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STRESS AND COGNITION IN CHILDREN;
Relation between a Stressor, Cognitive Performance
and Biochemical Alteration

by

© Sandra Wieland Elwood, B.A., M.A.

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfilment of
the requirements for the degree of
Doctor of Philosophy

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Carleton University
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December, 1983

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ABSTRACT

Although research with animals and with adults has indicated that stressor conditions can affect behaviour and cognitive performance, little attention has been given to the possibility that stressors may play a role in the learning problems experienced by children. In the present study cognitive performance, urinary biochemical (adrenalin [A], noradrenalin [NA], and 3-methoxy-4-hydroxyphenethylene glycol [MHPG]) levels and behavioural response (state anxiety [SA], observed tension [OT]) levels were measured for 38 normal children, ages 10-12, under stressor (presentation of a talk in front of the class, cognitive testing and urine sampling) and minimal stressor (cognitive testing and urine sampling) conditions. A group of children performing the cognitive tasks on two occasions but without the experimental stressors was used as a control for learning and practice effects. Personal and situational attributes which have been considered relevant to stressor response were measured.

Significant change in urinary A and OT at the time of the stressor (as compared to the minimal stressor condition) provided evidence that a stress response occurred for the majority of children. While 55% of the children showed an increase in A levels greater than one standard error, 29% showed a decrease greater than one standard error. Similar bidirectional change was shown for NA (47% increase, 39% decrease) and MHPG (39% increase, 42% decrease) with bidirectional MHPG changes occurring for A increasers and A decreasers. Possible meaning of these contrasting biochemical responses which have not been reported previously in the literature are discussed. Differences in gender response are also considered.

Significant alteration in cognitive performance, most notably selective and sustained attention, cognitive approach, performance with overlearned material and application of clustering strategy in a memory task was found to occur under the stressor condition. Performance on several tasks showed significant specific effects relating to an increase or decrease in urinary biochemical levels. Attention improved with increased A but deteriorated with decreased A, impulsive responding occurred with increased MHPG but greater adaptability was shown for MHPG decrease. These findings provide support for the hypothesis that a stressor condition may cause a deterioration in cognitive performance in children and that this effect may be explained in part by the physiological stress response.

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TO

Bruce, Marjorie, Ken

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INTRODUCTION

Stress has been a topic of scientific investigation for several decades. While research results have confirmed the subjectively recognized detrimental effect of stress on cognition, little attention has been given the possibility that stress may play a role in learning problems experienced by children. It is the thesis of this study that stress may cause or exacerbate learning problems for children and that the mechanism for this disruption may be, in part, a biochemical one. The present research was designed to measure the change which occurs in cognitive functioning, stress-related biochemicals and psychological measures of response in children under minimally-stressful and stressful conditions and to analyze the relationship between these variables. Antecedent factors (environmental situations, life change events and personality variables), which may influence vulnerability to acute stressors, also were measured and correlated with psychological and physiological response.

Stress has been defined and measured in numerous ways: the stimuli that lead to strain (Williams, 1973; Youngs, 1979), the imbalance between stimulus demands and an individual's ability to respond (Welford, 1974), and the response of the individual to these pressures (Mason, 1975). Even within one definition there are confusions. Researchers, owing to their individual orientations, have used different markers of stress (e.g., affect [Compton, 1980], behaviour [Gersten, Langner, Eisenberg & Simcha-Fagan, 1977], biochemicals [Frankenhaeuser, 1975; Levi,

1972; Mason, Maher, Hartley, Mougey, Perlow & Jones, 1976; Selye, 1979)). To establish, for use in this study, valid and comprehensive definitions of stress, antecedent factors, responses and stress effects, the development of the stress concept will be reviewed and recent definitions will be considered. Following this discussion, research relevant to antecedent factors, stress response, and altered cognitive functioning will be reviewed with particular attention given to research with children. The present research design and method will be described and results reported. The final chapter will discuss the results, considering not only the effects demonstrated but also the manner in which these effects may influence children's learning.

CHAPTER I

THE CONCEPT OF STRESS

The development of the stress concept since Selye first introduced the term into physiological research will be reviewed briefly. Alternative definitions used in the social and cognitive literature will be discussed. Since a number of studies relevant to antecedent factors and cognitive effects measure anxiety as opposed to stress, the relationship between stress and anxiety will be considered. Stress and the factors surrounding the stress response will be defined.

Stress

Selye traced experimentally a biological response which, although evoked by varied (i.e., nonspecific) occurrences to which the organism could not adjust, exhibited consistent and specific effects (Selye, 1936). This response, labelled by Selye as the "general adaptation syndrome" (GAS), appears to originate in the hypothalamus with the release of the corticotrophin releasing factor (CRF). The CRF, upon reaching the anterior pituitary via the median eminence, stimulates the release of the adrenocorticotrophic hormone (ACTH) which, in turn, stimulates the adrenal cortex to produce corticoids and other hormones.

The release of peripheral catecholamines from the adrenal medulla and sympathetic nerve endings following neural stimulation originating in the hypothalamus was hypothesized first by Cannon in 1929. The concurrence of this neural activation of

neuroendocrine release with the adrenal cortical response was recognized by Selye and has been included in his later descriptions of the GAS (Selye, 1976, 1980).

A third physiological response, increased central neurotransmitter activity (in particular, norepinephrine), has been demonstrated in research with animals (Anisman, Kokkinidis & Sklar, 1981b; Weiss, Glazer & Pohorecky, 1976) and inferred from research with humans (Sweeney, Gold, Pottash & Davies, 1980). While the link between central and peripheral neuroendocrine alteration is unclear, parallel changes have been hypothesized (Elsworth, Redmond & Roth, 1982; Frankenhaeuser, 1980; Selye, 1980).

Selye (1976, 1979) presented the GAS as a tri-phasic mechanism. The first phase or alarm reaction is the point at which the GAS is elicited. There is momentarily a deficient resistance to the stressor. If the GAS were not initiated successfully, this phase would persist and the organism in time would succumb to the stressor. With the GAS, phase two or the stage of resistance is achieved. This continues until the resources of whichever system is involved become depleted. At that point the third phase, that of exhaustion, occurs and the system's resistance drops below normal.

What was originally proposed as an intricate but fairly straightforward response to stressors has proven upon closer examination to be considerably more complex. Studies in the late 1950s and 1960s, most notably those of Lazarus (1966, Lazarus & Alfert, 1964), Levi (1967, 1972) and Spielberger (1975), indicated that response

intensity varied with the individual's perception of the stressor, not with the stressor itself. Citing both human and monkey studies, Mason (1971) proposed a re-evaluation of Selye's stress concept. He defined the "first mediator" (i.e., the initiator of the hypothalamic reaction), which Selye claimed could not be identified (Selye, 1980), as the individual's "psychological apparatus". Although Selye recognized emotional stimuli as stressors parallel to physical stimuli, he did not recognize psychological appraisal as a necessary component in the initiation of the stress response to physical and emotional stimuli. The findings of the past decade have supported Mason's hypothesis and identified further the factors which affect an individual's psychological appraisal.

Re-evaluation of the stress concept has not been limited to the initiation stage. The possibility of alternative responses beyond those of the physiological axes has been considered. Levi (1967) spoke of "adaptation syndromes" and Lazarus (1966) referred to "coping mechanisms". Mason (1975) posed the possibility that physical and cognitive activity could serve as alternative responses decreasing the gap between stressor demand and individual capability or adaptability level, thereby decreasing or eliminating a GAS response.

The imbalance between demand and capability has received increasing attention during the past fifteen years and has become, for a number of researchers, synonymous with the term stress. Welford (1974) used stress to indicate the state which precedes an adaptive or maladaptive response. McGrath (1970)

defined stress as starting from a perceived imbalance which constitutes a threat to the individual. Stress itself was seen as the reaction, usually behavioural, of the organism to the event which presented the threat. Appley and Trumbull (1967), in their review of psychological stress, considered the physiological and psychological integrative capacities that vary between individuals and within individuals from situation to situation. When these capacities are stretched close to or beyond their threshold level, the individual's response is conceived of as stress. Lazarus (1966) perhaps has resolved the difficulty of definition best by referring to three aspects of stress: stress stimuli, stress or threat appraisal, and stress response.

Anxiety

Anxiety, often used interchangeably for stress (see Kutash & Schlesinger, 1980; Spielberger, 1975), has been defined as feelings of apprehension, nervousness and tension which occur in conjunction with activation of the autonomic nervous system (Spielberger, 1975). Anxiety has been described as the initial (Ansari, Sampurna, Udupa & Agrawal, 1979; Persson & Sjöberg, 1978) or cognitive (Hamilton, 1979a) response to a stressor. Sweeney and Maas (1979), in their study of normal and depressed individuals, noted that both groups reported high anxiety which persisted after physiological stress measures returned to normal. Thus, while anxiety may represent the psychological reflection of the physiological response, it also can exist on its own. Indeed, anxiety, as

indicated in studies where a negative correlation exists between anxiety and stress (Rauste-von Wright, von Wright & Frankenhaeuser, 1981), may serve at times as a coping response.

Anxiety, as defined above, refers to state or situational anxiety. Studies on anxiety (Auerbach, 1973; I. Sarason, 1975; Spielberger, 1972, 1975) have distinguished between the momentary response to a stressor (state anxiety) and the relatively stable personality variable (trait anxiety) which represents an individual's tendency to interpret situations in threatening (high trait anxiety) or non-threatening (low trait anxiety) terms. As such, trait-anxiety exists separately from stress. It can be considered as a personality determinant of the likelihood that stress will occur, i.e., an antecedent factor, while state-anxiety represents the psychological correlate of stress or, alternatively, a coping mechanism.

A Definition of Stress

Stress, as used in the present paper, refers to the physiological response described by Selye, Cannon and Mason. A situation (potential stressor) presents itself in the individual's environment or inner world. The individual appraises the situation, that is, defines his or her relationship to the situation: does it disrupt one's relationship to the world? does it constitute a threat? Once appraised as a stressor, the individual interacts with this situation. The adaptability of the individual within this interaction determines the extent to which the appraised stressor can be "absorbed", that is, accepted without

disrupting the homeostasis of the organism. The individual responds to that part of the appraised stressor which has not been absorbed.

The initial response may represent a coping mechanism, that is, the individual's effort to deflect the stressor (Levi, 1972, 1975). This response (cognitive and/or behavioural) may alter the stressor itself, the individual's appraisal of the stressor, or the adaptability of the individual. That part of the stressor which cannot be deflected initiates psychological and physiological responses, i.e., Selye's GAS. This response affects body systems and the behaviours linked to these systems.

The physiological response, composed of peripheral and hypothesized central biochemical alterations, and reflecting the body's effort to meet the strain which psychological and behavioural mechanisms are unable to combat, is referred to as the stress response. The psychological and behavioural mechanisms occurring at the same time are referred to as alternative responses. Recent events and on-going situations together with the individual's personal characteristics which affect adaptability are defined as antecedent factors. Cognitive and behavioural responses which indicate that the individual's adaptability has been exceeded and reflect the individual's effort to deflect or control the stressor are referred to as coping responses. Subsequent alterations in functioning are referred to as stress effects.

CHAPTER II

A REVIEW OF THE LITERATURE

Human and animal research on stress during the past several decades has clarified the components, as defined above, of stress-provoking situations. Human research has included experimental, correlational and observational studies. While experimental studies have used fairly specific stressors (physical, sensory, cognitive, emotional) and measurement procedures, the settings all too often have been removed from real stressor situations. Stimuli often have been artificial, thus limiting the generalization of findings. The physiological measures of stress used most frequently with children, heart rate (Burgess, Johnson & Silverman, 1971; Elliott, 1964; Miklich, Rewey, Weiss & Kolton, 1973; Sturner, Rothbaum, Visintainer & Wolfer, 1980) and galvanic skin response (Buck, 1977; Elliott, 1964; Hamilton, 1979b; Melamed & Siegel, 1975), can be influenced by numerous other factors, endogenous and exogenous, thus making the actual occurrence and intensity of stress measured in child studies problematic.

Correlational studies have examined the relationship between predispositional factors and the occurrence of external stressors on the one hand and subsequent effects within ongoing real-life settings on the other. Particularly notable among these studies has been the life change event research. Although raising new questions and pointing to areas that need to be considered, correlational studies cannot demonstrate cause-effect relations

and have seldom tried to specify or quantify the mechanism whereby stressors and effects may be related. Observational studies adhere even more closely to reality. While these studies have the advantage of being able to note the many factors that may interact to produce a stressful situation and subsequent effects, they are unable to clarify the mechanism whereby stressors affect functioning.

Research with animals has used experimental paradigms to examine the biochemical and performance alterations which occur under a stressor condition. These studies clarify changes observed in human studies, identify changes which may be occurring in humans but cannot be studied directly, and suggest new approaches to the study of stress in humans.

The following review of literature on stress considers each of the approaches to human research (experimental, correlational and observational) noting not only the findings which have been established but also areas where further research is needed. The animal research which parallels these studies is in general agreement with human findings and therefore is not discussed. Animal research on neuroendocrine response, an area in which human studies are limited, is included.

The review is organized around the components discussed in the introduction: antecedent factors, response to stressors (coping, psychological, physiological), and the effects of stress. Research based on adult populations will be summarized, while the research with child populations will be discussed in greater detail.

Antecedent Factors

Potential stressors may be external (e.g., shock, injury) or internal (e.g., fear, sense of failure); they may be chronic (e.g., membership in a minority group) or acute (e.g., academic examinations). Whether an individual responds to a potential stressor has been shown to depend on his or her appraisal of and adaptability to the situation. The following discussion of antecedent factors considers each of these areas: appraisal, adaptability, and potential stressors. The final part of the section reviews research based on child populations.

Appraisal

The early studies on stress imposed acute physical stressors (e.g., noise, shock). Subjects often were subdivided into two groups according to trait-anxiety scores: those who tend to appraise events as anxiety-provoking (high trait anxiety, HA) and those who tend not to appraise events as anxiety-provoking (low trait anxiety, LA). Significant differences in physiological responses were found between the two groups with the HA individuals showing a greater response. While these studies yielded considerable information regarding physiological response and behaviour deterioration, it became apparent that the relationship between stressor and response was not as direct as had been thought.

Hodges and Spielberger (1966) found no relationship between anxiety-proneness and heart rate under threat of shock. These results appeared to contradict earlier findings until questionnaire responses on the subject's fear of shock were examined;

a significant positive correlation between fear of shock and heart rate change was found. The role of personally-perceived threat in determining the intensity of an experienced stressor has been supported by studies using threat-inducing films in which introductions manipulated threat content (reviewed in Lazarus, 1966). The stress response, as measured by heart rate and skin conductance, was significantly less when the stressor stimulus was seen as less threatening.

While these studies were based on external threats, experimental and observational studies have found that internal or emotional threats (e.g., failure) also serve as potential stressors (see Butkowsky & Willows, 1980; Murphy & Moriarty, 1976), the intensity of the stressor actually perceived being determined by an individual's appraisal of the threat. Appraisal has been found to reflect an individual's early experience with similar situations (Rutter, 1981), the amount of discrepancy between role expectations experienced (Mettlin & Woelfel, 1974), and the extent to which an individual attributes the outcome to his or her own abilities (Gaudry, 1977; Miller, 1980).

In addition to the appraised level of threat, human and animal research has shown that control over the potential stressor (Anisman, Kokkinidis & Sklar, 1981a; Averill, 1973; Frankenhaeuser & Rissler, 1970; Lundberg & Frankenhaeuser, 1978; Miller, 1980; Streiner, Norman, McFarlane & Roy, 1979) and predictability of occurrence or outcome (Cacioppo & Sandman, 1978; Frankenhaeuser & Rissler, 1970; Miller, 1980) affect the extent to which a potential stressor is experienced as a real stressor.

Novelty also has been hypothesized as a determining factor (Frankenhaeuser, 1975; Selye, 1976) but has received little experimental attention. While threat and novelty show a positive correlation with the amount of stress experienced, control and predictability demonstrate a negative correlation.

Although trait anxiety, considered as a personality characteristic (Endler, 1980; Spielberger, 1972), has long been recognized as an important determinant in the appraisal of a stressor, little attention has been given until recently to the role of other personality variables. Studies of stress or anxiety and locus of control indicate that individuals with greater externality in their perception of control demonstrate a significant and positive correlation between life events (hypothesized stressor) and psychological indicators of stress (depression and anxiety) (Archer, 1979; Johnson & I. Sarason, 1978). There are indications that the relationship between stress and control orientation is not a direct one. An interaction between control orientation and situation controllability approaching statistical significance level was demonstrated in a study of stress response (measured by catecholamine and cortisol excretion) to high level noise under control - no control conditions (Lundberg & Frankenhaeuser, 1978). Internals demonstrated no additional cortisol response (cortisol has been shown to reflect situational controllability, see page 33) with high levels of noise under control conditions while externals demonstrated a notable response. In contrast, under the no control condition internals demonstrated a greater cortisol response than did externals.

A recent study including measures of impulse control and self-rated levels of "stress" demonstrated a significantly higher perception of stress in university students with low (as opposed to high) impulse control under an experimentally-induced stress condition (Srivastava & Naidu, 1982). While research on the role of personality factors vis à vis stress is needed, studies, such as that of Srivastava and Naidu, based on single personality variables and self-rated response are inadequate. Not only was it unclear as to whether impulse control was a relevant characteristic or simply a variable reflecting other more important characteristics, but also the occurrence of stress was not established. This study may indicate only that students unable to tolerate frustration worry more.

Recent research on Type A and Type B personalities has been designed more carefully. In studies utilizing impossible jigsaw puzzles and mental arithmetic tasks as stressors, higher levels of catecholamines (Friedman, Byers, Diamant & Rosenman, 1975; Glass, Krakoff, Contrada, Hilton, Kehoe, Mannucci, Collins, Snow & Elting, 1980; Williams, Lane, Kuhn, Melosh, White & Schanberg, 1982) and cortisol (Williams et al., 1982) were measured for Type A individuals. In another study, Type A and B university students were matched on trait anxiety (Francis, 1981). Type A individuals demonstrated higher depression, hostility and state anxiety at the beginning of terms and during final exams (the differences were significant on the Multiple Affect Adjective Check List and approaching significance on Spielberger's Inventory) (Francis, 1981).

Rauste-von Wright, von Wright and Frankenhaeuser (1981), in a longitudinal study of Finnish adolescents, examined the correlation between personality variables (Cattell's 16 Personality Factor Test and a Finnish self-image test) and neurochemical response to a specific potential stressor (matriculation examination). They found that catecholamine response in boys showed a significant positive correlation with achievement-orientation and a significant negative correlation with anxiety. In girls, a significant negative correlation was shown between catecholamine response and (1) sense of self and (2) perceived ability to fulfill social expectations. Further study of catecholamine response in achievement-oriented situations (Collins & Frankenhaeuser, 1978; Johansson, 1977; Johansson, Collins & Collins, 1981) has indicated a positive correlation between neuroendocrine response and academic stressors for females in high pressure academic situations. While these studies have been interpreted as indicating that biochemical stress response is not gender dependent but rather reflects social pressures (i.e., learned behaviour), it should be noted that the population in these studies was small and selective (engineering and graduate students). Although using less direct measures, a recent study of life change events (weighted heavily with social as opposed to achievement situations) and psychological and somatic distress in which externally and internally-oriented males and females were compared (Toves, Schill & Ramanaiah, 1981) may be more informative with regard to gender and stress. Externally-oriented males showed a higher positive correlation between life

change events and distress than did internally-oriented males. Females (internal and external) demonstrated greater positive correlation ($r = .35$) than did either male group. Females appear not to be less responsive to stressors but to appraise different situations as stressful. Further studies relevant to gender and stress responses will be considered in the next section.

In summary, the stressor experienced by an individual varies according to (1) the individual's appraisal of the threat involved, (2) the extent to which the individual can predict or control the situation, and (3) the amount of novelty involved. Personality variables and learned behaviour appear to affect the appraisal of a potentially stressful situation.

Adaptability

Jenkins (1979), in a study of 299 air traffic controllers, described an individual's capacity for adaptation (i.e., ability to adapt to or absorb stressors) as involving four factors: biological, psychological, interpersonal and sociocultural.

Biologically, individuals who are in better health (Jenkins, 1979) and are more rested (Johansson in Frankenhaeuser, 1976) have been shown to be able to absorb a greater number of stressors (i.e., no coping or physiological response is demonstrated). Levi spoke of individuals as having different levels of endocrine tone which influenced their reactivity threshold as well as latency of return to baseline (Levi, 1967) and different patterns of endocrine response (Levi, 1972). Sweeney, Gold, Pottash and

Davies (1980), in their review of neurochemical response to stressors, suggested that baseline levels of 3-methoxy-4-hydroxyphenylglycol (MHPG, a major metabolite of NE) may reflect biochemical vulnerability to stressor situations.

Studies showing greater endocrine response (as measured in urinary excretion) by boys to academic stressors (Frankenhaeuser, Rauste-von Wright, Collins, von Wright, Sedvall & Swahn, 1978; Johansson, Frankenhaeuser & Magnusson, 1973; Johansson & Post, 1974) raised the possibility that catecholamine responsivity may be gender-related. Recent studies have found insignificant differences between (1) catecholamine and cortisol response of three-year old girls and boys in a hospital stressor situation (Lundberg, de Chateau, Winberg & Frankenhaeuser, 1981), (2) catecholamine response of pre-school girls and boys in day-care situations (no cortisol alteration occurred) (Lundberg, 1983b), and (3) catecholamine and cortisol response of adult females and males pursuing similar academic objectives (engineering and Ph.D. programmes) under examination conditions (Collins & Frankenhaeuser, 1978; Johansson, 1977; Johansson, et al., 1981).

It should be noted that although the alteration occurring for girls and boys in the pre-school study was insignificantly different, the level of noradrenalin and (in home situations) adrenalin excretion was significantly higher for boys than girls (Lundberg, 1983b). Lundberg ascribed this difference to the type of activities in which boys involve themselves. Based on these studies and the studies reviewed in the preceding.

section, sex difference in catecholamine reactivity appear to reflect an appraisal effect determined by social expectations and the demands of the situation, not an adaptability effect determined by endocrine tone.

Contradictory findings occurred in a recent study with young (22-35) and old (50-67) males and females. Aslan, Nelson, Carruthers and Lader (1981) found that young females demonstrated a significantly smaller adrenalin increase in response to a cognitive-conflict task than did young males or older females and males even though state-anxiety and heart rate indicated significant arousal in all groups. It was suggested that the hormonal production by young females may affect adrenalin production. Further research involving a wide range of ages is needed.

The possible role of biological factors in responsivity to stressor situations has been raised in recent Type A/B studies. A significant correlation was found between increased systolic blood pressure during surgery (patients were under anaesthesia) and Type A ratings (Kahn, Kornfeld, Frank, Heller & Hoar, 1980; Krantz, Arabian, Davia & Parker, 1982). Williams and colleagues (1982) found significant cortisol increases under stressor conditions for Type A individuals with a genetic predisposition to hypertension but not for Type A individuals without a predisposition. These results need to be replicated in a study measuring other personality and situation variables which might account for the cortisol response before a link between biochemical responsivity and genetic factors can be proposed.

As indicated by Jenkins, psychological factors also may affect an individual's ability to adapt to stressor situations. Studies relating life change events (hypothesized stressors) to inefficient immune response (hypothesized stress effect) found significant negative correlations between change events and immune response for individuals with high anxiety, low self concept or in a state of depression (Canter, Cluff & Imboden, 1972; Locke, Hurst, Williams & Heisel cited in Palmblad, 1981; Roessler, Cake, Lester & Couch cited in Palmblad, 1981). A similar negative correlation between life events and immune response was found for introverted, as compared to extroverted, individuals (measured by the Eysenck Personality Inventory) (Totman, Kiff, Reed & Craig, 1980).

A cognitive study with children (grade five) found a significant positive correlation between scores on a mastery orientation scale and maintenance of good performance in a situation of increasing negative assessment (hypothesized stressor) (Diener & Dweck, 1978). Locus of control and Type A/B personality studies discussed in the section on appraisal also may be relevant to level of adaptability. While considerably more research is needed in this area, it appears that individuals unsure of their own abilities, emotionally depressed or introverted are less able to adapt (or, alternatively, are more vulnerable) to stressor situations.

Research relevant to interpersonal relationships as a factor affecting an individual's adaptability within stressful situations indicates significant negative correlations between

strength of relationships and stress vulnerability (Antonosky, 1974; Brown, 1979; Hotelling, Atwell & Linsky, 1978; Kaplan, 1980; Simpson, 1980). Although life change events have been found to correlate with psychiatric symptoms in large-scale field research and with weakened immune defenses in small experimental research, this relationship did not hold true for individuals who experienced satisfactory social contacts and activity (Myers, Lindenthal & Pepper, 1975; Totman et al., 1980). A recent experimental study (I. Sarason, 1981) examining the effect of short-term interpersonal contacts on hypothesized stress effects found significantly better performance on a difficult anagram task by high anxiety students participating in a group discussion on test situations prior to task performance. Although interpreted within the stress paradigm, it is unclear from the study whether the interpersonal contact affected performance directly through motivation or indirectly by enabling the subject to counteract or absorb the imposed stressor.

Sociocultural variables are a fourth factor influencing an individual's adaptability to stressors. In his study of air traffic controllers, Jenkins (1979) found that individuals conforming to the accepted norms or forming a part of the majority group within a community showed fewer stress effects. While a positive relationship between middle-class membership and greater situation adaptability has been generally accepted, little research has been conducted within stress paradigms.

In summary, research findings have indicated that an individual's biological and psychological condition affects his

or her ability to adapt to stressors. Whether gender differences in adaptability are a result of physiological or psychological effects remains unclear. Individuals experiencing positive interpersonal relationships have been found to demonstrate less stress response when faced with potential stressors than do individuals without group or individual supports. As noted in the discussion above, it is seldom possible to delineate clearly between factors which affect the appraisal of a potential stressor and those which affect the individual's adaptability to the perceived stressor.

Stressors

Stressors have been discussed in terms of the individual's appraisal of and adaptability to single situations. Consideration also needs to be given to the possible additive effect of stressors. Studies utilizing inventories of recent life events based on a variety of scoring methods have shown low but consistent and significant correlations between the number and severity of life events and physical or affect disturbance (e.g., $r = .12 - .24$ [Rahe & Arthur, 1978]; $r = .16 - .36$ [Rahe, 1979]). Although the methodology of life event studies has been criticized (Minter & Kimball, 1980; Tausig, 1982), the consistency of effect shown lends support to the hypothesis that stressors affect the likelihood of stress response in an additive manner. Hotelling and colleagues (1978) in their study with adolescents noted that no correlation was evident between life change events and the occurrence of illness until the life change

units exceeded 250. Above that point a positive correlation occurred.

An accumulation of stressors can be seen either as depleting an individual's ability to adapt to additional stressors or as increasing an individual's sensitivity to stressors (i.e., a stress response occurs with situations representing minimal threat or loss of control). A similar situation may occur with the imposition of an acute stressor on top of on-going or chronic stressors (see Gersten, Langner, Eisenberg & Simcha-Fagan, 1977; Hansen & Johnson, 1979; Totman et al., 1980). Although the role on-going stressors may play in the determination of response to acute stressors has been emphasized in the literature on family stress, little attention has been given to this issue in experimental stress research.

Research with Child Populations

Before discussing appraisal and adaptability as they pertain to children, brief consideration will be given to the external stressors that confront children and to the manner in which these stressors may interact.

Stressors. On-going situations such as physical and mental handicaps (Levi, 1975; Varma, 1973), parental deprivation (Levi, 1975; Varma, 1973), membership in minority groups (Gersten et al., 1977; Phillips, 1978), single parenting (Felner, Stolberg & Cowen, 1975; Hodges, Wechsler & Ballantine, 1979), difficult parent-child relationships (Gersten et al., 1977) as well as single events such as separation from parents (Bowlby, 1980),

birth of a sibling (Dunn, Kendrick & MacNamee, 1981), overstimulation (Murphy & Moriarty, 1976) and school tests (Phillips, 1978; S. Sarason, Davidson, Lighthall, Waite & Ruebush, 1960) have been defined as potential stressors for children. The occurrence of a stress response in the studies referred to above was determined by measurement of hypothesized stress effects (e.g., withdrawal, aggression, poorer test performance). Child studies using trace measures of catecholamine or cortisol alteration as determinants of stress response have shown separation from parents, contact with strangers (infants: Tennes, Downey & Vernadakis, 1977), contact with an irritable adult (ages 3-4: Montagner, Henry, Lombardot, Benedini, Burnod & Nicolas, 1978), hospitalization (age 3: Lundberg et al., 1981), and anticipation of medical treatment (ages 7-14: Barnes, Kenny Call & Reinhart, 1972; ages 7-11: Knight, Atkins, Eagle, Evans, Finkelstein, Fukushima, Katz & Weiner, 1979) to be stressors for boys and girls while academic tests were found to be stressors for boys (ages 12-13: Johansson, Frankenhaeuser & Magnusson, 1973).

While single events, as noted above, may activate a stress response, the likelihood of this response appears to increase if chronic stressors also exist. The Manhattan longitudinal study (Gersten, Langner, Eisenberg & Orzeck, 1974; Gersten et al., 1977), based on a population of over 700 children (ages 6-18), found that single stressors (as indicated by life change events) by themselves did not show significant correlations with behavioural or cognitive problems (considered to reflect stress

effects). When on-going stressor scores were entered into the analysis, a significant correlation appeared. Similarly, Hodges and colleagues (1979) found that the variable 'divorced parents' showed an insignificant correlation with adjustment problems in preschoolers when analyzed by itself but a significant correlation when combined with high mobility, financial problems and young parental age. Since the occurrence of these items in intact homes did not correlate with adjustment problems, divorce was hypothesized as an on-going stressor which sensitized the system to other stressors (Hodges et al., 1979). A chronic stressor, such as divorce, can be interpreted as limiting the child's adaptability in two ways: (1) fewer social supports may be available to the child and thus the initial capacity of the system for adaptability is less, and (2) the divorce situation places demands on the child and thus depletes what may be a limited capacity system.

Child studies utilizing life change inventories (Aagaard, 1979; Boyce, Jensen, Cassel, Collier, Smith & Ramey, 1977; Heisel, Ream, Raitz, Rappaport & Coddington, 1973; Jacobs & Charles, 1980; Kashani, Hodges, Simonds & Hilderbrand, 1981; Patterson & McCubbin, 1983; Sandler & Ramsay, 1980), have found low but significant correlations between accumulated life events and both physical and psychiatric disturbances similar to the correlations found in adult studies. Of particular interest to a discussion of additive effect of stressors is a study of 350 children (ages 1-14) admitted to hospital in Denmark during

a one-year period. Life change events, family background variables (parent education, parental marital status, family income, number of siblings, relative size of residence) and type of illness were determined (Aagaard, 1979). When the occurrence of single life events was correlated with respiratory tract infections, infections outside the respiratory tract, psychosomatic and psychic diseases, and other diseases, a single significant ($p < .05$) correlation was noted for preschool children and a limited number for school age children. When the life event scores were summed, a significant ($p < .001$) positive correlation with psychosomatic and psychic diseases occurred for both age groups. A sum of background factors (none of which individually correlated with any of the disease categories) also provided a significant ($p < .001$) correlation with psychosomatic and psychic diseases. The amount of variance accounted for increased notably when measurements of family background variables and life events were combined. Whether an additive or sensitization effect was occurring cannot be determined from the study.

A follow-up study (Aagaard, 1982) indicated that on-going stressors (negative family factors) correlated with continued reports of poor health (interpreted as psychic or psychosomatic diseases) but not with hospital readmission. The life stress events, removed by over a year from the time being studied, no longer demonstrated significant correlations with poor health.

Appraisal. The role of appraisal has been highlighted in hospitalization studies with children. Children who receive

preparation before hospitalization or medical treatment (thus making the events in the hospital more predictable) have been shown to experience less anxiety (self-ratings, observer ratings), stress (skin response, pulse rate), and hypothesized stress effects (recovery room behaviour, post-situational behaviour) than children (ages 4-12) receiving no preparation (Ferguson, 1979; Melamed & Siegel, 1975; Sturner, Rothbaum, Visintainer & Wolfer, 1980; Visintainer & Wolfer, 1975).

Studies by S. Sarason and colleagues (1960) and Phillips (1978) have indicated that children (ages 9-12) expressing high test anxiety (measured separate from test experience) show more physiological indications of distress (perspiration, stomach-ache) at the time a test is taken and lower achievement on the test (IQ being controlled).

Moore (1975), in his review of stress in normal childhood, spoke of developmental stressors. It is perhaps more accurate to view developmental stages not as separate stressors but as altering a child's appraisal of situations (Rutter, 1981; Varma, 1973). This is particularly evident in hospitalization studies where separation has been found to be most threatening between the ages of six months and four years (reviewed in Traughber & Cataldo, 1982). The fact of separation continues but the threat appraisal diminishes as children, owing to experience, are able to predict the parents' return and, owing to ego-development, are able to see themselves as existing separately (Bowlby, 1980). Similarly, parental demands may not change as children grow older, but children may come to appraise these demands as a threat to

their developing self-image and thus the demands become stressors.

