control over life events. In another referred sample, low social competence was associated with high cortisol responses to the conflict discussion (Granger, Weisz, McCracken, Ikeda, & Douglas, 1996). Similar patterns were observed in a high risk sample (Granger et al., 1998). In contrast, Jansen et al. (1999) found social withdrawal to be associated with a blunted cortisol response to physical exercise in a heterogeneous child psychiatric sample.

Despite the findings of elevated cortisol relating to behavioural inhibition, studies also found elevated basal cortisol and cortisol reactivity in assertive and socially skilled children in preschool and early elementary years. Gunnar et al. (1997) showed that outgoing, socially skilled and liked by peers children had an elevated cortisol response to beginning preschool which disappeared during the following weeks. Davies et al. (1999) replicated these findings in older children beginning a new elementary school year. Similarly, classroom observers' ratings of social engagement with peers and on-task academic work were positively related to urinary cortisol in 2nd Grade children (Tennes & Kreye, 1985). These studies suggest that a cortisol increase in response to a social and/or academic context may also reflect an adaptive increase in arousal which helps the child to deal with the situation.

Finally, cortisol activity has been linked to self regulation abilities in children. Effortful control is a temperament dimension that influences how well children can regulate their behaviour and emotion under stressful conditions (Derryberry & Rothbart, 1997 cited in Donzella, Gunnar, Krueger, & Alwin, 2000). It implies the ability to purposefully regulate behaviour, to inhibit a prepotent response and direct attention to relevant stimuli (Bjorklund & Kipp, 1996, cited in Davis et al., 2001). Donzella et al. (2000) found that children who showed a salivary cortisol response to a rigged competition with an adult were described by teachers as more surgent and lower in effortful control. However, most children in the study did not show a cortisol response to the competition. Gunnar et al. (1997) found that preschoolers with attention and inhibitory control deficits had higher median cortisol. The authors proposed two alternative interpretations: (1) Children with attention and self regulation deficits create situations that activate the HPA axis; or (2) Elevated cortisol affects neural systems underlying attentional and inhibitory abilities. Similarly, children with high negative emotionality and low self-control showed increases in cortisol across the day in daycare, which was opposite to the expected circadian rhythm. This pattern was more likely in 3-4 year olds rather than 5 year olds as social interaction was likely more challenging to the younger age group. (Dettling, Gunnar, & Donzella, 1999; Dettling, Parker, Lane, Sebanc, & Gunnar, 2000) Also, Scerbo and Kolko (1994) found a relationship between elevated cortisol and inattention/overactivity in children with disruptive behaviours. However, not all studies found a relationship between cortisol and attention and effortful control deficits (Davies et al., 1999; Davis et al., 2001).

In summary, existing research showed that differences in cortisol levels were related to maladaptive (aggression, behavioural inhibition, self-regulation deficits) and adaptive behavioural styles (social and academic engagement). However, consistent patterns between specific cortisol profiles and specific behaviours were difficult to discern.

Present study

The reviewed research showed that preschool children's scores on measures of cognitive ability were influenced by their current state of cognitive and neural development while certain specific cognitive abilities were mediated by sex of the child. However, as recognized by clinicians and researchers, standardized tests do not provide error-free estimates of children's ability. Studies reviewed above showed that children's behaviour during the testing session influenced their obtained scores. Furthermore, studies on the physiological stress reactivity suggested that children may experience a change in cortisol levels in response to the novel testing experience. Previous work found cortisol under- and over-secretion to be associated with performance on cognitive tasks (particularly those mediated by the hippocampus). Furthermore, elevated and decreased cortisol levels were linked to adaptive and maladaptive behaviour styles.

However, no researcher to date has assessed the interrelations among all three domains in preschool children: cognitive ability, behavioural and cortisol response to the testing session in one study. Consequently, the goal of the current study was to examine preschoolers' behavioural and cortisol responses to cognitive assessment and how these related to the children's obtained cognitive scores.

Children participating in this study were recruited from the Francophone population in Montreal, Canada. Their cognitive abilities were assessed using a French edition of the Stanford-Binet IV (SB IV; Thorndike, Hagan, & Sattler, 1986) and Peabody Picture Vocabulary Test Revised (EVIP, Dunn, Theriault–Whalen, & Dunn, 1993) which were administered during two home visits. Salivary cortisol samples were collected immediately prior, during and after the SB IV test on the first day of testing. Following the cognitive assessment, the examiner filled out two sets of behaviour rating items which were used to derive factors describing the child's behaviour during the testing session. Also, the mother filled out the Child Behaviour Checklist (CBCL; Achenbach, 1991) as a measure of her child's problem behaviours in everyday life.

Study Hypotheses

Firstly, the study sought to derive dimensions describing preschool children's behaviour during the testing session based on examiner ratings of adaptive and maladaptive behaviour. Based on existing research, one or two highly correlated dimensions were expected to underlie test session behaviour. Subsequently, the relationships between the test behaviours factors and: (1) demographic data; (2) obtained cognitive scores (global IQ, verbal, nonverbal and individual subtests); (3) problem behaviours reported by the mother using the CBCL; were examined. Older children were expected to show more adaptive behaviour. Also, it was predicted that adaptive behaviour would be positively related to all cognitive scores.

Secondly, the study assessed children's cortisol levels prior, during and after the testing session and their relationship to: (1) cognitive scores; (2) test session behaviours; (3) problem behaviours reported by the mother. Given the mixed results of existing studies, no specific predictions were made regarding these relationships.

Thirdly, path models describing the hypothesized interrelationships among cortisol levels, test session behaviour factors and cognitive scores in preschool-aged children were tested. Based on the literature review, it was predicted that cortisol and cognitive ability may be related in two ways: (1) Directly, where cortisol levels predict cognitive test scores; (2) Indirectly, where cortisol levels predict child's adaptive behaviour during the testing session which in turn is positively related to the child's cognitive test scores. It was also expected that child's adaptive behaviour would be predicted by age. See Figure 1 for the hypothesized model.

Finally, the current study examined sex differences in the study variables. Existing studies documented a female advantage in verbal declarative memory (Geffen et al., 1990; Kimura & Clarke, 2002) which is mediated by the hippocampus and was linked to cortisol levels (Jameison, & Dinan, 2001). Also, some studies suggested sex differences in cortisol reactivity (Kirschbaum et al., 1992, 1999, 2000). Given the small sample size, child sex could not be included in the path analyses. Consequently, hierarchical multiple regressions were used to verify whether the same patterns of results were seen for girls and boys separately as with the two sexes combined. Given the mixed results of existing studies, no specific predictions were made regarding these relationships.

Method

Participants

Participants in the current study were drawn from a larger, ongoing longitudinal study, the Concordia Longitudinal Risk Project (CLRP). This project began in 1976 with the recruitment of 4, 109 francophone school children (Grades 1, 4 and 7) from French public schools in inner-city, low-socioeconomic areas of Montreal, Quebec. For a complete description of the original longitudinal study, see Schwartzman, Ledingham, and Serbin (1985).

Current Sample

The sample for the current study was recruited from those CLRP first generation participants (both male and female) who had become parents to date, and included 85 mothers and their children. Only one child per mother was included in the study. The mothers in the current study were Caucasian and francophone, living in or in proximity to Montreal, Quebec. At the time of birth of their first child, the women's ages ranged from 19.42 to 37.56 years (M= 26.57, SD= 3.33). At the time of testing, they ranged in age from 24.24 to 43.22 years (M= 31.40, SD=3.38) and had from 1 to 6 children (M=2.11, SD=0.95). Thirty-nine (45.9%) of the women were married, 30 (35.3%) were living common law, 9 (10.6 %) were single, 5 (5.9%) were separated, one (1.2%) was divorced and one was widowed. The mothers' education level ranged from 5 to 18 years (M= 11.69, SD= 2.31). In the province of Quebec, eleven years of school represents high-school graduation; 22 (25.9%) of the women in this sample did not meet this criterion.

Mothers' occupational prestige was rated using a scale designed by Rossi, Sampson, Bose, Jasso and Passel (1974). The ratings ranged from 15.4 (corresponding to occupations of an unskilled factory worker and hotel chambermaid) to 58.9 (corresponding to occupations of accountant and orchestra musician). The mean rating of 32.7 (*SD*= 9.92) corresponded to occupations such as bookbinder and machine operator. The mothers' annual family income ranged from $8 430 to $127 982 (*M*= $39 689, *SD*=$23 933). Thirty six (42.3 %) annual family incomes were below the poverty line or considered 'working poor', out of which 19 families (22.4 % of the whole sample) received social assistance.

The 85 children in the study sample ranged from 2.97 to 6.03 years old (*M*= 4.83, *SD*= 0.85). There were 45 boys and 40 girls. Their mean birth order was 1.71 (*SD*=0.90; range: 1 to 6). Their overall IQ score, based on the Stanford Binet IV, ranged from 73 to 132 (*M*= 100.18, *SD*=11.88). Seventy-seven children were administered the French edition of the Peabody Picture Vocabulary Test and their scores ranged from 74 to 143 (*M*= 106.58, *SD*=16.49). See Table 1 for descriptive sample data.

Procedure

The data for this study were collected between September, 1996, and April, 1998. Potential participants were contacted by telephone and informed of the general nature and procedures of the study, but they were not informed of the specific research hypotheses. Upon consent, the Demographic Information Questionnaire (DIQ; see Appendix A) was administered over the telephone. Also, two home visits of 3 hours each were scheduled, separated by a one week interval.

The home visits were conducted by an M.A. level psychologist and a research assistant. The psychologist conducted the psychometric testing, whereas, the research assistant interviewed the mother. Both examiners were kept blind as to the risk status of all participating families.

The sessions included a number of tasks such as intellectual assessment, naturalistic observations, interviews, questionnaires and saliva sampling. At the beginning of the first visit, the psychologist described the protocol to the mother and asked her to read and sign an informed consent form (see Appendix B). Then, the psychologist administered the Stanford Binet IV (SB IV; Thorndike, Hagan, & Sattler, 1986) to assess the current intellectual functioning of the child. At the same time, the research assistant administered a series of interviews and questionnaires to the mother in order to assess her and her child's physical health, behaviour, temperament and parenting practices. If required, both the SB IV and mother interview were completed during the second session. During the second session, the psychologist also administered the French edition of the Peabody Picture Vocabulary Test (EVIP; Dunn, Theriault-Whalen & Dunn, 1993) to assess receptive language skills. Following the second testing session, the psychologist rated the child's behaviour during SB IV and EVIP administration using the Ratings of Children's Behaviour During Testing Scale (RCBT, Rodgers, 1995) and Bayley's Behaviour Rating Scale (Bayley, 1993).

During both sessions, the mother and child participated in a series of structured interactions that were videotaped in order to provide observational measures of maternal stimulation, temperament and other variables. The observation tasks included free play sessions, a structured puzzle task, and an interference task; these are further described in Karp (2000) and Saltaris and Samaha (1998). However, the cognitive testing sessions were not videotaped. See Appendix C for a complete protocol for both home visits.

Measures

All measures used in this study were in French. If French translations were not available, English measures were translated into French.

Socio-demographic information

The Demographic Information Questionnaire (DIQ; see Appendix A) was administered during the initial telephone contact to obtain socio-demographic information on each participating family. Data obtained included parents' current age, age at first childbearing, marital and occupational status, years of education, annual family income, number of children in the family and their birthdays.

Child's cognitive abilities

a) Stanford Binet IV

The French edition of the Stanford Binet IV (SB IV: Thorndike et al., 1986) was administered to assess the child's current cognitive functioning. This intelligence test is designed for 2 to 23 year olds and is well standardized. The SB IV provides a composite index of general intellectual functioning (M=100, SD=16) and is composed of 15 different subtests which are presumed to tap into different abilities. The sets of subtests administered depend both on the child's chronological age and his or her performance on the routing vocabulary subtest. Thus, the children in the current study (aged from 3 to 6 years) received the following subtests: vocabulary, comprehension, absurdities, pattern analysis, copying, quantitative, bead memory, and memory for sentences. Factor analytic studies for the youngest age group (2 to 6 years) did not support the existence of four separate factors as presumed by Thorndike et al. (1986). Thus, for this age group a two-factor solution was proposed, consisting of a Verbal Comprehension factor and Nonverbal Visualization/reasoning factor (Keith, Cool, Novak, White & Pottenbaum, 1988; Sattler, 1988, 1992, 2001). The Verbal Comprehension composite score was computed based on the vocabulary, comprehension and absurdities subtests. The Nonverbal Reasoning/visualization composite score was computed based on the pattern analysis, copying, quantitative and bead memory subtests. Also, the examiners noticed that the children frequently responded with Quebecois phrases on the memory for sentences subtest for which they were penalized by the Parisian French answer scheme. Consequently, scores on the memory for sentences were excluded from the analyses and the overall IQ score was prorated.