Adaptability. The most extensive discussion of adaptability or, alternatively, vulnerability in children to stress-inducing situations is found in Murphy and Moriarty's book Vulnerability, Coping and Growth (1976). The measures of vulnerability in infancy were based on the baby's robustness or energy, autonomic stability, vegetative functioning and sensory reactivity (Heider, 1966; Murphy & Moriarty, 1976). For older children, flexibility of response to problem situations and cognitive abilities (including alertness and clarity of perception but not IQ) were considered as determinants of a child's ability to adapt to stressors (Murphy & Moriarty, 1976). Rutter (1981), noting the negative correlation between intelligence and psychiatric disorders in children, considered IQ to be relevant to stress resistance. Rutter raised the question of whether a higher IQ creates better cognitive mediation (appraisal) or greater resilience to stressors (adaptability).

In a study of 100 school children, interpersonal awareness (determined by a story completion exercise) was found to be a moderating variable between family life stressors (method of assessment not reported) and behavioural competence (determined by responses to story situations) while IQ altered the correlation between family life stressors and academic competence (Pellegrini, 1980). A negative correlation existed with low awareness or low IQ and a positive correlation with high awareness and high IQ. While the validity of the measures used in this study can be

questioned, interesting hypotheses are raised which should be examined in future research.

The positive role of the mother-child relationship and of societal supports in lessening a child's vulnerability to stressors has been indicated by the findings of numerous studies (Kauffman, Grunebaum, Cohler & Gamer, 1979; Murphy & Moriarty, 1976; Sandler & Block, 1979; Simpson, 1960). The effect of social relationships on a child's response to stressors is not, however, straight-forward. Boyce and colleagues (1977) found that illness following a high number of life change events was more severe for children from families with strongly established family routines. This finding, which contradicted the hypothesis originally posed, was interpreted as indicating that a highly routinized life may prevent a child from developing abilities to adapt, thus leaving the child more vulnerable when a disruption altering family routine occurs. Further research is needed to determine the elements of family life which affect a child's vulnerability.

Phillips (1978), in his study of anxiety in school children, noted that children from minority groups expressed more anxiety within the school setting than did other children. The negative correlation between anxiety and academic achievement was higher for these children than for children of the dominant socioeconomic group. The higher level of anxiety may reflect greater pressure to achieve or, alternatively, conflicting role expectations.

Child studies relevant to the physiological factor of

adaptability are limited. Parallel to the findings with adults, Type A behaviour (as measured on the MYTH scale, Matthews & Angulo, 1980) appears to be associated with elevated physiological responsiveness (age 3: Lundberg, 1983a; ages 11-12: Lawler, Allen, Critcher & Standard, 1981). The relevance of this reactivity to response in stressor situations has not been examined.

Summary

Experimental and correlational research has indicated that the amount of stress experienced depends on (1) the number of ongoing and/or acute stressors occurring within the same time frame, (2) the individual's appraisal of the stressor, and (3) the individual's level of adaptability, as determined by physiological, psychological and social factors. While research with children, and in particular experimental research, is limited, the general findings of adult research appear to be supported. A weakness of past research with adults and children has been the limited and sometimes unreliable measurement of antecedent factors and stress response.

Response to Stressors

As defined in chapter one, when an appraised stressor is of greater intensity or duration than an individual is able to adapt to or absorb, the individual's psychological and/or physiological processes are disrupted. One or both of two responses occur. The individual may seek to deflect or counter

this disruption with coping responses. When these are unsuccessful, a physiological response occurs.

Research on coping responses will be mentioned briefly with specific attention being given to child studies while findings related to research on the physiological stress response will be discussed in more detail. Studies measuring alteration in stress-related biochemicals in children will be reviewed.

Coping Responses

Coping responses have been described as behavioural (e.g., physical exercise, play activities, fighting and other outward expressions of tension or anger) and cognitive (e.g., information search, reappraisal of the stressor and defense mechanisms) (Coyne & Lazarus, 1980; Lazarus, 1966). These responses have been found to correlate negatively with the physiological stress response and with behaviour considered to reflect stress effects (e.g., poor surgery recovery) in studies with humans (Appley & Trumbull, 1967; Katz, Weiner & Gallagher, 1970; Wolff, Friedman, Hofer & Mason, 1964) and animals (McCarty & Kopin, 1978; Stolk, Conner, Levine & Barchas, 1974). Successful coping responses may deflect a stressor by altering the individual's appraisal of the situation or by increasing the individual's adaptability.

Expressions of anxiety, generally considered a psychological indicator of stress response, may serve in some situations as a coping response that relieves the individual (Katz et al., 1970). Rauste-von Wright and colleagues (1981) reported a significant negative correlation between trait anxiety and

catecholamine response for adolescent boys in an academically stressful situation. It may be that the boys who report feelings of anxiety (the general tendency of boys to report lower levels of anxiety than girls is considered a learned social behaviour rather than a true reflection of anxiety levels [Maccoby & Jacklin, 1974; Phillips, 1978]) are those who utilize anxiety as a coping response.

Several hospital studies have examined the correlation between coping responses and stress, or hypothesized stress effects, in adults and children. Preschool children who engaged in hospital-related play the day before surgery showed a quicker physical recovery and less disturbed post-surgery behaviour than children who did not include hospital symbols or activities in their pre-surgery play (Burnstein & Meichenbaum, 1979).

A more direct study of coping and stress response in children ages 7-11, compared Rorschach responses (rated for defence effectiveness) and urinary creatinine (a metabolite of cortisol) levels (Knight et al., 1979). The significant inverse correlation between Rorschach responses and creatinine was interpreted as indicating that successful defense mechanisms protected the children from a physiological stress response. Rorschach and urine measures taken a week before hospitalization did not show significant correlations, i.e., when an acute stressor was not imposed on the system these two variables were not related.

Stress Response

When an appraised stressor is of greater intensity or duration than the individual is able to adapt or to absorb and the individual is unable to deflect the disruption (i.e., the dynamic homeostasis of the psychological or physiological process is disrupted), the body manifests a physiological response. This response, initiated in the brain, occurs within three separate but seemingly interconnected systems: the pituitary-adrenocortical system, the sympatho-adrenomedullary system, and the CNS neurotransmitter system. Parallel with the physiological response, there may be an awareness on the psychological level that the system is being challenged.

The stress response occurring within each of these systems will be discussed. This discussion will be based on animal and human research with particular note being made of the few studies which have used child populations.

Pituitary-adrenocortical response. Stimulated either by recognition of a stressor to which the body cannot adjust (Mason, 1971) or by a decrease of NE in the hypothalamus (Anisman, 1978), the hypothalamus releases corticotrophin-releasing factor (CRF) into the vascular plexus (median eminence) which leads to the anterior lobe of the pituitary gland. The anterior pituitary is stimulated in turn to release several hormones (Selye, 1980). Of concern to this discussion is the release of adrenocorticotrophic hormone (ACTH) which in turn stimulates the adrenal cortex. While there is a circadian cycle for ACTH and the subsequent adrenocortical steroid production, the imposition of a

stressor causes increased variance in hormone production (Montagner et al., 1978). The increased production of corticoids triggers additional enzyme responses, suppresses inflammation and supplies additional sources of energy to the body (Selye, 1980). Cortisol (corticosterone in animals) released by the adrenal cortex and pituitary ACTH provides feedback to the brain, thereby influencing central neurological response and further hormone release (de Wied), 1980).

Animal studies have shown considerable variation in the response of the pituitary-adrenocortical axis depending on the type of stressor (Quirce & Maickel, 1981) and the age, species and sex of the animal (Hennessy & Levine, 1979). Human studies have noted that cortisol release depends on the level of control (Lundberg & Frankenhaeuser, 1978; Mason, Maher, Hartley, Mougey, Perlow & Jones, 1976; Rubin, Miller, Clark, Poland & Arthur, 1970) and the defense mechanisms (Vaernes, 1983) an individual exercises in a situation, and the novelty of the situation (Rubin, 1974; Sweeney & Maas, 1979). Although adult levels of cortisol are attained by age three, greater variability continues until age seven (Ranke, Rosendahl & Gupta, 1982; Sippell, Dorr, Biddlingmaier & Knorr, 1980). Sex does not appear to affect cortisol levels. While both plasma and urinary measures of cortisol and cortisol metabolites (17-hydroxycorticosteroids [17-OHCS] and creatinine) have been used in numerous adult studies, measurement of cortisol in children has been limited to urine analysis.

Six stress studies utilizing cortisol measures with children

ranging in age from infancy to 14 years were located (Barnes et al., 1972; Knight et al., 1979; Lundberg et al., 1981; Lundberg, 1983b; Montagner et al., 1978; Tennes et al., 1977). The potential stressors included separation and stranger situations for infants (Tennes et al., 1977), new or distressing social situations (Lundberg, 1983b; Montagner et al., 1978), hospitalization (Knight et al., 1979; Lundberg et al., 1981), and specific treatment situations (Barnes et al., 1972). With the exception of the Lundberg studies, cortisol levels showed a significant increase under stressor conditions. In the 1981 Lundberg study, children (age three) were participating in their fourth hospital day visit and were accompanied by their parents. The 1983 study included eleven children (ages 3-6) during their first three weeks at a day care centre. The children were accompanied by a parent for the first few days and special efforts were made by the staff to help the children adjust. Lack of significant cortisol alteration from home to hospital or from first week to third week may have reflected a lack of threat or unaltered sense of control perceived by the children. Unfortunately, cortisol excretion from the first and fourth hospital visit and from children with and without previous day care experience was not contrasted. The lack of significance in these studies, alternatively, may have reflected the high variability in cortisol which occurs at young ages.

Sympatho-adrenomedullary response. The sympatho-adrenomedullary axis has been found to react more quickly and to a stressor stimulus of lower intensity than the pituitary-

adrenocortical ~~axis~~ (Kagan & Levi, 1975). Stimulation of the adrenal medulla by hypothalamic neurons causes a release of adrenalin (A) and small amounts of noradrenalin (NA) into the blood. Hypothalamic stimulation of the sympathetic nervous system similarly increases the release of noradrenalin from sympathetic nerve endings (Frankenhaeuser, 1971; Levi, 1967). Concomitant with change in adrenalin and noradrenalin, the level of 3-methoxy-4-hydroxyphenethylene glycol (MHPG), a metabolite produced from the degradation of A and NA, changes under stressor conditions. Although MHPG does not provide a direct measure of sympatho-adrenomedullary response, it does indicate A and NA turnover and has been measured in human stress or anxiety studies (Cymerman & Francesconi, 1975; Frankenhaeuser et al., 1978; Maas, Dekirmenjian & Fawcett, 1971; Rubin, Miller, Clark, Poland & Arthur, 1970; Sweeney, Maas & Heninger, 1978).

Adrenalin stimulates the heart and skeletal muscles, causes an increase in the glucose levels in the blood and immobilizes the intestinal organs. While noradrenalin has a general vasoconstrictor action, the coronary vessels are dilated with both systolic and diastolic pressure increasing. In addition, plasma catecholamines increase oxygen consumption and the plasma level of free fatty acids, thus preparing the body for the additional demands being presented.

Studies have indicated that adrenalin may be released in response not only to threat appraisal but also to situational demands for concentration and alertness (Lundberg & Frankenhaeuser, 1980; Rubin, 1974). The alteration of noradrenalin during the

stress state is less clear but appears to be related to threatening situations which require a physiological or psychological exertion (Dimsdale & Moss, 1980; Leblanc, Cote, Jobin & Labrie, 1980). Adrenalin has been accepted as a more sensitive indicator of psychological arousal than noradrenalin in both adults and children (Frankenhaeuser & Johansson, 1976; Lundberg et al., 1981).

As with cortisol, plasma and urinary levels of catecholamines have been used as measures of stress response in adult studies. Although research has indicated that adrenalin and noradrenalin excretion reach adult levels by age seven (Moyer, Jiang, Tyce & Sheps, 1979), the only child stress studies utilizing this measure are those undertaken by Frankenhaeuser and her colleagues at the University of Stockholm. These studies have shown significant adrenalin increase for boys (ages 12-13) during cognitive tasks (Bergman & Magnusson, 1979; Johansson et al., 1973), significant noradrenalin increase for boys (ages 3-6) in new social situations (Lundberg, 1983b), and significant adrenalin and noradrenalin increases for boys and girls (age 3) during a hospital visit (Lundberg et al., 1981). North American studies of anxiety in children, ages 6 to 16, using heart rate and skin conductance as indicators of catecholamine response have shown increased response with cognitive (Burgess et al., 1971; Hamilton, 1979b), emotional (Miklich et al., 1973) and situational stressors (Melamed & Siegel, 1975; Sturner et al., 1980).

Levels of MHPG, a minor metabolite of adrenalin and noradrenalin in the peripheral system but a major metabolite of

central noradrenalin, have been measured in human (Cymerman & Francesconi, 1975; Frankenhaeuser et al., 1978; Maas et al., 1971; Rubin et al., 1970; Sweeney & Maas, 1979) and animal (Gilad & Jimerson, 1981; Korf, 1976) stress studies. While the majority of peripheral MHPG in rodents appears to be of peripheral origin (cf., DeMet & Halaris, 1979), numerous studies have indicated that a portion of peripheral MHPG in primates and man is either of central origin (Blomberg, Kopin, Gordon, Markey & Ebert, 1980; Cymerman & Francesconi, 1975; DeMet & Halaris, 1979) or closely reflects central levels (Elsworth, Redmond & Roth, 1982). Since alternative findings have been presented which may explain the correlation between central and peripheral MHPG (e.g., plasma MHPG can affect cerebrospinal fluid levels of MHPG [Kopin, Gordon, Jimerson & Polinsky, 1983]), interpretation of peripheral MHPG as an indicator of central activity must be considered speculative.

In a study in which MHPG was interpreted solely as an indicator of peripheral activity, Halaris and DeMet (1980) noted that the metabolite alterations depended on changes in the synthesis and degradation of NA (as opposed to NA levels) with MHPG first increasing and later decreasing when NA uptake was blocked. The decreased MHPG levels were interpreted as indicating an NA synthesis decrease that occurred with time.

A study of urinary and plasma MHPG and NA in rats following stress demonstrated differing catecholamine-metabolite relationships for different strains of rats (Gilad & Jimerson, 1981). The

high stress-reactive rats showed increased NA and decreased MHPG with stressors of varying time periods, while the low reactive rats demonstrated smaller increases of NA for all stressor time periods and a varying pattern in MHPG levels. With short time-span stressors, MHPG decrease was similar to that of the high-reactive rats; but with more lengthy stressors, only a small decrease was evident. This may imply the synthesis-degradation alteration referred to by Halaris and DeMet. The MHPG differences were interpreted as indicating different modes by which organisms can cope with stressor situations. The minimal decrease in MHPG demonstrated by the low-reactive rats encountering long-term stressors was interpreted as reflecting an adaptation to the stressor.

MHPG and catecholamine levels seldom have been measured simultaneously in human stress studies. The one study located (Frankenhaeuser et al., 1978) showed a significant positive relationship between NA and MHPG under control and examination stressor conditions and between A and MHPG under control but not under stressor condition. MHPG excretion has received considerably more attention in studies with depressives. In a review of research on MHPG changes in normals and depressives after presentation of moderate stressors, Sweeney and Maas (1979) concluded that depressives generally excrete significantly more MHPG under moderate stressor conditions than do normals. This was interpreted as indicating increased sensitivity to stressors among depressives owing to the presence of low chronic stressors. The findings presented above would indicate that the increase in MHPG among depressives may imply a maladaptive response, i.e., breakdown of NA despite a higher demand for NA.

CNS neurotransmitter response. The third physiological system to show alterations during a stressful experience is the central nervous system (CNS). Animal studies have demonstrated alterations in the synthesis, utilization and reuptake of several neurotransmitters: norepinephrine, epinephrine, dopamine, serotonin, acetylcholine and opiate peptides (Anisman et al., 1981b). Since norepinephrine (NE) alteration during stress is considerable and is, at present, best understood, the following discussion will focus on this neurotransmitter. Discussion will be based on findings from animal studies.

Animals exposed to moderate stressors, as determined by intensity, controllability and response opportunity factors, show a relative increase in synaptic NE levels as a result of decreased intraneuronal degradation (MAO inhibition [Welch & Welch, 1970]). It has been postulated that the increase in the level of NE is an adaptive process which helps the organism meet situational demands (Welch & Welch, 1970). As the stressor decreases, NE levels return to baseline. If, however, the stressor is more severe or longer lasting and thus high NE utilization continues, MAO inhibition alone cannot maintain sufficient NE. Enzyme activity (tyrosine hydroxylase and dopamine- β -hydroxylase) increases, thereby stimulating NE synthesis and re-establishing adequate synaptic levels (studies reviewed in Anisman et al., 1981b). If the stressor terminates or is otherwise modulated, utilization and synthesis return to normal. The mechanisms underlying normal NE activity do not appear to be disrupted.

If, however, the demand (i.e., utilization by brain systems)

continues to exceed synthesis, synaptic NE depletion occurs. With chronic stress, adaptive mechanisms come into play and NE baseline levels are re-established through continued higher synthesis and lower reuptake. The sensitivity of post-synaptic sites appears to decrease to avoid an abnormal effect from high NE release on the post-synaptic neuron (Anisman et al., 1981b). Thus, while NE synaptic levels can be considered normal, the state of the neurons is abnormal. With eventual termination of the stressor, normal NE utilization and synthesis is re-established. The state of the neuron, however, may not return to normal as is evidenced by the immediate NE depletion which occurs when a minor stressor is imposed (Anisman et al., 1981a).

Psychological Response

While stress, as defined in this paper, constitutes a physiological response, this seldom occurs without some awareness at the psychological level. Awareness, labelled as anxiety, may represent (1) the initial psychological response to the stressor (i.e., the appraisal which served to precipitate the stress), (2) an intrusion of the physiological alterations (e.g., increased heart rate, muscle tension) on the individual's consciousness, or (3) a combination of the two.

The relationship between anxiety and stress as alternative dimensions of the same event has been demonstrated in a number of studies by a positive correlation between state anxiety and catecholamine (Dimsdale & Moss, 1980; Sweeney, Maas & Heninger, 1978) or cortisol levels (Price, Thaler & Mason, 1957).

Findings, however, are not consistent. Barnes and colleagues (1972) found no correlation between urinary 17-OHCS and assessed anxiety for children undergoing open-heart surgery. It should be noted that the children in this study were encouraged to verbalize and express through play materials their fears and concerns. It may be that the expression of anxiety (assessed by the psychiatrist or pediatric nurse who interacted closely with the children throughout the hospital stay) represented a coping response, thus altering the relationship between psychological and physiological response. Alternatively, children's report of state anxiety may be less precise than that of adults or, as indicated in Vaernes' factor analysis study (1983), state anxiety may not correlate with biochemical measures. It should be noted that some of the studies showing a positive correlation between biochemical alteration and anxiety used depressives (Sweeney et al., 1978) or medical patients (Price et al., 1957) as subjects and, therefore, may have introduced a confounding factor.

Several recent studies measuring urinary catecholamines and cortisol and self-perceived affect have applied factor analysis to the physiological measures (Vaernes, 1983; Vaernes, Ursin, Darragh & Lambe, 1982) or to the combined physiological and psychological measures (Lundberg & Frankenhaeuser, 1980). Lundberg and Frankenhaeuser (1980), using data from eight situations (three baseline and five cognitive performance sessions), extracted two factors: (1) a distress factor with negative affect and cortisol excretion loadings and (2) an effort factor with

action-proneness and adrenalin excretion loadings. Parachutist, deep-sea diver and non-swimmer studies reviewed by Vaernes (1983) included measurement of several additional hormones. Three factors emerged, each relating differently (correlation analysis) to psychological variables: (1) a catecholamine factor demonstrating negative correlation with isolation scores on a coping preference inventory, (2) a cortisol factor demonstrating positive correlation with reaction formation scores on a projective defense mechanism scale, and (3) a testosterone factor demonstrating positive correlation with regression scores on the coping preference inventory. Correlations with anxiety self-reports (as measured on the Mood Questionnaire which has shown significant correlation with Spielberger's State-Trait Anxiety Inventory [Ryman, Biersner & LaRocco, 1974]) were not significant (Vaernes, 1983). While interesting hypotheses are raised by these studies, the validity and reliability of the psychological measures (story responses and interpretive ratings of sketches drawn following a tachistoscopic presentation of Thematic Apperception Test pictures) can be questioned. Similar studies employing more objectively scored psychological measures are needed.

Summary

Research with humans and animals has demonstrated a negative correlation between the presence of coping and physiological responses under stressor conditions. While plasma and urinary trace measures of adrenalin, noradrenalin and cortisol permit

measurement, albeit indirect, of alteration in the stress-related peripheral biochemical systems, alteration in the CNS cannot be measured in humans under normal conditions. The studies reviewed indicate equivocal findings with regard to the relation between self-rated state anxiety and the physiological stress response.

The Effects of Stress on Cognition

Although stress has been described as having both negative and positive effects (Selye, 1980), research has focused on the disruptions, physiological and psychological, which appear to occur as a result of stress. Life change event and immunological studies have indicated that emotional and physical illness may reflect, in part, stress effects. Of central concern to this study is the effect stress may have on cognitive functioning.

The following review will discuss the components of cognition which appear to be affected by stress, the processes whereby such effects may be occurring, and stress and cognition studies which have used child samples.

Components of Cognition

Cognition studies utilizing a stress paradigm have included measures of perception, matching, attention, memory encoding and retrieval, and conceptual restructuring. Findings in each of these areas will be reviewed briefly.

Perception as measured by immediate response (Bacon, 1974), letter cancellation (Chatterjea, Bhattacharya & Bhattacharyya, 1977) and Witkin's Embedded Figures (S. Sarason et al., 1960) has

shown no deterioration under stressor conditions. Studies which reported perceptual alteration (e.g., Postman & Bruner, 1948) were found to have used attention, rather than perception, tasks.

Possible disruption of matching skills has been tested in experiments employing recognition memory tasks in which a presented stimulus is compared with previously learned information (Mueller, 1976). Although high and low trait anxiety subjects (the cognitive task being considered as a stressor) showed differential decrement on a memory recall task, performance on recognition tasks was similar. While this would appear to indicate no effect on matching, the difference in performance may have reflected the instructions used rather than the tasks; recall instructions could have presented a threat while recognition instructions did not. More careful analysis of matching skills under stressor conditions is needed.

Attending, defined as the scanning and selection of information (i.e., cue utilization), has been shown to decrease or shrink when a variety of stressors are applied (Bruning, Capage, Kozuh, Young & Young, 1968; Easterbrook, 1959; Geen, 1975; Hockey, 1970, 1979; O'Malley & Gallas, 1977; O'Malley & Poplawsky, 1971; Wachtel, 1968). Although Postman and Bruner (1948) described the selection of information as being less well controlled, a review of their findings indicates a narrowing effect. Following the Yerkes-Dodson effect, initial narrowing of attention appears to improve performance, particularly on simple tasks, while more extensive narrowing or involvement in complex tasks which require

the use of peripheral cues leads to a deterioration of performance. These effects have been found with both sensory stressors (Hockey, 1970; O'Malley & Gallas, 1977; O'Malley & Poplawsky, 1971; Wachtel, 1968) and ego stressors (i.e., situations threatening to an individual's self-image [Bruning et al., 1968; Geen, 1975]). It should be noted that the presence of a stress response in these studies was inferred from performance deterioration and was not measured directly. Observational reports of the imposition of natural stressors in learning situations have noted a disorganization of attention (Lourie & Schwarzbeck, 1979; Schwartz, 1976).

Studies using sustained, as opposed to selective, attention tasks have shown no deterioration with increased A levels (Frankenhaeuser & Järpe, 1963; Obrist, Gaebel, Teller, Langer, Grignolo, Light & McCubbin, 1978). A third study showed better sustained attention performance under a mild stressor condition relative to a no stressor or a high stressor condition (Srivastava & Naidu, 1982).

Both negative and positive effects of stress on memory encoding have been reported. Recall of material presented in an established order has been found to improve under stress conditions (Eysenck, 1976; Hamilton, Hockey & Quinn, 1972; Hockey, 1970, 1973). In an experiment in which 100 adults were required to recall paired-associate words in the same order as presented or, only, ordered but not random recall improved under the stressor (noise) condition (Hamilton et al., 1972). Under the no-stress condition, ordered and random recall were the same. The improved recall was interpreted as reflecting increased attention

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to word order. In an experiment where recall depended on phonetic cues already provided within the word, memory (short-term and long-term) similarly improved under the stressor condition (Schwartz, cited in Hockey, 1979). When, however, a re-ordering of material was required, memory deteriorated (Hockey, 1979). Studies indicating poorer paired-associate recall than list recall under stressor conditions (Eysenck, 1976; Waite, Sarason, Lightfall & Davidson, 1958) may be reflecting a similar phenomenon, i.e., a difficulty establishing links and not a difficulty with memory.

Since the depressive state demonstrates neurochemical alteration similar to that evidenced during stress (Anisman & Zacharko, 1982), studies of memory in depressives were reviewed. Memory difficulties experienced by depressives have been found to reflect less efficient use of organizational and association strategies (Hasher & Zacks, 1979; Weingartner, Cohen, Murphy, Mantello & Gerdt, 1981). Memory not dependent on strategies was found to differ insignificantly between depressives and non-depressives (Hasher & Zacks, 1979). It would appear that memory encoding, as separate from memory strategies, is not affected under stress.

In contradiction to this conclusion is the commonly accepted relationship between performance on the digit span task (i.e., immediate memory) and anxiety, wherein poor performance is interpreted as an indication of high anxiety (Matarazzo, 1972). In a review of studies using the WAIS digit span subtest, Matarazzo (1972) concluded that no relation existed between

immediate memory and trait anxiety but if a stressful situation was perceived and therefore state anxiety occurred, digit span performance did deteriorate (e.g., Moldawsky & Moldawsky, 1952). This effect, however, is not consistent across studies, thus raising the question as to whether a third variable (e.g., motivation) and not anxiety may be affecting memory in these studies.

In a review of research looking at memory retrieval, Eysenck (1976) concluded that highly aroused individuals are able to access dominant information more easily than low aroused individuals, while low aroused individuals can access less dominant information more easily. This is similar to Persson and Sjöberg's (1978) conclusion that over-learned material remains accessible when a stressor occurs while new information becomes harder to remember. This conclusion is consistent with the drive theory of performance (Heinrich & Spielberger, 1982; Spence, 1958). The alteration in memory retrieval, however, may not be an effect of arousal but rather a result of decreased patterning during encoding (Mueller, 1978) or decreased cue utilization during retrieval. The only study located which directly examined memory retrieval (Schwartz, 1974) indicated that a shift in the use of retrieval strategies does occur under stressor (noise) conditions. Replication and extension to other stressor conditions are needed before it can be concluded that memory retrieval may be affected directly by stress.

The ability to abstract and pattern information as it is processed (i.e., conceptual restructuring) does appear to alter under stressor conditions. High-anxiety, depressed and

experimentally stressed individuals have shown significantly poorer performance than low anxiety, non-depressed or control subjects on cognitive tasks requiring abstract (Hamilton, 1979b; Krop, Alegre & Williams, 1969; Siegman, 1956) and associative thinking (Hasher & Zacks, 1979; Renner & Renner, 1972). Studies with high and low trait anxiety subjects found high anxiety individuals deficient on memory tasks requiring conceptual or semantic clustering while tasks dependent on direct attributional or acoustic clustering did not differentiate between high and low anxiety individuals (Mueller, 1976). A further study by Mueller (1978) designed to investigate the effect of anxiety on depth-of-processing indicated that high trait anxiety subjects performed as well as low anxiety subjects on first letter clustering but less efficiently on both taxonomic and rhyme clustering. While Mueller tentatively concluded that anxiety effects were not limited to deep (i.e., semantic) levels of processing, it may be that rhyme clustering for the high anxiety subjects was affected by narrowing of cue utilization (words were presented visually) and thus the results may not be relevant to the depth-of-processing issue. Owing to the almost exclusive use of memory tasks for measuring conceptual processing skills, any hypothesis regarding anxiety and stress effects on processing must remain tentative. Studies utilizing paradigms other than memory are needed.

Child and adult studies utilizing cognitive or ego stressors and examining performance on tasks which require alternation of response (digit-symbol, verbal coding and alternative button press

tasks) have shown a deterioration of performance under stress conditions (Castaneda, 1961; Castaneda & Lipsitt, 1959; Chatterjea et al., 1978; Katchmar, Ross & Andrews, 1958; Palermo, 1957). While these tasks cannot be considered to tap abstracting and patterning ability, they do require the inhibition of one pattern of thought or response and the initiation of another, a process necessary if information is to be patterned or re-organized. Tasks dependent on multiple-sort behaviour (i.e., abstraction plus alternation) have shown deterioration under stressor conditions (Beier, 1951; Ross, Rupel & Grant, 1952). The two studies located which showed no deterioration in creative or sorting behaviour under the experimental "stressor" condition (Belcher & Parisi, 1974; Wesley, 1953) can be questioned owing to the nature of the imposed stressor or task (observation by adults in a university-connected school and presentation of a card-sorting task to university students).

Studies have also indicated earlier and more impulsive decision-making by individuals under stress (Dittes & Smock cited in Persson & Sjöberg, 1978; Hockey, 1973; Moffitt & Stagner, 1956). As with decreased flexibility, premature decisions limit the processing within a cognitive task.

In summary, a review of the literature on stress and cognition has indicated two areas in which stress appears to affect cognition: attention and the abstracting and patterning of semantic information. This conclusion must be qualified since (1) the various components of cognition have not been examined within a single study, i.e., under identical stressor conditions,

(2) abstracting and patterning has not been adequately tested outside a memory paradigm, and (3) the existence of stress during cognitive performance seldom has been assessed by direct physiological measures.

Processes underlying Cognitive Disruption

Cognitive disruption during stress has been explained by a variety of theories: increased drive (Spence, 1958), intrusive thinking (Deffenbacher, 1978; Horowitz & Wilner, 1976; I. Sarason, 1975), learned helplessness (Alloy & Seligman, 1979; Diener & Dweck, 1978; Dweck & Licht, 1980), arousal (Hebb, 1955; Welford, 1976) and neurochemical alteration (Broverman, Klaiber, Kobayashi & Vogel, 1974; Tyler & Tucker, 1982).

The drive theory has proposed that increased drive, such as would occur with a stressor situation, causes well-learned or easily-apparent responses to become more accessible while less-practiced or less-apparent responses become less accessible. Although this theory has been supported by a number of experiments in which learning or accessibility of response was carefully manipulated (see Heinrich & Spielberger, 1982), the findings have not been analyzed to determine if they can be explained more adequately by alternative theories.

Intrusive thinking or self-preoccupation, being itself a cognitive process, uses part of an individual's cognitive capacity, thus less capacity remains for the task at hand (I. Sarason, 1975). While this process can explain the narrowing of attention, the deterioration of specific types of restructuring

which occurs under stressor conditions is only indirectly accounted for.

Learned helplessness has been described as causing a motivational deficit (reduced incentive), a cognitive deficit (reduced ability to learn), and eventually an emotional deficit (anxiety followed by depression (Alloy & Seligman, 1979)). Although studies of negative attribution in children have indicated decreased involvement in the learning or cognitive processes and poorer performance (Diener & Dweck, 1978; Dweck & Licht, 1980), alteration of cognitive processes has not been demonstrated.

The arousal theory indicates an alteration in cue utilization due to altered signal detection ratio, the signal becoming more pronounced in relation to "noise" at lower levels of arousal but blurred with "noise" at higher arousal levels. Once again the attention, but not the conceptual restructuring, effect of stress may be explained.

The possibility that cognitive disruptions under stressor conditions reflect neurochemical alterations has received little attention. Broverman and colleagues (1968, 1974) hypothesized that the improvement in over-learned or repetitive cognitive processing and deterioration on cognitive alteration tasks following imposition of a stressor reflected adrenergic dominance in the CNS. They noted that increased activity in adrenergic neurons leads, in time, to depletion and a subsequent increase in ACh which they described as further inhibiting the initiation of cognitive processes.

Tucker and colleagues, based on their research on anxiety

(Tyler & Tucker, 1982), stress (Tucker, Roth, Arneson & Buckingham, 1977) and depression (Tucker, Stenslie, Roth & Shearer, 1981), proposed deterioration in right hemisphere functioning related to alteration in the noradrenergic neurotransmitter system (hypothesized as being lateralized to the right hemisphere [Oke, Keller, Mefford & Adams, 1978] or as having more sensitive response in the right hemisphere [Robinson, 1979]). Alteration in right hemisphere functioning was interpreted as increasing the likelihood of a predominantly left hemisphere (analytic) approach to cognitive tasks under stressor conditions.

Research relevant to stress-related neurochemical changes and behaviour alteration will be reviewed to determine whether a neurochemical alteration theory can offer an explanation for the disruption of abstracting and patterning ability, i.e., an alteration of specific elements within cognition as opposed to restricted use or shrinking of cognitive capacity. Owing to the limited human research in this area, research with animals will be included.

Increased adrenocorticotrophic hormone (ACTH), as occurs with the stress response, has been found to increase attentional behaviour, the hypothesized underlying process being an alteration in signal-background ratio with the signal becoming more prominent (de Wied, 1980; Oades, 1979). Decreased habituation also has been noted as occurring with injections of ACTH (Endroczi, Lissak, Fekete & de Wied, 1970). While increased corticosterone (the animal neuroendocrine parallel to human

cortisol) appears to have similar effects on habituation (Micco cited in McEwen & Micco, 1980), attention to irrelevant cues (as opposed to the established and presumably relevant signal indicated in ACTH studies) appears to increase (McEwen & Micco, 1980). Regardless of the dimensions of the situation (relevant, irrelevant), alteration in cue perception and behaviour patterning appears to be inhibited.

Memory effects demonstrated in animal and human studies of ACTH are inconsistent (Rapoport, Quinn, Copeland & Burg, 1976; Rigler & Van Riezen, 1975). Generally, moderate increases in ACTH have been found to improve memory while larger doses are detrimental. The latter effects may be related to increased levels of corticosteroids (a memory inhibitor [McIntyre, 1976]).

Research with animals has indicated a positive correlation between NE neuron activity and orienting behaviour involving (1) attention to important cues and shifting between cues (Aston-Jones & Bloom, 1981; Segal & Bloom, 1976), (2) acquisition of active avoidance behaviour (Hraschek & Endroczi, 1979), and (3) initiation of delayed response and activity maintenance (Anisman, Kokkinidis & Sklar, 1981a). While improved functioning in each of these areas occurs with moderately increased levels of NE, high dose injection (Kety, 1970) or depletion (as is produced by the imposition of a severe stressor [Anisman et al., 1981a; Bruto & Anisman, 1981], pharmacological blockers [Anisman et al., 1981a; Hraschek & Endroczi, 1979] or lesions [Aston-Jones & Bloom, 1981]) has resulted in perseverative, disorganized and eventually depressed behaviour.

ACh, which has been shown to first decrease and then increase following the occurrence of a stressor (Zajaczkowska, 1975) has been found to facilitate memory encoding in humans when injected in moderate amounts (Sitaram, Weingartner & Gillin, 1978; Weingartner, Sitaram & Gillin, 1979), but to cause a detrimental effect when large dosages were used (Hunter, Zornetzer, Jarvik & McGaugh, 1977; Weingartner et al., 1979). ACh increases also have been found to inhibit the initiation of behaviour (Anisman, Glazier & Sklar, 1981) thereby decreasing performance and thus reinforcement of learning.

In summary, studies of NE and the ACTH/corticosterone-related behaviour indicate improved attention with moderate increases while excessive amounts or severe depletion leads to increasingly perseverative, disorganized (inability to pattern behaviour) and depressive behaviour with an apparent deficit in memory retrieval. High levels of ACh have been noted as disrupting memory encoding and the initiation of behaviour. The behaviours which occur in animals with neurochemical alterations parallel to stress-induced alterations appear similar to the cognitive behaviour which occurs in humans under stressor conditions. Thus, a neurochemical theory of stress effects on cognition may explain both the attentional and the patterning disruption which occur under stress.

Studies of peripheral epinephrine or adrenalin (A) in humans support this theory. Significant positive correlations have been found between both A and NA and performance on practiced mathematical equation tasks (Johansson et al., 1973) and previously

learned information tasks (Frankenhaeuser et al., 1978). Studies employing higher levels of stressors and/or more complex tasks in which disorganized cognitive behaviour has occurred have not included biochemical measurements. Decreased ability to cluster or structure information has been found to occur with depression, an NE depleted state hypothesized as being similar to that of extreme stress (Weingartner et al., 1981).

The relationship between cognitive performance and Tucker's theory of differential hemispheric activity under stressor conditions has received little research attention. While increased predominance of left hemisphere processing, hypothesized as being caused by an alteration in NE activity disrupting right hemisphere functioning (Tucker, 1981; Tyler & Tucker, 1982) is congruent with the observation of attention narrowing under stressor conditions, the effect on conceptual restructuring is unclear. Right hemisphere disruption would imply greater alteration on tasks based on spatial as opposed to verbal concepts (Lezak, 1976). Since the majority of the studies relevant to conceptual restructuring were memory tasks based on verbal content, a comparison between spatial and verbal processing is not possible.

A study of cognitive performance undertaken by Tyler and Tucker (1982) found that high trait anxiety university students reporting high state anxiety under noise conditions experienced significantly more difficulty on the Mooney Closure Faces Test (purported to measure right hemisphere functioning) but insignificant

alteration on digit span forward and verb count tasks (measuring left hemisphere functioning) compared to low trait anxiety students who reported low and high state anxiety and high trait anxiety students who reported low state anxiety.. While this study does not clarify verbal-spatial differences, it can be interpreted as indicating decreased right hemisphere functioning. Although the explanations by Tucker and colleagues are often unclear and at times contradictory and the research on lateralization of neurotransmitter systems is still explorative, the possibility of altered hemispheric functioning related to changes in specific neurotransmitter systems should be considered when reviewing possible relationships between neurochemical activity and cognitive functioning.

To summarize, attention narrowing can be explained by each of the theories which has been posed to explain cognitive alteration under stressor conditions. The disruption of abstracting and patterning ability (an alteration of specific elements within cognition as opposed to restricted use or shrinking of cognitive capacity), appears, however, to be accounted for more adequately by the neurochemical alteration theory.

Striking parallels exist between animal behaviour that occurs with alteration in stress-related neurochemicals and human cognitive behaviour that occurs with stress--an improvement under limited stressor conditions with simple tasks but deterioration under increased stressor conditions or with more complex tasks. These alterations in behaviour may reflect the variations in synaptic levels of neurochemicals which occur in animals under

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limited or extensive stressor conditions. A relation between neurochemical alteration and cognitive disruption, however, can be no more than conjecture until the two have been examined within a single study.

The above review of research supporting the hypothesis that stress-related cognitive disruptions may be related to neurochemical alteration is not intended to imply that intrusive thinking, learned helplessness, drive, and arousal do not affect cognition. Effects, as described at the beginning of this section, may coexist with, or indeed exist separately from, a neurochemical effect.

Research with child populations - Studies utilizing natural-occurring stressors with child populations have shown contradictory findings regarding effects on cognition. Children performing a mental arithmetic task under test conditions (Johansson et al., 1973) and adolescents taking a university matriculation examination (Frankenhaeuser et al., 1978) have shown significant differences in performance for adrenaline increasers and decreasers. In the study of 12-13 year olds which measured catecholamines during passive (film viewing) and active (a three-step mental arithmetic test) conditions (Johansson et al., 1973), a significant positive correlation between change in NA excretion and performance quality was found for girls but no correlation was found for either sex with alteration in A excretion. When, however, the children were divided into groups according to A alteration between conditions (A increasers, A decreasers), it was found that the increaser group did significantly

better than the decreaser group on arithmetic performance. Significant findings for an analysis of variance with insignificant findings for a correlation analysis may imply a categorical effect without a direct relationship between small unit changes. Since increased adrenalin alerts the individual, thus increased attention to the task at hand, the effect shown in this study may have been separate from an alteration in cognitive processing. This possibility is supported by the significant time by A interaction which occurred for boys. Performance difference between A increasers and A decreasers late in the task was greater than that occurring early in the task.

The study of older adolescents taking a matriculation examination (Frankenhaeuser et al., 1978) included urinary measures of cortisol, A, NA and MHPG and measures of examination performance. Adrenalin and MHPG levels were found to increase significantly from the control condition (a routine day at school) for both sexes with a significantly greater increase for boys. The increase in cortisol and NA levels under the stressor condition was significant only for boys. A positive correlation occurred for boys between A excretion and performance ($r = .47$, $p < .05$), with the correlation between MHPG and performance approaching significance ($r = .41$, $p < .10$). Adrenalin changes in girls were more varied than in boys and showed no correlation with performance and a negative correlation with sense of success ($r = -.42$, $p < .05$). Gender differences in this study were interpreted as a result of learned behaviour patterns with girls feeling under less pressure during an academic

examination (Rauste-von Wright et al., 1981). The different A and performance correlations demonstrated may indicate that moderate changes in an internal state, as experienced by the girls in this study, does not relate to cognitive performance while larger changes do, or, alternatively, some other variable possibly associated with gender may be affecting the relationship. Since multivariate statistics were not used in this study, the possibility of Type I error must be considered when evaluating these results.

In contrast to the generally positive influence of stress on cognitive performance noted in the above studies, a longitudinal study of children demonstrated a low but significant correlation between cognitive problems (mind drifts, slow thinking, trouble remembering and poor grades) and life change events (considered as acute stressors) when ongoing stressors (social and familial variables) were not factored out (Gersten et al., 1977). When ongoing stressors were factored out, the correlation was no longer significant. Similarly, school studies have indicated a significance negative correlation between academic performance on tests and high trait anxiety (Phillips, 1978; I. Sarason, 1963; S. Sarason et al., 1960; Young & Brown, 1973):

These findings may not be contradictory but may instead represent different levels within the stress response. Studies showing a positive correlation between peripheral stress response (adrenalin increase) and cognition included a population experiencing a single stressor while the studies showing a

negative correlation included a population experiencing chronic plus acute stressors. Alternatively, these findings may indicate differential effects of stress depending on the type of cognitive functioning required.

Hamilton and his students conducted a series of experimental cognitive studies with high trait anxiety and low trait anxiety children (Hamilton, 1979b). They found that low anxiety children were able to improve performance on automatic cognitive tasks (simultaneous reaction time and digit rehearsal tasks) as the number of stressors increased while the performance of the high anxiety children either remained the same or deteriorated. When equation and anagram tasks (i.e., complex tasks requiring restructuring) were presented, the performance of the low anxiety students remained the same under the stressor condition while that of the high anxiety students deteriorated. These results, similar to the findings reviewed above, may be interpreted in two ways. Since trait anxiety indicates the likelihood that a situation will be appraised as a stressor, high anxiety children most likely were perceiving more stressors than low anxiety children. In addition, the complex but not the simple test may have been interpreted as a stressor. Alternatively, the data may be interpreted as reflecting a disruption of conceptual processing but not of automatic processing during stress.

Although cognitive stress studies using child populations are limited, the immediate effects of stress on cognition appear to be similar for children and adults. The long-term consequences

of this effect, an area which has not been researched, may be very different. Adults under stress can fall back on over-learned and still accessible information to continue their daily activities. For the child who is dependent on productive thinking and performing in order to succeed in his or her daily school activities and to acquire basic academic skills, the effects of stress may be more pervasive.

Owing to narrowed attention, a child experiencing stress would be unable to learn from incidental teaching that occurs in the classroom and would be unable to use story context to assist word recognition and comprehension. Similarly, if stress caused deterioration of the ability to abstract and pattern material, comprehension would be disrupted and memory encoding would be less efficient. Since early learning is dependent on the accumulation of large quantities of material, the child experiencing stress would be placed at a severe disadvantage.

Learning problems themselves may become a stressor. While children who have not experienced difficulty learning may interpret an unfamiliar word as a challenge, children who do have difficulty are likely to interpret the same word as a threat and, thus, further immobilize their ability to recognize the word.

Summary

In summary, the research on cognition and stress in adults indicates that selective attention and the ability to abstract and pattern facts and concepts are altered under stressor conditions. Since research with children has been limited, similar

effects on children's cognition can only be hypothesized. A review of animal and human research suggests that the biochemicals involved in the stress response play a role in attention, alteration of attention, and the organization and patterning of stimuli and responses. A relation between biochemical alteration and changes in cognitive performance under stressor conditions was hypothesized.

Summary

The review of stress research has focused on three areas: antecedent factors, physiological response and cognitive effects. Because of the many variables which can be considered as antecedent factors, the literature in this area is extensive and diverse. The work by Spielberger (Hodges & Spielberger, 1966; Spielberger, 1972), Lazarus (1966; Coyne & Lazarus, 1980), Dohrenwend and Dohrenwend (1974) and Jenkins (1979) provided frames of reference in which these factors could be viewed. While experimental work with children has been limited and has tended to be narrow in terms of the number of factors analyzed, the observation study of Murphy and Moriarty (1976) and the longitudinal study (based on interview information) of Gersten and colleagues (1977) looked at the interaction of antecedent factors relevant to stress in children. The review of this research indicated that both personal (e.g., trait anxiety, locus of control, health) and situational factors (e.g., number of stressors, support systems) influence an individual's appraisal of and adaptation to a stressor condition.

Human and animal research on the physiological stress response utilizing both experimental and natural stressors has increased during the last five years. Of particular value to child research have been the studies conducted by Marianne Frankenhaeuser and her colleagues at the University of Stockholm. Until recently, however, Swedish studies have measured only catecholamine excretion. Child studies including urinary measures of cortisol under varied conditions (see in particular, Knight et al., 1979; Montagner et al., 1978) have helped to clarify the role of this biochemical in the stress response. The research reviewed indicated that the pituitary-adrenocortical (cortisol) response is linked with the distress factor of a stressor condition while the sympatho-adrenomedullary (A, NA) response is linked with the body's effort to meet the increased demands of the situation. While similar noradrenergic response within the CNS has been measured in animal studies, alteration in CNS neurotransmitter levels can only be inferred in humans.

Research on stress effects on cognition was extensive during the 1960s and 1970s with experimental studies concentrating on single components of cognition (see in particular, attention: Hockey [1970, 1973], memory: Mueller [1976, 1978], processing: Hamilton [1979b]). Review articles by Persson and Sjöberg (1978) and Hockey (1979) were helpful in offering an overview of alteration in cognitive performance under stressful conditions. A major limitation of the cognition and stress research has been the reliance on self-rating anxiety measures or condition manipulation to denote "stress level". While several biochemical studies did

include cognitive tasks (see in particular; Frankenhaeuser et al., 1978; Johansson et al., 1973; Lundberg & Frankenhaeuser, 1980), the tasks served as both experimental stressor and measure of performance. Cognitive performance under no-stress conditions was not measured, thus limiting interpretation.

The review of research on cognition indicated that a narrowing of attention and difficulty with concept restructuring occurs for adults under stressor conditions. A review of animal studies measuring behaviour alteration which occurs in conjunction with neurochemical alteration suggested that the effect of stress on cognition may be in part physiological.

This review has highlighted the need for research in which varied components of cognition are examined under the same stressor-control conditions, the occurrence of a stress response being corroborated by physiological and behavioural measures. Measurement of cognitive performance, biochemical levels, and state anxiety levels would allow analysis of the relation between the alteration occurring in each of these variables under stressor conditions. Measurement of antecedent factors within this paradigm would permit an examination of the influence these factors may have on stress response and subsequent stress effects.

Description of Present Study

The present research was designed to examine the alterations in cognitive performance which occur for children in a naturally-occurring stressor situation and the relation between these alterations and measured levels of psychological and physiological

response. In order to evaluate the effect antecedent factors may have on the stress response and, subsequently, stress effects, measures of personality characteristics, family patterns, and life change events were included.

Owing to the subjective nature of stressor appraisal and adaptability and the need to use change measures for biochemical variables, a within-subject design was chosen with cognitive and psychological response measures repeated twice (stressor - minimal-stressor conditions) and physiological response measures repeated three times (stressor - minimal-stressor - non-stressor conditions).

Presentation of a talk in front of the class was selected as the stressor condition. Because talks are included within the language arts curriculum, use of this event as a stressor did not present an ethical issue. Ideally the stressor condition would have been counterbalanced between Time I and Time II. Since, however, involvement in a familiar testing situation was foreseen as providing relief from the experimental stressor, the stress condition was placed at Time I for all the children. Cognitive testing was considered a minimal stressor. It was recognized that the first collection of a urine sample might serve as a stressor for some children.

Behavioural and biochemical measures were used to assess response to the stressor condition. Because state anxiety may serve as a coping response rather than as a reflection of the occurrence of a stress response, it was felt that an additional behavioural measure was needed. Observer-rated tension levels

were used as an alternative measure. Self-rated state anxiety and observer-rated tension measures were included at Time I and Time II.

While skin response and heart rate has been used as measures of physiological response in a number of child studies, they have been shown to have limited validity and reliability and to be influenced by cognitive factors (Cacioppo & Sandman, 1978; Coates, 1982; Hutt & Hutt, 1978; Venables, 1980). With improved assay techniques, acceptable sensitivity and reliability has been reported for biochemical trace measures (Forsman, 1982; Soldin, Lam, Pollard, Allen & Logan, 1980). Even though the demands of a cognitive task may serve as a stressor and cause or increase biochemical response, performance on a cognitive task does not counteract biochemical alteration.

Although biochemical levels in blood provide a more direct measure of adrenal metabolism, urinary measures are less invasive and, therefore, were chosen for this study. Since synthesis of biochemicals reflects a myriad of internal and external factors and excretion levels provide a measure considerably removed from that of synthesis, levels per se were not considered indicative of situation response. Change measures, with the subject's health and the time within the diurnal cycle held constant, can provide an indication of response (Frankenhaeuser, 1975; 1979). A recent study of repeated urine sampling (Forsman, 1982) has indicated that voluntary bladder emptying can be complete and permits specification of the changes in excreted biochemicals to changes in synthesis and breakdown of chemicals

during the collection period..

Change measures of urinary adrenalin, noradrenalin and cortisol were selected as indicators of physiological response. Measurement of MHPG, a catecholamine metabolite, was selected to provide an indicator of the process whereby catecholamine presence within the system had altered. Although peripheral MHPG has been referred to in several studies as an indicator of central levels (it is able to pass the blood-brain barrier), this interpretation is considered speculative. Because of difficulties encountered in the development of a sensitive protocol for cortisol, it was not possible to include measures of this biochemical in the present study.

Samples of urine were obtained at three times: Time I -- the experimental stressor condition plus cognitive testing, Time II -- cognitive testing, and Time III -- no additional task.

Tasks tapping different aspects of attention and processing were used to delineate any cognitive changes occurring during stress. Since clustered and non-clustered memory lists could provide a means for observing processing patterns as well as provide information on an area of cognition which has presented equivocal findings, a memory task was included. In all, eight tasks requiring 70 to 90 minutes to complete were presented at Time I and Time II with performance at Time II considered as a control condition for within-subject cognitive functioning.

This design did not control for possible learning or carry-over effects. While a pilot study (n=15) had been conducted to

examine the effect of practice on the tasks selected, the testing format and two tasks were changed somewhat between the pilot study and the main study. It was felt, therefore, that the results of the pilot group could not be compared with the experimental study results. In order to provide a control for learning effect on the cognitive tasks, a separate group of children was tested subsequent to the main study. They were presented with the same tasks within the same testing format but without any additional stressors (i.e., talk presentation and urine sampling). The results of this group were used to assess test-retest performance under control conditions.

Measures of personal attribute and situation variables were included in the study as antecedent factors. Trait anxiety and locus of control inventories were completed by the children following cognitive testing at Time II while a recent life event schedule and a family structure and behaviour pattern questionnaire were completed by parents. Assessment of intellectual ability, administered prior to the study by the school or subsequent to the study by the examiner, was used to test for a possible IQ buffer effect vis-à-vis stress response or stress effects.

The present research was designed to examine the effect of stress on children's cognitive processes and the relation between this effect and the psychological and physiological stress responses. The presentation of the experimental condition provided an opportunity to study two further issues relevant to stress in children: the relation between behavioural and

biochemical responses in children under a stressor condition and the role of antecedent factors in children's adaptability to a stressor condition.

CHAPTER III

METHOD

Subjects

The experimental study was composed of two groups of children. One group was selected according to the criterion that they were likely to become anxious before presenting a talk to the class, while the second group was selected as being unlikely to become anxious before presenting a talk.

Since the adrenomedullary system matures around seven years of age (Moyer et al., 1979) and the cortisol system matures around three years of age with variability similar to that seen in adults being achieved by age seven (Ranke et al., 1982; Sippell et al., 1980), children age 8 or older were considered sufficiently mature physiologically for inclusion in the study. The inclusion of conceptual processing within the cognitive tasks meant, however, that a slightly older group of children was required. Pretesting with the object sorting task showed that the conceptual and organizational skills required are sufficiently developed by age ten. The upper age limit of 12 was established in order that the findings reflect child rather than adolescent response. Inclusion of both boys and girls allowed an analysis of gender response to a stressor with social as well as academic implications.

Following acceptance of the research proposal by the Ottawa Board of Education in February, 1983, nine schools were contacted and the participation of grade five, six and seven teachers was requested. Twenty-two classes from seven schools participated in the study.

In the identification stage of the study, children likely to appraise the experimental condition as stressful were identified by means of (1) high scores on a likes-dislikes questionnaire and (2) nomination by the class teacher. Letters requesting permission for the children in each of the 22 classes to participate in the initial stage were sent home to parents (Appendix A). The research was described as examining the effects specific school experiences may have on a child's thinking. A likes-dislikes questionnaire (Appendix B) was administered to 548 children in grades five through seven by a research assistant. The examiner did not administer the questionnaire since it was hoped that the final group of children would not associate selection for the study with their responses on the likes-dislikes questionnaire.

The teacher of each participating class listed the children in the class whom she/he felt would become anxious before presenting a talk. For some classes there was a high level of agreement between child self-identification and teacher-identification. In other classes, teachers appeared to have interpreted "being anxious" as "doing poorly" or children indicated a dislike for performing in front of others because they did not want to do the extra work involved and thus low agreement occurred between the two measures. When low agreement occurred, the examiner prepared a list including an equal number of children scoring high and low on the likes-dislikes questionnaire. The teacher was asked to indicate any children on the list who might become anxious before presenting a talk.

Sixty-six children (12%) received scores above the arbitrary cutoff point established for inclusion in the study and are referred to as the "target" group. Of these children, 19 were eliminated because they were not identified by the teachers on either the initial or the follow-up list and one child was eliminated because the family's English was limited. Fifteen children with low scores on the likes-dislikes questionnaire, who were not identified by the teachers, were selected as controls. Whenever possible, controls were selected from classes having only one target child in order that the target child not become overly concerned with inclusion in the study.

Letters explaining the research study as a study of the effects specific experiences may have on thinking and listing each of the measures to be used (Appendix C) were sent home with 45 sample and 15 control children. Each of these families was then contacted by phone. The central purpose of the study as assessing stress effects was explained and their child was identified as either a target or a control as based on questionnaire completion. One target child was eliminated at this point because the mother felt the child did not become stressed but would have scored high on the questionnaire because she was very open in her expression of feelings. The intent that the child not be aware of the stress-related element of the study or of the way she/he was selected (in order that inclusion in the study not increase a child's negative response to talk presentations or present to the child an image of being stressed) was explained. Eleven of the target families (24%) and one of

the control families (7%) chose not to participate. Of the twelve refusals, eight were based on the child not wishing to give a urine sample and four were based on parental refusal (in one instance refusal occurred because of an objection to the family background questionnaire). This was considered a very positive response and was attributed to the fact that the children had participated in a kidney-testing programme in the schools and, therefore, were not overly-concerned about the request for urine samples. An additional two target and three control children were eliminated owing to medical problems or the use of medications. Four target and one control child were eliminated after the testing sessions owing to errors in procedure (e.g., the time of the talk was altered). A final sample of 29 target and 10 control children with mean ages of 11.6 and 11.1 was included. Based on Chi-square analyses, the control group was not significantly different from the target group on age, sex or intellectual ability. All children were tested during the spring term (April through June), 1983.

Children for the cognitive control study were contacted through day-camp programmes, local soccer teams and friends. The study was described as control testing for a battery of cognitive tasks which had been used in a study of the effects specific school experiences may have on children's thinking (see letter, Appendix D). Eleven children were initially included in the control study. Two children were eliminated following testing because of a high score or inaccurate completion of the state anxiety measure at Time I. Since these results suggested

that the child had become stressed at Time I (a lower score and correct completion occurred at Time II), it was felt that these children should not be included in a control group. The final control study sample consisted of nine children with a mean age of 11.2. The age, sex and intellectual level of the control group was not significantly different from that of the experimental study sample (Chi-square analysis). These children were tested during July, 1983. Since the testing occurred during vacation time, each child was paid \$2.00 per session for participation.

Measures

The present study included five measures representing two response areas, five measures representing two antecedent factor areas and eight measures representing one effect area. Each measure is described briefly below. The likes-dislikes questionnaire used in the initial screening for the target group is also described.

Response. Physiological and psychological responses were measured at Time I and Time II with additional physiological measures at Time III. Urine samples collected in 80 ml sterile bottles were stored in the school refrigerator until the end of the day at which time they were acidified with an EDTA/GSH compound and frozen at -20°C until all the samples from a child had been collected. The catecholamine assays were performed by high-performance liquid chromatography (HPLC) with electrochemical detection according to an adaptation of a procedure

developed by Bioanalytical Systems (LCEC Application Note #15, 1980) (Appendix E). The free monoamine metabolites were assayed in a similar manner by HPLC according to a procedure adopted from Joseph, Kadan and Risby (1981) (Appendix F).

The state-anxiety portion of the Spielberger State-Trait Anxiety Inventory for Children (STAIC) (Appendix G) was administered at a mid-point in testing at Time I and Time II to attempt to measure psychological response. The inventory has three-alternative, forced-choice items for each of the 20 dimensions (e.g., very jittery, jittery, not jittery; very satisfied, not satisfied, satisfied). This inventory, which has been used extensively in stress and anxiety studies, has shown high construct validity (control condition $\bar{x} = 32$; test condition $\bar{x} = 43$) with children of ages similar to those included in the present study (Spielberger, 1973). Test-retest reliability, as would be expected, is low with alteration reflecting an interaction of trait anxiety levels and situational demands.

Because state anxiety may reflect a coping response or learned behaviour, as opposed to a reflection of the stress response, an additional behavioural response measure was included. The examiner scored each child on a scale of 1 to 10 according to the amount of tension observed during the testing session at Time I and Time II. While a formal checklist had not been prepared prior to testing, the following items were used to assess tension: body rigidity, strained facial expression, twisting hands, shaking voice, biting of lips. The intensity of characteristics, as opposed to number of characteristics

demonstrated, was used to determine tension rating. Although neither validity nor reliability was determined for this measure and the scoring was open to bias (the examiner was aware of which children had been identified as likely to be stressed at Time I), it was felt that the observed tension score might reflect a specific response experienced by some children which may not have been evident in the other response measures.

Self-rated levels of response to the experimental stressor would have provided a valuable additional response measure. This evaluative measure was not included since it was felt that requiring a child to verbalize what might be a negative feeling could intensify that feeling.

Antecedent factors. The trait anxiety portion of the STAIC, the Nowicki-Strickland Locus of Control Scale for Children (Nowicki & Strickland, 1973) and selected subtests of the Canadian Cognitive Abilities Test (CCAT) (Thorndike & Hagan, 1974) were used to obtain measures of relatively stable personality and ability factors. Two questionnaires were completed by parents to provide measures of potential situation stressors in the child's life.

The STAIC A-trait scale (Appendix H) was presented following the cognitive testing at Time II. The scale presents three response choices (hardly ever, seldom, often) for statements related to emotional, behavioural or physiological sensations. This scale has shown only moderate test-retest reliability and concurrent validity with other anxiety scales (correlations ranging between .65-.75) in contrast to the adult scale

(Spielberger, 1973). The greater variability is felt to reflect the less stable nature of trait anxiety in children in addition to any psychometric limitation. Owing to the extensive normative and experimental research conducted with this inventory, it was judged to be appropriate for the present study.

The Nowicki-Strickland Locus of Control Scale for Children (Appendix I) was presented following the STAIC at Time II. This scale lists statements which reflect a belief or lack of belief in control of the environment and asks the child to indicate agreement or disagreement with each statement. Correlation and factorial studies with this scale have indicated strong construct validity (Nowicki, 1976; Nowicki & Strickland, 1973; Wolf, Sklov, Hunter & Benenson, 1982). Test-retest reliability has been shown to be between .63 and .66 in a number of studies with the 10-12 age group (reviewed in Nowicki, 1976).

The four subtests of the CCAT most directly related to reasoning skills (verbal tests 3 and 4, non-verbal subtests 1 and 2) were selected as measures of general verbal and performance ability levels. The scores from these subtests were prorated to obtain overall scores. The total test was not used in order to limit the time the child was withdrawn from class.

Although correlations between subtest and overall performance were not available, this was not considered a problem since the scores were used to determine rank placement or as an independent covariate and not as a dependent measure. While validity and reliability studies have not been conducted with

the CCAT, the Lorge-Thorndike Intelligence Test from which it was adapted has shown highly acceptable validity and reliability (correlations ranging between $r = .60 - .80$; cf. Tittle, 1975).

The second area of antecedent factors considered was additional stressors, both acute and chronic. The Coddington Life Event Record (Coddington, 1972, Appendix J) was selected as a measure of preceding events. Although the validity of the score weighting units on this inventory can be questioned owing to adult rather than child specification, the items were judged to have greater face validity for children than those on the Holmes and Rahe inventory. One item was added to make the inventory more relevant for the present study: increased learning problems in school with score units equivalent to suspension from school. High levels of reliability have been found for this inventory (Monaghan, Robinson & Dodge, 1979). The Coddington Life Event Record has been used in numerous studies of stress in children (Aagaard, 1979; Bedell, Giordani, Amour, Tavormina & Boll, 1977; Boyce et al., 1977; Heisel et al., 1973; Kashani, Hodges, Simonds & Hilderbrand, 1981; Padilla, Rohsenow & Bergman, 1976). Since some studies using life change event inventories have indicated that scores for the preceding 12 months are most predictive of stress disturbance and others have indicated higher predictability for the preceding 6 months, parents were asked to complete this inventory for both periods.

A family background questionnaire (Appendix K) was designed using those items within the family interview schedule from the Manhattan longitudinal study of children (Gersten et al., 1977)

which demonstrated high correlation with behaviours interpreted as distress effects (Langner, 1983). The initial portion of the questionnaire dealt with socio-demographic factors: number of parents, adults and children in the family, number of times the family has moved since the child was born, and welfare status. Questions relating to the child's general health and mild but recurring complaints also were included. The second part of the questionnaire (to be filled out by father and mother independently) dealt with parent health (physical and emotional), language spoken, financial concerns, number of extended separations from the child, and patterns of discipline and parent responsibility. Although it was not possible to conduct a validity and reliability study on the questionnaire, close adherence to items on the Manhattan questionnaire which showed significant predictive validity was considered a sufficient basis for the exploratory analyses in which data from this measure was used.

Cognitive effects. Eight cognitive tasks measuring varying aspects of three components of cognition (attention, memory, processing) were used in the present study. Each of these tasks is described briefly and, based on the literature reviewed, a prediction is made for performance under the experimental stressor condition. Further description of tasks, instructions and scoring is included in Appendices L to Q.

The Continuous Performance Task (CPT) (Rosvold, Mirsky, Sarason, Bransome & Beck, 1956) was selected as a measure of attention. This task, programmed on an Apple Computer (Blouin,

1981), presented single random letters at 1.3 second intervals on the computer screen. The child was instructed to press the response button on a paddle each time a B-X sequence appeared. Two scores were calculated by the computer: omissions (the number of target sequences to which the child did not respond indicating level of sustained attention) and commissions (the number of responses made when sequences did not appear indicating level of impulsivity).

Although specific validity testing has not been carried out for the CPT, use as an attention task in a number of drug studies (Connors & Taylor, 1980; Gittelman-Klein & Klein, 1976) has supported the assumed face validity. High test-retest reliability ($r = .74$) has been demonstrated (Rosvold et al., 1956). Since contradictory findings have been shown for sustained attention under stressor conditions, a prediction was not made for the omission score. A higher commission score indicating increased impulsivity, i.e., poorer performance, was predicted for the experimental stressor condition.

The second attention task was a computer adaptation of the zeros task developed by Zaffy and Bruning (1966) to measure cue utilization under a variety of potentially-stressful situations. In order to adapt the task for computer presentation, rectangles rather than zeros were used (Appendix L). Two sets of seven items were presented by the serial-anticipation method (2-second presentation) seven times or until all items were anticipated correctly. An item consisted of a row of six rectangles (2.5 cm x 2 cm) with subscripts (.5 cm). A single target

rectangle with the same subscript as the rectangle directly above was placed below one of the six rectangles. One set included serially-ordered subscripts while the other set included randomly-ordered subscripts. Two target rectangle position patterns were established and counterbalanced between sets for presentation at Time I and Time II.