Sattler (1988, 1992, 2001) discussed the strong psychometric properties of SB IV. The composite IQ score has high internal consistency (median: 0.97) and high test-retest reliability in samples of 5- and 8-year-olds (0.97). The individual subtests have relatively high internal consistencies (range: 0.73 to 0.94) and high to low test-retest reliabilities (range: 0.28 to 0.90). Concurrent validity of SB IV was supported by its relatively high median correlation (0.80) with other intelligence tests. Construct validity was established in several ways: (1) raw scores increase with age; (2) factor analytic studies; (3) moderate to high correlations between subtest scores and the composite scores.

b) Peabody Picture Vocabulary Test

A French translation of the Peabody Picture Vocabulary Test Revised (Echelle de vocabulaire en images Peabody, EVIP, Dunn et al., 1993) was used to assess the child's receptive language skills. The EVIP is suitable for individuals from of 2 ½ years old to adulthood. The examiner reads out a word and the child is asked to select one of four pictures which best represents the word. The EVIP takes 10 to 15 minutes to administer and produces a normed index of receptive language (M=100; SD=15; range: 40 to 160).

The French version was standardized on a large sample of French-Canadian children. The EVIP overall score has a median split-half reliability of 0.81 and a median test-retest reliability of 0.72. Sattler (1992) reviewed the validity evidence based on the English edition (PPVT-R; Dunn & Dunn, 1981). The PPVT-R correlated highly with other cognitive ability tests such as the WISC-R (median r = .68), but was correlated more strongly with verbal subtests than nonverbal. The PPVT-R was also related to measures of reading, language and achievement (r's range from 0.30 to 0.63).

Children's behaviour during testing

a) Ratings of Children's Behaviour During Testing Scale

The Ratings of Children's Behaviour During Testing Scale (RCBT, Rodgers, 1995) was used to assess the children's adaptive and maladaptive behaviour during the administration of the SB IV and the EVIP. This 24-item questionnaire (see Appendix D) assessed attention, motivation, problem solving style, anxiety and response to the examiner. Each item was scored on a 5-point Likert scale from "Never" to "Always". Items which assess maladaptive behaviours were reverse coded so that a high score always reflected adaptive behaviour. Cooperman (1999) found the internal consistency of the RCBT to be 0.93. One item was dropped from the analyses, "Benefits from instruction on difficult items.", as it was deemed inapplicable to the cognitive testing protocol.

b) Bayley's Behaviour Rating Scale

The second questionnaire which assessed child's behaviour during testing was an adaptation of the Behaviour Rating Scale (BRS; Bayley, 1993), originally developed for infants and toddlers. Behaviour ratings were collected on 18 items taken from this scale (See Appendix E). Three items were dropped from the analyses due to their inapplicability to preschool children tested in their home ("Soothability when upset", "Hypersensitivity to test materials", and "Exploration of objects and surroundings'). Each item was scored on a 5-point Likert scale where 1 reflected extremely maladaptive behaviour or complete lack of adaptive behaviour and 5 reflected lack of maladaptive behaviour or high adaptive behaviour. As the Behaviour Rating Scale was developed for 1 to 42 month old children, psychometric data is only available for this age group which partly overlaps with the present study's sample. As reviewed by Bayley (1993), the BRS has high internal consistency (mean $r = .86$), moderately high test-retest validity (mean $r = .64$) and high interscorer agreement (mean $r = .82$). Construct validity was assessed using factor analysis. BRS items used in the current study loaded on two factors, Emotion Regulation and Orientation/Engagement in the oldest age group (13 to 42 months). Criterion-related validity of the BRS was established by assessing its ability to differentiate children with significant impairments from children developing normally.

c) Test Behaviour Items List

The 23 retained items from the Ratings of Children's Behaviour During Testing Scale (RCBT, Rodgers, 1995) and the 15 retained items from the Behaviour Rating Scale (Bayley, 1993) were collapsed into a list of 38 items to be included in the analyses.

Children's behaviour styles outside of testing

a) Child Behaviour Checklist 4 – 18 (CBCL; Achenbach, 1991)

Problem behaviours outside of testing were assessed using the CBCL which is a standardized questionnaire for parents of children age 4 to 18 years of age. Parents indicated which of 118 problem behaviours are exhibited by their child. The questionnaire generated T scores that reflected a child's problem status relative to same gender peers. There were three overall scales (Total Problem, Externalizing and Internalizing Behaviours) and nine subscales: Anxiety/Depression (e.g., feels unhappy, sad or depressed); Somatic Complaints (e.g., stomachaches without medical cause); Social Problems (e.g., does not get along with other children); Aggression (e.g., gets in many fights); Delinquency (e.g., vandalism); Attention Problems (e.g., cannot concentrate); Social Withdrawal (e.g., shy or timid); Thought Problems (e.g., hears or sees things that are not there); Sex Problems (e.g., wishes to be of the opposite sex). As reviewed by Achenbach (1991), the CBCL has moderate to high internal consistency (Cronbach's alpha values: .54 - .96), and high one-week test-retest reliability (mean $r =$ .89). CBCL's construct validity was supported by its moderate to high correlations ($r =$ .59 - .86) with analogous scales such as the Conners (1973) Parent Questionnaire. CBCL's criterion validity was demonstrated by its ability to discriminate between referred and non-referred children.

Saliva Cortisol Samples

Saliva samples were collected from both the mother and the child, immediately prior, during and immediately after the Stanford Binet IV test. Times at which each saliva sample was taken were recorded. Participants were asked to hold a strip of filter paper (65mm x 25mm) under their tongue until it was saturated with saliva. Subsequently, the filter paper was air dried and stored in individual plastic containers at -20°C until assay. The cortisol assays were performed at the Douglas Hospital Research Laboratories (DHRL). Cortisol levels were established via competitive protein binding radioimmunoassay using a technique developed by Krey et al. (1975). Previous studies at the DHRL determined the variability of intra- and inter-assay reliability and validity coefficients to be well within acceptable ranges (3.5 to 5.0 %). Sensitivity unique to saliva cortisol is high (Laudat et al., 1988). Cortisol antibody (F3314) was acquired from Endocrine Sciences, CA, and other [3H] cortisol was obtained from New England Nuclear, MA to serve as the tracer.

Descriptive Cortisol Data

Fifty-six children provided three valid cortisol samples, 64 provided at least two and no child provided only one valid sample ($M = 2.16$, $SD = 1.28$). Consequently, the sample sizes were as follows: 62 first cortisol samples, 60 second samples and 62 third cortisol samples. See Table 2 for descriptive cortisol data.

Forty-two children were tested in the morning (first sample taken at M = 9:39 am, SD = 20 minutes), 20 in the afternoon (first sample taken at M = 1:44 pm, SD =36 minutes), and time data were missing for 2 children. The time interval between first and second saliva sample ranged from 16 minutes to 1 hour and 25 minutes (M = 43 minutes, SD = 12 minutes). The time interval between the second and the third saliva sample ranged from 16 minutes to 1 hour and 23 minutes (M = 30 minutes, SD = 13 minutes). The inconsistent timing of cortisol sampling may be attributed to the variable time of SB IV administration across participants.

Results

Overview

The results are presented in five sections. The first section describes the test behaviour factor analyses using the overall sample (*N*=85). The second section describes the comparisons between children who complied with the saliva protocol (*n*=64) and those who did not (*n*=21). The third section examines the relations between cortisol and study variables. Next, path models of relations among child cortisol, age, test behaviour and overall IQ are presented. Finally, hierarchical multiple regressions predicting child IQ for the combined sample with cortisol (*n*=64) and separately by child sex (34 boys, 28 girls) are presented.

All reported bivariate correlations are two-tailed and all post hoc comparisons were conducted with Bonferroni corrections. If the Levine test for inequality F-value in independent groups t-tests was significant, the t-test value for unequal variances is reported. Significance level was set at $p < .05$.

Preliminary Analyses for Overall Sample

Preliminary analyses indicated no differences between girls and boys in age, family income, SB IV and EVIP scores, CBCL data or test behaviour factors in the overall study sample (*N* = 85). All study variables except cortisol were normally distributed.

Test Behaviour Factors

Complete test behaviour data (38 item ratings) were collected for 77 children. Seven children had one item rating missing each. Mean substitution was used for those 7 missing item ratings (Tabachnick & Fidell, 1996). One child had only 3 out of possible 39 item ratings and was excluded from all analyses involving the test behaviour data.

An overall Principal Components Analysis (PCA) with an oblimin rotation was conducted on the 38 items based on data from 84 children. The PCA produced 7 factors. Inspection of the eigen values and scree plot pointed to the first two factors as accounting for the most variance. The respective eigen values and percentages of explained variance by each factor were: 15.94 (41.93%) and 4.37 (11.50%). Each set of items which loaded highly on each of the first two factors was entered again into a PCA to verify that it constituted a single factor (Bonneville, 2003). The first obtained factor, Attentiveness/ Compliance (AC), was based on 14 items (See Tables 3 and 4). High scores on AC indicated high levels of attentiveness and compliance. The second factor, Nervous/ Anxious (NA), was based on 5 items (See Tables 5 and 6). The NA factor was inverted so that high scores indicated high levels of nervousness and anxiety. Consistent with predictions, the AC and NA factors were highly negatively correlated, $r = -0.49$, $p < .001$. Factor reliabilities were estimated using Cronbach's (1951) alpha and were found to be high for both the AC, $r = 0.95$, and NA, $r = 0.88$, factors.

Test Behaviour Factors and Child Demographic Data

The next set of analyses focused on the relationships between the derived test behaviour factors and child demographic data. Consistent with predictions, AC was positively related to child's age, $r = .25$, $p < .05$. Older children showed higher levels of attentiveness and compliance. Contrary to predictions, NA was not significantly related to age. Neither test behaviour factor was significantly related to child sex.

AC was positively, $r = .27$, $p < .01$, and NA was negatively, $r = -.31$, $p < .01$

related to family income, indicating that higher rates of adaptive behaviour during testing were observed in children from families with higher income. Also, there was a trend for a negative relationship between NA and mother's education, $r = -.18$, $p < .10$, indicating that mothers with higher education had children who showed less nervousness or anxiety during cognitive testing.

Test Behaviour Factors and Cognitive Scores

Consistent with predictions, both test behaviour factors were low to moderately correlated with all SB IV and EVIP scores (AC: mean bivariate $r = .38$; NA: mean bivariate $r = -.30$). Consequently, children who were more attentive, compliant and less nervous or anxious during the test session obtained higher cognitive test scores. As shown by the partial correlations, AC was more strongly uniquely related to cognitive scores, mean partial $r = .28$, than NA, mean partial $r = -.14$. Table 7 presents the bivariate and partial correlations between cognitive scores and test behaviour factors.

To examine the clinical utility of these findings, t-tests were used to compare children who exhibited highly adaptive behaviours (scoring in the top 25 % of each factor) and those who exhibited highly maladaptive behaviours during testing (scoring in the bottom 25 % of each factor). As Table 8 shows, children who exhibited highly adaptive behaviours scored on average 12 points higher on the SB IV and 14 points higher on the EVIP than children who showed highly maladaptive behaviours.

Test Behaviour Factors and Child Problem Behaviours

Bivariate correlations between the CBCL 4-18 scales and the test behaviour factors were also examined and are presented in Table 9. CBCL 4-18 data were obtained from 70 mothers whose children were at least 4 years old. AC was negatively related to the CBCL 4-18 Total Problem score, $r = -.26$, $p < .05$; Internalizing Problem Scale, $r = -.29$, $p < .05$; and the Anxiety/Depression subscale, $r = -.23$, $p < .10$. NA was not significantly related to any of the CBCL 4-18 indices. These results suggest that children who were more attentive and compliant during testing had lower rates of mother-rated internalizing problems. At the same time, only 3 out of 24 correlations were significant, indicating weak relationships between behaviour observed during testing and mother-reported problem behaviours.

Comparing children who did and who did not comply with the request for saliva samples

Twenty one out of the 85 children failed to comply with the examiner's request for saliva samples. Consequently, group differences between children who complied with the saliva protocol ($n = 64$) and those who did not ($n = 21$) were analyzed. Independent t-tests with a Bonferroni correction were conducted on demographic variables and study variables to look for group differences as a function of compliance with the saliva protocol.

In general, children who provided saliva samples scored higher on the cognitive measures (See Table 10). Furthermore, children who provided saliva samples showed more adaptive test session behaviour as evidenced by higher scores on AC, $t\,(82) = -2.80$, $p < .01$, and lower scores on NA, $t\,(82) = 2.08$, $p < .05$. Also, children who complied with the request for saliva had mothers who reported higher numbers of years of education ($M = 12.05$, $SD = 2.30$) than those children who did not ($M = 10.62$, $SD = 2.06$), $t\,(83) = 2.54$, $p < .01$. There was also a modest trend for children with saliva samples to come from families with higher income (M = \$41 919, SD = \$24 551) than children without (M

= 32 895, *SD* = 21 042), *t* (83) = -1.51, $p < .14$. No group differences were found on child age, rank in the family, number of children in the family, and CBCL scales. Also, there were no differences in proportions of girls and boys in both groups.

Cortisol Samples

Cortisol concentrations in saliva samples are reported in μg/dl. Consistent with other studies, the distributions of the three salivary cortisol samples were positively skewed. Thus, the cortisol data were log transformed. The transformed data were normally distributed and were used in all analyses. However, non-transformed data are reported in all tables and text to facilitate interpretation. One outlier (exceeding 3 standard deviations above the mean) was recoded to 2.00 μg/dl, just above the highest value that was not considered an outlier (1.99 μg/dl). There were slight variations in sample sizes in cortisol analyses due to missing data.