The child's task was to indicate the position of the target rectangle on a response card before each item was presented (self-paced) on the screen (the set of seven items was viewed once before responding began). Total error scores for each set and a perseverative score for the random subscript set were calculated. The perseverative score included each error which was identical to the error made on the same item on the previous trial.

While validity testing has not been conducted with this task, the consistency with which results have agreed with the theory of attention narrowing (Bruning, Capage, Kozuh, Young & Young, 1968; Geen, 1976; Zaffy & Bruning, 1966) suggests strong construct validity. Previous research has not used repeated-measures designs. The pilot study and the cognitive control study indicated a learning effect for the subset with random subscripts which was taken into consideration when examining effects on this task. Based on the theory of narrowed cue utilization under stressor conditions and on findings from previous research, it was predicted that performance on the set with serial subscripts would be worse under stressor conditions (a narrowed attention span would exclude the subscripts which

2

would facilitate accurate recall) while performance on the set with random subscripts would be better (narrow attention would exclude the subscripts which would hinder accurate recall).

Two memory tasks were selected as measures of processing and memory. The first task, an adaptation of Weingartner's cluster/non-cluster memory task (Weingartner et al., 1981), employed lists of 15 words which were reported by free recall following an interim task and by recognition later during the testing session. The second task was a standard digit-span task (Koppitz, 1977) requiring immediate recall.

Eight lists of fifteen words each (five words in each of three semantic categories) were prepared for the clustered/non-clustered memory task (Appendix M). Extensive pre-testing was done to establish lists of equal difficulty for the 10-12 age group. Four lists were presented at each session, the within-list presentation order being clustered list (AA...BB...CC...), non-clustered list (ABCAB...), clustered list, non-clustered list. The lists were counterbalanced across sessions with the order of lists (and, therefore, word by clustering combination) counterbalanced within sessions).

Following presentation of the list, the child counted backwards from 20 to 1 and then repeated back the words recalled. Before presentation of the fourth list the examiner commented, "Have you noticed that it is easier to remember the words when you group them?" This instruction was included in order to activate strategies that might be available within a child's repertory but not automatically used (see Flavell, 1970). If a

true measure of the effect on ability to cluster rather than a motivation effect was to be measured, all available strategies would need to be activated. Each list was scored by number remembered and clustering ratio (Roemaker, Thompson & Brown, 1971). The scores for the first and third lists were averaged for an overall score for clustered lists. The scores from the second and fourth lists were recorded separately.

Two recognition lists were presented following two unrelated cognitive tasks. The first recognition list included words from the first clustered word list randomized with 15 new words (5 from each of the three semantic categories) and the second list included the non-clustered words with an additional 13 semantically related words. The words recognized were to be circled. These lists were scored for misses and false positives.

The two versions of the digit span task developed by Koppitz (1977) were used with oral presentation. Each version was counter-balanced across conditions. The highest number of digits recalled (a second set for each span length was presented if an error were made on the first set) was recorded.

While high validity and reliability has been established for the digit span task (Koppitz, 1977), little research has been done on reliability ratings for word lists, clustered or non-clustered, with children. The pre-testing and pilot testing indicated good reliability. The validity of these tasks as measures of encoding and retrieval is based on memory theory, i.e., construct validity, while the use of clustering within memory as a measure of internal organizational skills rests on face validity.

Previous research has shown poorer recall for anxious or depressed individuals when semantic reordering was required before effective encoding could be accomplished. When re-ordering was not required, memory did not appear to be affected. Poorer performance on lists two and four was predicted for the experimental stressor condition with insignificant variation on lists one and three. Owing to the lack of research on long-term memory, predictions were not made for performance on the recognition task. Non-significant alteration was predicted for performance on the digit span task under the stressor conditions.

Three tasks were used as measures of the processing component of cognition. The arithmetic tasks provided measures of verbal functioning based on over-learned information. The Raven's Progressive Matrices and the object sorting task (scored for concepts) offered measures of spatial and verbal conceptual functioning. Alteration of processing was examined in the arithmetic equation task and the object sorting task (scored for sorts) while reorganization or clustering was examined in the memory task and the object sorting task scored for concepts.

The first part of the arithmetic task, a standard single-digit addition and subtraction task (Appendix N), measured performance on over-learned material. The second part of the task employed an adaptation of the arithmetic task used in the Swedish studies (Johansson et al., 1973; Nprinder, unpublished). In the Swedish version, two sets of single digits were combined according to a set of rules which had been taught previously.

For use in this study, the digits were presented in equation format with the arithmetic signs printed within the equation (Appendix O). A significant difference occurring for this task but not for the simple task was interpreted as reflecting difficulty with alteration between processes and/or short-term memory. Both time and errors were scored.

Reliability of simple arithmetic tasks is fairly well accepted and was confirmed for this particular version in the pilot testing ($r = .97$). Reliability on the equation task was expected to be lower, particularly for the younger children. Time and error differences, therefore, were adjusted for any learning effect demonstrated in the cognitive control study. It was assumed on the basis of face validity that the equation task measured alteration between processes and short-term memory. The difficulty of separating these two factors was recognized. No effect was predicted for the simple arithmetic task while poorer performance under the stressor condition was predicted for the equation arithmetic task.

Raven's Standard Progressive Matrices [A, B, C, D] (Raven, 1958) (Appendix P) were selected for the second processing task. This task is used in general psychometric testing as a measure of spatial reasoning including both inductive and deductive processing. In more specific terms, the task involves pattern recognition and application. An overall pattern or a multi-item picture is presented with one part missing. The child then selects a response from an array of six or eight choices. The Children's Coloured Ravens Matrices were found to be too easy

for this age group during the pilot study. The first four subsets of the adult matrices were used with odd and even items separated into two tasks with presentation counterbalanced.

A review of reliability studies of Raven's Standard Progressive Matrices reported test-retest and even-odd reliability coefficients of .76 - .98 for children in the 10 to 12 age range (Raven, Court & Raven, 1983). Concurrent validity studies have reported correlations below .7 with verbal intelligence tests but stronger correlations with non-verbal and performance intelligence tests (Raven et al., 1983). These results were considered as support for the use of this task as a measure of spatial concept accessibility. Measurement of the more specific process of pattern organization was assumed on the basis of face validity. Based on the theoretical formulation of lateralized performance deterioration under stressor conditions (Tyler & Tucker, 1982; Tucker & Williamson, in preparation), poorer performance on the Standard Progressive Matrices could be predicted to occur under stressor conditions. Since this hypothesis was considered speculative, no prediction was made.

The third processing task was adapted from Goldstein and Scheerer's Sorting Test (1953). This test, which was developed originally for testing conceptual abilities in brain-damaged patients, has been used as an alternative to the Wechsler similarities task in order to separate the testing of concept formation from memory and attention (the latter two playing a role in the similarities task but not the Sorting Task [Rapaport, 1968]).

Several of the objects in the original version were altered

to make the task more appropriate for children (e.g., a candle and match in place of a cigarette and match) (Appendix Q). A second set of objects was developed and pre-tested with children ages 10 to 12. Ease of sorting and concept recognition was equated for the two sets. Task presentation and scoring also differed somewhat from that originally proposed by Goldstein and Scheerer. All 30 items were placed on the table in front of the child who was then asked to put the objects into groups "so that the objects that belong together in some way are together". Following the first sort, the child was asked to explain why each set of objects was grouped as it was. Each grouping explanation (e.g., they are all used for making things, they are all red, you use them at school) was noted on a record sheet with items coded for group membership.

Two scores were used within the research analyses: the number of sorts made (an indication of alternation between processes) and the number of unique concepts named (an indication of clustering or patterning ability and concept accessibility). Guidelines for scoring have been presented in Appendix Q. Ten sets of score records were selected at random and scored independently by a research assistant blind to the session condition. Inter-rater reliability coefficients of .97 and .87 were obtained for sort and concept scoring, respectively. The lower coefficient for concept scoring was felt to be a result of the greater complexity and subjectivity involved in concept scoring. In order to control for subjectivity, it was decided to have all protocols scored by two people, the examiner and a research assistant.

Any differences in initial scoring was discussed between the two and a final score was determined.

Validity and reliability studies of the Sorting Test were not located. A study by Reichard, Schneider and Rapaport (1944) found close agreement between age mean scores (234 children ages 4-14) and Piagetian theory, thus giving some evidence of construct validity for this task. Reliability across the two sets of objects (presentation counterbalanced across time) was tested in the pilot study (sorts: $r = .86$, concepts: $r = .49$); following revision of object sets reliability was retested in the control study (sorts: $r = .90$, $p < .001$; $r = .81$, $p < .01$). Poorer performance on both sorting and concept identification was predicted for the stressor condition.

The final task included within the cognitive test battery was the Stroop colour-word task (Stroop, 1935). In this task colour words in colours incongruous with the words are written on a white sheet and presented to the child. The child is to say the colours that the words are written in and not the name of the word. The reading time has been used as a measure of the amount of interference experienced while doing the task. This interference effect has been explained by a number of different theories, two of which are relevant to hypothesized stress effects. The attention theory places interference at the perceptual level and explains the task as a measure of selective attention. If attention narrows, as is hypothesized to occur under stressor conditions, performance on the Stroop task would improve. Several studies using a noise stressor have shown this effect (O'Malley & Gallas, 1977; O'Malley & Poplawsky, 1971).

A second theory places interference at the processing stage, that is, at the point at which a response is selected. Since saying the colour has been found to be more difficult (higher latency scores), than reading the word (cf., Jensen & Rohwer, 1966), the words have been defined as the dominant response with colours the non-dominant response. According to drive theory, increased arousal (assumed to occur under stressful conditions) increases accessibility of the dominant response (words) while low arousal increases the relative accessibility of the non-dominant response (colour). Higher latency scores under assumed stressor conditions have been demonstrated in several studies (cf., Jensen & Rohwer, 1966). Support for the second part of the drive theory, that performance improves during low arousal, is unclear due to methodological errors in studies designed to address this issue (Hockman, 1969; Pallak, Pittman, Heller & Munson, 1975).

In the studies referred to above, the Stroop task served as a measure of cognitive performance. In other stress studies, the Stroop task has been used as a stressor. Significant increased levels of adrenalin excretion have been measured during normal presentation and presentation with an auditory distractor (Frankenhaeuser & Johansson, 1976; Lundberg & Frankenhaeuser, 1980). Maintenance of speed and quality of performance during both conditions was explained as an indication that increased adrenalin enabled the system to accommodate to increased demands. The nature of the demands (attention or processing) was not discussed.

The results of reliability studies with the Stroop are contradictory. Some studies show lower reliability during the first few trials ($r = .71$) as compared to later trials ($r = .90s$) (see Jensen & Rohwer, 1966), thus indicating a learning effect, while other studies have shown greater reliability between initial trials with a learning effect occurring later on (Roe, Wilsoncroft & Griffiths, 1980). Effects of learning within the present research procedure were determined by analysis of the cognitive control study data. Validity studies on the Stroop have not been carried out and likely would be futile until the effect observed is better understood. Since a variety of response changes have been demonstrated under stressor conditions, each having been assumed to indicate a different effect (improved performance $\rightarrow$ attention effect; poorer performance $\rightarrow$ response accessibility effect), it was felt that inclusion of the Stroop would help to define the effect produced by the stressor condition. No prediction was made.

Screening. A likes-dislikes questionnaire (Appendix B) was designed to aid in the identification of children who would become stressed under the experimental condition. The questionnaire presented 5 target items relating to performance in front of others, 3 matched items (response to these items determined whether the related target items were relevant, e.g., if a child does not like to read, the item "reading aloud in class" was not considered a target item), and 15 filler items. The children responded to each item on a five-point Likert scale ranging from "dislike very much" to "like very much".

All questionnaires on which the item "giving an interest talk to the class" was marked "dislike a little" or "dislike a lot" were scored by the examiner. Weights indicating the apparent relevance of an item for performing in front of others were used in scoring each target item (see Appendix B for scoring protocol). The weighted scores were summed and divided by the total score possible for that child. A score of .5 was designated as a cutoff point for inclusion in the study. Random scoring of 100 questionnaires showed that none of the questionnaires not marked for dislike of interest talks scored over .5 while 51% marked for dislike of interest talks scored over .5. Although it was not possible to obtain measures of validity and reliability, the questionnaire was considered adequate as an initial screening technique. Scores on the questionnaire did not constitute a measure for the main study.

Procedure

After parental permission had been received, teachers were contacted and testing sessions were scheduled. The first session occurred during the hour and a half immediately preceding the oral presentation with the second and third sessions occurring at one week intervals thereafter. The time of testing was held constant (a 15-minute variation for the three beginning times and for the three urine sampling times was considered acceptable). The initial timing had to be adjusted to assure that the third session would not occur during a physical education period since excess activity might have caused alterations in the biochemicals measured. Owing to scheduling difficulties, 10 children were

tested during the latter part of the morning and first part of the noonhour (11:00 - 12:30) preceding an afternoon talk.

A packet including (1) a letter which listed testing dates, explained phoning procedure and requested diet restriction during the two meals preceding testing (Appendix R), (2) a list of foods which may have effects on catecholamine levels (Appendix S), (3) a life-event inventory (Appendix J), (4) two copies of a family-background questionnaire (Appendix K), and (5) an envelope addressed to the examiner (c/o the local school) was delivered to each child's home the week before the first session.

Cognitive testing took place in a quiet room adjoining or close to a private bathroom (i.e., that used by staff members rather than students). Whenever possible the same location was used for the second session in order to avoid a new environment which could initiate a stress response. Because of space limitations this was not possible for 12 children and on several occasions the location of the second session was considered by the examiner to present a greater potential stressor (a classroom adjacent to areas being used by other students) than the first session location. Since this would serve to reduce the change being measured, thus creating a conservative effect, no correction or separate analyses were considered necessary.

The child was met at the classroom or sent by the teacher to the testing area. The examiner started the session by referring to the letter sent home. She explained that the research study was looking at the relation between biochemical levels and thinking skills and that urine samples could be analyzed for biochemicals.

The importance of totally emptying the bladder at the beginning of the session was emphasized. When students stated that they did not need to urinate, they were asked to try anyway since there might be a small quantity of urine which had been made since they last went to the bathroom. There were no indications that the children did not comply with this request.

A 200 ml cup of Diet 7-Up was given to each child to drink during the session. An additional cup was provided if the first one was finished before the end of the session. Additional drinks were provided at the child's request.

The cognitive tests were presented in randomized order with the exception of the zeros task which was placed last. The children in the pilot study had become frustrated during the zeros task and it was felt that this might affect motivation during the remaining tasks. The memory recognition lists were presented following an interval of two different cognitive tasks unless the memory task was positioned seventh, in which case recognition lists were placed after the two parts of the zeros task. The state-anxiety measure (STAIC) was completed following the fourth cognitive task. A format identical to Time I was followed at Time II with the addition of trait-anxiety (STAIC) and locus of control (Nowicki-Strickland Locus of Control Scale for Children) measures following the cognitive tasks.

The testing-session was designed to last for 70 to 90 minutes since this was considered a minimal time interval for production of sufficient urine. This guideline was departed from for only one child who had to walk his sister home for lunch.

If a child completed all of the tasks in less than 70 minutes, the Wisconsin Card Sorting Task (WCST; Berg, 1948) was used as a filler task at Time I. The completion of the additional measures increased all Time II sessions sufficiently. The original intention had been to analyze the scores from the WCST within a single task analysis. Since the task was administered only 5 times, no analysis was conducted.

Following completion of the cognitive and psychological measures, the children returned to the bathroom to collect urine in a sterile container. Two children each at Time I and Time II and one child at Time III were not able to urinate a sufficient quantity. In three cases the children drank more 7-Up and talked with the examiner until they were able to urinate some more; in two cases (Time II and Time III) the children returned to the classroom and the urine samples were collected at the end of the half-day. It is likely that not being able to urinate presented an additional stressor and thus may have altered the biochemical levels from what they would have been at the end of the testing session. Since this situation occurred at each time, it was felt that the results would not be affected significantly.

Parents were phoned during the evenings before Time II and Time III. They were asked if any unusual or otherwise stressful events had occurred for their child in the past few days and were reminded of the diet. If the diet had not been followed at Time I, they were asked to err in the same manner at Time II. No evaluation was made regarding diet compliance.

The one week time span between sessions was altered for 16

children due to field trips, absence from school, the incidence of an outside stressor, use of medication or retesting for Time II condition. A MANOVA analysis indicated that these children were not significantly different from the other children in their biochemical response at the second session.

Behavioural observation at Time II indicated that four of the children experienced more tension at that time than they had at Time I. In three cases this appeared to result from the relocation of the testing area and in one case the child mentioned at the end of the session that the judging of science projects had occurred during the preceding hour and that now he would find out how he had done. In two cases, it was possible to schedule an additional session which was then substituted for the second session in the data analyses. Because more than a month had passed since the initial testing it was decided to use Time I tasks for the retesting session. For the two children who were not retested, any distortion of Time II cognitive scores would have a conservative influence on analysis results and, therefore, correction of the data was not considered.

At Time III the child went to the bathroom, drank a 200 ml cup of Diet 7-Up and returned to class. At a time consistent with the termination of the earlier sessions the child met the examiner or was called out of class. Children whose testing had extended over the noon hour spent that time in the classroom or the nurse's room reading quietly. They did not eat lunch until after the sample was collected. While the children, for the most part, appeared relaxed at Time III, one exception was noted. A grade

seven girl who was withdrawn from a woodworking class, a class situation which would permit comments to be made by other students, seemed extremely embarrassed. It was felt that the withdrawal situation, as it presented itself to the child, was sufficiently different from that experienced by other children that this child should not be included in analyses including Time III data.

Because of scheduling conflicts, 10 of the Time III sessions were initiated by and samples collected by a research assistant. A Hotelling's T^2 showed that the difference between the biochemical response of this subgroup and the examiner-collected group approached significance ($p < .14$). Since Time III levels were not included in the major analyses, this was not considered a problem. Owing to early departure for vacation, Time III samples were not collected from 2 children, reducing the Time III sample to 35 children.

Additional small group testings on subtests of the Canadian Cognitive Abilities Test were scheduled for the children who had not completed these tests with their class during the previous two years. Twenty tests were administered in groups of two or four after the main study was completed.

A similar testing procedure, but without the experimental stressor and the urine sampling, was followed in the cognitive control study (CCAT subtests were administered following the trait personality measures at Time II). Testing was conducted in a private office at Carleton University with the examiner driving the children to and from each session. It was recognized

that the initial session could have represented a stressful situation for some of the children. The two children whose responses on the state anxiety inventory indicated that they may have experienced stress at Time I were eliminated. If stress was experienced by the remaining children and did cause an alteration in cognitive performance, this would have inflated the "learning effect" measured, thereby decreasing the experimental study performance alteration attributed to the stressor condition.

Every effort was made during both the experimental and the control study testing sessions to engage the interest of the children. Each child was told that she/he was doing extremely well. A number of parents reported during the phone call which preceded Time II that their child had enjoyed the initial testing and that the subsequent talk presentation had been very successful. The latter was confirmed by teachers. As one child reported to his parent, "Having something to do before the talk, I didn't get all upset, and the talk was easier".

CHAPTER IV

RESULTS

The analysis of behavioural and physiological response, cognitive performance, and antecedent factor data was conducted in three stages.

(1) Biochemical, state anxiety and observed tension results were analyzed for evidence indicating that a stressor response had occurred at Time I. The data were examined further to determine any gender specificity for physiological or behavioural response, the relation between biochemical changes, and the relation between behavioural and biochemical changes. Multivariate analyses of variance with follow-up ANOVAs and Pearson product-moment correlations were used as the primary analyses.

(2) In the second stage, change in cognitive performance from Time I to Time II was examined. The performance of the children in the cognitive control study was analyzed to determine which tasks demonstrated learning effects. These results were compared to the cognitive changes demonstrated in the experimental study. A series of multivariate analyses of variance was carried out to determine whether there were post-hoc groupings based on response measures within the experimental study which could provide information regarding cognitive performance under stressor conditions. Canonical correlations with single multiple regression follow-up analyses were performed to identify which, if any, cognitive tasks shared significant variance with changes in body biochemicals, state anxiety or observed tension. Then each task was examined individually by ANOVA analysis and data

plotting to examine the directional changes in task performance as related to biochemical or behavioural responses. These results were compared to the predictions regarding performance under a stressor condition which were presented in the methods chapter. The possible effect of IQ on the relation between response to the stressor condition and cognitive performance was examined.

(3) Antecedent factor scores were correlated with biochemical and behavioural response changes to examine the possibility that the antecedent factors measured may predispose children to response in the manner observed. Chi square analyses with a measure of predictive association were used to examine possible general effects, each factor being considered on its own. Canonical correlation analyses permitted an examination of effects using the continuous data available for each antecedent and response variable.

Preliminary Discussion of Data

Preliminary Inspection

A preliminary examination of the raw data indicated that the scores of a number of cognitive tests (and in particular, Time I results) demonstrated extreme positive skewness. Among the antecedent factor data, life change events and family background scores presented positively skewed data. The only response variable of concern was MHPG with positive skewing and one extreme outlier.

Trial log and negative reciprocal transformations, as suggested by Erickson and Nosanchuk (1977), for data with positive

skewed distributions, were performed on the cognitive data. Examination of box-plots (produced by SPSS release 7-9; Hull & Nie, 1981) of the transformed data indicated that although these transformations brought in the extreme upward skew, some skewing with outliers remained. Since the statistical advantage gained by use of transformations could be questioned and ease of interpretation would be lost, it was decided to retain the data in original form.

Following an initial set of analyses of the cognitive and biochemical data, contradictory findings by the ANOVA and regression analyses were indicated for a few tasks, the CPT omission task being most radically affected. Inspection of the scattergram for this task indicated that the child with high MHPG increase at Time I (noted above as the outlier) had obtained an exceptionally high number of errors on the CPT and thereby created a significant linear regression which did not exist for omission scores, and only approached significance for commission scores, when this child's results were taken out. While this relationship may be meaningful with high levels of MHPG affecting attention, the limited sample size of the present study does not provide an adequate test of extreme effects. Examination of the variance demonstrated by biochemical scores similarly indicated that data from this child might disguise or distort response patterns. It was decided, therefore, to eliminate the biochemical, cognitive and antecedent factor data from this child from the analyses. The results reported below are based on 38 children.

Change Scores

As noted in the discussion of the research design, change scores were used in the majority of analyses. While the use of change data has been considered suspect, standard deviations and reliability coefficients change under any two conditions, Zimmerman and Williams (1982) have shown that difference scores can present reliable results. The importance of establishing adequate levels of reliability for measures used within change score statistics was emphasized (Zimmerman, personal communication).

An examination of pilot study data (t-test analyses) indicated non-significant differences between performance at Time I and Time II (one week intervening) for all tasks except zeros-random and some time scores. These differences were expected and are considered in the interpretation of the experimental study results. The cognitive control study results were used to check for reliability within the specific testing format used. A recent study measuring catecholamine excretion over consecutive time periods reported stable test-retest levels (Forsman, 1981). The sensitivity and consistency of high performance liquid chromatography as an assay procedure for catecholamines and metabolites has been reported in several studies (Joseph et al., 1981; Soldin et al., 1980). It was felt that the data collected within the present research study was sufficiently reliable that change scores could be used for statistical analyses.

Biochemical Response

Human stress research using biochemical measures has used both proportions (e.g., Lundberg & Frankenhaeuser, 1980) and difference scores (e.g., Frankenhaeuser et al., 1978). In deciding which type of score to use, the focal question was: if there is a relation between the biochemical milieu of the body and cognitive performance, would this relation be a function of an absolute change (e.g., an increase of 20 ng/ml relates to a 1 unit change of performance) or a proportional change (e.g., an increase of 20 ng/ml for an individual with an 80 ng/ml baseline relates to a 1 unit performance increase while 40 ng/ml increase is required before an individual with a 160 ng/ml baseline would experience a similar performance increase). Since research comparing the relationships of these scores with cognitive performance was not found, it was decided to run each multivariate regression analysis twice, once with difference scores and again with proportion scores. The proportion ratio used was $\text{Time I} / (\text{Time I} + \text{Time II})$. This permitted the designation of .5 as a no change score. ANOVA analyses automatically use difference scores.

Because biochemical synthesis and turnover is a dynamic process, some variation in excretion levels is to be expected with no change in condition. In order to identify the range of alteration in proportion scores which may imply no condition effect, the mean and standard error for each biochemical at Time I and Time II were determined. Using the mean and standard error from the time with greatest variance (Time I), two proportion

scores were calculated for each biochemical. The mean was entered as Time I and the mean $\pm$ standard error was entered as Time II. The calculated proportion scores represented the upper and lower limits of proportion change which could be expected to occur between times with no change in condition. Proportion scores within this range were considered to reflect marginal fluctuation (see Appendix T). Defining children with proportion change above the marginal fluctuation range as "increasers" and children with proportion change below this range as "decreasers", three subgroups were formed for each biochemical -- adrenalin: increase, $n = 21$; marginal fluctuation, $n = 6$; decrease, $n = 11$; noradrenalin: increase, $n = 18$; marginal fluctuation, $n = 5$, decrease, $n = 15$; MHPG: increase $n = 15$, marginal fluctuation, $n = 7$, decrease, $n = 16$. These subgroups were used when examining biochemical response and when examining the relation between antecedent factors and biochemical response.

Although the middle range of proportion scores may represent marginal fluctuation for body biochemicals, there is no research to indicate that limited biochemical alterations have no effect on other functions. In addition, the meaning of increase, marginal fluctuation and decrease groups vis à vis a response to the stressor condition can only be hypothesized. For these reasons, biochemical response data was divided according to categorical change from Time I to Time II (increase, decrease) when used in analyses with cognitive data. The following groups were established -- adrenalin: increase, $n = 26$; decrease, $n = 12$; noradrenalin: increase, $n = 22$; decrease, $n = 16$; MHPG: increase,

n = 19; decrease, n = 18 (one child showed no change). In analyses in which the biochemical scores were used as independent variables (ANOVAs), the combined use of A and NA reduced the sample size (four children had contrasting A and NA scores) and, thus, the power of the analyses. Because A has been reported as the body biochemical more sensitive to stressor conditions (Frankenhaeuser & Johansson, 1976a; Lundberg et al., 1981) and has traditionally been used in research on peripheral response to stressors, it was used as a single indicator of catecholamine activity in those analyses.

Inspection of the biochemical data indicated subgroups within the A change groups with some children in each group demonstrating an increase in MHPG and others demonstrating a decrease. Since this difference in biochemical behaviour might indicate a relevant factor, these sub-groups were used in some analyses.

An initial inspection of the biochemical data indicated higher excretion of A and NA at Time I relative to Time II and at Time III relative to Time II. Although Time III had been included in the research design to provide "baseline" levels for the biochemical measures, such levels clearly had not occurred. It appeared that some aspect of the Time III procedure (e.g., being called out of class two times as opposed to once, the lack of a distracting activity [testing] prior to urine collection) may have created a novel stressor. While Time II could not be considered strictly as a baseline condition (cognitive testing was occurring), it provided the lowest biochemical, state anxiety and observed tension measures, a condition consistent with that

of "least stress" in the literature. Time II measures, therefore, were used as the base measure from which change values to Time I and Time III were calculated.

Behavioural Response Data

Several of the analyses required that state anxiety and observed tension data be divided into categorical groups. As with the biochemical data, two different schemes for categorization were used. The first scheme was used in the Chi-square analyses which examined correlations between behavioural and biochemical response alterations under stressor conditions and correlations between antecedent factors and response measure changes. A second scheme was used in the analysis of variance tests with cognitive performance.

State anxiety scores were categorized into three groups in a manner similar to that used for the biochemical response measures, i.e., determination of a marginal fluctuation group based on the proportion equation using the mean $\pm$ standard error as Time II. Three subgroups were formed: increase, $n = 13$; marginal fluctuation, $n = 18$; decrease, $n = 7$. Observed tension scores could not be handled in the same manner since only three children showed a lower level of tension at Time I and this was felt not to be a result of Time I functioning but rather a reflection of additional stressors at Time II. Observed tension change scores were divided into two groups: changers (range including -2 and +2 and above, $n = 23$) and non-changers (range including -1 to +1, $n = 15$).

The second scheme was established for use in the ANOVA tests designed to examine the possible relevance of behavioural response to alteration in cognitive performance under stressor conditions. To maintain group divisions parallel to those established for the biochemical scores, state anxiety scores were divided into two groups on the basis of directional change. There were, however, 5 children who responded with identical self-ratings at Time I and Time II. Since eliminating these children from the analyses would reduce the degrees of freedom, it was decided to include them within the decrease group, thus establishing two groups: increase, $n = 24$; decrease, $n = 14$. The same scheme was applied to observed tension scores: increasers, $n = 27$; decreasers (including 9 children showing no change), $n = 11$.

Cognitive Data

In order to retain as much power as possible for the multivariate analyses, cognitive task scores were examined (Pearson product-moment correlations) to determine whether there were scores showing similar behaviour between Time I and Time II that could be combined. Similar response patterns were noted for the two non-clustered memory lists (list two without instructions and list four with instructions) (and the error scores and time scores on the simple and equation arithmetic tasks. The number and order scores for the non-clustered lists were averaged in the same manner as the scores from the clustered lists. The arithmetic error and time scores were combined by summation.

Missing cognitive data, caused by a malfunctioning stop

watch, presented a problem for the MANOVA analyses. Since pairwise deletion of missing data is not permitted within the SPSS MANOVA programme and listwise deletion causes a reduction in numbers and, therefore, in test sensitivity, the mean score for a child's age group on a particular task was used for missing scores. Since pairwise deletion is permissible within regression analyses, substitute scores were not included within regression data. Substitution scores also were not included in the Chi-square and univariate analyses of variance; sample number was reduced according to the number of children for whom accurate scores were obtained.

Analyses

Owing to the large number of variables measured and, thus, the inherent problem of Type I errors, all preliminary analyses were multivariate. The initial examination of biochemical data and of biochemical and cognitive data included multivariate analyses of variance (MANOVA) with repeated measures using the SPSS release 7-9 programme (Hull & Nie, 1981). Within this analysis, the dependent variables are combined in a linear combination, that is, they are provided with coefficients which weight them in such a way that the difference between groups will be optimized. The sum of each linear combination for each individual (a centroid) becomes the basis from which an F ratio is obtained. Since some of the dependent measures were not normally distributed and thus violated the assumption of homogeneity, the Pillai's statistic was chosen for testing the

F ratio. This statistic is more conservative than Wilks Lambda and has been found to give a truer estimate with skewed data (Olson, 1976).

When using multiple dependent variables within an analysis, greater variance will occur. The requirement of an $\alpha_{\text{total}} = .05$ has been considered, therefore, unrealistic for multivariate analyses. Using Bonferonni inequality, the α of the family (or set) of analyses can be the sum of the α s expected for each variable within the analysis (Miller, 1966). If an effect on individual tasks would be considered of acceptable significance at .01 then $\alpha_{\text{total}} = 2.01$. In order to maintain a conservative error rate without being overly restrictive, an α of .025 was chosen. Application of the Bonferonni inequality permitted an $\alpha_{\text{total}} = 1.0$ for four dependent variables and an $\alpha_{\text{total}} = 1.5$ for six dependent variables. Although criterion levels of significance were used for reporting univariate analyses, exact levels of significance were reported for the multivariate analyses. Exact levels of significance also are used in the appendices.

Contrast testing within the MANOVA programme permits designation of specific orthogonal contrasts (e.g., Time I-Time II, Time II-Time III) to be tested. The required critical F value for contrasts was calculated using the equations presented by Harris (1975), the appropriate equation being determined according to whether the contrast and/or the linear combination being tested was selected a priori or a posteriori.

Univariate analyses of variance were conducted for each

cognitive task included within a MANOVA which indicated a significant between-subject effect (that is, task performance reflected a variable being examined in the present research design). While performance of large numbers of ANOVAs has been criticized, the present analyses were considered necessary in order to evaluate the a priori predictions of cognitive performance change based on the literature review.

Further testing of response and cognitive data and testing of antecedent and response measures was done by canonical correlation analysis, SPSS release 7-9. A canonical correlation is a descriptive, as opposed to inferential, analysis (Tabachnick & Fidell, 1983) and was used to indicate what relation (i.e., shared variance), if any, existed between response level change and cognitive performance change and between antecedent factors and response change. Within a canonical correlation, the coefficients established for each set of variables are adjusted to maximize overall fit between the independent and dependent variable matrices. Thus, the first linear combination of the scores of each of the dependent variables presents a canonical variate matched for greatest predictive power with the canonical variate presented by the first linear combination of independent variables. Although several pairs of canonical variates (number of pairs equalling the number of dependent or independent variables, whichever is smaller) are available from each analysis, interpretation was limited to the first and most important set of equations. A correlation level of .30, establishing a R^2_C or shared variance of .10, was considered as the minimal level for interpretation (Tabachnick & Fidell, 1983). The R^2_C (percent of shared

variance between dependent and independent variates) represents the test statistic of greatest interest within a canonical correlation with significance level reflecting to a large extent the size of the sample studied.

Although canonical coefficients (weights within the linear combination) are often used as indicators of the importance of a variable within an analysis, they reflect the relationship between variables within a linear combination as well as the relationship to the predicted canonical variate (Tabachnick & Fidell, 1983). Structure coefficients, on the other hand, reflect the relationship of a variable with the opposing canonical variate without consideration of the other variables within its own linear combination (Borgen & Seling, 1978). Since the concern in this study was not with the relationship between cognitive tasks but with the relationship between a single task and the independent (i.e., response) variables, structure coefficients were chosen for interpretation. Simple multiple regressions were used for follow-up analyses.

Biochemical and Behavioural Response

Biochemical and behavioural response measures taken at Time I, Time II, and (biochemical measures alone) Time III were analyzed to determine whether a stress response, as identified by urinary A and NA alteration and/or behavioural alteration, could be considered to have occurred at Time I. Since research findings regarding the response of females and males to stressor situations have been equivocal, the biochemical

and behavioural response data were analyzed further for possible sex effects. The correlation within and between each set of response measures and between response measures and intellectual ability was examined.

Determination of Changes in Biochemical and Behavioural Response Measures

To determine whether changes which would support the conclusion that a stress experience had occurred for a subgroup of children at Time I, two MANOVA analyses were performed. The first included biochemical measures, A and NA excretion at Time I, II and III ($n = 35$), and the second included behavioural measures, state anxiety and observed tension at Time I and II ($n = 38$). MHPG was not included in the initial biochemical analysis since it has been considered a measure of the manner in which catecholamine levels are altered (i.e., a by-product of MAO activity) and possibly an indirect measure of central catecholamine activity, as opposed to a direct measure of sympatho-adrenomedullary axis response. Group (children predicted to become stressed under the experimental condition and children predicted not to become stressed under the experimental condition) and sex were included as between-subject variables with time as a within-subject variable. The results of these analyses are summarized in Table 1.

The overall Time effect was significant ($p = .01$) with follow-up contrasts showing a significant difference for A between Time I ($\bar{x} = 8.3$, $SE = .96$) and Time II ($\bar{x} = 5.9$, $SE = .64$).

The between-factor Group effect was nonsignificant while the Sex effect was significant ($p = .03$). Follow-up ANOVA tests (Appendix U) supported the significant Time and Sex effects for A (Time: $p < .01$; Sex: $p < .01$). Examination of means (see Figure 1-A) indicated that although girls and boys differed significantly on A excretion with boys having higher levels, the pattern of change was similar.

The analysis of NA excretion indicated a Time effect approaching significance (I: $\bar{x} = 58.6$, $SE = 7.1$; II: $\bar{x} = 47.1$, $SE = 5.7$; III: $\bar{x} = 64.6$, $SE = 7.7$; $p \leq .1$) and a significant Sex effect ($p < .05$). The contrast in response pattern for girls and boys (see Figure 1-B) may explain the lack of a strong Time effect (means are collapsed across the between-factor Sex when testing for Time).

The MANOVA including behavioural responses indicated a significant Time effect ($p = .001$). The follow-up ANOVAs (Appendix V) indicated no between-factor significant differences for state anxiety but a significant Group effect for observed tension ($p \leq .01$). The stress-predicted or target group showed significantly more observed tension than did the stress-non-predicted group (Time I--Target: $\bar{x} = 5.3$, $SE = .60$; control: $\bar{x} = 2.5$, $SE = 1.0$; Time II--Target: $\bar{x} = 2.6$, $SE = .33$; control: $\bar{x} = 1.1$, $SE = 0.1$). Since the observed tension score was determined by the examiner who was aware of the group to which each child belonged, the possibility of a rating bias having occurred for this variable must be considered.

Having established significant biochemical (as measured

Figure 1

Urinary Adrenalin, Noradrenalin and MHPG Levels Under Stressor/
Non-Stressor Conditions for Girls and Boys
(means and standard error)

URINARY LEVELS (ng/ml)

by urinary excretion) and behavioural (as measured by observed tension) responses at Time I, the MANOVA based on biochemical data was performed a second time with MHPG included as a third dependent variable (see Table 1). Both Sex and Time effects showed weak significance (time: $p = .05$; sex: $p = .06$). The MANOVA indicated no significant effects for MHPG.

Gender Effect

Given the equivocal evidence in the literature regarding gender effects on biochemical response under stressor conditions, it was decided to examine these data in greater detail. The total group was divided into subgroups according to Time I response (increase, marginal fluctuation, decrease--as described in the preliminary discussion) for each biochemical. Examination of subgroups indicated that A levels beyond ($\pm$) one standard error were measured for 32 (84%) of the children, NA levels beyond ($\pm$) one standard error for 33 (87%) of the children and MHPG levels beyond ($\pm$) one standard error for 31 (82%) of the children. These subgroups were then used in three separate ANOVAs (one for each biochemical) with 2 between-subject factors (sex, subgroup) and 1 within-subject factor (time). The results of these analyses are summarized in Appendix W, means and standard errors are reported in Appendix X, while Figures 2 to 4 present a graphic display. The ANOVA analyses for the increase and decrease subgroups demonstrated a significant Time effect for Time I to Time II alteration while the Time II to Time III alteration was nonsignificant. The marginal fluctuation groups

Table 1

MANOVA Results for Response Measures under Stressor/Non-Stressor Conditions

Variables	Source	Approx. F	df	Sig. (Pillais)
A NA (n=35)	time	3.83045	4,28	.01
	A: I - II			.007*
	II - III			.15
	NA: I-II			.12
	II-III			.19
	sex	4.17114	2,30	.03
	sex x time	1.40388	4,28	ns
	group	.61328	2,30	ns
	group x time	.48537	4,28	ns
OT SA (n=38)	time	16.71499	2,33	.001
	sex	1.15399	2,33	ns
	sex x time	.19013	2,33	ns
	group	3.13730	2,33	.06
	group x time	1.22085	2,33	ns
A NA MHPG (n=35)	time	2.43774	6,26	.05
	A: I - II			.007*
	II - III			.15
	NA: I-II			.12
	II-III			.19
	MHPG: I-II			ns
	II-III			ns
	sex	2.71646	3,29	.06
	sex x time	1.39790	6,26	ns
	group	.53427	3,29	ns
	group x time	.70409	6,26	ns

*significant level, based on a priori contrast, a posteriori linear combination.

Figure 2

Urinary Adrenalin Levels under Stressor/Non-stressor Conditions
for Girls and Boys by Time I Response Subgroups
(means and standard errors)

GIRLS

BOYS

URINARY ADRENALIN (ng/ml)

TIME

Figure 3

Urinary Noradrenalin Levels under Stressor/Non-stressor

Conditions for Girls and Boys by Time I Response

Subgroups

(means and standard error)

GIRLS

BOYS

Figure 4

Urinary MHPG Levels under Stressor/Non-Stressor Conditions
for Girls and Boys by Time I Response Subgroups
(means and standard error)

GIRLS

BOYS

showed no significant Time effects between Time I and Time II but a significant Time effect for NA between Time II and Time III ($p < .02$). Since the NA marginal fluctuation group was very small ($n = 5$), this finding was considered tentative.

The Sex effect was found to be significant for two of the biochemical subgroups and approached significance for a third: A for increasers ($p < .05$), NA for the marginal fluctuators ($p < .01$) and NA for increasers ($p \leq .1$). In order to examine the nature of the difference between girls and boys further, the parallelism test, a test within a profile analysis (Harris, 1975), was performed. The parallelism test examined Time I - Time II difference and Time II - Time III difference in biochemical excretion in order to determine if the biochemical alteration slopes for girls and boys were significantly different.

To examine the significant Sex effect demonstrated for A increasers by the parallelism test, the A alterations from Time I to Time II and from Time II to Time III for each sex were calculated and entered into a Hotelling's T^2 analysis as the dependent variable (girls--I-II: $\bar{x} = 6.8$, $SE = 3.4$; II-III: $\bar{x} = 1.8$, $SE = .9$; boys--I-II: $\bar{x} = 5.2$, $SE = .68$; II-III: $\bar{x} = 9.5$, $SE = 5.7$) with girls and boys representing groups. The F statistic was nonsignificant indicating that the shape of the slopes representing biochemical alteration was not significantly different for girls and boys. The difference between sexes demonstrated by the ANOVA analysis was confirmed as indicating an overall level difference.

Although the ANOVA had shown a significant Sex effect for NA within the marginal fluctuation subgroup, it was felt that the number of children in the group was too small ($n = 5$) for further analysis to be meaningful. The NA increase group which had shown a Sex effect approaching significance ($p \leq .1$) was analyzed by the parallelism test. The shapes of the slopes (girls--I-II: $\bar{x} = 69.5$, $SE = 39.0$; II-III: $\bar{x} = 9.2$, $SE = 3.8$; boys--I-II: $\bar{x} = 42.3$, $SE = 8.8$, II-III: $\bar{x} = 90.0$, $SE = 62.2$) were not significantly different.

Since response pattern did not explain the significant sex effect, the distribution of girls and boys across subgroups was examined to determine any differences (Table 2). Distribution of girls and boys between increase, marginal fluctuation and decrease groups differed with 42%, 25% and 25% of the girls being in the A, NA and MHPG increase groups, respectively, while 62%, 58% and 46% of the boys were in these groups. In contrast, 42%, 58% and 67% of the girls were in the decrease groups as compared to 23%, 31% and 34% of the boys.

Intellectual Ability Effects

Since the central concern of the present research was with cognitive performance, it was important to test for possible relations between alteration on response measures and tested intellectual abilities. A series of Pearson product-moment correlations was computed with intellectual ability level, verbal and performance as measured by the CCAT, and response measure scores (behavioural and biochemical) occurring at Time I, at

Table 2
Sex Frequency in Biochemical Change Groups

Groups	Girls (n=12)			Boys (n=26)		
	Biochemical					
	A	NA	MHPG	A	NA	MHPG
Increase	5 (42) ^a	3 (25)	3 (25)	16 (62)	15 (58)	12 (46)
Marginal fluctuation	2 (16)	2 (16)	1 (08)	4 (15)	3 (11)	6 (23)
Decrease	5 (42)	7 (58)	8 (67)	6 (23)	8 (31)	8 (31)

^aNumber in parentheses represents the percentage of girls or boys in each subgroup.

Time II, and between Time I and Time II (i.e., change score).

The results are reported in Appendix Y.

The only biochemical to show a consistent correlation with intellectual level was MHPG. A positive correlation was shown with Time II scores (VIQ: $r = .36$, $p \leq .02$; PIQ: $r = .51$, $p < .01$), and a negative correlation was shown with change scores (VIQ: $r = -.22$, $p \leq .1$; PIQ: $r = -.37$, $p \leq .02$). Children scoring higher on intellectual ability demonstrated a decrease in MHPG levels from Time II to Time I (stressor condition).

Among the behavioural responses, state anxiety under the stressor condition (Time I) showed a weak correlation with intellectual level (verbal: $r = .28$, $p < .1$; performance: $r = .24$, $p \leq .1$) while observed tension showed a low but significant negative correlation with verbal intellectual ability (Time I: $r = -.32$, $p < .04$; change: $r = -.37$, $p \leq .02$) and a weak negative correlation with performance intellectual ability (Time I: $r = -.24$, $p < .1$; change: $r = -.28$, $p < .1$).

Relation between Response Alterations

Biochemical response. A series of Pearson product-moment correlations was computed to examine the relation between levels of individual biochemicals excreted at Time I, II, III and the change between times for both sexes together and for girls and boys separately (see Table 3). A and NA were highly correlated ($r = .62-.92$, $p < .001$) for all groups at all three times with the within-sex correlation higher for females but lower for males with the imposition of Time I stressors. The only significant

MHPG correlation with A or NA occurred for girls at Time II, the time with lowest biochemical scores (A-MHPG: $r = .47$, $p < .1$; NA-MHPG: $r = .54$, $p < .05$). The correlation at Time I, stressor condition, was negative and nonsignificant. For boys, the correlation was low ($r = .08-.31$) and nonsignificant at all three times. Since the primary interest of this study was with change measures, correlations were determined for both proportion scores and difference scores. The correlations were low ($r = .03-.38$) and nonsignificant. Since no distinct differences appeared between the results based on difference and proportion scores, it was decided to use only difference scores in further biochemical analyses.

As noted in the initial inspection of the biochemical data, a number of children demonstrated decreasing levels of MHPG as A levels increased or increasing levels of MHPG as A decreased. Since these contrasts could hide significant relations within subgroups, the A, NA, MHPG change score correlations were recomputed for A-MHPG subgroups (see Appendix AA). Nonsignificant correlations between catecholamines and MHPG were shown for all subgroups except A+MHPG+. Within this subgroup the A-MHPG correlation was significant ($r = .80$; $p < .05$) while the NA-MHPG correlation approached significance ($r = .63$; $p < .1$).

Behavioural response. Correlations were carried out for state anxiety and observed tension change scores in a format similar to that used for the biochemical correlations: girls and boys together, girls alone, boys alone. While the correlation between these measures was negligible and nonsignificant for

boys ($r = .02$, $p = \text{ns}$), state anxiety change and observed tension change showed a correlation for girls which approached significance ($r = .48$; $p \leq .06$).

Biochemical and behavioural response. The relation between biochemical and behavioural response scores was examined by canonical correlation and Chi-square analyses. While parametric correlation makes the greatest use of the data available, it assumes a specific (e.g., linear) model for the relationship. Since the measures developed for specifying response to the stressor condition are considerably removed from the actual response, it may be inaccurate to view measure scores as precise indicators of response. It also may be that the state or condition of the response of one system may reflect the state or condition of the other system even though a linear relationship may not exist. Chi-square analyses permit the examination of such associations.

Within the canonical correlation, the biochemical difference scores were entered as the independent variables (i.e., the variables establishing the experimental condition) on the right side of the regression equation with state anxiety and observed tension change scores entered as dependent variables. In as much as sex differences have been noted in reports of research on state anxiety, separate sets of analyses were conducted for each sex (Appendix BE). The only analysis to approach significance ($p = .13$, weak but acceptable significance using the Bonferonni inequality equation) was the analysis of biochemical difference with state anxiety and observed tension change scores for females.

State anxiety change and MHPG change were indicated by the structure coefficients as the variables playing the greatest role in establishing the correlation between variates. Since the sample number for this analysis was small ($n = 12$), the results must be viewed with caution. Because self-reports of anxiety often have been used in non-physiological stress studies as a measure of on-going stress, it was decided to examine the relation between change in state anxiety and change in biochemical measures occurring under the stressor condition by univariate multiple regression.

Two univariate analyses were run to examine the relationship between state anxiety change (dependent variable) and biochemical change (independent variables) for girls and boys separately. With α set at 0.1, none of the biochemical change measures entered either analysis. Analyses with forced entry showed no significant relationship for boys but a relationship approaching significance ($R^2 = .40$, $p < .1$) for girls when A and NA change scores were entered as a block and before MHPG change scores were entered. While a positive relation between A and state anxiety change was demonstrated, a negative relation was found between NA and state anxiety change (Appendix CC).

The possible relation between biochemical and behavioural response under stressor conditions also was examined by Chi-square test of association. As described in the initial discussion, increase, marginal fluctuation, and decrease groups were used for the biochemical and state anxiety response variables. Two groups -- change, no-change -- were used for the observed

tension variable. Each biochemical response was examined with each of the behavioural responses. No significant Chi-squares were obtained.

Summary

Analysis of the biochemical data indicated a significant increase in urinary A at Time I, as contrasted to Time II. When the children were divided into response subgroups, 82-87% of the children showed alteration in urinary biochemical levels beyond ($\pm$) one standard error. These alterations provide evidence that Time I did represent a stressor condition.

The overall significant sex effect was found on further analysis to reflect (1) a difference in levels but not pattern of A alteration within the A increase subgroup for girls and boys and (2) a difference in the percentage of girls and boys in the increase or decrease group at Time I. A larger percentage of boys than girls demonstrated biochemical alteration placing them in the increase subgroups while the percentage of girls in the decrease subgroups was larger than that of boys.

Analysis of the behavioural data indicated significantly higher observed tension for the groups for whom a stress response had been predicted. No significant change occurred for state anxiety.

An examination of the relationship between response scores and tested intellectual ability levels indicated a negative correlation between MHPG alteration (non-stressor to stressor condition) and intellectual level and a negative correlation

between observed tension (Time I and alteration score) and intellectual level.

The relationship within and between each of the response areas (behavioural and biochemical) was examined. The only correlation to approach significance between the behavioural responses occurred between state anxiety change and observed tension change for girls. Correlations between biochemical response scores showed significant correlation between A and NA for both boys and girls for each time and for change scores. All catecholamine-MHPG correlations were nonsignificant with the exception of Time II excretion levels for girls (NA-MHPG, significant; A-MHPG, approaching significance). When the biochemical change scores were examined for the A-MHPG subgroups, highly significant correlations were found for the A+MHPG+ subgroup.

Analyses examining the possible relations between biochemical measure changes and behavioural measure changes demonstrated under the stressor condition showed a complex relationship (approaching significance) between state anxiety change and A and NA change in girls. Owing to the small numbers involved, this relation must be considered tentative. No relation between state anxiety or observed tension change and changes in urinary biochemical levels was demonstrated for boys.

Cognitive Performance

The present study was designed to test the hypothesis that stress affects children's cognition and that this effect is related, in part, to biochemical alteration. This hypothesis was examined by asking two questions. First, was the children's cognitive performance affected by the imposed stressor con-dition? Second, what was the relation between cognitive performance and changes occurring in self-rated state anxiety, observed tension and urinary biochemicals? The first question was addressed by examining the alteration in cognitive performance which occurred between stressor and non-stressor conditions. This alteration was compared to that exhibited by the cognitive control study sample in order to control for learning and practice effects.

The second question was more complex to answer and less sensitive to statistical procedures due to (1) the number of variables beyond those measured which may affect performance differences at Time I and Time II, (2) the indirect character of the measures used, and (3) the indirect correspondence between the time at which cognitive performance and response variables were measured. Recognizing that each cognitive task constituted only a small portion of the time period from which response levels were measured, close agreement between performance on a particular task and a response measure was not expected. For example, if adrenalin synthesis or tension had been particularly high at the beginning of a testing session or during a specific task but decreased toward the end (as the situation became more known

or comfortable), the final measurement would have indicated moderate A or observed tension levels although the early tasks or more stress-inducing tasks were performed under higher response conditions. Since the attenuation of transient biochemical fluctuations would disguise, to some degree, correlation occurring between response measure scores and cognitive performance scores, any results demonstrated were expected to be conservative.

In the analysis of biochemical and behavioural response results, children were categorized as showing an increase, marginal fluctuation or decrease on the assumption that children showing a marginal fluctuation did not identify the situation as stressful. Increasers and decreasers were considered to demonstrate a response to the situation. Since these divisions were recognized as having only hypothesized meaning, it was felt that they could not be used when analyzing cognitive data. A single categorical division of response data--increase/decrease with children demonstrating no change on behavioural response measures being included--was used in the analyses of cognitive data. This permitted an examination of the relation between alteration in cognitive performance and alteration in biochemical body states, as measured by urinary trace levels, and in psychological-behavioural states, as measured by self-ratings and observer ratings, without inferring stress response. The meaning a relation between cognitive performance change and response change may have for performance under stressor conditions is considered in the discussion chapter.

Cognitive Alteration under Stressor Condition

Cognitive performance at Time I and Time II was analyzed in four series of MANOVA tests, one each for attention and processing tasks and two for the memory tasks (it was necessary to form two analyses--recall and delayed recognition--since the control study sample was smaller than the number of memory scores). Five attention task scores, six processing task scores and five and four memory task scores were included as dependent variables. Each analysis had one within-subject independent variable (time, 2-levels) and one between-subject independent variable (group, 2-levels). The results of the MANOVA analyses are summarized in Table 4, and presented in detail in Appendices DD to GG.

An initial analysis with the target (stress-predicted, $n = 28$) and control (non-stress-predicted, $n = 10$) groups was carried out for each set of cognitive tasks. Highly significant Time effects for attention, processing and delayed recognition memory tasks were demonstrated ($p = .001$; $p = .004$; $p = .077$). A weak but acceptable (owing to the multivariate nature of the analysis) Group effect was shown for processing tasks ($p = .12$). The only significant Group by Time interaction occurred with delayed recognition memory tasks ($p = .007$).

Since a Time effect on cognitive measures may reflect learning, similar analyses were conducted for the results from the cognitive control study. The Time effect was nonsignificant for recognition memory and processing tasks but significant for the recall memory and attention tasks (see Table 4, row 1).

Possible distortion of the Time effect as a result of the small number of subjects within the control study is considered in the discussion of individual task results. The univariate F 's obtained within the multivariate F test (confirmed by follow-up ANOVAs; see summary Table 7, column 3) indicated that among the attention tasks, only the Stroop showed a Time effect for the control study sample, in contrast to the Time effect occurring for each task for the experimental study sample. Since the follow-up ANOVAs conducted on the recall memory tasks found only two task scores which demonstrated a Time effect approaching significance ($p \leq .1$), the multivariate Time significance was not considered meaningful. Although the non-significant Time effect for the control study on processing tasks did not justify follow-up ANOVAs, results from univariate analyses performed at a later point in the research analyses indicated a tentative (i.e., not supported by a multivariate analysis) significant Time effect for the arithmetic equation task with an effect approaching significance for the simple arithmetic task. In contrast, the experimental study children showed Time effects for five processing scores (including three of the four tasks). Among recognition memory tasks no Time effects occurred for the control study. The Time effect on recognition memory tasks for the experimental study sample represented a single task effect (clustered list scored for misses). Since this effect was isolated and did not relate to previous research findings or theoretical hypotheses, it was recognized that it might represent a spurious finding.

The lack of a strong Group effect between the target and control groups within the experimental study, similar to the non-significant Group effect noted in the biochemical and state-anxiety analyses, indicated that children in both groups (those identified ahead of time as being stressed before presenting a talk to the class and those identified as not being stressed in such situations) were affected similarly by the experimental condition. It should be noted that the experimental condition included not only the anticipation of presenting a talk but also anticipation of needing to collect a urine sample and participation in cognitive tasks. Although urine collection and cognitive testing also were included at Time II, they were by then a "known" experience and thus represented a different psychological experience for the child.

Based on the analytic procedure used by Johansson and colleagues (1973) in their study of children in an academic pressure situation, the experimental study sample was divided into two groups according to biochemical response, increase/decrease, for further analysis. Since adrenalin had been used in previous stress and cognition studies, it was selected as the measure for establishing biochemical response groups for use in the MANOVA analyses. As in the previous analyses, cognitive task scores were the dependent variables.

Significant Time effects occurred within the MANOVA analyses divided for A groups for three sets of tasks (attention, $p = .001$; recognition memory, $p = .004$; processing, $p = .004$). A strong Group effect was demonstrated for attention tasks ($p = .02$),

an acceptable Group effect for processing tasks ($p = .13$), and a nonsignificant Group effect for both sets of memory tasks (see summary Table 4 and Appendices DD to GG for all MANOVA results).

In order to examine the effect behavioural response may have had on cognitive performance, similar analyses were carried out with the experimental study sample divided according to alteration in observed tension and in self-reported state anxiety--increase/decrease with no-change included within the decrease group. As with the other MANOVA analyses, significant Time effects occurred for the attention, processing and recognition memory tasks but not for recall memory tasks. Based on the observed tension variable, a significant between-subject effect occurred for processing tasks ($p = .09$) but not for attention and memory tasks. Based on the state anxiety variable, only the recall memory tasks demonstrated a between-subject effect.

In summary, the MANOVA analyses of cognitive task scores demonstrated a significant Time effect for the experimental study sample indicating alteration in attention and processing performance with the imposition of a stressor condition at Time I. Nonsignificant Time effects for the control study sample on all processing and attention tasks but two supported the conclusion that alteration by the experimental sample reflected the condition imposed and not a learning or practice effect. Between-subject effects were less consistent indicating that different response variables may affect different tasks. In order to test these selective effects and to examine more specifically the relation

Table 4

Summary Table of MANOVA Results (probabilities): Cognitive Task Scores Analyzed by Group and Time^a

Groups	n ^b	Cognitive Tasks							
		Attention		Memory Recall		Memory-Recog.		Processing	
		Group	Time	Group	Time	Group	Time	Group	Time
Effects									
Cognitive Control Sample									
	9 (9)		.001		.01		.9		.2
Experimental Sample									
Predicted target control	28 (25) 10 (9)	.7	.001	.3	.6	.4	.007	.12	.004
Adrenalin increasers decreasers	26 (22) 12 (12)	.02	.001	.3	.6	.7	.004	.13	.004
Observed Tension increasers decreasers	27 (25) 11 (9)	.5	.001	.7	.6	.3	.009	.09	.004
State Anxiety increasers decreasers	24 (22) 14 (12)	.3	.001	.02	.6	.2	.01	.3	.002

^a Individual MANOVA tables are reported in Appendices^c DD to GG.^b Numbers in parentheses indicate number of children in memory analyses.

between cognitive and response measure change, further analyses were carried out for the task and response measures which demonstrated significance in the MANOVA analyses.

Although an overall Time effect was shown for the recognition memory task, no Group effect was shown for any of the variable dimensions being examined. Whether the Time effect, relevant to only one measure within the task, was a spurious finding or a meaningful response could not be determined within the present research study owing to the lack of relationship between performance on the task and the response variables being measured. The recognition memory tasks, therefore, were not analyzed further.

Since there was no theoretical basis for predicting whether cognitive performance alteration might be associated with graded response changes (a small response change being associated with a small cognitive change while a greater response change was associated with a greater cognitive change) or with categorical response changes (increase, decrease), two types of follow-up analyses were planned: (1) a series of canonical correlations, with selected univariate multiple regressions, were performed to test for a graded relationship (i.e., shared variance) between cognitive performance alteration and response alteration and (2) a series of univariate ANOVAs were performed to test for a categorical relationship between cognitive performance alteration and response change. The ANOVAs permitted a comparison of task performance with the predictions of performance change for the stressor condition which were made prior to testing.

Cognitive Alteration and Graded Response

Canonical correlation analyses were carried out with urinary biochemical scores (A, NA, and MHPG), observed tension scores, and state anxiety scores entered as determinants of the experimental condition (independent variables) while the cognitive scores--attention tasks and processing tasks--were entered as response (dependent) variables. Owing to the limited research regarding a relation between A, NA, MHPG and cognitive performance, it was decided to conduct a series of exploratory analyses in which the measurement dimension of the biochemical alteration was varied. (1) Two initial analyses were conducted using biochemical difference scores and biochemical proportion change scores. (2) The more significant of these was then computed with two variations. In the first variation, MHPG categorical change scores (negative, positive) were used.

Since MHPG alteration appears to reflect the state of the system as it responds to a stressor rather than the response itself, it was hypothesized that a significant correlation might exist between the condition represented by MHPG increase or decrease and cognitive performance while the degree of MHPG alteration and cognitive performance might not correlate. (3) The second variation maintained MHPG as a categorical or continuous score, whichever was shown by the previous analyses to be the best predictor, and entered A and NA increasers and decreasers as separate variables. It was hypothesized that a different relationship might exist between increasing levels of biochemicals and cognitive performance and decreasing levels

of biochemicals and cognitive performance. By entering increasers and decreasers separately, separate and thus more accurate regression lines of best fit could be established in place of a singular regression line which results in greater residuals. Since increasing the number of variables decreases degrees of freedom and, thus, the likelihood of finding a significant effect, Kerlinger and Pedhazzer (1973) suggested that a regression analysis with divided variables be viewed as an exploratory analysis to be rejected if the increase in variance is outweighed by loss of significance.

The only significant Group effect shown by the MANOVA analyses with observed tension as the between-subject variable occurred with processing tasks. A canonical correlation was carried out with processing task scores and observed tension scores. Since observed tension has not been considered in the research on stress and cognition, there was no theoretical basis for determining whether cognitive performance alteration would be more likely to reflect levels of observed tension under the stressor condition (Time I) or change in levels from non-stressor to stressor conditions. It was decided to include both Time I and Time I to Time II change scores as an exploratory analysis.

Although the MANOVA analyses based on state anxiety groups had shown a significant Group effect for memory recall tasks, no Time effect had occurred. Since regression analyses are based on change scores, it was anticipated that a canonical correlation with recall memory tasks would offer no additional information and, thus, was not planned.

The statistical findings of the canonical correlation analyses are summarized in Table 5. The analyses of attention task performance and biochemical excretion showed stronger correlation and higher significance level ($R_c = .62$; $p = .12$) between the linear combinations of these measures (1) when biochemical change was measured by difference scores as opposed to proportion scores and (2) when MHPG was entered into the analysis as a continuous score. (3) Although the correlation increased slightly when A and NA increasers and decreasers were entered separately, there was a loss of significance owing to a decrease in degrees of freedom and, thus, the analysis with single A and NA variables was considered to be most meaningful. Examination of the structure coefficients within the first and most significant of the canonical variates indicated that the CPT (commission errors) was the most important of the cognitive tasks in establishing the shared variance between cognitive and biochemical variates while the adrenalin difference score was the most important of the biochemical measures. The structure coefficients for the zeros-ordered and zeros-random tasks in the alternative canonical correlations indicated that these tasks also played a relevant role in establishing the canonical correlations.

The canonical correlation analyses of alteration in processing task performance and biochemical excretion showed a stronger correlation and higher significance ($R_c = .75$, $p = .01$) when, similar to the analyses with the attention tasks, (1) difference scores were used and, in contrast to the attention tasks, (2) MHPG was entered as a categorical score, and (3) A

Table 5

Summary Table of Canonical Correlation Results: Cognitive Task Scores
with Response Measure Scores

Response Measures	Cognitive Tasks					
	Attention			Processing		
	R	R ²	sig	variables ^a	R	R ² sig variables ^a
AΔ, NAΔ, MHPGΔ	.62	.39	.12 ^b	cog:CPT-com Zeros-Or Zeros-ran		.3
AP, NAP, MHPGP			.2	resp: AΔ		.5
AΔ, NAΔ, MHPG	.68	.46	.15		.66	.44 .06
AΔ+, AΔ+, MHPGΔ, NAΔ+, NAΔ+	.66	.44	.16			
AΔ+, AΔ+, MHPG NAΔ+, NAΔ+					.75	.57 .01 ^b
						cog:Arith-t Obj-Sort-s resp:A+ NA+
OT-Time I, OTΔ					.66	.44 .09
						cog: Obj-Sort-c Obj-Sort-s resp: OT-Time I

^avariables indicated by structure coefficients as the most important in forming primary correlation.

^bAnalysis which was considered most meaningful.

and NA increase and decrease scores were entered as separate variables. Examination of the structure coefficients for the most significant of the analyses indicated that the arithmetic time score and, to a lesser extent, the object sorting task scored by sorts and A and NA increase were the important variables in establishing shared variance.

Processing task difference scores analyzed with observed tension scores showed acceptable significance ($R_c = .66$, $p = .09$). High structure coefficients were shown for the object sorting task scored by sorts and by concepts and for observed tension at Time I.

Tasks identified by the canonical correlation analyses as important in establishing shared variance between sets of independent and dependent variables (i.e., having high structure coefficients) were selected for further analysis by univariate multiple regression. Response measures were entered as the independent variables while the cognitive task score was the dependent variable being predicted. A stepwise regression with α set at .1 for entry was used. Because interdependence between response measures may cause a single independent variable to be rejected although two variables in combination may establish a significant relationship, a regression equation with no entry under the stepwise procedure was rerun with forced entry. Univariate regression results are summarized in Table 6 (see Appendices JJ and KK).

Of the seven relationships predicted as significant on the basis of structure coefficients demonstrated by the canonical

Table 6

Summary Table of Univariate Multiple Regression Results: Cognitive Task Scores with Response Measure Scores

Variables		Results		
Cognitive Task	Response Meas.	R	R ²	sig.
CPT-com.	AA, NAA	.44	.20	≤.06
Zeros-or.	AA, MHPA	.45	.20	≤.05
Zeros-ran.				ns
Arith-time	AA+, AA+, NAA+	.54	.30	<.001
simple	AA+, NAA+	.39	.15	≤.06
equation	NAA+, NAA+	.47	.22	≤.01
Obj-Sort-s	NAA	.30	.09	<.1
Obj-Sort-s	OT-Time I, OTA	.45	.20	<.02
Obj-Sort-c	OT-Time I, OTA	.58	.34	<.001

correlations, five were found to be significant and meaningful. When the two arithmetic tasks were run separately, the shared variance ~~between~~ alteration in urinary biochemical and performance variation was significant for the equation task and approached significance for the simple task. Low but significant shared variance was indicated between A. excretion change and performance alteration on the CPT-commission, zeros-ordered, and the equation arithmetic task scored for time, between NA excretion change and performance on the two arithmetic tasks scored for time, between MHPG excretion change and the zeros task with ordered subscripts, and between observed tension (Time I and difference measures) and the object sorting task. These results are considered in more detail in the discussion of individual cognitive tasks.