Preliminary Analyses in the Sample with Cortisol Data

Consistent with the results for the overall sample, preliminary analyses in the sample of children with cortisol values ($n = 64$) showed no differences between boys and girls on age, family income, SB IV and EVIP scores, CBCL data or NA. However, a trend was found for girls to score higher on AC than boys, *t* (62) = -1.78, $p < .10$.

Time of Collection

Given the documented diurnal rhythm of cortisol secretion, analyses were conducted to examine the impact of time of collection. A 2 x 3 time (morning vs. afternoon) x sample (first, second and third) ANOVA indicated no significant main effects or interaction involving time of cortisol collection. However, the lack of significant effects may be explained by the large variability in the cortisol data (See Table 2 for standard deviations). Cortisol samples from children tested in the morning and in the afternoon were analyzed together without controlling for time of collection.

Relationships Among the Three Cortisol Samples

Table 13 presents the intercorrelations among the three cortisol samples. The first cortisol sample was positively related to the second and third cortisol samples. The second cortisol sample was not significantly related to the third cortisol sample.

Cortisol and Demographic Variables

None of the three cortisol samples were significantly related to child's age and family income. Also, no sex differences were noted for the first and second cortisol sample. However, girls had higher mean cortisol values ($M = 0.36$, $SD = 0.46$) than boys ($M = 0.19$, $SD = 0.25$) on the third cortisol sample, $t\ (60) = -2.06$, $p < .05$.

Cortisol and Cognitive Scores

Bivariate correlations indicated that none of the three cortisol samples was significantly related to any of the cognitive test scores on the SB IV or the EVIP (See Table 11).

Cortisol and Test Behaviour Factors

The AC test behaviour factor was positively related to the first cortisol sample, $r = .39$, $p < .01$, and there was a trend for a positive relationship with the second cortisol sample, $r = .24$, $p < .10$. Thus, children who were more attentive and compliant during the cognitive testing exhibited higher cortisol levels prior to and during testing. In contrast, the NA test behaviour factor was not significantly related to any of the cortisol samples (See Table 13).

Cortisol and CBCL Problem Behaviours

Bivariate correlations between the three cortisol samples and the CBCL indexes indicated only one significant correlation: the first cortisol sample was negatively related to the child's score on the Withdrawal subscale as rated by the mother, $r = -.33$, $p < .05$, $n = 53$. Also, there was a trend for a negative relationship between the first cortisol sample and the Internalizing Behaviours Scale, $r = -.25$, $p < .10$. However, since a large number of correlations was investigated (36), these significant correlations may have been spurious (See Table 12).

Path Analyses

Structural Equation Modelling (SEM) using EQS 5.7 for Windows (Bentler, 1998) was used to test the hypothesized model of relations among child cortisol, age, behaviour during test session and overall IQ score. Unfortunately, the high correlation between AC and NA test behaviour factors could not be accounted for in the path model due to EQS specifications which do not allow correlations between variables that are both independent and dependent variables (Bonneville, 2003). Also, given the small sample size, it was not feasible to include the three cortisol samples in the same model. Consequently, it was decided to test AC and NA, as well as the three cortisol samples in separate models. Thus, six models were tested, based on a permutation of two test behaviour factors by three cortisol samples. Maximum likelihood estimation was used to estimate all models. See Table 13 for intercorrelations among the study variables.

Model with Attentiveness/Compliance Test Behaviour Factor

The hypothesized model was based on Figure 1 where child behaviour was indicated by the AC test behaviour factor, child's cortisol was indicated by the first cortisol sample and child cognitive ability was assessed using the overall IQ on the SB IV. According to this model, child's overall IQ score was predicted directly by both initial cortisol levels and AC, whereas AC was predicted directly by child's age and initial cortisol levels. Results of the χ^2 statistic and Comparative Fit Indices indicated that this model poorly fit the sample data: χ^2 (2, N = 62) = 9.32, $p < .01$, NFI = 0.75, NNFI = 0.28, CFI = 0.76.

Post hoc modifications were performed in order to develop a better fitting model. On basis of the Lagrange Multiplier test, a path predicting child IQ score from child age was added. The addition of this path resulted in a reasonably well-fitting model: χ^2 (1, N = 62) = 1.98, $p = .16$, NFI = 0.95, NNFI = 0.81, CFI = 0.97. The chi-square difference test indicated that the model was significantly improved by the addition of this path, $\chi^2_{d.ff}$ (1, N = 62) = 7.34, $p < .01$.

Subsequently, the path predicting child IQ from initial cortisol levels was dropped as its coefficient was non-significant. The re-estimated model was well-fitted: χ^2 (1, N = 62) = 1.98, $p = .37$, NFI = 0.95, NNFI = 1.00, CFI = 1.00. This model indicated that child's initial cortisol levels were only indirectly related to child IQ via their link with AC during testing. Cortisol and child age were both positively related to AC, indicating that older children and children with higher initial cortisol levels showed higher rates of adaptive behaviour during testing. AC was positively related to child IQ, indicating that children who were more attentive and compliant during testing obtained higher cognitive scores. Also, child age was negatively related to child IQ, indicating that older children obtained lower overall IQ scores than younger children. All path coefficients were significant ($p < .05$).

The model indicated that initial cortisol levels and children's age accounted for 21% of variance in AC. Also, children's age and AC accounted for 27% of variability in children's cognitive test scores. See Figure 2 for the final model and path coefficients.

Two subsequent path models which included the second and third cortisol samples were tested separately. These models were also based on the hypothesized model (Figure 1) but given the results in Figure 2, they included a direct path predicting child IQ from child age. Both models indicated reasonably high fit. Goodness-of-fit data for model including the second cortisol sample was as follows: χ^2 (1, $N = 60$) = 0.35, p = .55, NFI = 0.99, NNFI = 1.18, CFI = 1.00. The goodness-of-fit data for the model including the third cortisol sample was as follows: χ^2 (1, $N = 62$) = 1.17, $p = .28$, NFI = 0.96, NNFI = 0.95, CFI = 0.99. However, the path coefficients for the direct path from cortisol to child IQ scores and cortisol to AC were not significant in both models. Consequently, these paths were dropped but the resulting model was overfitted, thus, goodness-of-fit data could not be assessed. The remaining path coefficients describing relations among child age, AC and IQ score remained highly similar to those depicted in Figure 2.

Model with Nervous/Anxious Test Behaviour Factor

The following model analyses were also based on Figure 1. In these analyses child behaviour was indicated by the NA test behaviour factor, child's cortisol was indicated by the first cortisol sample and child cognitive ability was assessed using the overall IQ on the SB IV. According to this model, child's overall IQ score was predicted directly by initial cortisol levels and NA, whereas NA was predicted directly by child's age and initial cortisol levels. Results of the χ^2 statistic and Comparative Fit Indices indicated that this model did not fit the sample data: χ^2 (2, N = 62) = 5.63, $p < .01$, NFI = 0.62, NNFI = -0.21, CFI = 0.60. The Lagrange Multiplier test did not suggest any paths to be added that would improve the model fit significantly.

Corresponding path models with the second and third cortisol samples were also tested. These models are not presented in Figures since goodness-of-fit data for both were indicative of a poor fit: Second cortisol sample, χ^2 (2, N = 62) = 3.25, $p < .20$, NFI = 0.76, NNFI = 0.51, CFI = 0.84; Third cortisol sample, χ^2 (2, N = 62) = 2.90, $p < .23$, NFI = 0.79, NNFI = 0.64, CFI = 0.88. As with the model with the first cortisol sample, the Lagrange Multiplier test did not suggest any paths to be added that would improve the model fit significantly.

Predicting Cognitive Ability in Boys and Girls

Hierarchical regressions were conducted to predict overall cognitive ability as indicated by the composite IQ score on the SB IV for the full sample, and for boys and girls separately. All variables were converted to z-scores prior to entering them in the multiple regressions. Adjusted R^2 values were used to estimate the percentage of explained variance.

Bivariate correlations between the dependent variable (cognitive ability) and independent variables are reported for the entire sample in Table 13 and separated by sex in Table 14. As can be seen in the referred tables, the bivariate correlations between the independent variables varied from small to large, $r = .00$ to $r = .71$. None of these correlations exceeded the 0.90 criterion suggested for the presence of multicollinearity (Tabachnick & Fidell, 1996). However, given the high correlation between AC and NA in the girls' sample, $r = -.70$, and the combined sample, $r = -.48$, the two factors were analyzed in separate regressions.

For the combined sample, the hypothesized predictors were entered in the following order: child age and sex, first cortisol sample, test session behaviour factor (AC or NA) and child sex by first cortisol sample interaction. For the separate boys' and girls' samples, the hypothesized predictors were entered in the following order: child age, first cortisol sample, and test session behaviour factor (AC or NA). Given that only the first cortisol sample emerged as a significant predictor in the path analyses described above, the second and third cortisol samples were not included in the regression analyses.

Sample with Both Genders Combined

The hierarchical multiple regression which included boys and girls together and the AC test behaviour factor yielded a multiple R that was significantly different from zero, $F = 5.19, p < .001$. All the predictors together accounted for 26% of the variance (See Table 15). The child's cognitive ability was significantly predicted by child's age (Beta = -.30, $p < .01$), but only once AC was entered in the regression equation. This indicated that once AC was controlled for, the older children were shown to score lower on the SB IV than younger children. Also, the child's overall cognitive ability was significantly predicted by AC (Beta = .49, $p < .01$), indicating that children who were more attentive and compliant obtained higher cognitive test scores.

Furthermore, a significant interaction of sex and first cortisol sample (Beta = .25, $p < .05$) emerged after all other variables were entered into the regression equation. As demonstrated in Figure 3, girls with initial cortisol values above the mean scored higher on the SB IV than girls with cortisol values below the mean. In contrast, boys with initially lower cortisol scored higher on the SB IV than boys with higher initial cortisol.

The hierarchical multiple regression which included boys and girls together and the NA test behaviour factor yielded a multiple R that was significantly different from zero, $F = 2.54$, $p < .05$. All the predictors together accounted for 11% of the variance (See Table 16). There was a trend for the child's cognitive ability to be predicted by age (Beta = -.23, $p < .10$) once NA was controlled for but the trend was no longer evident once the sex by cortisol interaction was entered. In the final step, there were trends for cognitive ability to be predicted by NA (Beta = -.22, $p <. 10$) and interaction of sex and first cortisol sample (Beta = .22, $p <. 10$). These results suggest that children who were less nervous and anxious during testing obtained higher scores. The sex by first cortisol sample interaction was not examined as it was a trend only.

Predicting Cognitive Ability in Boys

The hierarchical multiple regression which included boys only and the AC factor yielded a trend for a multiple R to be different from zero, $F = 2.55$, p <.10. All predictors together accounted for 12% of the variance. Boys' cognitive ability was significantly predicted by age (Beta = -.39, $p < .05$) and AC (Beta = .37, $p < .05$) indicating that higher cognitive scores were predicted by younger age and higher attentiveness and compliance during testing (See Table 17).

The hierarchical multiple regression which included boys only and the NA factor yielded a multiple R that was not significantly different from zero, $F = 1.21$, n.s. Consequently, the results of the regression were not interpreted (See Table 18).

Predicting Cognitive Ability in Girls

The hierarchical multiple regression which included girls only and the AC test behaviour factor yielded a multiple R that was significantly different from zero, $F = 11.80$, $p < .001$. All the predictors together accounted for 55% of the variance. The first cortisol sample significantly predicted cognitive ability in girls (Beta = .55, $p < .001$) when their age was controlled for. However, once AC was entered into the regression equation, the positive relationship between initial cortisol levels and cognitive ability became a trend only (Beta = .26, $p <.10$). The girls' AC scores significantly predicted cognitive ability (Beta = .67, $p < .001$) suggesting that girls who were more attentive and compliant during testing obtained higher test scores. These results suggest that in girls cortisol is related to cognitive ability both directly and indirectly, via its link with AC. See Table 19 for the regression analyses.

The hierarchical multiple regression which included girls only and the NA test behaviour factor yielded a multiple R that was significantly different from zero, $F = 4.92$, $p < .001$. All the predictors together accounted for 38% of the variance. The first cortisol sample significantly predicted cognitive ability in girls (Beta = .55, $p < .001$) when their age was controlled for. Entering NA scores did not result in a significant step, consequently, its results were not interpreted. See Table 20 for the regression analyses.

Discussion

Cognitive development is a fundamental process in children's growth and maturation. Many standardized cognitive ability tests were designed to assess individual and age-related differences in children's cognitive ability. Accurate assessment during the preschool years is crucial for the development of early childhood education and early intervention programs (Johnson, Howie, Owen, Baldwin & Luttman, 1993). However, as indicated by a small research area, the validity of scores obtained on standardized tests is dependent on the child's behaviour during assessment. Inattentive and/or disruptive children tend to obtain significantly lower scores on composite measures of cognitive ability; whereas, children who comply with the demands of the testing situation tend to score higher (Glutting et al., 1996). The impact of behaviour is very important in a population that shows a wide range in behaviour such as preschoolers.

In addition to a behavioural response to the testing situation, children are also likely to respond on a physiological level, as suggested by the rapidly growing literature on the hypothalamic-pituitary-adrenal axis and its principal product, cortisol. Studies found associations between cortisol levels and performance on various cognitive tasks, especially verbal declarative memory. Similarly, differences in cortisol profiles have been linked to various adaptive and maladaptive behavioural styles. The goal of the current study was to assess how preschool children's cognitive test scores are influenced by both their behavioural and physiological responses to the cognitive assessment process.