Cognitive Alteration and Categorical Response

In order to provide a test of the task performance predictions made on the basis of the literature review (the predictions were reported in the methods section), univariate analyses of variance were planned for each attention, processing and recall memory task. These analyses also provided an examination of the relation between cognitive performance and categorical response alteration--did the cognitive alteration occurring under the stressor condition differ significantly between the increase and decrease groups for a particular response measure? Task performance constituted the dependent variable while response measures (2-levels) and time (2-levels) were the independent variables.

Since the combination of A and NA as one variable or the use of NA as a separate variable would decrease either number of subjects (four children demonstrated opposite A and NA alteration) or degrees of freedom, and A has been attributed to have greater sensitivity to stressor conditions (Frankenhaeuser & Johansson, 1976; Lundberg et al., 1981), A was used as a single catecholamine variable within the ANOVA analyses. MHPG was used as a second between-subject variable with the interaction between A and MHPG providing an analysis of the effect of the A/MHPG subgroups. One within-subject variable, time, and three between-subject by time interactions were tested.

A second set of analyses with behavioural response measures was run. One within-subject variable (time), two between-subject variables (state anxiety and observed tension), and two between-subject by time interactions were tested. All analyses were based on the unique sum of squares, i.e., each independent variable is corrected for every other independent variable in the model.

The results of the ANOVA analyses are summarized in Table 7. The table lists each task, the cognitive behaviour the task measured, the a priori prediction of change under stressor conditions, the significance of the Time effect occurring for the cognitive control sample (a measure of possible learning or practice effect), the significance of the biochemical analysis variables (Time, biochemical Group, Group by Time interaction effects), the significance of the behavioural analysis variables (Time, behavioural Group and Group by Time interaction

Table 7

Summary Table of ANOVA Results: Cognitive Task Scores by Response Measure Alteration

Task	Cognitive Behaviour	Predicted Alteration	Control (n=9) Time	Response Measures ^a					Nature of Alteration
				TIME A	AXT MHPG	MXT AXM	AXMXT	Behavioural (n=33-38) TIME SA SEXT OT OTXT	
CPT-om	sustained attention	-	ns	<.01	<.15			<.01	worse
CPT-com	impulsivity	worse	<.1	<.001	<.1	<.1		<.001	worse
2arc-om	selective attention	worse	ns	<.01	<.2	<.1	<.2	<.05	worse
2arc-com	selective attention	better	<.15	<.001	<.01	<.02		<.001	better
perse- vera- tion	alternating	-	ns	<.01	<.06	<.05	<.1	<.02	worse
Stroop	attention/response selection	better/ worse	<.01	<.001			<.05	<.001	worse ^a
Arith-om	over-learned processing error	no change	<.15	<.05				<.06	worse
			ns	<.05	<.15	<.2		ns	
Arith-com	alternating short-term memory error	worse	<.01	<.05			<.2	<.1	no change
			ns	.1	<.02	<.1	<.1	<.1	
Ravens	concept accessibility patterning		ns	<.01	<.1	<.05		<.05	worse
			<.2	<.15	<.01	<.1	<.2	<.15	
Obj- Sorting	concept accessibility alternating patterns	worse	ns	ns				ns	no change
sorts concepts			ns	<.15	<.15			<.15	no change

^a Performance evaluation based on percentage of children making errors.

Table 7 (cont'd.)
Summary Table of ANOVA Results: Cognitive Task Scores by Response Measure Alteration

Task	Cognitive Behaviour	Predicted Alteration	Control (n=9) Time	Response Measures										Nature of Alteration
				Biochemical (n=32-37)					Behavioural (n=33-38)					
				TIME A	AXT	MHPG	MXT	AXM	AXMXT	TIME	SA	SAXT	OT	
Memory-number	clustered list	no change	ns	ns				<.2		ns	<.001		no change	
	non-cl list	worse	ns	ns	<.15					ns	<.1		worse	
	non-cl & comment clustering	worse	ns	ns	<.01		<.1	<.05		ns		<.1	worse	
Memory-order	clustered list	no change	ns	ns		<.15			<.15	ns	<.02		no change	
	non-cl list	worse	<.1	ns		<.2				ns	<.01		worse	
	non-cl & comment clustering	worse	<.1	ns	<.05		<.2			ns	<.2		worse	
Digit span	memory	no change	ns	ns						ns			no change	

effects), and the nature of task performance alteration occurring between Time I and Time II. The information in the last column was based on a comparison of means demonstrated in Figures 5 to 15.

The univariate analyses of variance demonstrated a more significant alteration between Time I and Time II performance for children presented with a stressor condition at Time I on all attention task measures and on five processing task measures. It should be noted that the more significant Time effect occurring for the experimental study sample, as compared to the control study sample, on zeros-ordered, zeros-random and Ravens-error, appeared to reflect the smaller standard deviations demonstrated by the experimental sample rather than a difference in means (see Figures 7(A), 8(A), and 12(A)). Performance on the memory recall tasks did not differ significantly between Time I and Time II. Scattered effects were demonstrated for the between-subject variables representing response measures (A, MHPG, state anxiety, observed tension). These effects are reported in the discussion of individual tasks.

Analysis of Individual Task Performance

While ANOVA analyses can indicate significant effects on cognitive task performance, they do not describe the nature of these differences, and thus, do not permit comparison of performance between groups at Time I (the stressor condition) or comparison to a priori predictions. Graph A in Figures 5 to 15 illustrates task performance at Time I and Time II (as indicated

by means and standard error bars) for the experimental study sample and the cognitive control study sample; Graphs B, C, D, and E illustrate task performance for the increase/decrease groups for each response measure (A, MHFG, state anxiety (SA), observed tension (OT)). In order to explore further the group and interaction effects demonstrated in the ANOVA analyses, tests for simple effects between means at Time I (t-tests), between slopes, Time I to Time II, (parallelism tests), and between Time I and Time II for one variable (t-tests) were conducted. Effects not demonstrated by the ANOVA analyses were not tested.

The alteration in cognitive performance on each task variable under the stressor condition as indicated by an examination of means, t-tests, analyses of variance and univariate multiple regression analyses is reported below. The determined alteration has been compared to the predictions for task performance change which were made on the basis of the literature review.

Continuous Performance Task - omission errors (Figure 5).

Accurate response to target sequences on the CPT deteriorated under the stressor condition with more target sequences being missed (I: $\bar{x} = 2.6$, SE = .4; II: $\bar{x} = 1.4$, SE = .2; ANOVA-time: $p < .01$). No change in performance between times was demonstrated by the control group (I: $\bar{x} = .8$, SE = .4; II: $\bar{x} = 1.0$; SE = .4; $p = ns$). While the A increase group experienced difficulty under the stressor condition approaching significance (I: $\bar{x} = 2.3$; SE = .5; II: $\bar{x} = 1.4$, SE = .3; $t = 1.62$, $df = 24$, $p < .1$), the A decrease group experienced significant deterioration (I: $\bar{x} = 3.3$, SE = .7, II: $\bar{x} = 1.3$, SE = .3; $t = 2.65$, $df = 11$, $p < .02$). The difference between slopes was not, however, significant

Figure 5

Continuous Performance Task - omission error score ($\pm$ SE)*
as a Function of Time and Group

*See Appendix PP for mean and standard error scores.

($t = -1.31$, $df = 36$, $p < .2$) thus confirming the weak differentiation between A responses presented on the ANOVA (G by T: $p < .15$). MHPG, OT and SA groups showed no differentiation in their response to Time I.

Because of conflicting reports in the literature, no prediction for sustained attention had been attempted. Deterioration under stressor condition was indicated by the present research. Although significant effects on sustained attention by the response variables measured were not demonstrated, a weak effect by adrenalin was indicated.

Continuous Performance Task - commission errors (Figure 6). While the cognitive control sample showed poorer CPT commission performance (responding when a target sequence did not appear) at Time I which approached significance (I: $\bar{x} = 2.7$, $SE = .9$; II: $\bar{x} = 3.4$, $SE = .6$; ANOVA-time: $p < .1$), the deterioration of performance by the experimental study sample with the stressor condition was highly significant (I: $\bar{x} = 3.4$, $SE = .6$; II: $\bar{x} = 1.3$, $SE = .3$; ANOVA-time: $p < .001$). MHPG groups showed differing patterns of deterioration approaching significance (ANOVA: Groups, $p < .1$; Groups by Time, $p < .1$). Performance of the MHPG decrease group was similar to that of the cognitive control group and, therefore, alteration may have reflected a simple practice or learning effect. In contrast, the MHPG increase group demonstrated significant deterioration (Time I: $\bar{x} = 4.4$, $SE = 1.1$; Time II: $\bar{x} = 1.7$, $SE = .5$; $t = 3.54$, $df = 18$, $p < .01$). A test of slopes, however, indicated that the difference between performance deterioration by MHPG increasers and

Figure 6

Continuous Performance Task - commission error score ($\pm$ SE)*
as a Function of Time and Group

*See Appendix PF for mean and standard error scores.

decreasers only approached significance ($t = 1.52$, $df = 35$, $p < .15$).

The regression analysis indicated a significant negative relation between A alteration and CPT over-responding and a significant, but small, positive relation between NA alteration and CPT over-responding (total $R^2 = .20$, $p < .06$). Higher error rate at Time I (as compared to the cognitive control sample) and greater deterioration (relative to Time II) by the experimental sample supported the prediction of poorer performance on this task under the stressor condition. A tentative relation between biochemical measures and task performance was indicated.

Zeros-ordered subscripts (Figure 7). While the experimental study sample demonstrated a significant Time effect, more difficulty recalling the target zero at Time I relative to Time II (I: $\bar{x} = 5.6$, $SE = 1.1$; II: $\bar{x} = 3$, $SE = 2.4$; ANOVA-time: $p < .01$), the control study sample demonstrated poorer performance at both times (I: $\bar{x} = 6.7$, $SE = 2.4$; II: $\bar{x} = 5.1$, $SE = 2.1$; ANOVA-time: $p = ns$). The lower rate of errors for the experimental sample at Time I appeared to be accounted for by the A and SA increase groups and the MHPG and OT decrease groups. Although the weak MHPG group effect demonstrated by the ANOVA analysis was not supported by a follow-up test of slopes, an effect did appear in the regression analysis based on continuous scores. A significant correlation between zeros-ordered performance and A and MHPG alteration was indicated ($R^2 = .20$, $p < .02$) with an increase in MHPG relating to an increase in errors and an increase in A relating to a decrease in errors.

Figure 7

Zeros Task with Ordered Subscripts - error score ($\pm$ SE)*
as a Function of Time and Group

*See Appendix PP for mean and standard error scores.

While performance alteration supported the prediction of poorer performance, the experimental sample demonstrated better Time I performance than did the cognitive control sample and, therefore, agreement with the a priori prediction must be questioned. Examination of the A groups indicated that the increase group did not show poorer performance than the decrease group as expected according to an hypothesis of narrowed cue utilization. Since a relationship between A and narrowed cue utilization was supported by results on the subtask with randomized subscripts, it would appear that the children may have been centring their attention on the subscripts rather than zeros and thus improved their performance or, alternatively, the zeros-ordered task was measuring some cognitive process other than attention narrowing. The latter alternative is supported by the contrasting effect demonstrated by MHPG, an increase relating to an increase in errors.

Zeros-randomized subscripts (Figure 8). All children experienced greater difficulty recalling the target zero on this task at Time I, the control sample showing a Time effect approaching significance (I: $\bar{x} = 25$, SE = 2.9; II: $\bar{x} = 12$, SE = 2.9, $p < .15$) and the experimental sample showing a significant Time effect (I: $\bar{x} = 20$, SE = 1.6; II: $\bar{x} = 12$, SE = 1.6; $p < .001$). The difference in significance would appear to reflect the smaller number of degrees of freedom available for testing the control sample as well as the greater variance demonstrated by the control sample. Of interest was the significant difference in performance by the A increase/decrease groups

Figure 8

Zeros Task with Random Subscripts - error score ($\pm$ SE)*

as a Function of Time and Group

Zeros Task with Random Subscripts - perseveration error score ($\pm$ SE)*

as a Function of Time and Group

*See Appendix PF for mean and standard error scores.

at Time I (A^+ : $\bar{x} = 16$, $SE = 1.9$; A^- : $\bar{x} = 28$, $SE = 1.2$; $t = 3.81$, $df = 34$, $p < .001$; ANOVA-group: $p < .01$) with the A increase group showing better performance. A significant Group by Time interaction (ANOVA: $p \leq .02$) was demonstrated with both groups showing similar performance at Time II. Since the regression performed for this task did not show a significant correlation between A change and performance, this effect was assumed to be a categorical one.

An examination of the errors made on this task indicated similar perseveration by both study samples. While the A increase group experienced less perseveration than the A decrease group (A^+ : $\bar{x} = 3$, $SE = .5$; A^- : $\bar{x} = 6$, $SE = .9$) this would appear to reflect difference in overall error rate and not an actual difference in perseveration between groups.

Although the prediction of better performance was not supported when the experimental and control samples were examined, behaviour by the adrenalin change groups did support the prediction. Improved performance by the A increase group was in agreement with the hypothesis of narrowed cue utilization under stressor conditions. An adrenalin effect on selective attention was indicated.

Stroop Task (Figure 9). Since the cognitive control sample experienced significantly more difficulty on the Stroop task at Time I than at Time II (ANOVA: $p < .01$), the significant Time effect for the experimental study group (ANOVA: $p < .001$) may be explained as a practice effect. While none of the response variable groups showed a significant effect, a complex interaction

Figure 9
 Stroop Task - time score ($\pm$ SE)*
 as a Function of Time and Group

*See Appendix PP for mean and standard error scores.

effect, A by MHPG by Time, did appear with the A+M+ group showing considerably better behaviour at Time II (I: $\bar{x} = 78$, $SE = 7.6$; II: $\bar{x} = 59$, $SE = 7.3$; ANOVA: $p < .05$). It would appear that either the learning occurring at Time I or the baseline level of performance was considerably better for this group. Since only six children were in the group, any interpretation should be cautious.

Although error rate usually is not scored for this task (errors normally being negligible), considerable difference was noted for the number of children in the experimental sample making errors at Time I (42%) as compared to the number making errors at Time II (14%) or the number of children in the cognitive control sample making errors (11%). High error scores would indicate an inability to check verbalization of an initial incorrect response. When error rate was calculated for the adrenalin groups (Time I: increasers, 43%; decreasers, 13%; Time II: increasers, 15%; decreasers, 25%) and the MHPG groups (Time I: increasers, 44%; decreasers, 27%; Time II: increasers, 17%; decreasers, 11%), it was noted that both increase groups demonstrated a higher percentage of children making errors under the stressor condition.

Because conflicting results had been reported in the literature for performance on the Stroop task under hypothesized stressor conditions, no prediction had been made for performance under the stressor condition. Due to the practice effect indicated by the change in time scores from Time I to Time II by the cognitive control sample, the significant

deterioration demonstrated by the experimental sample could not be interpreted as a stress effect. Occurrence of errors, however, did indicate poorer performance by the experimental sample and, in particular, the A and MHPG increasers under the stressor condition. Poorer performance on the Stroop has been hypothesized by the drive theory of cognitive alteration to reflect difficulty at the response, and not attention, level of processing.

Simple arithmetic (Figure 10). The experimental study sample experienced difficulty on this task at Time I (time: $\bar{x} = 97$, SE = 19; errors: $\bar{x} = .5$, SE = .2) relative to the cognitive control study sample (time: $\bar{x} = 66$, SE = 6; errors: $\bar{x} = .1$, SE = .1) and relative to its own error rate at Time II ($\bar{x} = .1$, SE = .1; ANOVA-time, $p \leq .05$). Time remained high (slow performance) at Time II ($\bar{x} = 91$, SE = 18). Similar Time II time and error alteration patterns appeared for the other timed tasks (equation arithmetic, Ravens, Stroop) with errors decreasing and time remaining high. This may suggest some carry-over effect from Time I to Time II for time (speed) or, alternatively, slower baseline performance speed for particular groups of children. The latter alternative is argued against by the fact that the MHPG groups alternated between fast and slow performance on different tasks.

Within the regression analysis, while A increasers did not enter alone with α set at .1, NA increasers and A increasers entered together did show limited shared variance with performance speed which approached significance ($R^2 = .15$, $p \leq .06$). Although

Figure 10

Simple Arithmetic - errors score (*SE)
as a Function of Time and Group

Simple Arithmetic - time score (*SE)
as a Function of Time and Group

this was the only significant effect or relationship with time to be indicated for the measured variables, the contrasting time and error rates were of interest. These rates were examined to determine any pattern which might appear across tasks indicating particular cognitive behaviour by specific response groups. The A and MHPG increase groups took more time than the decrease groups and experienced fewer errors. The SA increase group, in contrast, took less time to complete the task but made more errors, while the SA decrease group increased its time and was able to avoid an increase in errors.

The response group for whom this task presented the greatest difficulty was the observed tension increase group. Although these children performed slower under the stressor condition, their error rate increased significantly (Time I: $\bar{x} = .7$, $SE = .2$; Time II: $\bar{x} = .0$, $SE = .0$; $t = 2.56$, $df = 26$, $p < .02$) with performance at Time I being significantly different from that of the decrease group ($t = 3.46$, $df = 36$, $p < .05$; ANOVA-group, $p < .05$).

The no change prediction for performance with overlearned material under the stressor condition was not supported. While the high variance for the response groups demonstrating poorer performance would indicate an inconsistent effect, significant deterioration was shown by the total experimental sample and, in particular, by OT increasers. Since the pattern of effects as demonstrated by the response variables was different from that demonstrated on attention tasks, it would not appear that deterioration was a function of attention.

Equation arithmetic (Figure 11). The learning effect demonstrated by the cognitive control sample on equation arithmetic time indicated that the significant Time effect demonstrated by the experimental sample could be a function of learning or practice and not related to the imposition of the stressor condition. No Time effect was indicated for the error score. Several patterns were demonstrated which paralleled findings on other tasks.

As noted for the simple arithmetic tasks, time scores did not change from Time I to Time II while error scores did vary. In contrast to the pattern on the simple task, MHPG increasers worked more quickly than decreasers but made more errors at Time I relative to Time II (Time I: $\bar{x} = 3.5$, $SE = .5$; Time II: $\bar{x} = 2.3$, $SE = .5$; $t = 2.71$, $df = 18$, $p \leq .01$). A significant difference in the error slopes for MHPG increasers and decreasers was found ($t = 2.02$, $df = 35$, $p \leq .05$). An interaction between A and MHPG approaching significance (ANOVA: $p \leq .1$) indicated considerable deterioration for the A+M group at Time I. Because of the limited number of children in the group and the isolated nature of this effect (i.e., deterioration did not occur on any other task), this effect was not tested further. Different adrenalin responses by themselves did not appear to be related to performance on this task (ANOVA and regression analysis). Noradrenalin did show significant shared variance with speed of performance ($R^2 = .22$, $p \leq .01$).

Equation Arithmetic - error score ($\pm$ SE)
as a Function of Time and Group

Equation Arithmetic - time score ($\pm$ SE)
as a Function of Time and Group

The prediction of deterioration of performance on the equation task under the stressor condition was not supported. The lack of Time effect differences between the experimental sample and the control study sample may have reflected the task used (i.e., the high practice effects may have hidden effects related to the stressor condition) and not a lack of effect by the stressor condition on cognitive processes.

Raven's Standard Progressive Matrices (Figure.12). The Time effect for speed of performance on the Ravens task (identification of spatial concepts) was significant for the experimental study sample (Time I: $\bar{x} = 256$, $SE = 10$; Time II: $\bar{x} = 238$, $SE = 12$; ANOVA: $p < .01$). In contrast, the cognitive control sample showed a nonsignificant decrease in speed, thus indicating that the alteration experienced by the experimental sample may be attributed to the conditions imposed. Error differences between the experimental and control samples appeared minimal.

Performance on this task by the biochemical response groups (but not the behavioural response groups) was similar to performance patterns demonstrated on the equation arithmetic task. The A increasers appeared to adjust (increase) their time in order to maintain low errors. Since the differences between A groups (speed: ANOVA, $p < .1$; error: ANOVA, $p < .01$) was consistent across both testing times, these scores may reflect the way these groups respond to cognitive tasks in general and not the stressor condition specifically. The MHPG increasers, in

Figure 12

Raven's Standard Progressive Matrices - error score ($\pm$ SE)*
as a Function of Time and Group

Raven's Standard Progressive Matrices - time score ($\pm$ SE)*
as a Function of Time and Group

contrast, worked faster relative to the decreasers (Time I-- MHPG+: $\bar{x} = 230$, $SE = 12$; MHPG+: $\bar{x} = 285$, $SE = 17$; ANOVA Group effect: $p < .05$) but made more errors (MHPG+: $\bar{x} = 8.5$, $SE = .6$; MHPG+: $\bar{x} = 6.6$, $SE = .7$; $t = 2.47$, $df = 18$, $p \leq .02$). This pattern was similar to performance on the complex arithmetic task but opposite to the pattern occurring for the simple task. Faster time and more errors also occurred for the increased observed tension group. This would not appear to be an intelligence effect (changes in MHPG and OT were shown to correlate negatively with intelligence) since speed and error rates improved simultaneously at Time II. The prediction of deterioration in Ravens performance under a stressor condition was supported by the increase in time, but not by alteration in error rate.

Object Sorting (Figure 13). A comparison of the performance of the experimental study sample and the cognitive control sample would indicate nonsignificant alteration on the object sorting task under the stressor condition. Although the ANOVA indicated a Time effect approaching significance for the concept score ($p < .15$), a contrasting performance pattern by the control sample would indicate that the Time effect may reflect weak reliability for the task rather than stressor condition effects.

The regression analyses demonstrated nonsignificant correlation with biochemical response (a correlation with NA did approach significance but was too small to be meaningful: $R = .30$, $p < .1$) but significant correlation with observed tension

Figure 13

Object Sorting Task - sorts and concepts (#SE)*
as a Function of Time and Group

difference scores and observed tension at Time I (sort score: $R = .45$, $R^2 = .20$, $p \leq .02$; concept score: $R = .58$, $R^2 = .34$, $p < .001$). This relationship was difficult to interpret because of the contrasting coefficients assigned to the two predictor variables, a negative coefficient for observed tension at Time I and a positive coefficient for the observed tension difference score. The ANOVA analysis indicated an OT Group effect approaching significance ($p < .1$). Owing to the negative correlation between OT Time I and intellectual level, the possibility that this effect reflected intelligence and not stressor effect must be considered. The prediction of poorer performance on the object sorting task under the stressor condition was not supported.

Recall Memory (Figures 14 & 15). The comparisons of interest for this task were the number and order of words recalled between the different types of lists: clustered word list, non-clustered word list, non-clustered word list with a preceding comment mentioning the value of clustering. Although the experimental study sample and the cognitive control sample demonstrated similar recall (number and ordering) for the clustered word lists, notable differences occurred with the two non-clustered word lists. The control sample showed a deterioration in recall-ordering when the first non-clustered list was presented (C1 list: $\bar{x} = .9$, $SE = .03$; N-C1: $\bar{x} = .4$, $SE = .12$; $t = 4.27$, $df = 8$, $p < .01$). When the non-clustered list plus comment was presented, ordering improved to the extent that the difference from the clustered list only approached significance. Number recalled was the same as for the clustered list. At Time I,

Figure 14
 Recall Memory-- clustering score (+SE)
 as a Function of Time and Group

Clustered Lists ———
 Non-Clust. List - - - -
 N-Cl List + comment - - - -

Figure 15
Recall Memory - number of words ($\pm$ SE)*
as a Function of Time and Group

Clustered Lists —————
Non-Clust. List - - - - -
N-Cl List + comments - - - - -

the experimental study sample showed significantly lower recall with the first non-clustered list, as compared to the clustered lists (Number--Cl list: $\bar{x} = 10$, $SE = .3$; N-Cl: $\bar{x} = 7.8$, $SE = .31$; $t = 7.51$, $df = 33$, $p < .001$; Order--Cl: $\bar{x} = .9$, $SE = .02$; N-Cl: $\bar{x} = .4$, $SE = .06$; $t = 6.59$, $df = 33$, $p < .001$). While an improvement in clustering occurred from the first non-clustered list to the non-clustered list with comment, clustering was still significantly below that occurring for the already-clustered lists (N-Cl + comment: $\bar{x} = .6$, $SE = .07$; $t = 3.88$, $df = 31$, $p < .001$). Despite the limited improvement in clustering for the cluster-comment list, number of words recalled did not increase.

A lack of correspondence between amount of clustering and number of words recalled was particularly evident for the behavioural response groups; although clustering improved when a comment was made, the number recalled did not change from the first to the second non-clustered list. The negative effect on memory recall under the stressor condition did not appear to be limited to poor clustering. Alternatively, clustering may have been imposed during retrieval rather than encoding and thus did not benefit the memory process. Memory performance at Time II by the experimental study group on all lists was similar to performance at Time I (ANOVA-time: $p = ns$) in contrast to the control sample which demonstrated a learning effect for clustering between Time I and Time II.

A significant Group difference appeared for performance on the initial clustered list with the increase SA group recalling and clustering more than the decrease group (number:

was a reflection of the SA decrease (no change) group which showed poorer recall at Time II. The SA ordering pattern with the non-clustered list presented an exaggerated version of this pattern (ANOVA $G \times T$: $p < .01$), performance by the SA decrease group being lower at Time II. This complex interaction of effects may have reflected poorer motivation on the part of the SA decrease group at Time II.

A significant difference was shown between A groups on the cluster-comment non-clustered list with the A increase group showing an improvement in clustering but no improvement in recall while the A decrease group showed no improvement in clustering and a deterioration in recall (Order--A+: $\bar{x} = .7$, $SE = .07$; A+ $\bar{x} = .5$, $SE = .13$; ANOVA: $p < .05$; Number--A+: $\bar{x} = 6.0$, $SE = .5$; A+ $\bar{x} = 6.2$, $SE = .4$; ANOVA $< .01$).

The prediction of poorer performance with non-clustered as compared to clustered word lists under the stressor condition was supported. Of particular interest was the inability of the experimental study sample to improve memory performance (in particular the number of words recalled) when a comment on clustering was made.

Recognition Memory. Although the recognition memory tasks were not analyzed further by statistical analyses, the means and variances were examined. Both study groups demonstrated a 100% increase in misses between the clustered and non-clustered lists and a 50% increase in false positives. The alteration that did occur for some of the specific response variable groups from Time I to Time II showed a nonsignificant improvement in performance under the stressor condition. Since no meaningful pattern of behaviour could be discerned and the

one significant difference shown on the MANOVA (more misses on the clustered list at Time II) could have been spurious, further analysis was not done. No prediction for memory recognition alteration under the stressor condition had been made. No meaningful alteration was found.

Digit Span (Figure 16). Behaviour on the digit span by the experimental sample and the cognitive control sample was very similar with minimal deterioration occurring for the experimental sample under the stressor condition (ANOVA-time: $p = ns$). Because low performance on the digit span task has been interpreted as indicating high levels of anxiety, performance by the SA groups was examined. The SA increasers were shown to have recalled more digits than the SA decreasers, the difference between the groups being nonsignificant (SA+: $\bar{x} = 6.2$, $SE = .3$; SA-: $\bar{x} = 5.6$, $SE = .4$; $t = 1.19$, $df = 36$, $p = .25$). The prediction of no alteration under the stressor condition was supported.

Summary

Significant alteration in performance under the stressor condition that could not be explained by learning or practice effects occurred for four attention tasks, two processing tasks and one memory task. On the two attention tasks hypothesized as being related to selective attention, performance improved. Performance on tasks measuring sustained attention and impulsivity, processing with overlearned material, semantic reorganization of words, and restructuring of spatial information

Figure 16

Digit Span Task - number of digits ($\pm$ SE) *
as a Function of Time and Group

Study experiment(28) &
Comparison: cog. con.(9)

Adrenalin: increase(26) &
decrease(12) &

MHPG: increase(19) &
decrease(18) &

Observed increase(27) &
Tension: decrease(11) &

State increase(24) &
Anxiety: decrease(14) &

*See Appendix QO for mean and standard error scores.

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deteriorated. Performance on the memory tasks did not deteriorate when a clustered word list was presented but did deteriorate when an unclustered list was presented. Clustering but not recall improvement occurred when a cluster-comment preceded the second unclustered list.

Examination of performance by the increase/decrease response groups indicated patterns of alteration in cognitive performance. Adrenalin increasers at Time I showed significantly better performance than A decreaseers on a selective attention task (zeros-random) and better performance than A decreaseers which approached significance on a sustained attention task (CPT-omission). Although self-imposed clustering for the memory task was low, significantly better ordering by the A increase group, contrasted to the A decrease group, with the cluster comment may have indicated better attending. Memory recall itself did not improve (clustering was performed but not used). Adrenalin increasers appeared to adjust to the stressor condition by increasing time scores (simple arithmetic, equation arithmetic, Ravens) and thereby maintaining an error rate parallel to that occurring for the control sample on timed tasks. The only tasks to indicate poorer performance for A increasers were the Stroop (interference appearing to occur at the responding, as opposed to the attending, stage of processing) and ordering and recall for the non-clustered memory list without an instruction. Adrenalin decreaseers, in contrast, showed poorer sustained and selective attention; they worked quickly on the time tasks and experienced, on some of the tasks,

twice as many errors as did the A increasers.

Although most of the MHPG effects were of weak significance (i.e., $p < .05$ - $p < .1$), a pattern did seem to appear with MHPG increasers performing poorly on tasks requiring response control (CPT commission errors, Stroop). Similar impulsivity may have been indicated on the complex time tasks when MHPG increasers worked faster and made more errors. Error rate did not appear to be solely a function of speed, since MHPG decreasers worked more slowly but also made a high number of errors.

Observed tension increasers experienced difficulty with the overlearned information task and the object sorting task. Observed tension decreasers did not show unusual difficulty on any task. State anxiety response groups showed little difference in performance on any of the tasks presented. SA increasers were noted as maintaining time scores very close to those of the control sample. A possible carry-over effect for time scores, with Time II speed being the same as Time I speed, was noted for all groups.

Although NA excretion scores were not included in the analyses of variance, they were included in the regression analyses. A correlation between NA and time occurred for tasks with known material (arithmetic) but not for tasks with unknown material (Ravens). In combination with A, NA correlated with high impulsivity scores on an attention task (CPT - commission errors).

The Effect of Intellectual Level on the Relation between Response and Cognitive Change

Intellectual level showed a nonsignificant relation with A and NA excretion and with state anxiety scores, but a significant positive correlation with urinary levels of MHPG at Time II (verbal: $r = .36$, $p \leq .02$; performance: $r = .51$, $p < .01$) and a limited negative correlation with MHPG change (V: $r = -.22$, $p \leq .1$; P: $r = -.37$, $p \leq .02$), with OT at Time I (V: $r = -.32$, $p < .05$; P: $r = -.24$, $p \leq .1$) and with OT Change (V: $r = -.35$, $p < .05$; P: $r = -.28$, $p < .01$) (Pearson product-moment correlations reported in the section on biochemical results). It may be that intelligence alters the appraisal of or adaptability to an imposed stressor thereby affecting responses or, alternatively, intelligence may reflect a level of internal activity which also is reflected in or related to internal and external responses such as MHPG and tension.

A second question can be raised regarding the role of intelligence vis-à-vis stress effects on a child's cognitive performance. Once a response has been initiated, can high or low levels of intelligence protect a child's cognitive functioning from the detrimental or beneficial effects which have been demonstrated to occur in conjunction with an increase or decrease in biochemical or behavioural response? In order to examine this question, the five cognitive tasks on which specific response measures were shown to have significant effects within the ANOVA analyses were selected for examination by covariate analysis.

Each task was tested by an analysis of covariance in which homogeneity of regression was determined and the covariate

(verbal ability level and performance ability level as measured by the CCAT) was regressed against the dependent variable thus removing from the cognitive task score any variation due to intellectual level. The independent or response variable was then entered into the equation. If the correlation significance for the independent variable was lost; it was inferred that the covariate, intelligence, was an important variable within the response-cognitive performance relation. As such, intelligence may influence the manner in which the dependent and independent variables relate. In order to examine possible influence, the top 10 children (VIQ: 114-133) and bottom 10 children (VIQ: 88-98) were selected. Separate ANOVAs with the response measure as the between-subject variable, but without the covariate, were performed for each subgroup. The significance of the Group effects was examined to determine whether the effect of the response variable (A, MHPG) differed for high and low IQ groups.

Tasks demonstrating significant response variable effects were selected: three tasks showing A effects, one task showing MHPG effects and one task showing OT effects. Since the only task on which SA groups showed a significant effect was a memory list where motivation may have presented a confounding factor, no task with SA as the independent variable was tested. Homogeneity of regression was not supported for IQ and the simple arithmetic task, thus analysis of a task with observed tension as the independent variable could not be carried out. Of the four tasks tested with verbal intellectual level and then with

performance intellectual level as covariate, one task, zeros-random, retained a significant or close to significant group effect indicating that intelligence was not related to a significant portion of the relationship between A and performance. Further testing with IQ subgroups was not carried out for this task. High and low IQ subgroups were tested for each of the other tasks (Table 8).

The Group significance levels shown for the high IQ and low IQ subgroups tested with the same dependent variable (i.e., cognitive task) were similar (zeros-random: high IQ, $p \leq .1$, low IQ, $p < .1$; Ravens-time: high IQ, $p > .5$, low IQ, $p \geq .5$; Ravens-error: high IQ, $p < .05$, low IQ, $p \leq .05$). This would indicate that the level of tested intelligence did not alter the manner in which the children's performance was related to biochemical response. Because of the small size of the present sample and the relatively few children in the high IQ range, these results must be considered tentative.

Antecedent Factors and Stressor Response

Antecedent factors and biochemical and behavioural response measures were examined by correlational statistics to determine what relation, if any, existed between them. Canonical correlation was used as a preliminary analysis. Since children experiencing a high or low level of an antecedent factor (e.g., on-going family pressures, intellectual level) may be more or less vulnerable to an imposed stressor while small changes within these categorical groups may not affect

Table 8

Summary Table of ANCOVA and Follow-up Probability Results:
Cognitive Task Scores and Response Measure Scores with IQ
as Covariate

Variables			Significance Level		
			Group		
			Total	High IQ	Low IQ
Dependent	Independent	Covariate	ANCOVA	ANOVA	
Zeros-Ran	A	VIQ	.14		
		PIQ	.01		
Zeros-Or	MHPG	VIQ	.4	.1	.07
		PIQ	.4		
Ravens T	A	VIQ	.3	.9	.5
		PIQ	.3		
Ravens Er	A	VIQ	.8	.03	.05
		PIQ	.8		

response, a series of Chi-square analyses also was performed and indices of predictive association were obtained. Results from analyses using 6-month and 12-month life change events were compared to determine if these measures differed in their relation to the stressor response within the context of this study, i.e., did either of the measures serve as a better predictor of response.

Relation between Antecedent Factors and Graded Response

Six canonical correlation analyses were conducted to examine the relation between continuous, and therefore specific, antecedent factor scores and response scores under the stressor condition. Since stressors may have a cumulative effect, a new variable, "cumulative factor", was created including family background, life change events and trait anxiety. Trait anxiety was included in this measure since it has been shown to be an important factor in the appraisal of stressors, i.e., if trait anxiety is high it is more likely that situations within the child's environment will become stressors. Family background, life change events in the past 6 or 12 months and trait anxiety each were given a point score based on 1/2 standard deviation intervals within the original variable score distribution (below the mean = 0; mean - 1/2 sd = 1; 1/2 sd - 1 sd = 2; 1 sd - 1 1/2 sd = 3; 1 1/2 sd and above = 4, see Appendix LL).

Alterations in catecholamine (A and NA) and metabolite (MHPG) excretion were entered as the response or dependent variables with antecedent factors as the independent, predictor

variables in the first set of three analyses. The situation antecedent factors included in the first analysis were 6-month life change events, cumulative factor scores based on 6-month scores and family background; and in the second analysis: 12-month life change events, cumulative factor (12 months) and family background. The third analysis included personal attribute antecedent factors. In the second set of three analyses, behavioural response measures (state anxiety difference scores and observed tension difference scores) were entered as the dependent variables while the same three combinations of independent or predictor variables were retained. The results of these analyses are summarized in Table 9, with significant analyses reported in Appendix MM.

The analysis including 12-month life change events was the only analysis with biochemical response measures demonstrating an acceptable significance level ($R_C = .49$, $R_C^2 = .24$, $p = .1$; acceptable for multivariate analysis based on the Bonferonni inequality equation). An examination of structure coefficients indicated that family background score was the most important of the antecedent factor variables and urinary MHPG alteration was the most important of the response variables in establishing the relationship between the canonical variates. A follow-up univariate multiple regression was performed with urinary MHPG change scores entered as the dependent variable and the situation antecedent factors (family background, life change events for 12 months and cumulative factor for 12 months) as the independent predictor variables. With entry criteria set at $\alpha = 0.1$, family

background scores entered on the first step ($R = .30$, $R^2 = .09$, $p \leq .06$) and cumulative factor scores, demonstrating a negative relationship, entered on the second step (total: $R = .42$, $R^2 = .18$, $p \leq .05$).

The only significant canonical correlation between antecedent factors and behavioural response measures included trait anxiety, locus of control and intellectual level as the predictor variables ($R_c = .74$, $R_c^2 = .54$, $p = .02$). Intellectual level and observed tension change were indicated by structure coefficients as the variables most responsible for the relationship between variates. A univariate stepwise regression analysis with observed tension change as the dependent variable entered intellectual level on the first step ($R = .51$, $R^2 = .26$, $p < .01$) and trait anxiety on the second step with a minimal increase in the amount of variance in observed tension change accounted for (increase: $R = .11$, total: $R^2 = .27$; $p < .01$).

Since the relation between trait anxiety and state anxiety has been debated in the literature, a second regression was performed with state anxiety change as the dependent variable. None of the predictor variables (trait anxiety, locus of control, intellectual level) was entered with a stepwise procedure. When forced entry was used, intellectual level showed the most significant relation between predictor variables and state anxiety change ($p = .19$). Even when all three predictor variables were entered, minimal variance was accounted for ($R^2 = .08$). It should be noted that these analyses were examining trait anxiety as a prediction of state anxiety alteration. A

Table 9

Summary Table of Canonical Correlation Results: Antecedent
Factor Scores with Response Measure Scores

Variables		Results			
independent	dependent	R_c	R_c^2	sig	variables ^a
antecedent factor	response measure				
Life change events (12)	AA	.49	.24	.10	<u>antecedent:</u> Family back. <u>response:</u> MHPGA
Cumulative factor (12)	NAA				
Family background	MHPGA				
Life change events (6)	AA	.46	.21	.18	
Cumulative factor (6)	NAA				
Family background	MHPGA				
Trait anxiety	AA			ns	
Locus of control	NAA				
Intellectual level	MHPGA				
Life change events (12)	SAA			ns	
Cumulative factor (12)	OTA				
Family background					
Life change events (6)	SAA			ns	
Cumulative factor (6)	OTA				
Family background					
Trait anxiety	SAA	.74	.54	.02	<u>antecedent:</u> Intellectual level <u>response:</u> OTA
Locus of control	OTA				
Intellectual level					

^aVariables indicated by the structure coefficients as the most important in forming primary correlation.

Pearsons product-moment correlation between trait anxiety and state anxiety at Time I and at Time II did demonstrate a significant correlation between these variables with a higher level of correlation occurring under the stressor condition (Time I: $r = .66$, $p < .001$; Time II: $r = .48$, $p \leq .001$).

The importance of intelligence vis-à-vis response measure may reflect the setting and procedure of the present study and not a true relationship.

The similarity of results obtained from the analyses based on life events and cumulative factor variables scored for a 6-month period and scored for a 12-month period would indicate little difference between the influence of 6-month and 12-month events on vulnerability to the relatively mild stressor condition presented in this study. It should be noted that these children, as a group, did not experience high levels of life events and that the lack of distinction between the 6-month and 12-month period would not necessarily hold true for a group of children who had experienced more life events.

Relation between Antecedent Factors and Categorical Response

The relation between each of the single biochemicals, combined A/MHPG and behavioural response variables and each of the personal attribute (trait anxiety, locus of control, intellectual level) and situation (life change events in the past 6 months, life change events in the past 12 months, family background) antecedent factors was examined by Chi-square analyses. A lambda statistic estimating the predictive association

of antecedent factors with response measures (Hayes, 1973) was computed. The biochemical and state anxiety response measure scores were divided into three categorical groups--increase, marginal fluctuation, decrease--and the observed tension response scores were divided into two groups--change, no-change--as described in the initial discussion on response measures. The combined A/MHPG scores were divided on the basis of the four subgroups (A+MHPG+, A+MHPG-, A-MHPG+, A-MHPG-). The group divisions established for antecedent factors depended on the nature of the variables and the data collected on that variable (see Appendix NN for summary). Locus of control, family background and life change event scores were each divided into two groupings. Because of the skewed distribution of life change events and family background scores, the median, as opposed to the mean, was used as a dividing point. The mean was used as the dividing point for locus of control scores. Trait anxiety, following the pattern used in most anxiety studies, and the cumulative factor scores were divided into three groupings with children within the range of the mean $\pm 1/2$ standard deviation making up the middle or average group. Five groups were designated for intellectual level based on CCAT scores--low verbal and performance, low in one area and average in the other area, average verbal and performance, average in one area and high in the other, high verbal and performance (see Appendix OO for summary of Chi-square analyses).

Among the personal attribute factors, locus of control showed a significant association with MHPG alteration groups ($\chi^2 = 6.7$,

df = 2, $p < .05$) and an association with state anxiety groups ($\chi^2 = 8.6$, df = 2, $p < .01$). Children with high externality scores on the locus of control scale were more likely to demonstrate marginal fluctuation in urinary MHPG and a decrease in state anxiety. Children demonstrating internality showed the opposite pattern; they were more likely to reveal an increase in urinary MHPG under the stressor conditions and marginal fluctuation in state anxiety.

Among the situation factors, the cumulative factor based on 6 month scores showed an association approaching significance with NA groups ($\chi^2 = 7.8$, df = 4, $p < .1$) and with A groups ($\chi^2 = 7.3$, df = 4, $p < .1$). Children with lower cumulative factor scores were more likely to demonstrate an increase in catecholamines while those with average cumulative factor scores were more likely to demonstrate marginal fluctuation. No unexpected association was demonstrated by the children with higher cumulative factor scores. The significant relation between background factors and cumulative factor scores and MHPG alteration based on continuous data (regression analysis) did not appear when scores were categorized.

While a Chi-square statistic indicates association between two variables (a significant Chi-square indicating that two variables are not independent), it does not demonstrate the strength of association or the power of one variable to predict the other variable. The lambda statistic calculated from the Chi-square table can give this information. Lambda (λ), ranging between .0 and 1.0 with 1.0 as perfect predictability, states

that given information on one variable, the probability of error in the prediction of the second variable is reduced by a certain percent (Hayes, 1973). The lambda asymmetric statistic with response measure groups as the dependent variable and the antecedent factors independent variables was selected.

Although significance of a Chi-square statistic reflects to a large extent the size of the sample studied, the lambda is not similarly restricted by numbers. Thus, lambdas are able to indicate the reduction in error of predictability of response measures, given information on an antecedent factor, for variables not demonstrating significant Chi-squares. While these lambdas have been reported, they should be considered tentative until a study with a larger sample is completed. Lambda statistics for antecedent factors with response measure variables, given the specific stressor condition presented in this study, are reported in Table 10. Lambdas below .15 are not reported.

Error in prediction of urinary MHPG alteration was found to be reduced by information on several antecedent factors: intellectual level ($\lambda = .36$) and family background ($\lambda = .18$). Although locus of control showed a significant association with MHPG response groups in the Chi-square analysis, the ability to predict this response once locus of control scores are known is low ($\lambda = .09$). Trait anxiety and intellectual level reduced error in prediction of A/MHPG groups ($\lambda = .20$, $\lambda = .36$, respectively). Information on the cumulative factor was shown to reduce error of prediction for urinary NA alteration .20 but did not reduce

Table 10

Reduction of Error in Predicting Response to Stressor Condition
Given Information on Antecedent Factors

Antecedent Factor	Response Measure	λ
Behavioural responses		
Intellectual level	SA	.15
*Locus of control	SA	.24
Life change events (12)	SA	.19
Biochemical responses		
Trait anxiety	A/MHPG	.20
Intellectual level	MHPG	.36
	A/MHPG	.35
Family background	MHPG	.18
*Cumulative factor (6 mo)	NA	.20

*Based on significant or approaching significant χ^2 analyses.

error of prediction at a meaningful level for urinary A alteration. For the behavioural response measures, knowledge of locus of control and life change events for a child can reduce the error in prediction of state anxiety change by .24 and .19 respectively.

Summary

Regression analyses using continuous measure scores showed limited relationships between the antecedent factors and response changes measured in this study. Family background and cumulative factor scores were found to account for .09 of the variance occurring in urinary MHPG alteration from Time I to Time II. Intellectual level and trait anxiety accounted for .27 of the variance in observed tension alteration.

Chi-square analyses using categorical scores, and therefore correlating state changes as opposed to continuous changes, showed several associations between antecedent factors and response changes. Children with high externality were more likely to show no change in MHPG excretion but more likely to show a change in state anxiety levels while children with scores indicating internality showed the opposite pattern. An association was shown between cumulative stressors and A/NA excretion, children with low cumulative stressors being more likely to demonstrate catecholamine increases and those with average stressor scores more likely to demonstrate marginal fluctuation. No unexpected association was shown for children with high on-going stressors.

When antecedent factors were analyzed to determine their ability to reduce the error in prediction of response measure change, moderate power ($\lambda = .20-.35$) was demonstrated by trait anxiety and intellectual level in predicting A/MHPG groups, by locus of control in predicting state anxiety response groups, and by cumulative factors in predicting NA groups. Although trait anxiety showed moderate correlation with state anxiety levels, knowledge of trait anxiety levels did not improve predictability of state anxiety change groups (increase, marginal fluctuation, no change).

CHAPTER V

DISCUSSION

Alteration was found to occur in several areas of cognitive performance for children ages 10 to 12 with the imposition of a relatively mild natural-occurring stressor. Significant change in urinary levels of adrenalin and observer-rated tension at the time of the imposed stressor provided evidence that a stress response had occurred for the majority of children. Examination of cognitive task performance and response measures demonstrated significant specific relationships between cognitive alteration and alteration in state anxiety, observed tension and urinary levels of A, NA and MHPG. Based on these findings, the present data present support for the hypothesis that cognitive alteration occurring under a stressor condition reflects, in part, a physiological stress response as indicated by biochemical excretion levels.

The cognitive findings of this study replicated for children the adult research on stress effects on attention and memory and provided information which may help to explain the contradictory results which have been reported in previous studies with children. Cognitive processes involved in restructuring or patterning of information showed only limited alteration under the stressor condition.

Biochemical findings replicated a gender effect, boys demonstrating higher levels of A and NA excretion than girls, which has been demonstrated in previous studies using urinary measures. When the children were grouped according to the manner in which they responded under the stressor condition -- increase,

marginal fluctuation, decrease -- the gender effect, with two exceptions, disappeared. Where an effect was shown, the difference in response represented higher levels for boys across all conditions as opposed to different patterns of response between conditions. A difference was found in the percent of girls and boys who demonstrated increases and decreases in levels of urinary A, NA or MHPG in response to the stressor condition. The failure to find an expected correlation between A/NA excretion and MHPG excretion raises several questions about the manner in which children respond to stressor situations. The lack of a significant correlation between self-rated state anxiety and A, NA or MHPG response, as measured by excretion levels, for boys and only weak correlation for girls indicated that state anxiety cannot be considered a valid reflection of physiological stress response in children.

Analyses of antecedent factor data indicated significant association between several situational and personal attribute factors and the behavioural and biochemical responses occurring under the stressor condition. While locus of control demonstrated varying association with MHPG and state anxiety, the cumulative background factor showed an association with the measured catecholamines. Based on analyses of predictability, these associations, however, were found to be of relatively low strength.

Cognitive Alteration

The literature on stress has presented conflicting views of stress effects on cognition with some studies showing improvement and other studies showing deterioration. Initially, this contradiction was explained by the Yerkes-Dodson inverted-U effect: lower levels of stress cause an improvement and higher levels of stress cause deterioration. Research with humans and animals indicated an alternative explanation with performance differences occurring as a result of the task (i.e., cognitive process) required. The results of the present study provide support for both explanations.

Even though the research design did not include different stressor conditions, the levels of urinary A, N, and MHPG measured at Time 1 (stressor condition) demonstrated differential biochemical alteration with some children showing an increase and others showing a decrease. Although these responses occurred as a result of a single stressor condition, they may represent differing stressor experiences--reflecting the individual child's appraisal of the situation, adaptability to the demands of the situation, and autonomic responsivity. Different response change (increase, decrease) thus may provide a model of stress response occurring under different "stressor" intensities. Within this model, performance on one task across response subgroups could be hypothesized to reflect the effects of differing stressor intensities. Performance across tasks by one response subgroup could be hypothesized as reflecting the effect of a single stressor level on different cognitive processes.

Tasks

Alterations in cognitive performance found to occur with the stressor condition are discussed under three headings-- attention, processing and memory. Within the area of attention, three specific behaviours were measured: sustained attention, selective attention and impulsivity; within processing, four behaviours: performance on overlearned material, alternation between processes, patterning of material, and concept accessibility; within memory, two behaviours: recall and recognition.

Sustained attention. Deterioration of sustained attention (as measured by omission errors on the CPT) under the stressor condition occurred for all response subgroups thus indicating an overall stressor effect separate from the response variables measured. The differences in deterioration experienced by A increasers and decreasers may explain the conflicting evidence presented in past research on the relation of A to sustained attention. Adrenalin increasers have been shown not to differ from baseline (Frankenhaeuser & Järpe, 1963; Obrist et al., 1973) yet to differ significantly from A decreasers (Johansson et al., 1973). In the present study, the poorer performance relative to "baseline" (Time II) demonstrated by the A increasers on the sustained attention task only approached significance, thus supporting the "no effect" thesis. The A decrease group, in contrast, showed significant deterioration from "baseline" with an error rate higher than that of the A increasers.

Although the difference between the two A groups only approached

significance, this may have been due to the short time span for the CPT (five minutes in contrast to the 40 minute task in the Swedish study). Since Johansson and colleagues found that the differences between the two response groups increased over time, the present results can be projected to a point of significant difference.

Selective attention. Better selective attention (as measured with the zeros task with randomized subscripts) by the A increase group, relative to the control study group, provided qualified support for the hypothesis of narrowed cue utilization under stress. The significant difference between the A increase and decrease groups (A decrease demonstrating poorer selective attention) indicated that the selective attention effect was limited to a specific stress response subgroup, i.e., increased adrenalin. Although improvement in selective attention on the zeros task has been demonstrated in a number of studies with hypothesized stress response (Bruning et al., 1968; Geen, 1975; Zaffy & Bruning, 1966), this task has not been used previously in a study including biochemical measures. The hypothesized link between adrenalin increase and improved selective attention was supported. Deterioration in selective attention, similar to that demonstrated by A decrease, has been noted in observation studies for subgroups of children under stressor conditions (Lourie & Schwarzbeck, 1979; B. Schwartz, 1976) but not in adult studies. Lack of deterioration with adults may reflect the fact that adult studies have been primarily of an experimental design using university students and, thus, may have elicited a more uniform stress response (i.e., A increase).

Based on the hypothesis of cue narrowing, poorer performance had been predicted for the zeros task with ordered subscripts. This did not occur. Since a number of children vocalized the subscripts, attention may have centred on subscripts rather than the zeros, thus causing an improvement, as opposed to the predicted deterioration, with narrowed attention. In addition, the significant relation between MHPG alteration and performance on this task suggests that response style (which was found to relate to MHPG change) may have played a role in performance on this subtest of the zeros task.

Performance on several other tasks indicated better attending to the task at hand by A increasers as compared to A decreasers. On the memory task, the significant improvement in clustering behaviour for the non-clustered plus comment list by the A increase group (but not the A decrease group) suggests greater attention to instructions. Since memory recall itself did not change, this difference cannot be explained by difference in memory per se.

On each of the timed tasks (simple arithmetic, equation arithmetic, Ravens), the A increasers demonstrated slower performance speed with an error rate similar to that of the control study group, suggesting that they were aware of (i.e., attended to) the demands of the task and therefore adapted their performance. The A decrease group, in contrast, performed faster and made more errors. While these differences only approached significance, their consistency across tasks lends reliability to the findings.

In summary, performance of tasks requiring selective attention demonstrated an association with A, attention improving

With A increases and deteriorating with A decreases. The other response variables measured did not show effects relevant to selective attention.

Impulsivity. The task most directly affected by impulsive responding was the CPT with commission errors representing level of impulsivity. The most distinctive association between performance on this task and response measures was that occurring for the MHPG increase group. While MHPG decreaseers maintained an error rate parallel to that of the control group, the MHPG increase group made almost twice as many incorrect responses. An interesting pattern appeared on the equation math and Ravens task which also may reflect impulsive responding. Children who completed these tasks at a speed comparable to that of the control study group, most notably the MHPG increase group, exhibited a high error rate. In contrast, children working more slowly (MHPG decreaseers, A increaseers) made fewer errors. This suggests a lack of adaptation to the increased demands of the experimental condition by MHPG increaseers and A decreaseers, thereby leading to impulsive responding.

An additional task to provide information on impulsivity was the Stroop task. While minimal differences occurred for time, the number of errors (which may indicate an inability "to check" inaccurate responses) was notably higher for A and MHPG increaseers. While this would match the other effects noted for MHPG increaseers, it does not fit the pattern of attention behaviour demonstrated by A increaseers. Previous research with the Stroop task has referred to two levels of performance--

an initial attending level at which the colour and words are perceived, and a responding level at which the correct response is chosen. Deterioration in Stroop performance under stressor conditions has been considered to reflect interference at the response level. This may suggest that A increase, while having a beneficial effect on attending, may have a detrimental effect when the cognitive task requires response choice.

Adrenalin and MHPG decrease did not evidence difficulty on the Stroop beyond that demonstrated by the control study group.

Processing overlearned material. The simple arithmetic task was included as a measure of performance under stress with overlearned material. With the exception of the OT decrease, all of the response subgroups demonstrated difficulty with this task. In contrast to the relation indicated between attention processes and biochemical response measures, alteration in performance with overlearned material was associated with behavioural response measures. This may suggest that intrusive thinking, which has been described as preoccupation with personal thoughts and body tension (Horowitz & Wilner, 1976; I. Sarason, 1975), or worry, described as the cognitive component of stress (Deffenbacher, 1977), may be associated with a disruption of cognitive processing with overlearned material.

Alternation between processes. The equation math task and the sorting task scores for sorts were included as measures of ability to alternate between processes. The perseveration score for the zeros task also provided information on this process. None of these tasks showed significant alteration at Time I

which could be attributed to the stressor condition. Looking at the response variable effects, notable differences occurred between the MHPG subgroups (significant effects) and the OT and SA subgroups (effects approaching significance) on the equation math task. Performance on this task by the MHPG subgroups may be associated with an impulsive pattern of responding and thus may not be relevant to the process of alternating. Since the performance of the non-physiological response groups paralleled performance occurring on the simple arithmetic task, these differences may reflect difficulty with computing and not difficulty with alternation between processes.

Previous research with the equation math task (Johansson et al., 1973) showed a significant association with A which has not been replicated in the present study. This difference may be explained by the considerably longer task used in the Swedish study whereby sustained attention, which has been linked with A alteration, would become an important factor in task performance.

Patterning of material. The cognitive process referred to as information patterning was tested by clustered-unclustered memory lists, Ravens scored for errors and the object sorting task scored for sorts. While both the experimental and the control study sample experienced difficulty with the first non-clustered list, the experimental study sample showed less improvement when presented with a cluster-comment before the second unclustered list than did the control study sample. It should be noted that there was no improvement in the number of words recalled when the clustering improved, also in contrast to the

control sample. The lack of effect on number recalled may imply clustering at retrieval rather than encoding level, suggesting that the meaning of the clustering comment was recognized and an effort to follow instructions was made, but that the children were unable to apply clustering as a working strategy.

The adrenalin response groups showed significant differences in the clustering and recall of the nonclustered list plus comment. While the improvement by the A increase group (order but not number) with the cluster comment may be explained as a result of improved attention, the further decrease in number recalled by the A decrease group when a comment was made suggests deterioration in areas other than attention. Since a floor effect may have occurred for clustering by the A decrease group (with very few words recalled, the correction for chance clustering is inadequate), the association between clustering and A is unclear.

The deterioration in performance at Time I on the Ravens task, scored for errors only, approached significance. Although the increase in time was highly significant, the differences between the increase and decrease A and MHPG subgroups may have reflected differences in the manner in which the task was approached (adaptability/impulsivity) and not alteration in patterning ability. Adrenalin increasers worked slowly but with an error rate comparable to the control sample, suggesting increased attention and therefore adaptation to the demands of the task, while A decreasers worked quickly and made more errors. MHPG

increasers similarly worked faster with more errors suggesting lack of adaptation while MHPG decreasers showed the contrasting pattern of slower and more accurate performance. Due to the possible influence of cognitive approach, the Ravens results cannot be interpreted as providing evidence of deterioration in cognitive patterning under stress.

The third task, object sorting, did not show significant deterioration under the stressor condition. While a significant difference occurred between the OT increasers and decreasers, this must be viewed with caution since (1) it does not support a pattern of behaviour occurring across several tasks, (2) it may reflect the negative correlation between OT and intelligence, and (3) OT was a subjectively determined measure.

The apparent contradiction between the results on the clustering memory task, the Ravens, and the object sorting task may reflect a differing effect of stress on auditory as opposed to visual information or a differing effect on information that must be manipulated in the abstract as compared to information that remains in sight. These possibilities should be looked at in future research.

Concept accessibility. The last processing dimension examined was concept accessibility tested by the Ravens and the object sorting task scored for concepts. The findings discussed above apply here. While the results of the present study suggest that a child's approach to a patterning task changes under a stressor condition, alternation between processes and concept accessibility does not appear to be affected. Patterning or

organization, as measured by the memory clustering task, did show deterioration under the stressor condition in the present study. An association with adrenalin response was indicated.

Memory. Although the results of past research on the digit span task have been equivocal at best, this task has been accepted as an indicator of high anxiety (Matarazzo, 1972). No difference in performance was demonstrated between Time I and Time II for the children in the experimental study sample. Looking specifically at the SA response variable, children with increased state anxiety at Time I remembered more digits than did the SA decrease group ($p > .2$). A low but positive correlation approaching significance was demonstrated between digit recall and self-rated anxiety at Time I. While these findings are too weak to be interpreted, they do indicate that poor recall on the digit span is not related to high anxiety as experienced in a transient situation.

The minimal differences between number and ordering of already clustered words by the experimental study sample at Time I and Time II and between the experimental sample and the control study sample suggest that stressor effects on memory, as opposed to effects on the strategies used within memory, are minimal. Similar nonsignificant differences appeared for the recognition task.

Task Effect or Response Effect?

The results of the present study suggest that task demands and stressor response (as measured by an increase or decrease

in urinary indices of physiological response or by an alteration in anxiety and tension indices of behavioural response) interact to determine cognitive performance under a stressor condition. An increase in urinary A was associated with a particular response pattern which improved performance when selective or sustained attention or an adaptation of speed was important but lowered performance when task demands could not be met by attention alone, i.e., performance depended on the use of strategies or the selection of response. Children demonstrating an A decrease, hypothesized as reflecting a different stressor intensity or system vulnerability, showed a deterioration in attention performance and clustering but better response selection on the Stroop task than A increasers. Contrasting changes in performance on one cognitive task occurred for children demonstrating different responses (hypothesized as representing different perceived stressor intensities) and contrasting changes in performance on different tasks (representing different cognitive demands) occurred for children demonstrating the same response.

While different urinary MHPG alterations (increase, decrease) were associated with different cognitive performance patterns, less variation appeared to occur across tasks. The MHPG increase group demonstrated impulsive responding which resulted in poor performance on all tasks. Although the MHPG decrease group showed better attention, poor performance still occurred on processing tasks.

Observed tension, interpreted as a behavioural response to the stressor condition, showed a significant association with

performance change on tasks with familiar material. The meaning of this differentiation is unclear. With the exception of the zeros-ordered and the arithmetic tasks, state anxiety response also demonstrated minimal association with cognitive performance change occurring under the stressor condition.

Given the variations in cognitive performance associated with different biochemical and behavioural responses elicited by a stressor condition, the conflicting findings reported in cognitive studies with children are not surprising. Improved performance on a 40 minute arithmetic test (a task dependent on sustained attention) by children demonstrating an A increase (Johansson et al., 1973) would be expected. The poor academic performance and thinking skills reported for children identified as experiencing high cumulative stressors in the Manhattan study (Gersten et al., 1977) may indicate that children under prolonged stressor situations experience different responses when faced with performance demands. Based on the present findings, differing cognitive performance is to be expected when the response to a stressor condition differs.

The school studies which have emphasized the role of state anxiety in cognitive deterioration under stressor conditions (Phillips, 1978; S. Sarason et al, 1960) may reflect the association demonstrated in the present study between behavioural response and cognitive performance with familiar material. Since these studies did not look at cognitive processing separate from school tests, their failure to consider a relation between cognitive deterioration and physiological stress effects is not surprising.

Processes Underlying Cognitive Disruption

The literature reviewed considered five theories to explain the effects of stress on cognition: increased drive, intrusive thinking, learned helplessness, arousal and biochemical alteration. While each of these theories explained alteration in attention, it was suggested that the biochemical alteration theory could account more adequately for the deterioration hypothesized as occurring in the patterning or restructuring of information. Although the deterioration shown on patterning tasks was less than expected, the demonstrated association of urinary biochemical alterations with performance on attention tasks was greater than expected.

Performance on a number of the cognitive tasks included within the present research demonstrated deterioration under the stressor condition with no significant differences appearing between response subgroups. This suggests an effect occurring under the stressor condition but independent of the physiological and behavioural measures included in the present study. This effect may represent intrusive thinking or another of the theories referred to above. Within or on top of this effect, the selected response variables, and in particular the biochemical responses as measured by urinary levels, showed significant relation to changes in cognitive performance.

These relationships appear to support the hypothesis that alteration in cognitive performance under the stressor condition results in part from the physiological stress response occurring at that time. This hypothesis does not imply a direct effect by A, NA

or MHPG, whether peripheral or central, on cognitive performance. Rather, changes within the system as identified by higher or lower specific biochemical levels appear to affect cognitive performance in specific ways.

Tucker and colleagues' theory of lateralized stress effect, i.e., right hemisphere functions deteriorating while left hemisphere functions are not affected (Tucker et al., 1977; Tucker et al., 1981), received qualified support from the present findings. Children within the experimental study sample took significantly longer under the stressor condition (Time I) to complete the Ravens task (considered to reflect right hemisphere functioning) while the control study sample showed no difference in speed of performance between Time I and Time II. In contrast, speed of performance on the arithmetic tasks (left hemisphere functioning) was similar between the two study samples and across time. The simple arithmetic task did show a greater error rate for the experimental sample but since this appeared to be more closely related to behavioural factors than to physiological factors, it does not argue against a right hemisphere effect occurring with a physiological stress response.

The theory of Broverman and colleagues (1968, 1974) that linked cognitive change under stressor conditions with changes in the adrenergic and cholinergic neurochemical systems was examined in part by the present study. The hypothesis of improvement in repetitive or attention-dependent tasks with increased levels of adrenalin (seen as occurring with short-term exposure to stressors) and deterioration with decreased levels of

adrenalin (hypothesized as occurring with longer-term stressors) was supported. Broverman and colleagues hypothesized further that a short-term A increase would impair performance on perceptual restructuring tasks while a long-term A increase would induce an acetylcholine increase which would facilitate performance on cognitive tasks requiring restructuring. Performance on the perceptual restructuring tasks within the present study did not differentiate between A groups. Although the A increaser group did experience difficulty with clustering and took longer to complete the Ravens task, the A decrease group experienced similar difficulties. It should be noted, however, that the present response groups were based on short-term increases and decreases and not short-term versus long-term stressor conditions. Since acetylcholine was not measured in the present research, the second part of Broverman's hypothesis cannot be considered as either supported or refuted by the present study.

In summary, the results of the present research demonstrate an alteration in children's cognitive performance under a stressor condition. The nature of this alteration was found to differ depending on the task presented and the stressor response experienced. The results further indicate that the alteration occurring in cognitive performance is related in part to physiological alteration, as reflected in changes in urinary biochemical levels, which occurs under stressor conditions.

Biochemical Alteration

The initial analysis of urinary indices of stress--A, NA, MHPG--at Time I, II and III showed significant alteration for A between Time I and Time II. The absence of a significant effect for either NA or MHPG and the moderate level of significance for A may be explained by the differential biochemical profiles demonstrated by the children in the experimental study.