Test Session Behaviour

The first objective of the study was to assess children's behaviour during the standardized assessment and its impact on the obtained cognitive scores. Two factors were derived based on examiner's ratings of child behaviour. The most variance was accounted for by the Attentiveness/Compliance factor which described the child's conformity with the test requirements and instructions. The second factor, termed Nervous/Anxious described nervousness, fearfulness and apparent lack of confidence.

The two factors were negatively correlated as high scores on Attentiveness/Compliance and low scores on Nervous/Anxious indicated adaptive behaviour. The magnitude of the correlation was consistent with previous studies (Campbell et al., 1994; Glutting & McDermott, 1988; Glutting et al., 1989; Konold et al., 1998) which found two or three highly correlated dimensions describing test behaviour in referred and non-referred children.

As predicted, older children exhibited higher rates of attention and compliance. Contrary to predictions, scores on the Nervous/Anxious factor were not associated with age. The reason for this distinction may lie in the focus of each factor. The Attentiveness/Compliance factor assessed behaviours specific to the assessment situation. In contrast, the Nervous/Anxious factor may have tapped a more social, temperament-oriented dimension of behaviour such as the response to an unfamiliar stranger. The more global nature of the second factor may explain its lack of association with age (Kagan et al., 1987, 1988).

Both test behaviour factors were positively related to family income, indicating that children from higher SES backgrounds exhibited higher rates of adaptive behaviour. Two studies which examined samples with more variable SES (Glutting et al., 1994; Oakland & Glutting, 1990) found little effect of SES. However, as most studies recruited participants from middle- and upper-class backgrounds, the impact of SES on children's behaviour during assessment should be further addressed in future studies with more representative samples.

Consistent with study hypotheses, children with higher rates of appropriate behaviours scored significantly higher on global, verbal, nonverbal indices and individual

SB IV subtests. Comparisons between children who scored in the upper and lower quartiles of each factor showed that on average, children with highly adaptive behaviours scored 12 points higher on the SB IV composite and 14 points higher on the EVIP than children with highly maladaptive behaviours. These differences reflect the magnitude of almost one standard deviation on the SB IV composite ($SD = 16$ points) and the EVIP ($SD = 15$ points). These results underscore the need for examiners to account for the impact of children's behaviour on their scores on tests of cognitive ability.

The study also examined the relationships between test session behaviour and mother-rated problem behaviours on the CBCL. Children with lower rates of mother-rated anxious/internalizing behaviours were more attentive and compliant with cognitive test demands. Surprisingly, scores on the Nervous/Anxious factor were not related to any of the CBCL subscales, even the Anxiety/Depression subscale. These results may reflect compromised validity of the two test behaviour factors. Alternatively, the lack of clear associations between different measures of similar constructs may be attributable to methodological differences such as (1) different raters with very different levels of familiarity with the target child; (2) different contexts of behaviour assessment (individual testing session vs. everyday situations). Also, nervousness and anxiety during cognitive testing may not necessarily be indicative of internalizing problems in general.

The current study's results point to the importance of collecting systematic behaviour observations when conducting cognitive assessment of preschool children. Behaviour ratings are straightforward and efficient to fill out. As noted by Glutting et al. (1989) test behaviour observations help determine whether a child's obtained score is valid and verify proper testing procedures by ensuring that the child is comfortable, motivated and aware of expectations. However, as discussed by Watson (1951) behavioural observations are not without their caveats. At times, it may be difficult to distinguish purely behavioural observations (what an individual did) from the clinician's inferences about the meaning of the behaviour. Also, one needs to be aware of individual differences in behaviour. For example, a child who frequently looks around the room may have strong divided attention skills rather than attention difficulties. Furthermore, the examiner needs to be aware of sources of error in ratings such as stereotyping by experienced raters based on their prior experience and subjective impressions.

Cortisol Sampling Patterns

The second goal of the study was to assess the pattern of interrelationships among cortisol levels in saliva, test session behaviours and overall cognitive ability. Regrettably, valid cortisol samples were collected only from 75% of the participating children. Analyses showed that children who provided saliva samples scored higher on cognitive measures, were more attentive and compliant, and less nervous or anxious during testing. Also, their mothers had higher education and there was a trend for children complying with the saliva protocol to come from families with a higher income.

Although this led to a biased sample for the second part of the study, the lack of saliva samples from less compliant children is not surprising. Children who attend to and comply with the examiner's instructions during cognitive testing are more likely to comply with other instructions such as "hold this strip of paper in your mouth until it's wet". Unfortunately, cortisol levels cannot be independently observed like overt behaviour. Furthermore, despite the significant differences between the two groups, the mean overall SB IV scores for each group were both classified in the 'Average range' and the variability in cognitive scores were similar in both groups. Consequently, the two groups did not have clinically different levels of cognitive ability.

Descriptive Cortisol Findings

Based on the documented circadian rhythm in cortisol release (Kiess et al., 1995; Sapolsky, 1992), one would expect the children tested in the morning to exhibit higher cortisol levels than children tested in the afternoon. However, in the current study, cortisol concentrations in the three samples were not related to the time of saliva sampling. One explanation would be the large variability of the cortisol data in general. Alternatively, cortisol levels may have increased in the afternoon due to a meal. Ward, Brathwaite, Maloney, Lee, Polan and Lipper (1995) (cited in Watamura, Sebanc & Gunnar, 2002) documented an increase in children's cortisol levels 45 minutes after a meal. Unfortunately, the current study did not account for timing of meals prior to saliva collection. However, the possibility that cortisol levels peaked in the afternoon is supported by a previous study conducted in the same laboratory and which included some of the same participants. Cortisol levels were sampled in young children (age 2 to 6) every two hours across one waking day. The results showed an afternoon peak in cortisol levels which was not quite as high as the peak shortly after awakening (Ben-Dat, 2002).

The current study found no significant differences among the cortisol samples collected prior, during and after the SB IV. As the SB IV was administered shortly after the examiners' arrival, the initial cortisol levels may be interpreted as the HPA response to the entry of unfamiliar people to the home. Consequently, on average children did not show a different physiological response to the entry of the examiners rather than the cognitive testing per se. This is not surprising as cognitive testing tends to be introduced to children as a series of games in order to decrease their anxiety and/or boredom. Habituation and increased familiarity with the examiner likely served to further control arousal. Furthermore, preschool children may not be aware that their performance is being evaluated like older children and adults would be. Consequently, younger children may be expected to exhibit less physiological arousal and anxiety due to testing.

Path Model of Interrelations among Cortisol, Test Behaviour and Cognitive Ability

Based on the literature review, a model describing the relations among cortisol, age, test behaviour and overall cognitive ability was proposed (See Figure 1). It was expected that cortisol and cognitive ability would be related in two ways: (1) Directly, where cortisol levels predict cognitive test scores; (2) Indirectly, where cortisol levels predict child's adaptive behaviour during the testing session which in turn is positively related to the child's cognitive test scores. It was also expected that child's adaptive behaviour would be predicted by age.

The path analyses showed that a modified model fit the data better (See Figure 2). This model indicated that the child's initial cortisol levels were only indirectly related to child IQ via their positive association with Attentiveness/Compliance during testing. Cortisol and child age were both positively related to child's Attentiveness/Compliance, indicating that older children and children with higher initial cortisol levels showed higher rates of adaptive behaviour during testing. Also, Attentiveness/Compliance was positively related to child IQ, indicating that children who were more attentive and compliant during testing obtained higher cognitive scores. Finally, child age was negatively related to child IQ, indicating that older children obtained lower overall IQ scores than younger children. Each of the documented significant and non-significant relationships will be discussed separately.

Interestingly, only the cortisol sample obtained prior to testing was significantly and positively related to children's attentive and compliant behaviour during testing. The first cortisol sample may be conceptualized as the physiological response to the entry of the unfamiliar examiners into the child's home. Higher cortisol levels were associated with attentive and compliant behaviour during testing and consequently, with higher cognitive scores. At the same time, lower cortisol levels were associated with less adaptive behaviour during testing and consequently with lower cognitive scores. This pattern of results may be explained by interpreting cortisol levels as a marker of arousal. Arousal can be viewed in behavioural terms as increased rate of response, vigour and response output or as physiological activation of the organism's sympathetic nervous system (Ferguson, 2000). The current study's findings are consistent with Born et al. (1987) who found an association between elevated cortisol and evoked-related potentials related to arousal in adults. Unfortunately, children's behaviour was observed only in the context of testing. Consequently, there is no data on children's behaviour during and immediately after the collection of the first cortisol sample. It would be interesting to examine whether increased cortisol levels were associated with greater behavioural arousal in terms of children's attentiveness and responsivity to the examiner shortly after her arrival and prior to the onset of testing.

The current study did not find any direct relationships between cortisol levels and cognitive ability as assessed by the composite score, verbal, nonverbal indices and individual subtest scores in the overall sample. As previously reviewed, the clinical utility (i.e., normative data) of standardized tests comes at a price. Standardized cognitive tests produce global estimates only since their individual subtests tap multiple abilities, mediated by different brain regions. One of the more consistent findings in the adult and animal literature is that hippocampus-mediated cognitive abilities (e.g., verbal declarative memory in humans) are more likely to be related to cortisol levels. Child studies that found significant relationships between cortisol and cognition in children (Bender et al., 1988, 1991; Heffelfinger et al.) used tasks tests measuring verbal declarative memory. Verbal declarative memory is mediated by the hippocampus (Nelson & Carver, 1998) which has the highest concentration of cortisol receptors in the brain (Sapolsky, 1996). Besides the current study, no other research has examined the relationship between cortisol and standardized measures of cognitive ability in children such as the SB IV. Adult studies that used standardized measures of cognitive ability found significant relationships between cortisol levels and cognitive performance but these were conducted with clinical samples only such as PTSD (Bremner, 1999) and Cushing's Disease (Starkman et al., 2001). Thus, it is difficult to compare their findings to those of the current study.

Furthermore, the present study measured cortisol levels on a single day of testing in young children in their familiar environment. It is possible that the children did not experience cortisol levels that were high enough to induce impairments in cognitive ability. Also, children who did experience significant elevations in cortisol, may not have experienced them for long enough to induce cognitive impairment. Based on animal data, Lupien, Nair et al. (1999) argued that it is the cumulative exposure of the hippocampus to high levels of cortisol that is detrimental for an organism rather than acutely high levels of cortisol at one point in an individual's life. Without longitudinal data in cortisol levels, it is not possible to examine the impact of chronic exposure to high cortisol on children's cognitive abilities.

Surprisingly, after controlling for children's attentive and compliant behaviour during testing, a negative correlation was found between the SB IV composite score and children's age. This finding may indicate that older children in the study's sample are actually performing worse than the younger children. Breakdown of the sample by sex of the participant suggested that it was the boys who performed worse with increasing age.

Alternatively, one may question the validity of the SB IV scores in different age groups. The SB IV may be overestimating the ability of younger children or underestimating the ability of older children. The first proposition is supported by the literature on the validity of SB IV with toddlers and younger preschoolers. Johnson et al. (1993) and Robinson, Dale and Landesman (1990) noted that if a child fails to get at least one item correct on a SB IV subtest, that subtest is dropped and the overall composite score is prorated. Consequently, children who get one item correct on a subtest receive a lower composite score than those who got none correct. Saylor, Boyce, Peagler, and Callahan (2000) found that the SB IV failed to detect large proportions of preschoolers with cognitive delays in a high risk sample. Flanagan and Alfonso (1995) and Sattler (1992, 2000) also concluded that the SB IV has inadequate floors for children with delays or youngest children tested. Vig and Jedrysek (1996) found that the SB IV verbal scores overestimated the ability of young children with language impairments. In a sample of gifted children, the SB IV produced scores that were 8 points higher (1/2 standard deviation) than K-ABC (Hayden, Furlong, & Linnemeyer, 1988). Although these studies suggest that the validity of SB IV scores for the youngest children is suspect, it is difficult to explain why the SB IV would be overestimating the scores of young boys and not girls.

Unfortunately, it is not possible to determine whether the older children are truly scoring lower than the younger children or whether the result is an artefact of the SB IV's poor validity in youngest age groups, without an independent measure of cognitive ability. However, it is important to note that if the children's attentive and compliant behaviour was not explicitly controlled for in the analyses, the negative association between child age and SB IV IQ score would not have been found.

Nervous/Anxious Behaviour during Testing

The current study did not find significant associations between nervous and anxious behaviour and cortisol levels during testing. This is consistent with existing studies that also did not document a relationship between cortisol and behavioural inhibition (Davies, et al., 1999; de Hann et al., 1998; Schmidt et al., 1999). However, as reviewed in the introduction, research on cortisol and behavioural inhibition has produced mixed findings.

Sex Differences

The results showed a trend for girls to have higher cortisol levels after cognitive testing than boys. The issue of sex differences in HPA activity remains largely unstudied in child populations. Adult studies showed that men tend to show higher salivary cortisol responses to psychosocial (Kirschbaum et al., 1992, 1999, 2000) and cognitive stressors (Seeman, Singer, Wilkinson, & McEwen, 2001) than women. Assuming that adult findings may be generalized to child populations, it appears that the boys in the current study are showing a lower cortisol response than would be expected based on the adult findings.

The final set of analyses examined predictors of overall cognitive ability in the combined sample and separately for boys and girls. The combined sample hierarchical regressions showed a significant sex by first cortisol sample interaction. Girls with higher cortisol levels scored higher on the SB IV than girls with lower cortisol levels. The opposite pattern was noted for boys where high cortisol levels were associated with lower SB IV composite scores. Thus, it appears that for girls an increase in cortisol levels is adaptive and maladaptive for boys. This finding is consistent with Wolf et al. (2001) who reported a significant relationship between cortisol increase due to the Trier Social Stress Test and impaired verbal declarative memory in men but not in women.

Furthermore, analyses in the girls' sample showed that girls' SB IV scores were both directly related to cortisol levels and indirectly via the Attentiveness/Compliance behaviour. This finding supports the hypothesized direct relationship between cortisol and cognition which was not apparent in the whole sample. Given the lack of research into sex differences in cortisol reactivity in children, it is difficult to explain why this relationship was seen in preschool girls and not boys. The pattern should be replicated in future studies with larger samples before it can be interpreted.

Study Limitations

The main limitation of the current study is its small sample size. Consequently, results need to be replicated with a much larger sample, particularly those associated with participants' sex. Furthermore, the use of the Stanford Binet IV which has questionable validity for youngest children has obscured the interpretation of the finding that children's cognitive ability scores declined with age. The study should be replicated with a more recent standardized measure of cognitive ability for preschoolers such as WPSSI-R (Wechsler, 1989) or the recently released WPSSI-III (Wechsler, 2002).

Also, the current study has several limitations in regards to the collection of cortisol data. The sample was biased in favour of children with slightly higher IQ scores, rates of adaptive behaviour and SES. Furthermore, there was no control for time of awakening which determines the timing of the circadian release of cortisol (Sapolsky, 1992) and time of meals which are associated with cortisol increases (Ward et al., 1995, cited in Watamura et al., 2002). Furthermore, recent studies that looked at children's cortisol reactivity to stressful situations such as beginning preschool (Gunnar et al., 1997) or elementary school (Davies et al., 1998) collected comparison cortisol samples on non-stressful days such as weekends. Consequently, future studies of physiological reactivity to standardized testing should compare cortisol measured during testing to cortisol measured at similar times on a non-testing routine day. Also, in the current study, cortisol samples were not systematically collected at equal time intervals throughout the administration. This may be attributed to the variable time of administration of standardized tests of cognitive ability across participants.

Two final limitations of the current study are shared by most of the cortisol literature in children and adults. Studies tend to classify elevated or decreased cortisol levels relative to the changes in cortisol secretion seen in a given study's sample. However, there appears to be little emphasis on comparison of specific magnitudes of 'high' and 'low' cortisol levels across studies. Given the mixed findings of the associations between cortisol and cognition or behaviour styles, a metanalysis comparison of studies may help elucidate the recurring patterns in data.

Finally, although individual differences in cortisol basal and reactivity levels have been documented (Negrao et al., 2000; Stone et al, 2001), studies still lack adequate control for individual differences. A promising biological marker is the cortisol level measured shortly after awakening which was shown to be relatively stable in individuals (Pruessner et al., 1997).

Concluding Comments and Future Directions

The current study examined preschoolers' behavioural and cortisol responses to standardized cognitive assessment conducted in their home. The results showed that children who are observed to be highly attentive and compliant with little nervousness or anxiety, scored almost a standard deviation higher than children who showed extremely maladaptive behaviours. These findings emphasize the need for clinicians and researchers to assess and evaluate the impact of children's behaviour styles during standardized cognitive testing. Given the current interest in early childhood education and prevention (Johnson et al., 1993) it is very important for psychometric examiners to be able to assess the reliability and validity of an individual child's scores. Future directions in this area should focus on developing reliable and valid instruments for assessing test session behaviour in preschool populations, which would be co-normed for use with popular standardized tests of cognitive ability such as the SB IV or WPSSI-III (Wechsler, 2002). Currently, only the GATSB (Oakland & Glutting, 1997) provides a standardized measure of test session behaviour in elementary school-aged children that has been co-normed with the WISC III (Wechsler, 1991).

The second purpose of the study was to examine children's physiological responses to cognitive testing. The study added to the growing literature on cortisol and HPA reactivity in young children by demonstrating that children who show elevated cortisol in response to meeting the unfamiliar examiner, tend to be more attentive and compliant during testing and consequently obtain higher cognitive scores. Interestingly, a direct, positive relationship for cortisol levels and composite IQ scores was demonstrated in girls but not boys. These patterns should be replicated in larger samples. Also, future work should consider the impact of other hormones in the HPA cascade such as CRH and ACTH which have also are related to cognitive effects (reviewed in Mendl, 1999). Perhaps one day, clinicians will be able to evaluate the validity of cognitive testing by monitoring the child's physiological as well as behavioural responses.

Tables

Table 1

Means, Standard Deviations and Ranges for Demographic Information for Overall Sample (N=85)

	M	*SD*	*Range*
Mother's Current Age	31.40	3.38	24.24 – 43.22
Mother's Age at first child	26.57	3.33	19.42 – 37.56
Number of children	2.1	0.95	1 - 6
Maternal Education (Years)	11.69	2.31	5 - 18
Occupational Prestige[a]	32.7	9.92	15.4 - 58.9
Family Income	\$39 689	\$23 933	\$8 430 - \$127 982
Child's Current Age	4.83	0.85	2.97 – 6.03
Child's SB IV Full Scale IQ	100.18	11.88	73 - 132
Child's EVIP Overall score[b]	106.58	16.49	74 - 143

[a]Scale of Occupational Prestige (Rossi et al., 1974)

[b]Echelle de vocabulaire en images Peabody (*N*=77) (Dunn et al., 1993)

Table 2

Cortisol (μg/dl) Descriptive Data

	n	*M*	*SD*	Range
Cortisol sample 1 (Pre-test)	62	0.35	0.38	0.01 - 1.61
Cortisol sample 2 (During test)	60	0.35	0.45	0.01 - 2.00
Cortisol sample 3 (After test)	62	0.26	0.37	0.01 - 1.91

Table 3

Item Means and Standard Deviations for the Items Included in the Attentiveness/Compliance Factor (N = 84)

Items	*M*	*SD*
Persistence	3.51	0.92
Enthusiasm towards tasks	3.64	0.99
Concentration-focused attention	3.29	0.89
Cooperation	4.08	0.85
Persistent	3.10	1.06
Attention to tasks	3.66	0.80
Requires encouragement to persist on tasks (R)	2.99	1.02
Intrinsic pleasure from completing tasks	3.22	0.97
Initiative with tasks	3.58	0.87
Interest in test materials	3.51	0.86
Requires encouragement to initiate tasks (R)	3.40	1.06
Responsive to praise	3.66	0.90
Impulsive-careless errors (R)	3.23	0.83
Negative Affect	3.79	1.05

Note. Items scored so that higher scores indicate more adaptive behaviour (higher attentiveness and compliance).

Table 4

Attentiveness/Compliance Factor Item Loadings.

Item	Item loading
Persistence	0.93
Enthusiasm towards tasks	0.86
Concentration-focused attention	0.85
Cooperation	0.84
Persistent	0.82
Attention to tasks	0.80
Requires encouragement to persist on tasks (R)	0.79
Intrinsic pleasure from completing tasks	0.79
Initiative with tasks	0.75
Interest in test materials	0.75
Requires encouragement to initiate tasks (R)	0.73
Responsive to praise	0.72
Impulsive-careless errors (R)	0.67
Negative Affect	0.61

Note. (R) Items reverse coded so that higher values indicate more adaptive behaviour.

Eigen value: 8.66

Variance accounted for: 61.86%

Table 5

Item Means and Standard Deviations for Items Included in the Nervous/Anxious factor (N=84).

Item	*M*	*SD*
Nervous anxious	2.77	1.07
Tense – not relaxed	3.01	1.05
Fearfulness	1.87	0.93
Low confidence in competence	2.87	0.76
Low positive affect	2.29	1.09

Note. Items scored so that higher scores indicate higher nervousness and anxiety.

Table 6

Nervous/Anxious Factor Item Loadings

Item	Item loading
Tense – not relaxed	0.88
Nervous anxious	0.87
Fearfulness	0.84
Low positive affect	0.76
Low confidence in competence	0.75

Note. Item descriptions were re-written to be consistent with high scores indicating high levels of nervousness and anxiety.

Eigen value: 3.39

Variance accounted for: 67.71%

Table 7

Bivariate and partial correlations between Stanford Binet IV, EVIP scores and Test Behaviour Factors (N=84).

	Attentiveness/Compliance		Nervous/Anxious	
	bivariate r	partial r	bivariate r	partial r
SB IV Full Scale IQ	.49**	.38**	- .38*	-.18[t]
Verbal Comprehension	.42**	.28**	- .42**	-.26*
Vocabulary	.20[t]	.06	- .30**	-.24*
Comprehension	.30**	.20[t]	- .26*	-.13
Absurdities	.42**	.31**	- .34*	-.17
Nonverbal Reasoning/Visualization	.51**	.40**	- .38**	-.17
Pattern Analysis	.40**	.30**	- .30**	-.13
Copying	.50**	.43**	- .28*	-.05
Quantitative	.26*	.17	- .22*	-.11
Bead Memory	.27*	.21*	- .18[t]	-.05
EVIP Overall Score (n=77)	.46**	.39**	- .28*	-.06

Note. Partial correlations were computed between all SB IV indices and each test behaviour factor while controlling for the other factor.

$^{**}p < 0.01$, $^{*}p < 0.05$, $^{t}p < 0.1$.

Table 8

T-tests Comparing Children Who Exhibited Highly Adaptive and Maladaptive Behaviours on Both Test Behaviour Dimensions.

	Overall IQ SB IV			Total EVIP score		
	M	*SD*	*t*	*M*	*SD*	*t*
Attentiveness/Compliance[a]						
Adaptive (n=23)	106.35	9.75		113.90	14.83	
Maladaptive (n=20)	92.30	13.60		95.56	17.91	
			-3.93**			-3.41**
Nervous/Anxious[b]						
Adaptive (n=20)	103.33	10.92		111.96	14.68	
Maladaptive (n=27)	93.20	14.83		102.33	18.25	
			2.70*			1.87^t

[a] Attentiveness/Compliance: Adaptive corresponds to scores above 75th percentile; Maladaptive corresponds to scores below 25th percentile.

[b] Nervous/Anxious: Adaptive corresponds to scores below 25th percentile; Maladaptive corresponds to scores above 75th percentile.

$^{**}p < 0.01$, $^{*}p < 0.05$, $^{t}p < 0.1$.

Table 9

Bivariate Correlations Between the Two Test Behaviour Factors and CBCL Indices (n=70).

	Attentiveness/Compliance	Nervous/Anxious
Total Problem	-.26*	.08
Externalizing Behaviours	-.14	.06
Internalizing Behaviours	-.29*	.08
Anxiety/Depression	-.23^{t}	-.01
Somatic Complaints	-.07	-.04
Social Problems	-.13	.07
Aggression	-.19	.02
Delinquency	-.16	.07
Attention Problems	-.14	.01
Sex Problems	-.05	-.17
Social Withdrawal	-.19	.11
Thought Problems	-.08	-.07

**$p < 0.01$, *$p < 0.05$, $^{t}p < 0.1$.

Table 10

Means (standard deviations) and t-test values of SB IV and EVIP scores as function of compliance with the request for saliva samples.

	No saliva provided (n = 21)		Saliva provided (n = 64)			
	M	*SD*	*M*	*SD*	*t*	$p <$
Stanford Binet IV Full scale IQ	92.95	11.08	102.55	11.23	-3.41	.001**
Verbal Comprehension	87.81	11.87	93.97	12.52	-1.98	.051[t]
Vocabulary	49.14	5.82	48.31	6.77	0.50	ns
Comprehension	45.86	5.65	48.77	5.82	-2.00	.049*
Absurdities	48.52	7.57	52.16	5.51	-2.04	.051[t]
Nonverbal Reasoning/Visualization	91.67	11.07	103.25	11.62	-4.01	.001**
Pattern Analysis	52.19	7.10	54.67	7.43	-1.34	ns
Copying	47.71	10.52	52.97	8.15	-2.09	.046*
Quantitative	46.00	6.48	49.88	6.29	-2.43	.017*
Bead Memory	44.81	4.86	49.89	7.00	-3.08	.003*
EVIP Overall Score[a]	103.71	17.53	107.40	16.24	-0.81	ns

[a] For the EVIP, the sample sizes are 17 children without and 60 with saliva samples.

Table 11

Bivariate Correlations Between the Three Cortisol Samples and the Cognitive Scores.

	Cortisol Samples		
	1.	2.	3.
SB IV Full Scale IQ	.14	.14	.10
	(*N*=62)	(*N*=60)	(*N*=62)
Verbal Comprehension	.11	-.06	-.05
	(*N*=62)	(*N*=60)	(*N*=62)
Vocabulary	.07	-.10	.07
	(*N*=62)	(*N*=60)	(*N*=62)
Comprehension	.01	-.08	.02
	(*N*=62)	(*N*=60)	(*N*=62)
Absurdities	.18	.17	-.21
	(*N*=61)	(*N*=59)	(*N*=61)
Nonverbal Reasoning/Visualization	.14	.18	.14
	(*N*=62)	(*N*=60)	(*N*=62)
Pattern Analysis	.02	.13	.14
	(*N*=62)	(*N*=60)	(*N*=62)
Copying	.06	.19	.20
	(*N*=62)	(*N*=60)	(*N*=62)
Quantitative	.14	.13	-.10
	(*N*=62)	(*N*=60)	(*N*=62)
Bead Memory	.12	.10	.05

	(*N*=62)	(*N*=60)	(*N*=62)
EVIP Overall Score	-.01	-.05	-.15
	(*N*=58)	(*N*=56)	(*N*=62)

Note. Due to missing values, sample sizes are unequal across cells.

$^{**}p < 0.01$, $^{*}p < 0.05$, $^{t}p < 0.1$.

Table 12

Bivariate Correlations Between the Three Cortisol Samples and the CBCL Indices.

	Cortisol Samples		
	1. (*N*=53)	2. (*N*=52)	3. (*N*=53)
Total Problem	-.17	-.10	-.07
Externalizing Behaviours	-.05	-.04	-.15
Internalizing Behaviours	-.25^{t}	-.15	.04
Anxiety/Depression	-.04	.01	.11
Somatic Complaints	-.04	-.02	.20
Social Problems	.07	.09	.19
Aggression	-.03	-.01	-.19
Delinquency	-.01	-.18	.12
Attention Problems	-.08	-.06	.10
Sex Problems	-.10	-.10	.01
Social Withdrawal	-.33*	-.11	-.05
Thought Problems	.02	.08	-.12

**$p < 0.01$, *$p < 0.05$, $^{t}p < 0.1$.

Table 13

Intercorrelations Among Cortisol Samples, Age, Sex, Test Behaviour and Cognitive Ability in Children Who Provided Valid Cortisol Samples.

	1.	2.	3.	4.	5.	6.	7.	8.
1. Cortisol		.41**	.31*	.18	.11	.39**	-.14	.14
Sample 1	--	(*N*=58)	(*N*=60)	(*N*=62)	(*N*=62)	(*N*=62)	(*N*=62)	(*N*=62)
2. Cortisol			.10	.08	.07	.24^{t}	-.10	.14
Sample 2		--	(*N*=58)	(*N*=60)	(*N*=60)	(*N*=60)	(*N*=60)	(*N*=60)
3. Cortisol				.14	.26*	.15	-.20	.10
Sample 3			--	(*N*=62)	(*N*=62)	(*N*=62)	(*N*=62)	(*N*=62)
4. Child Age					-.04	.35**	-.24^{t}	-.14
				--	(*N*=64)	(*N*=64)	(*N*=64)	(*N*=64)
5. Child Sex						.22^{t}	-.06	.13
					--	(*N*=64)	(*N*=64)	(*N*=64)
6. Attentiveness							-.48**	.40**
/Compliance						--	(*N*=64)	(*N*=64)
7. Nervous/								-.24^{t}
Anxious							--	(*N*=64)
8. Overall IQ								
								--

Note. Due to missing values, sample sizes are unequal across cells.

$^{**}p < 0.01$, $^{*}p < 0.05$, $^{t}p < 0.1$.

Table 14

Intercorrelations Among Cortisol Samples, Child Age, Test Behaviour Factors, And Child Cognitive Ability For Girls And Boys Separately.

	1.	2.	3.	4.	5.	6.	7.
1. Cortisol Sample 1	--	.18	.29^{t}	.26	.32^{t}	.13	-.11
		(*n*=32)	(*n*=33)	(*n*=34)	(*n*=34)	(*n*=34)	(*n*=34)
2. Cortisol Sample 2	.65**		-.12	-.03	.08	.26	-.08
	(*n*=26)	--	(*n*=33)	(*n*=34)	(*n*=34)	(*n*=34)	(*n*=34)
3. Cortisol Sample 3	.32^{t}	.29		.12	-.01	-.10	.01
	(*n*=27)	(*n*=25)	--	(*n*=35)	(*n*=35)	(*n*=35)	(*n*=35)
4. Child Age	.08	.19	.19		.32^{t}	-.17	-.29^{t}
	(*n*=28)	(*n*=26)	(*n*=27)	--	(*n*=36)	(*n*=36)	(*n*=36)
5. Attentiveness/	.46*	.37^{t}	.26	.43*		-.29^{t}	.20
Compliance	(*n*=28)	(*n*=26)	(*n*=27)	(*n*=28)	--	(n=36)	(n=36)
6. Nervous/Anxious	-.48*	-.37^{t}	-.30	-.32^{t}	-.70**		-.05
	(*n*=28)	(*n*=26)	(*n*=27)	(*n*=28)	(*n*=28)	--	(n=36)
7. Overall IQ	.55**	.41*	.19	.12	.71**	-.50**	
	(*n*=28)	(*n*=26)	(*n*=27)	(*n*=28)	(*n*=28)	(*n*=28)	--

Note. Intercorrelations for boys are above the diagonal, intercorrelations for girls are below the diagonal.

Note. Due to missing values, sample sizes are unequal across cells.

$^{**}p < 0.01$, $^{*}p < 0.05$, $^{t}p < 0.1$.

Table 15

Summary of Hierarchical Regression Analysis For Variables Predicting SB IV Overall IQ In Boys and Girls Together Using the Attentiveness/Compliance Test Behaviour Factor (N=62).

Variable	*B*	*SE B*	β	ΔR^2	ΔF
Step 1					
Child's Age	-.13	.12	-.14		
Child's Sex	.12	.12	.13		
				.04	1.15
Step 2					
Child's Age	-.16	.12	-.17		
Child's Sex	.10	.12	.11		
Cortisol Sample 1	.15	.12	.16		
				.03	1.52
Step 3					
Child's Age	-.31	.12	-.33**		
Child's Sex	-.005	.11	.001		
Cortisol Sample 1	.001	.12	.001		
Attentiveness/Compliance	.52	.13	.53**		
				.20	15.31**
Step 4					
Child's Age	-.29	.11	-.30**		

Child's Sex	-.005	.11	-.005		
Cortisol Sample 1	.05	.12	.05		
Attentiveness/Compliance	.49	.13	.49**		
Child Sex x Cortisol Sample 1	.24	.11	.25*		
				.06	4.62*

Total equation following step 4: $R^2 = .32$ $R^2adj = .26$ $F = 5.19$**

Table 16

Summary of Hierarchical Regression Analysis For Variables Predicting SB IV Overall IQ in Boys and Girls Together Using the Nervous/Anxious Test Behaviour Factor (N=62).

Variable	*B*	*SE B*	*β*	*ΔR²*	*ΔF*
Step 1					
Child's Age	-.13	.12	-.14		
Child's Sex	.12	.12	.13		
				.04	1.15
Step 2					
Child's Age	-.16	.12	-.17		
Child's Sex	.10	.12	.11		
Cortisol Sample 1	.15	.12	.16		
				.03	1.52
Step 3					
Child's Age	-.22	.12	-.23^{t}		
Child's Sex	.09	.12	.09		
Cortisol Sample 1	.13	.12	.13		
Nervous/Anxious	-.32	.14	-.30*		
				.08	5.39*
Step 4					
Child's Age	-.19	.12	-.20		

Child's Sex	.09	.12	.09		
Cortisol Sample 1	.17	.12	.18		
Nervous/Anxious	-.23	.15	-.22[t]		
Child Sex x Cortisol Sample 1	.22	.13	.22[t]		
				.04	2.87[t]

Total equation following step 4: $R^2 = .19$ $R^2adj = .11$ $F = 2.54*$

Table 17

Summary of Hierarchical Regression Analysis For Variables Predicting SB IV Overall IQ in Boys Using the Attentiveness/Compliance Test Behaviour Factor (N=34).

Variable	*B*	*SE B*	β	ΔR^2	ΔF
Step 1					
Child's Age	-.30	.17	$-.29^t$		
				.09	3.05^t
Step 2					
Child's Age	-.29	.18	-.29		
Cortisol Sample 1	-.03	.17	-.03		
				.001	.03
Step 3					
Child's Age	-.39	.18	-.39*		
Cortisol Sample 1	-.12	.18	-.12		
Attentiveness/Compliance	.40	.19	.37*		
				.12	4.34*

Total equation following step 3:

$R^2 = .20$ $R^2 adj = .12$ $F = 2.55^t$

Table 18

Summary of Hierarchical Regression Analysis For Variables Predicting SB IV Overall IQ in Boys Using the Nervous/Anxious Test Behaviour Factor (N=34).

Variable	*B*	*SE B*	*β*	*ΔR²*	*ΔF*
Step 1					
Child's Age	-.30	.17	-.29[t]		
				.09	3.05[t]
Step 2					
Child's Age	-.29	.18	-.29		
Cortisol Sample 1	-.03	.17	-.03		
				.001	.03
Step 3					
Child's Age	-.32	.18	-.32[t]		
Cortisol Sample 1	-.01	.18	-.01		
Nervous/Anxious	-.18	.22	-.15		
				.02	.67

Total equation following step 3:

$R^2 = .11$ $R^2adj = .02$ $F = 1.21$

Table 19

Summary of Hierarchical Regression Analysis For Variables Predicting SB IV Overall IQ in Girls Using the Attentiveness/ Compliance Test Behaviour Factor (N=28).

Variable	*B*	*SE B*	β	ΔR^2	ΔF
Step 1					
Child's Age	.10	.16	.12		
				.02	.39
Step2					
Child's Age	.07	.14	.08		
Cortisol Sample 1	.49	.15	.55**		
				.30	10.86**
Step 3					
Child's Age	-.16	.12	-.19		
Cortisol Sample 1	.23	.13	.26[t]		
Attentiveness/Compliance	.61	.15	.67**		
				.28	16.78**

Total equation following step 3:

$R^2 = .60$ $R^2adj = .55$ $F = 11.80^{**}$

Table 20

Summary of Hierarchical Regression Analysis For Variables Predicting SB IV Overall IQ in Girls Using the Nervous/Anxious Test Behaviour Factor (N=28).

Variable	*B*	*SE B*	*β*	*ΔR²*	*ΔF*
Step 1					
Child's Age	.10	.16	.12		
				.02	.39
Step2					
Child's Age	.07	.14	.08		
Cortisol Sample 1	.49	.15	.55**		
				.30	10.86**
Step 3					
Child's Age	-.01	.14	-.01		
Cortisol Sample 1	.36	.16	.41*		
Nervous/Anxious	-.27	.17	-.31		
				.07	2.62

Total equation following step 3:

$R^2 = .38$ $R^2adj = .30$ $F = 4.92**$

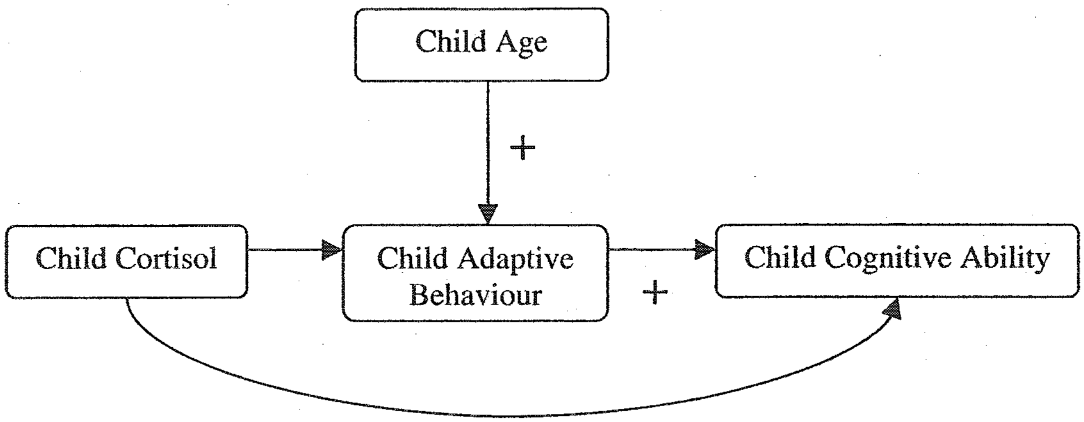

Figure 1

Representation of the hypothesized relations among child cortisol, age, behaviour during test session and overall cognitive ability as assessed by SB IV.

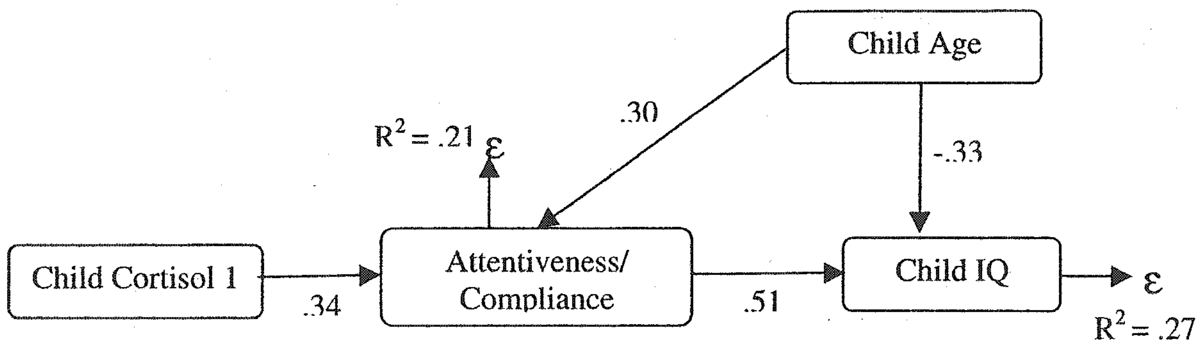

Figure 2

Final path model showing the relations among first child cortisol sample, child's attentiveness/compliance during testing, age and IQ obtained on SB IV.

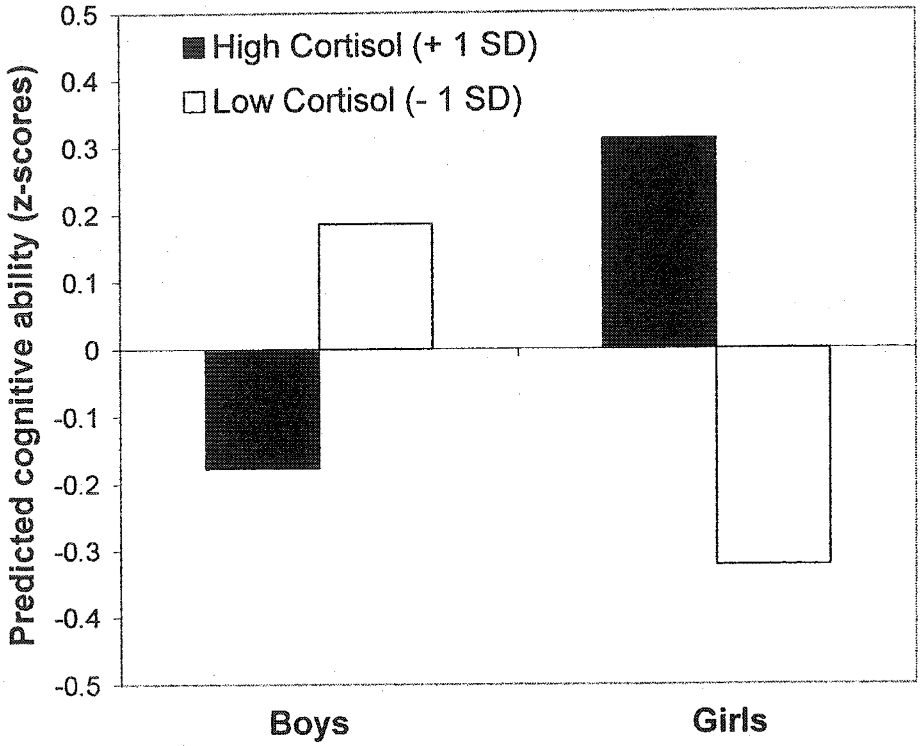

Figure 3
Overall cognitive ability as a function of child sex and first cortisol sample values.

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Appendices

Appendix A

Demographic Information Questionnaire (DIQ)

Septembre 1997 No d'identification ____________

Date: ____________

L'INDIVIDU DANS SON MILIEU
Renseignements sociodémographiques

Tous ces renseignements sont traités de façon totalement confidentielle

1. **Sexe** ☐ M ☐ F

2. **Âge** ______ ans Date de naissance AN ____ MO ____ JR ____

3. **État civil**

Note:"Conjoints de fait": désigne deux personnes qui vivent ensemble comme si elles étaient mariées. Il s'agit de ton état actuel; même si tu es légalement divorcé(e) ou autre, mais que tu vis avec un(e) conjoint(e) présentement, inscris conjoint de fait.

☐ Célibataire	☐ Conjoint de fait	Depuis quelle date?
☐ Marié(e)	☐ Séparé(e)	AN MO JR
☐ Divorcé(e)	☐ Veuf/veuve	____ ____ ____

4. **Nombre d'enfants** ______

Si enceinte (ou conjointe enceinte), bébé attendu pour: ____ ____ AN MO

Sinon, prévoyez-vous avoir un enfant dans les prochains 12 mois? OUI _____ NON ____

dans les prochains 24 mois? OUI _____ NON ____

Pour <u>chaque enfant</u>:

1 -Inscrire le nom, le sexe, la date de naissance

2 -Encercler"**TE**" si c'est ton enfant (tu es le parent biologique)
"**EC**" si l'enfant du conjoint (le conjoint actuel est le parent biologique)
"**EA**" si c'est un enfant adopté /"**FA**" en foyer d'accueil et qui vit chez toi
Si "TE" et "EC" sont vrais, encercler les deux.

3 -Indiquer si l'enfant vit avec toi, **OUI** ou **NON** ou **GP** (garde partagée)

4 -Inscrire l'année scolaire (si applicable) ainsi que si l'enfant fréquente une classe ou une école spéciale.

(Si tu as plus de quatre enfants, inscrire leurs informations sur une feuille séparée.)

1 NOM ______________________ SEXE ☐ M ☐ F AN MO JR ____ ____ ____

L'enfant est: TE EC EA / FA Vit avec toi: OUI ☐ NON ☐ GP ☐

Année scolaire: ____________ Classe spéciale: ____________________

2 NOM ______________________ SEXE ☐ M ☐ F AN MO JR ____ ____ ____

L'enfant est: TE EC EA / FA Vit avec toi: OUI ☐ NON ☐ GP ☐

Année scolaire: ____________ Classe spéciale: ____________________

3 NOM ______________________ SEXE ☐ M ☐ F AN MO JR ____ ____ ____

L'enfant est: TE EC EA / FA Vit avec toi: OUI ☐ NON ☐ GP ☐

Année scolaire: ____________ Classe spéciale: ____________________

4 NOM ______________________ SEXE ☐ M ☐ F AN MO JR ____ ____ ____

L'enfant est: TE EC EA / FA Vit avec toi: OUI ☐ NON ☐ GP ☐

Année scolaire: ____________ Classe spéciale: ____________________

5. **Ta scolarité** <u>complétée</u> (dernière année terminée):
En quoi? (spécialisation/général): ________________________

Études-tu présentement? OUI : Temps plein ☐ partiel ☐ NON ☐
Si oui, quel diplôme postules-tu ____________ pour quand? ____/____/____/

6. **As-tu un emploi** (rappel: renseignements gardés confidentiels)?

OUI ☐

Occupation: ________________________
____

Tes tâches: ________________________
____

NON ☐

As-tu déjà eu un emploi?

Oui ☐ Non ☐

⇓

En quoi?

Combien d'heures/sem.? ___________

Salaire de l'heure ____________ $

travailler:
Depuis quand es-tu à cet emploi? inscrire la date
AN MO
____/____/

° Pendant combien de temps?
° ____ an(s) ____ mois
°
° Quand as-tu arrêté de
° date: ____/____/
° AN MO
°

Au cours des <u>12 derniers mois</u>, as-tu bénéficié de:

Oui ☐ Non ☐l'Assurance chomâge?
Oui ☐ Non ☐ Prestations d'aide sociale?
Oui ☐ Non ☐ la CSST? (préciser:_____________________________)

7.Informations sur le conjoint (renseignements gardés confidentiels):

AN MO JR

a) Son nom:_____________________________Date de naissance ____ ____ ____

Son occupation:________________________________

Ses tâches:___________________________________

Son salaire: _______ $/ heure Nombre d'heures ______ / semaine

AN MO

Il/Elle travaille là depuis: date ____ ____

b) Au cours des <u>12 derniers mois</u>, a-t-il/elle bénéficié de:
Oui ☐ Non ☐l'Assurance chomâge?
Oui ☐ Non ☐ Prestations d'aide sociale?
Oui ☐ Non ☐ la CSST? (préciser:_____________________________)

c) Sa scolarité <u>complétée</u> (dernière année terminée):

En quoi? (spécialisation/général):_____________________

Étudie-t-il (elle) présentement? OUI : Temps plein ☐ partiel ☐ NON ☐

Si oui, diplôme postulé?____________________pour quand? (date) ____/____/

8.Informations sur le père (si n'habite pas avec la mère)

AN MO JR

a) Son nom:_____________________________Date de naissance ____ ____ ____

Son occupation:________________________________

Ses tâches:____

Son salaire: ________ $/ heure   Nombre d'heures _______ / semaine

AN   MO

Il/Elle travaille là depuis: date _____ _____

b) Au cours des <u>12 derniers mois</u>, a-t-il/elle bénéficié de:
Oui ☐ Non ☐ l'Assurance chomâge?
Oui ☐ Non ☐ Prestations d'aide sociale?
Oui ☐ Non ☐ la CSST? (préciser:________________________________)

c) Sa scolarité <u>complétée</u> (dernière année terminée):

En quoi? (spécialisation/général):________________________

Étudie-t-il (elle) présentement? OUI : Temps plein ☐ partiel ☐ NON ☐

Si oui, diplôme postulé?________________________pour quand? (date) ____/____/

9. **Disponibilité pour le test parent-enfant**

☐ Le matin ☐ L'après-midi
☐ La semaine ☐ La fin de semaine

10. **Vision des couleurs**: Il y a une section de la recherche qui porte sur les couleurs. Est-ce que tu as de la difficulté à percevoir certaines couleurs?

☐ Oui (préciser: ______________________________) ☐ Non

S.V.P. Vérifier l'adresse et les numéros de téléphone.

______________   ____
No   Rue   app.

____   _______   ________
Ville   Code postal

Téléphones☎: Personnel: (______) ______ - ___________
Travail: (______) ______ - ___________
Parents: (______) ______ - ___________
Autre ___________________: (______) ______ - ___________

Ton numéro de téléphone personnel est à quel nom dans l'annuaire téléphonique: Nom complet et lien avec toi:
____

Adresse des parents: ____
____

Appendix B

Consent Form

"L'INDIVIDU DANS SON MILIEU: Les parents et leurs enfants"

Directeurs du projet: - Lisa A. Serbin, Ph.D.
- Dale M. Stack, Ph.D.
- Alex E. Schwartzman, Ph.D.

FORMULAIRE DE CONSENTEMENT

Je,____________________________, m'engage volontairement avec mon enfant, ____________________________, à participer à l'étude "L'individu dans son milieu: Les parents et leur enfant" de l'Université Concordia. Les buts du projet m'ont été expliqués. L'étude comprend une série de questionnaires, une évaluation du fonctionnement intellectuel de mon enfant, ainsi que trois périodes de jeux lors desquelles nous serons observés et filmés. L'étude comporte deux sessions d'une durée maximale de 3 heures chacune et une rémunération totale de $50.00 me sera allouée aussitôt que les questionnaires seront remis. En signe de courtoisie, les résultats sommaires de l'évaluation de mon enfant me seront communiqués par téléphone. De plus, les chercheurs seront prêts à effectuer une ou deux visites additionnelles, au besoin, pour terminer l'évaluation, discuter de résultats problématiques, ou m'offrir un service de référence.

Je comprends que toutes les informations que nous fournissons, qu'elles soient écrites ou filmées, sont strictement confidentielles et qu'elles ne serviront qu'à des fins de recherche. Dans toutes les circonstances, je suis assuré(e) que l'anonymat sera conservé. Cependant, selon la loi sur la protection de la jeunesse, toute information indiquant de l'abus physique ou sexuel devra être divulguée à l'Office de la Protection de la Jeunesse.

Je comprends aussi que je suis libre de cesser notre participation à n'importe quel moment. Comme le projet "L'individu dans son milieu" est à long terme, je comprends que je pourrais être appelé(e) dans l'avenir pour participer à d'autres étapes de ce projet. Je me réserve le droit de décider, à ce moment, de donner suite ou non à la demande de participation.

Signature:________________________________

Nom:____________________________ Date:______________________

Assistant(e) de recherche:____________________________

Appendix C

Home Visit Protocol

PARENT-CHILD/HEALTH CANADA:
Full Protocol

May 21, 1997

DAY 1 PROTOCOL:

1- Examiner: - takes care of introductions,
- reminds mother that Interviewer cannot interact with child until Series 2 has been filmed,
- builds rapport with child,
- summarizes study and explains general Day 1 procedures to Ss,
- makes sure mother has read and signed consent form,
- for Cohort 2 Ss, explains that saliva sampling is optional and, if mother consents, obtains a sample from both of them **immediately before standard testing** (record the time at which all samples were taken on the saliva form).

Interviewer: - chooses the most appropriate room for interaction series,
- sets up camera and materials for Series 1 in the standard order (see toy lay- out sheet)
- removes all other unnecessary materials, if possible,
- unplugs that room's telephone if present,
- and attempts to remain as invisible to the child as possible until Series 2.

2- Examiner: - begins administering Bayley II or SB4.

Interviewer: - **a)** if mother does not need to stay with child (for SB4): Interviewer begins administration of the demographic, health battery, and general impressions of temperament questionnaires;
- **or b)** if mother needs to stay with her child, the Interviewer can supervise siblings, score data, or read a good book!!!

BREAK

- For Cohort 2 Ss, the 2nd saliva sample is taken from both mother and child within 10 min. following standard testing. Examiner asks mother to come, if she's with Interviewer.

- Make sure you ask Ss if they need to go to the bathroom or get a change of diaper.

- If needed, Interviewer informs Examiner of interaction setup location.)

3- Before bringing Ss to the interaction room, the Examiner gives mother the following Series 1 instructions.

SERIES 1

"Maintenant, on aimerait vous voir jouer ensemble. Comme tu sais, on va enregistrer ça sur vidéo. Donc, pour être sûr que vous restiez tous(tes) les deux bien en vue pendant qu'on filme, c'est très important que vous restiez assis(es) tous(tes) les deux sur le tapis qu'on a mis par terre. Moi, je vais quitter la pièce et je vais revenir vérifier la caméra une ou deux fois pour être bien sûr qu'elle fonctionne bien. Alors, la première chose qu'on

aimerait que tu fasses est simplement de jouer avec (ENFANT) comme vous le faites d'habitude pendant environ 15 minutes et essayez d'être le plus naturels possible. Vous pouvez prendre les jouets qu'on a mis sur le tapis si vous voulez, mais vous n'êtes pas obligés. Puis, quand tu entendras l'alarme sonner, tu pourras arrêter de jouer. As-tu des questions?"

Examiner then gets Ss settled on the carpet and instructs child (if s/he can understand such instructions) to remain within its limits; e.g.:

"Maintenant, (CHILD), tu vas jouer avec maman, mais j'aimerais que tu restes sur le tapis. Fais comme si le tapis était ton carré de sable et que c'est défendu de sortir du carré de sable..." etc.

Before getting out of view, Examiner tells mother they can begin. Examiner is responsible for timing all 3 Series and should position herself close enough to the interaction area so she can still hear Ss and thus know when to start and stop the timer. No camera person will be present during filming. The camera should be positioned on the tripod so as to encompass the carpet tightly. The Examiner should periodically check the position of the camera so that dyad is being properly filmed. [If there is an interruption of filming during the **first** half of the series (e.g., bathroom), reset the timer to 15 min. and start over. If the interruption occurs in the **second** half of the series **and** lasts less than 2 min., just pause and restart timer when the interaction resumes; but if the trip takes **more** than 2 min., Series 1 will have to be repeated at the end of Day 2.]

At the end of Series 1, Examiner takes saliva samples from both Ss (Cohort 2 only) and administers "Maternal perceptions" questionnaire. If mother reports a score of 1 or 2, thus indicating that either her or her child's behavior was not natural, Series 1 should be repeated on Day 2.

BREAK - Bathroom check

(±5 min.)- The Examiner or the Interviewer repositions materials for Series 2 and, if needed, prepares the barrier so it will <u>safely</u> prevent a 12-42 mo. child from leaving interaction room during separation episode.

4- While the Examiner supervises the child, she asks mother to join with the Interviewer. The Interviewer will then give mother the following Series 2 instructions so as not to be heard by child. (If child becomes upset about his/her mother's departure, Examiner will give her the instructions in the child's presence.)

SERIES 2

<u>FREE PLAY (4 MIN)</u>

"La prochaine période de jeux va aussi être filmé mais va avoir 4 parties: En premier, tu va recommencer à jouer avec (ENFANT) comme tantôt, avec ou sans les jouets,

mais juste pour une couple de minutes jusqu'à ce que tu entendes l'alarme sonner, comme tantôt."

PUZZLES (7 MIN, 4 MIN for 12-42 cohort)

"A ce moment-là, pousse les jouets de côté et choisis un casse-tête à faire avec (ENFANT). (FOR OLDER COHORT, EXPLAIN TO MOTHER THE LABELLED BAGS OF PUZZLE PIECES AND THEIR CORRESPONDING BOARDS. PRESS BEEPER WHEN THEY BEGIN WORKING ON THE PUZZLE). Si vous finissez ce casse-tête-là, vous pouvez travailler sur un autre. Après quelques minutes, l'alarme va sonner de nouveau et je (or INTERVIEWER) vais entrer dans la pièce."

SEPARATION AND REUNION (2+4=6 MIN)

"A ce moment-là, tu sortiras de la pièce pour laisser (ENFANT) jouer tout seul avec les jouets. Et pour être sûr qu'il/elle ne te suivra pas quand tu va sortir, je vais placer une barrière en travers la porte/arche. Bien sûr, si (ENFANT) devient trop dérangé par ton absence, ou si tu te sens mal à l'aise, tu pourras le/la rejoindre. Sinon, après une couple de minutes, (EXAMINER) va te dire que c'est le temps d'aller rejoindre (ENFANT) sur le tapis. Puis, tu passera 3-4 minutes de plus avec lui/elle et on te laissera savoir quand tout est fini."

Interviewer comes in at the beep and waits next to the door until mother has left. Then s/he puts the barrier in place (for 12-42 mo. cohort) or closes the door and then goes behind the camera to keep child in view during both the separation and reunion episodes. Examiner presses "start" when mother exits the room. Then, after 2 minutes, she signals mother to join her child.

"Donc, pour résumer, commencez par jouer ensemble comme vous le faites d'habitude; puis, quand tu entendras l'alarme, pousse les jouets de côté et choisis un casse-tête. Quand tu me verras entrer, sors de la pièce jusqu'à ce qu'on te dise te rejoindre (ENFANT). J'ai une petite liste qui pourra t'aider à te souvenir des étapes, et je vais la placer juste ici. As-tu des questions? J'aimerais juste te rappeler encore de rester sur le tapis pour que vous puissiez rester bien en vue. J'aimerais aussi quand tu sortiras que tu restes invisible pour (ENFANT), mais assez près de (EXAMINER) pour entendre son signal, OK?"

At the end of Series 2, Interviewer administers "Maternal perceptions" questionnaire. If mother reports a score of 1 or 2, Series 2 should be repeated on Day 2. Interviewer also administers Day 1 Touch Questionnaire.

5- At the end of Day 1, Interviewer gives instructions for mother and father questionnaire packages, for cortisol sampling, and makes the appointment for Day 2.

N.B. If child needs to nap during Day 1, Interviewer can take that opportunity to continue interviews with mother.

Fill out the Cortisol and VideoTape log sheet. Clean Bayley II and toys, if needed.

DAY 2 PROTOCOL:

1- Examiner reconnects with child and gives Day 2 general instructions.

2- Examiner finishes Bayley II or SB4. If mother does not need to stay with child, Interviewer answers any questions she might have about the questionnaires and finishes interviewing her. But if mother still needs to stay with child, Interviewer can set up Series 3 materials and check parental packages for missing data or clinical concerns (e.g., SCID screeners, SCL-90).

BREAK **- Series 3 setup, if not done already**
- Bathroom check

3- While Examiner supervises child away from interaction room, she tells mother to go to the interaction room to meet Interviewer who gives her the following Series 3 instructions so as not to be heard by child. If child becomes upset about mother's departure, the Examiner gives her the instructions in the child's presence.

Série 3

FREE PLAY (4 MIN)

"C'est la dernière fois qu'on va vous filmer, et il y a 4 choses qu'on aimerait que vous fassiez ensemble. D'abord, comme l'autre jour, on aimerais que tu joues avec (ENFANT) comme vous le faites d'habitude, avec ou sans les jouets, jusqu'à ce que tu entendes l'alarme sonner.

COMMAND TASK (3 MIN) - NOT DONE FOR 12-24 MO. CHILDREN

A ce moment-là, vous arrêterez de jouer pour faire quelque chose de complètement différent. Pour les 2-3 prochaines minutes, j'aimerais que tu demandes à (ENFANT) de faire quelques petites tâches pour toi. Tiens, voilà une liste de tâches que tu peux utiliser (GIVE HER THE LIST). Comme tu peux voir, il y en a qui sont plus difficiles que d'autres; c'est parce qu'on visite différentes familles avec des enfants d'âges différents. Celles du début sont plus faciles que celles de la fin (READ FIRST 3 AND LAST 3). On aimerais que tu prennes au moins 4 ou 5 des tâches de la liste. Tu peux en prendre plus si tu veux et tu peux même inventer tes propres tâches, mais pourvu que (ENFANT) n'ait pas à quitter le tapis. La liste sera placé tout près du tapis. (PRESS BEEPER WHEN MOTHER BEGINS INTRODUCING TASK)

INTERFERENCE TASK (3 MIN)

Quand tu entendras l'alarme sonner, vous arrêterez pour faire autre chose encore. On aimerais voir comment (ENFANT) réagit quand tu es très occupée. Tu sais comment c'est des fois quand tu es au téléphone ou bien en train de faire à manger et que c'est pas possible de lui donner toute l'attention qu'il/elle demande. Pour observer ça, on aimerais que tu remplisses le questionnaire qui est juste en-dessous (SHOW HER). Et pendant que tu le remplis, on aimerait que tu te retournes un peu pour lui faire comprendre que ce que tu fais est trés important. Si tu termine ce questionnaire avant l'alarme, tu pourras lire ces magazines-là (SHOW HER). (ENFANT) pourra continuer à jouer avec les jouets pendant ce *temps-là; mais assure-toi encore qu'il/elle reste assis(e) sur le tapis. Tu continueras de travailler sur le questionnaire ou de lire jusqu'à ce que tu entendes une autre alarme. (PRESS BEEPER WHEN MOTHER BEGINS QUESTIONNAIRE)*

FREE PLAY (4 MIN)

A ce moment-là, mets tout ça de côté et recommence à jouer avec (ENFANT) comme vous le faites d'habitude jusqu'à ce l'alarme te dise que c'est fini. N'oublie pas de rester à l'intérieur des limites du tapis pour que la caméra puisse vous garder tous les deux bien en vue.

Donc, en résumé, commencez par jouer avec (ENFANT) comme vous le faites d'habitude; ensuite, quand tu entends la 1ère alarme, prends la liste et fais-lui faire des tâches; puis, à la 2e alarme, commence à travailler sur le questionnaire jusqu'à ce que tu entendes la 3e alarme. A ce moment-là, tu recommences simplement à jouer avec (ENFANT). Comme la dernière fois, on a une petite liste qui va t'aider à te rappeler des étapes. As-tu des question?"

At the end of Series 3, Interviewer administers "Maternal perceptions" and finishes "Touch" questionnaires.

BREAK

4- Examiner administers the remaining HOME interview items **(both HOME versions are completed for 37-42 mo. children)**, and investigates any clinical concerns that might have arisen through other questionnaires. Examiner and Interviewer then decide who will administer the "Parenting Practices Interview" (AUDIOTAPED), the SCID modules (if required), and the Peabody to the child. When Examiner is done with her interviews, the Interviewer joins her for the wrap-up which includes the "Needs Assessment Questionnaire" (AUDIOTAPED).

Fill out the Cortisol and VideoTape log sheet. Clean Bayley II and toys between each visit, if needed.

Summary breakdown of administration times

	Time: mean (range) - in minutes
- Introductions + rapport building + materials set-up =	**15 (10-20)**
- Series 1-3 + maternal perceptions quest. + touch quest. =	**75 (60-90)**
- Bayley or SB4 + behavior ratings =	**75 (60-90)**
- Additional sociodemographic info. =	**10 (5-20)**
- Obstetric quest. =	**90 (60-120)**
- Health quest. =	**10 (5-20)**
- Genetic profile =	**30 (15-60)**
- General impressions of child temperament =	**10 (5-15)**
- Needs assessment =	**15 (10-20)**
- Cohort 2 cortisol sampling + instructions =	**20 (15-30)**
- Parenting interview + HOME =	**45 (30-60)**
- Wrap-up =	**15 (10-20)**

Appendix D

Ratings of Children's Behaviour During Testing Scale (RCBT; Rodgers 1995)

Ratings of Children's Behaviour During Testing Scale (RCBT, Rodgers, 1995)

1 Requires encouragement to initiate tasks (R)

2 Intrinsic pleasure from completing tasks

3 Requires encouragement to persist on tasks (R)

4 Nervous Anxious

5 Confident in competence

6 Flexible-adaptive problem solving

7 Relaxed

8 Responsive to praise

9 Respects limits on behaviour

10 Complies with directives

11 Appears withdrawn (R)

12 Reflective style (as opposed to impulsive)

13 Directions need to be repeated (R)

14 Relies on trial and error (R)

15 Benefits from instruction on difficult items*

16 Impulsive-careless errors (R)

17 Awareness of errors

18 Willingness to compromise

19 Acknowledges difficulties

20 Necessary to place firm limits on child's behaviour (R)

21 Concentration-focused attention

22 Persistent

23 Developmentally inappropriate-disruptive frustration

24 Organized approach to solving tasks

Note. *Item dropped from analyses

Note. (R) Items reverse coded so higher score denotes more adaptive behaviour.

Appendix E

Behaviour Rating Scale (Bayley, 1993)

Behaviour Rating Scale

1 Positive affect

2 Negative Affect

3 Soothability when upset*

4 Hypersensitivity to test materials*

5 Energy

6 Adaptation to change in test materials

7 Interest in test materials

8 Initiative with tasks

9 Exploration of objects & surroundings*

10 Attention to tasks

11 Persistence

12 Enthusiasm towards tasks

13 Fearfulness

14 Frustration with inability to complete tasks

15 Orientation to examiner

16 Social engagement

17 Cooperation

18 Hyperactivity

Note. *Item dropped from analyses

Note. All items coded so that higher score represents more adaptive behaviour.