Fifty-five percent of the children demonstrated the classic A increase response (greater than one standard error) described in stressor research (Dimsdale & Moss, 1980; Frankenhaeuser, 1971; Levi, 1972; Selye, 1980). The decrease in A levels (beyond one standard error) by 28% of the children was unexpected. These children may be similar to those described by Frankenhaeuser and her colleagues as "paradoxical" stress responders. In a study using a university matriculation examination as the stressor condition, 40% of the females and 5% (one) of the males showed an A/NA decrease. The one male (5%) and 10% of the total females showed what was described as an "extreme" decrease (Frankenhaeuser et al., 1978; Rauste-von Wright et al., 1981). In a study of children ages 12-13 in which an arithmetic test served as the stressor condition, 34% of the girls and 28% of the boys showed decreased levels--a middle range was not removed before these percentages were reported (Johannson et al., 1973).

Noradrenalin alterations, 47% of the children showing increases greater than one standard error above the mean and

19% showing decreases greater than one standard error, were similar to those of adrenalin. While NA levels have not been examined routinely in human experimental stress research, they have been used extensively in human studies with depressives and in animal studies. A decrease in NA (norepinephrine) levels in stressed animals or depressives has been considered to be a maladaptive neurochemical response; one which presumably reflects the inability of the organism to cope with more severe or longer-lasting stressors (Anisman & Zacharko, 1982). The NA or A increase groups within the present research may be hypothesized as demonstrating an adaptive response parallel to the NA increase in animals which occurs with moderate stress, i.e., body resources are increased to meet the imposed demand (Henry & Ely, 1980; Lundberg & Frankenhaeuser, 1980). Interpretation of a decrease in catecholamines as a maladaptive response concurs with the cognitive findings of greater deterioration for this group. While NA decrease in animals has been found to occur with extreme or chronic stressors (Anisman et al., 1981b), similar conclusions regarding the cause of catecholamine depletion in children cannot be proposed until further research is conducted with a larger sample and one that represents a broader cross-section of the population. Such a population might include a larger number of children who have experienced chronic or more extreme stressors, thus permitting a more adequate examination of the stressor/response relationship than was possible in the present study.

The increased and decreased urinary A levels demonstrated by the children under the stressor condition were associated with both increased and decreased MHPG levels. This finding of contrasting directional changes in urinary A/NA levels and MHPG levels (contrary to previous reports [Frankenhaeuser et al., 1978]) raises questions as to the role of MHPG within the stress response. As noted in the review of stress research, MHPG levels provide one index of catecholamine activity and thus may prove to be an indicator of neurochemical adaptation to stressor conditions. Studies showing peripheral NA increase/MHPG increase (Halaris & DeMet, 1980) and NA increase/MHPG decrease (Gilad & Jimerson, 1981) suggest that MHPG alterations can be accounted for on the basis of (1) an excess or a deficiency of NA and (2) the means by which A/NA adjusts to the demand imposed, e.g., synthesis, degradation. A decrease in MHPG, concurrent with A/NA increase may indicate neurochemical adjustment to increased demand. Such an effect has been described in the animal literature as the initial response to the imposition of a moderate stressor (Welsh & Welsh, 1970). MHPG increase, in combination with an A/NA increase, may indicate an over-adjustment to the imposed demand by increased synthesis. The absence of a correlation between A/NA change and MHPG change within the A↑MHPG↑ subgroupings suggests that the MHPG alteration also is reflecting responses beyond those of A and NA increase.

Analysis of MHPG alteration within the A decrease group showed a significant correlation between A and MHPG for the

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A+MHPG+ subgroup ($r = .80$, $p < .05$). This correlation may suggest a neurochemical adaptation, to the decreased A response, thus increasing the probability that normal levels will be restored within a limited period of time. If A+ indicated a maladaptive response to the imposed stressor, as discussed above, then the A+MHPG+ subgroup may indicate a "resilience" within the system to counteract this maladaptation.

The A+MHPG+ group would appear to be the least adaptive of the subgroups. Despite the decrease in A, the increased levels of the metabolite may indicate enhanced utilization. While the cognitive test results of the present study suggest greater disruption in performance among children demonstrating A decrease (relative to A increase) and MHPG increase (relative to MHPG decrease) this may or may not relate to the hypothesized maladaptive state consisting of A and MHPG+. It should be emphasized that the discussion regarding neurochemical changes, as measured in the urine, are speculative. These possibilities, however, warrant further investigation.

Gender Effect

The significant sex effect found in previous stress studies with both adults and children has been explained on the basis of learned behaviour (e.g., academically demanding situations presenting more of a threat for males than for females [Rauste-von Wright et al., 1981]) and differing on-going activities (boys being more physically active [Lundberg, 1983b]). While the present study supports previous findings of an overall significant sex effect, analyses based on biochemical change

groups indicated that the A increase group was the only subgroup with a meaningful significant sex effect. Further analysis of the A increase group indicated that the difference between girls and boys reflected a higher level of urinary A for boys at all three times but no difference in the pattern of alteration between times (i.e., response to the stressor situation). These findings indicate that although a subgroup of boys may demonstrate a higher level of activity in the adrenergic system, the capability for neuroendocrine response appears to be similar for girls and boys.

A difference in the percentage of girls and boys who responded to the stressor situation with increasing or decreasing biochemicals in the urine was noted. A lower percentage of girls (A: 42%; NA: 25%; MHPG: 25%) than boys (A: 62%; NA: 58%; MHPG: 46%) was in the increase groups. In contrast, a higher percentage of girls (A: 42%; NA: 58%; MHPG: 67%) than boys (A: 23%; NA: 31%; MHPG: 31%) was in the decrease group. It should be noted that although the same percent of girls and boys demonstrated A and NA responses beyond one standard error ($\pm$) to the stressor condition (83%-89%) a somewhat lower percent of boys demonstrated an MHPG response ($\pm$ SE) (girls: 92%, boys: 77%). These findings suggest that the difference between girls and boys may not be whether they respond to stressors but rather the manner in which they respond. Gender differences in the present data suggest (1) that higher levels of A/NA activity occur for a subgroup of boys, (2) that boys are more likely to demonstrate increased neurochemical

activity under a stressor condition while girls are more likely to demonstrate decreased neurochemical activity, and (3) that fluctuation in MHPG levels may be more extensive in girls than in boys. Each of these possibilities should be considered in future research.

Antecedent Factors

When antecedent factors were examined for predictive association with stressor response, several factors were found to provide low predictive power. Life change events and locus of control showed low predictive association with state anxiety alteration. Based on research linking life change events to illness, a predictive association between these situations and biochemical response might have been expected. Lack of association may be explained by the short-term nature of the stressor condition in the present study or the absence of negative psychological factors for children with high life change events.

Family background and cumulative on-going stressors did show low predictive association ($\lambda = .18, .20$) with urinary MHPG and NA change respectively. Children with low cumulative stressors were more likely to demonstrate an NA increase while children for whom a high number of stressors had been reported were found in all three response groups--increase, marginal fluctuation and decrease. A similar indistinct pattern appeared for family background factors and MHPG excretion. The lack of a distinct pattern of distribution may reflect the fact that the present sample was drawn from a narrow segment of the population (the middle-class and upper-middle class) and may have had

lower overall background and cumulative stressor scores than the general population.

The low level of predictive association ($\lambda = .20$) between trait anxiety and physiological response (A/MHPG) appears to support previous findings that response alteration under a stressor condition is determined more by an individual's perception of threat than by level of trait anxiety (Hodges & Spielberger, 1966). The absence of association between trait anxiety and state anxiety change was contrary to expectation. While a significant correlation was found between trait anxiety and state anxiety at Time I ($r = .66$) and Time II ($r = .48$), a significant correlation did not occur between trait anxiety and state anxiety change.

No correlation was found between state anxiety change and observed tension or physiological response in boys. A moderate correlation approaching significance ($r = .48$) was found between state anxiety change and observed tension for girls. The relation between state anxiety and physiological response which approached significance for girls was difficult to interpret due to the contradictory direction of correlation with A(+) and NA (-). The correlation between A, in particular, and state anxiety change under stressor conditions in girls should be examined further. Based on the present research findings, state anxiety scores cannot be used as a valid index of stressor response in boys and should be viewed with caution as an index of stressor response in girls. The significant association between locus of control and state anxiety, with information on locus control removing .24 of the

error of prediction for state anxiety, may indicate that changes in responses on the Spielberger State Anxiety Inventory for Children under a stressor condition reflect personality characteristics more than the actual stressor response experienced.

The antecedent factor best able to reduce error in prediction ($\lambda = .35$) of biochemical response (MHPG) to the stressor condition used in this study was intelligence. This reflects the negative correlation indicated between urinary MHPG alteration and intelligence. The nature of the stressor condition (class presentation), the setting in which the present research was conducted (school), and the measures used (cognitive tasks) must be recalled when considering this correlation. Replication in a non-academic study is needed before the negative correlation between intellectual level and MHPG alteration should be considered as a relationship occurring under a general stressor condition.

Summary

The present study demonstrated a variety of changes in the cognitive performance of children placed under a stressor condition. These alterations were found to vary depending on the child's individual response to the stressor condition and the particular cognitive demands within the performance task. A deterioration in cognitive performance was demonstrated on some tasks for all of the response variable subgroups (e.g., CPT-omission), thus indicating a stressor effect on cognitive performance unrelated to the response variables measured in the

present study. Other cognitive alterations were found to vary significantly with an increase or decrease in A, NA, MHPG, state anxiety or observed tension. The consistency of association between biochemical changes, as measured in the urine, and cognitive alterations was particularly evident lending support to the thesis that a part of the cognitive alteration occurring under stressor conditions may be related, either directly or indirectly, to the neurochemical changes occurring under these conditions.

While the results of the present study are of interest to researchers trying to untangle the maze of variables affecting cognition, the meaning of this study for the child in the classroom is less clear. Presented with a stressor condition--a talk presentation, a test, a challenge from another child or from the teacher--the biochemical and behavioural response of each child in the class will be unique. Thus, for some children a stressor-related alteration in cognitive performance could be minimal or could facilitate performance, while for others cognitive performance could deteriorate. Since this deterioration may reflect, in part, a physiological effect, it is unlikely to be remediated by teacher admonition or increased work. More attention would need to be given by the teacher to the factors of appraisal, adaptability and coping if negative effects arising from a stressor condition are to be lessened.

Teaching methods adapted for the cognitive limitations occurring with stressor response should be considered for children recognized as vulnerable to stress. Direct methods of teaching would be appropriate for children showing improved selective attention

as well as those showing disorganized attention. Peripheral or incidental learning should not be expected. A child's classroom behaviour--narrowed attention, increased impulsivity --may be able to indicate to the teacher the manner in which the child is responding to an imposed stressor. Recognition of this response would assist the teacher in providing guidelines and setting realistic expectations.

The results of the present research have indicated a relation between cognitive performance alteration and physiological response. Questions and tentative suppositions regarding neurochemical response under stressor conditions have been raised. Further research in this area is needed.

A research design including three conditions--no stressor, stressor, no stressor--would delineate more clearly the response occurring. Ideally the stressor condition would be more severe than that included within the present study (e.g., surgery)--thus providing the possibility of a more extreme response--and the sample would be more diverse (e.g., lower and middle class)--thus providing the possibility of more diverse responses and more accurate measurement of predictive associations. Tasks measuring perceptual restructuring should be chosen carefully to permit a contrast between clustering with concrete and abstract information and a contrast between left and right hemispheric functioning. In addition, measurement of cortisol excretion should be included to provide a more precise identification of response to a stressor situation and a more complete view of the relation between stress response and cognitive

performance.

Research and consideration of the relation between potential stressors, stressor response (behavioural and biochemical) and cognitive performance will add to an understanding of the learning problems, both short-term and longer-term, experienced by children.

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research for action

March, 1983.

Dear

The Advisory Research Committee of the Ottawa Board of Education has approved the request of Sandra Elwood, a doctoral candidate at Carleton University, to conduct a study of the effect school experience can have on a child. The principal of your child's school has given permission for the school to be involved in the research. Your child's class has been selected, along with other classes in the school, to take part in the project.

Your child will be asked to indicate how much he or she likes or dislikes a variety of activities which may occur on a typical day. The questionnaire will be distributed to all the children in the class who have permission to participate in the study. It will take 10 to 15 minutes to complete. There will be no individual interview. While the information gained from the study will be used to indicate to the researchers the reactions children have to different activities, information on individual children will be confidential. A few of the children may be asked to participate in the second stage of this project. A separate letter and permission request would be sent home at that time.

The long-term goal of this project is to better understand the effects of experiences on children and on their ability to learn in school. If you have any questions about the study please contact Sandra Elwood at 231-7134 or 233-8228 or Jackie Unitt of the Research Centre at 563-2408.

If you do not wish to have your child participate in the first stage of this project, please sign and return the form below. We hope your child will be able to participate in the study and appreciate your support for the research programmes being carried out in the Ottawa school system.

Yours sincerely,

Frances E. Morrison

Frances E. Morrison
Director of Research

FM/mce

I do not give permission for my child to participate in Ms. Elwood's study of the effects of school experiences on children's thinking.

Date: _____ Signature: _____

Student's Name: _____ Name of Parent
or Guardian: _____

research centre / centre de recherches
The Ottawa Board of Education / Le Conseil scolaire d'Ottawa
Location: 662 Lyon St. E., K1S 3Z2, tel. 563-2408 Mailing address: 130 Clilmour St., K2P 0P9

Appendix B

Likes-Dislikes Questionnaire

A LIKES-DISLIKES SURVEY FOR CHILDREN

Below are listed activities that you might do in a typical day. This survey has been set up to find out which of these activities you like a great deal, which you like a little or don't care about, and which ones you dislike. At the right of each item is a scale that goes from dislike very much - dislike some - dislike a little - do not care - like a little - like some - like very much. Please mark the scale next to each item to indicate how you feel about the item. Put an X on the vertical line for your answer.

for example:

having a day off school

	very much dislike	some dislike	a little dislike	do not care	a little like	some like	very much like
1) going on field trips							
2) being in Christmas concerts							
3) doing errands for the teacher							
4) making mistakes							
5) playing sports for fun							
6) taking tests							
7) reading							
8) singing							
9) going to the dentist							
10) being teased							
11) getting a good mark on a test							
12) going to see the principal							
13) reading aloud in class							
14) getting a shot from a nurse							
15) doing projects							
16) doing something new							
17) being called on by the teacher							
18) singing a solo							
19) taking part in a sports competition							
20) giving an interest talk to the class							
21) participating in phys. ed. class							
22) playing card games							
23) going to the doctor							
24) going to a play							
25) performing in a recital							
26) solving problems on the blackboard							

Appendix B cont'd.

<u>Filler items</u>	<u>Matched items</u>	<u>Target items</u>
1	(Second item is scored	4
2	only if first item is	16
3	marked like some, like	17
5	very much.)	20
6	7-13	26
9	8-18	
10	24-25	
11		
12		
14		
15		
19		
21		
22		
23		

Scoring:

<u>item value:</u>	4	=1
	17	=2
	26; 13, 18, 25	=3
	20	=4
<u>answer value:</u>	dislike some	=2
	dislike very much	=3

procedure: Total possible score was calculated by multiplying each of the values of the target items by 3 and each of the values of the matched items, where first item is marked 'like some', 'like very much' by 3. Each target and identified paired item was multiplied by 2 or 3 depending on response to establish total score. Total score then was divided by total possible score to obtain a ratio. Children scoring over .50 were selected for possible inclusion in the target group.

Appendix C: Letter to Parents regarding
Experimental Study

research for action

March 31, 1983.

Dear Parents:

Recently your child has completed a questionnaire as part of the first stage of a study on the effect school experiences can have on a child. The Advisory Research Committee of the Ottawa Board of Education has approved this study which is being conducted by Sandra Elwood, a doctoral candidate at Carleton University. The second stage of the study is concerned with changes that may occur in thinking skills as a result of specific school experiences. A few of the children in several classes in your child's school are being asked to participate in this part of the study.

Your child will be asked to work on a number of tasks which measure different types of thinking. The tasks measure how a child is able to think at a particular moment and do not measure IQ or basic abilities. All of the tasks are presented in the form of games and there will be two sessions one week apart, each taking a little less than two hours.

Your child will be asked to complete two short questionnaires, one relating to anxiety and the other to the child's sense of control over his or her world. With your permission, scores on the Henman-Nelson Test of Mental Abilities will be obtained from the child's school file. If this test has not been administered to your child's class, permission to administer this group test will be requested. In order to obtain a measure of the effect of background experiences, you as parents will be asked to complete two short questionnaires. All information on individual children will be confidential.

The study will be examining whether a change in thinking skills occurs with specific experiences and whether these changes reflect the child's emotional response to the experience, the child's body response, or both. In order to measure body response your child will be asked to provide a urine sample at the end of each of the two testing sessions and on a third non-testing occasion. The bathroom attached to the nurse's room will be used to assure your child's privacy. The urine will be tested for the biochemicals which change when an individual becomes anxious.

The long-term goal of this study is to improve our understanding of how specific demands or experiences may interfere with children's ability to think and learn. It is felt that the information provided by this study will help teachers and parents identify and deal appropriately with a child's response to experiences.

In order to explain the study in more detail, Sandra will contact you by phone within the next few days. If you have any questions please contact Sandra Elwood at 233-8228 or 231-7134 or Jackie Unitt of the Research Centre at 563-2408.

If you wish to have your child participate in this study, please sign and return the attached form. The results of the study will be made available in the participating schools next fall. We hope your child will be able to participate in the study and appreciate your support for the research programmes within the Ottawa school system.

Yours sincerely,

Frances E. Morrison

Frances E. Morrison
DIRECTOR OF RESEARCH

research centre / centre de recherches

The Ottawa Board of Education / Le Conseil scolaire d'Ottawa
Location: 662 Lyon St. E., K1S 2Z2, tel. 563-2408 Mailing address: 330 Glenora St., K2P 0P9

Appendix D: Letter to Parents regarding Cognitive Control Study

Carleton University
Ottawa, Canada K1S 5B6

July 18, 1983

Dear Parents,

We are contacting you with regard to a study being conducted through Carleton University on the effects specific school experiences may have on children's thinking. With the approval of the Advisory Research Committee of the Ottawa Board of Education, school principals and parents, a group of sixty children were tested on a number of tasks during the past four months. Each child was tested on two different occasions, once in association with a particular experience and once when nothing unusual was occurring. In order to evaluate how much of the observed alteration in performance was an effect of the associated experience and how much resulted from performing the task two times, we would now like to test a group of children for whom no unusual experience has occurred.

You child, if interested in participating, would be asked to work in a one-to-one situation for two one-and-a-half hour periods (one week apart). The tasks, some of which are programmed on a computer, measure how a child is able to think at a particular moment. A short ability level test (the Canadian Cognitive Abilities Test which is used on a standard basis within both the Ottawa and Carleton Board of Education) would be given to each child following the second testing session in order to compare the children being tested in this phase of the study with the original group.

The time of testing would be arranged with you in order that it not interfere with activities in which your child is already participating. Testing would take place at _____ and transportation, if required, would be arranged. Each child would be given two dollars per testing session in appreciation for the time and effort involved.

If you are willing to have your child take part in this study, please sign the form below and have your child return it to his or her camp counselor tomorrow. Sandra Elwood will contact you with regard to arranging times convenient to you and your child. If you have any questions please call Sandra at 233-6228 (evenings) or 231-7134 (day).

Sandra Elwood
PhD Candidate

H.B. Ferguson
Associate Professor

I am willing to have my child participate in the study on the effects of school experiences on children's thinking. I understand that I shall be contacted by Sandra Elwood in order that times for testing can be arranged.

Child's name _____

telephone number _____

Parent's name _____

date _____

Appendix E

HPLC Procedure for Catecholamine Assay

Following acidification with an EDTA/GSH compound and freezing at -20°C , urine samples were assayed by high-performance liquid chromatography with electrochemical detection according to an adaptation of a procedure developed by Bioanalytical Systems (LCEC Application Note #15, 1980).

A sample of 5 ml. was extracted from the urine sample and the pH level was raised to 6.2 - 6.7 with a pH phosphate buffer. The sample was then applied to a miniature cation-exchange isolation column for preliminary purification. The catecholamines were eluted twice, first with dilute Sulfuric acid and then with 4 ml of $2\text{M}(\text{NH}_4)_2\text{SO}_4$ solution. A small amount of Alumina Oxide and 500 μl concentrated TRIS buffer (pH 8.6) were added and the samples were agitated for rapid absorption. The samples were washed twice with water and allowed to settle. Following aspiration the catecholamines were desorbed from the alumina with a small volume of strong acid and stored at -20°C until rejection into the HPLC.

The HPLC procedure was carried out with an SP8770 HPLC pump, a 7125 Reodyn injector, a μ Bondapak C_{18} column with an LC4B/TL5 electrochemical detector applied at +0.65 oxidation, range 50 nA. The peaks were quantified and recorded.

Appendix F

HPLC Procedure for MHPG Assay

Following acidification with an EDTA/GSH compound and freezing at -20°C , urine samples were assayed by high-performance liquid chromatography according to a procedure adapted from Joseph, Kadam and Risby (1981).

A sample of 0.5 ml urine was prepared with a solution of 0.05 ml 1M tris-Acetate (pH 6.0) buffer, 0.012 ml 6M HCL, 0.20 ml internal Std dissolved in 0.2 M HClO_4 (MOPET) and 0.238 ml H_2O . The prepared urine was extracted twice using 1.5 ml and 1.0 ml Ethyl Acetate. The solvent layers were pooled and evaporated.

The HPLC procedure was carried out with an SP8770 HPLC pump, a 7125 Reodyn injector, a μ Bondapak C_{18} column with an LC4B/TL5 electrochemical detector applied at +0.750 oxidation, range 100 nA. The peaks for free MHPG were quantified and recorded.

Appendix G

SPIELBERGER STATE-TRAIT ANXIETY INVENTORY FOR CHILDREN (STATE)
(Spielberger, 1973)

DIRECTIONS: A number of statements which boys and girls use to describe themselves are given below. Read each statement carefully and decide how you feel *right now*. Then put an X in the box in front of the word or phrase which best describes how you feel. There are no right or wrong answers. Do not spend too much time on any one statement. Remember, find the word or phrase which best describes how you feel right now, *at this very moment*.

1.	I feel	☐ very calm	☒ calm	☐ not calm
2.	I feel	☐ very upset	☐ upset	☐ not upset
3.	I feel	☐ very pleasant	☐ pleasant	☐ not pleasant
4.	I feel	☐ very nervous	☐ nervous	☐ not nervous
5.	I feel	☐ very jittery	☐ jittery	☐ not jittery
6.	I feel	☐ very rested	☐ rested	☐ not rested
7.	I feel	☐ very scared	☐ scared	☐ not scared
8.	I feel	☐ very relaxed	☐ relaxed	☐ not relaxed
9.	I feel	☐ very worried	☐ worried	☐ not worried
10.	I feel	☐ very satisfied	☐ satisfied	☐ not satisfied
11.	I feel	☐ very frightened	☐ frightened	☐ not frightened
12.	I feel	☐ very happy	☐ happy	☐ not happy
13.	I feel	☐ very sure	☐ sure	☐ not sure
14.	I feel	☐ very good	☐ good	☐ not good
15.	I feel	☐ very troubled	☐ troubled	☐ not troubled
16.	I feel	☐ very bothered	☐ bothered	☐ not bothered
17.	I feel	☐ very nice	☐ nice	☐ not nice
18.	I feel	☐ very terrified	☐ terrified	☐ not terrified
19.	I feel	☐ very mixed-up	☐ mixed-up	☐ not mixed-up
20.	I feel	☐ very cheerful	☐ cheerful	☐ not cheerful

SCORING: All checks for column 2 are scored with a 2. Scores for column one and three reverse with numbers 1, 3, 6, 8, 10, 12, 13, 14, 17, 20 being scored 1 (very) and 3 (not) and numbers 2, 4, 5, 7, 9, 11, 15, 16, 18, 19 being scored 3 (very) and 1 (not). The scores are totalled for the final SA score.

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Appendix H

SPIELBERGER STATE-TRAIT ANXIETY INVENTORY FOR CHILDREN (TRAIT)
(Spielberger, 1973)

DIRECTIONS: A number of statements which boys and girls use to describe themselves are given below. Read each statement and decide if it is *hardly-ever*, or *sometimes*, or *often* true for you. Then for each statement, put an X in the box in front of the word that seems to describe you best. There are no right or wrong answers. Do not spend too much time on any one statement. Remember, choose the word which seems to describe how you usually feel.

1.	I worry about making mistakes	☐ hardly-ever	☐ sometimes	☒ often
2.	I feel like crying	☐ hardly-ever	☐ sometimes	☐ often
3.	I feel unhappy	☐ hardly-ever	☐ sometimes	☐ often
4.	I have trouble making up my mind	☐ hardly-ever	☐ sometimes	☐ often
5.	It is difficult for me to face my problems	☐ hardly-ever	☐ sometimes	☐ often
6.	I worry too much	☐ hardly-ever	☐ sometimes	☐ often
7.	I get upset at home	☐ hardly-ever	☐ sometimes	☐ often
8.	I am shy	☐ hardly-ever	☐ sometimes	☐ often
9.	I feel troubled	☐ hardly-ever	☐ sometimes	☐ often
10.	Unimportant thoughts run through my mind and bother me	☐ hardly-ever	☐ sometimes	☐ often
11.	I worry about school	☐ hardly-ever	☐ sometimes	☐ often
12.	I have trouble deciding what to do	☐ hardly-ever	☐ sometimes	☐ often
13.	I notice my heart beats fast	☐ hardly-ever	☐ sometimes	☐ often
14.	I am secretly afraid	☐ hardly-ever	☐ sometimes	☐ often
15.	I worry about my parents	☐ hardly-ever	☐ sometimes	☒ often
16.	My hands get sweaty	☐ hardly-ever	☐ sometimes	☐ often
17.	I worry about things that may happen	☐ hardly-ever	☐ sometimes	☐ often
18.	It is hard for me to fall asleep at night	☐ hardly-ever	☐ sometimes	☐ often
19.	I get a funny feeling in my stomach	☐ hardly-ever	☐ sometimes	☐ often
20.	I worry about what others think of me	☐ hardly-ever	☐ sometimes	☐ often

SCORING: All checks in column one are scored 1, column two are scored 2 and column three are scored 3. The scores are totalled for final TA score.

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Appendix I

Nowicki-Strickland Locus of Control Scale for Children
(Nowicki & Strickland, 1973)

Directions: Decide if you agree or disagree with each of these questions most of the time. Check yes if you agree; check no if you disagree.

	Yes	No
1. Do you believe that most problems will solve themselves if you just don't fool with them?		
2. Do you believe that you can stop yourself from catching a cold?		
3. Are some kids just born lucky?		
4. Most of the time do you feel that getting good grades means a great deal to you?		
5. Are you often blamed for things that just aren't your fault?		
6. Do you believe that if somebody studies hard enough he or she can pass any subject?		
7. Do you feel that most of the time it doesn't pay to try hard because things never turn out right anyway?		
8. Do you feel that if things start out well in the morning that it's going to be a good day no matter what you do?		
9. Do you feel that most of the time parents listen to what their children have to say?		
10. Do you believe that wishing can make good things happen?		
11. When you get punished does it usually seem it's for no good reason at all?		
12. Most of the time do you find it hard to change a friend's (mind) opinion?		
13. Do you think that cheering more than luck helps a team to win?		
14. Do you feel that it's nearly impossible to change your parent's mind about anything?		
15. Do you believe that your parents should allow you to make most of your own decisions?		
16. Do you feel that when you do something wrong there's very little you can do to make it right?		
17. Do you believe that most kids are just born good at sports?		
18. Are most of the other kids your age stronger than you are?		
19. Do you feel that one of the best ways to handle most problems is just not to think about them?		
20. Do you feel that you have a lot of choice in deciding who your friends are?		
21. If you find a four leaf clover do you believe that it might bring you good luck?		
22. Do you often feel that whether you do your homework has much to do with what kind of grades you get?		
23. Do you feel that when a kid your age decides to hit you, there's little you can do to stop him or her?		
24. Have you ever had a good luck charm?		
25. Do you believe that whether or not people like you depends on how you act?		
26. Will your parents usually help you if you ask them to?		
27. Have you felt that when people were mean to you it was usually for no reason at all?		

	Yes	No
28. Most of the time, do you feel that you can change what might happen tomorrow by what you do today?		
29. Do you believe that when bad things are going to happen they just are going to happen no matter what you try to do to stop them?		
30. Do you think that kids can get their own way if they just keep trying?		
31. Most of the time do you find it useless to get your own way at home?		
32. Do you feel that when good things happen they happen because of hard work?		
33. Do you feel that when somebody your age wants to be your enemy there's little you can do to change matters?		
34. Do you feel that it's easy to get friends to do what you want them to?		
35. Do you usually feel that you have little to say about what you get to eat at home?		
36. Do you feel that when someone doesn't like you there's little you can do about it?		
37. Do you usually feel that it's almost useless to try in school because most other children are just plain smarter than you?		
38. Are you the kind of person who believes that planning ahead makes things turn out better?		
39. Most of the time, do you feel that you have little to say about what your family decides to do?		
40. Do you think it's better to be smart than to be lucky?		

Scoring: A "yes" for the following items indicates an external locus of control and was scored (1): 1, 3, 5, 7, 8, 10, 11, 12, 14, 16, 17, 18, 19, 21, 23, 24, 27, 29, 31, 33, 32, 35, 36, 37, 38, 39.

A "no" for the following items indicates an external locus of control and was scored (1): 2, 4, 6, 9, 13, 15, 20, 22, 25, 26, 28, 30, 32, 34, 40.

All points received were summed together for the final Locus of Control Score.

APPENDIX J

Life Change Event Schedule Completed by Parents (Coddington, 1972)

Life Event Record

Below are listed 36 events which may or may not have occurred for your child during the previous 12 months. Please place a check in the 6 month column if the event occurred in the last 6 months. Place a check in the 12 month column if the event occurred in the preceding 6 months (that is 6-12 months ago).

The responses to this questionnaire will be used to determine whether children experiencing particular home patterns are more or less likely to show emotional, thinking or body changes in situations which are stressful for them.

	6 months	12 months	
Beginning another school year.....			(27)
Outstanding personal achievement.....			(39)
Beginning school.....			(46)
Move to a new school district.....			(46)
Increase in number of arguments with parents.....			(47)
Change in parents' financial status.....			(29)
Death of a grandparent.....			(38)
Decrease in number of arguments between parents.....			(25)
Mother beginning to work.....			(44)
Becoming a full fledged member of a church.....			(25)
Brother or sister leaving home.....			(36)
Serious illness requiring hospitalization of parent.....			(55)
Decrease in number of arguments with parents.....			(27)
Change in father's occupation requiring increased absence from home.....			(45)
Change in child's acceptance by peers.....			(51)
Increase in number of arguments between parents.....			(51)
Death of a close friend.....			(53)
Birth of a brother or sister.....			(50)
Pregnancy in unwed teenage sister.....			(36)
Serious illness requiring hospitalization of brother or sister.....			(41)
Loss of job by a parent.....			(38)
Failure of a grade in school.....			(57)
Divorce of parents.....			(84)
Suspension from school.....			(46)
Addition of third party to family.....			(41)
Marital separation of parents.....			(78)
Serious illness requiring hospitalization of child.....			(62)
Increased learning problem in school.....			(46)
Marriage of parent to step-parent.....			(65)
Having a visible congenital deformity.....			(60)
Acquiring a visible deformity.....			(69)
Death of a brother or sister.....			(68)
Discovery of being an adopted child.....			(52)
Becoming involved with drugs or alcohol.....			(61)
Jail sentence of parent for 30 days or less.....			(44)
Jail sentence of parent for 1 year or more.....			(67)

Scoring: Each item checked was scored according to the weighting units presented in parentheses. These were added to obtain a total 6 month score or a total 12 month score.

Family Background Questionnaire - Completed by Mother and Father Independently
(Adapted from Langer, 1983)

Your child has been chosen for this study on the basis of two criteria: (1) normal response to daily activities and (2) concerned response to speaking in front of others.

The following questions relate to the make-up of the family and to situations that arise in a family. The replies to the questionnaire will be used to determine whether children with particular home experiences are more or less likely to show emotional, thinking or body changes in specific situations which are of concern to them.

Please check the answer which most closely fits your situation or, where indicated, fill in numbers. If you wish, you may add comments to clarify your responses.

- (1) How many children are in the family home? [more than 4:1]
- (2) How many adults are in the family home?
 Natural parents (mother , father) [Single parent: 2
 Step parents Combin. of parent
 Other 1 and other: 1]
- (3) Did your child spend most of his/her first six years with one natural parent: [1]
 with both parents together:
 with both parents but separately: [1]
 with neither parent: [2]
- (4) Did your child spend most of his/her last 4-6 years with one natural parent [1]
 with both parents together
 with both parents but separately [1]
 with neither parent [1]
- (5) Do you feel that your child's health is
 excellent
 good
 fair [1]
 poor [1]
- (6) Does your child experience
 recurring headaches [1]
 stomach aches [1]
 colds [1]
 allergies [1]
- (7) How many times has your family moved to a different neighbourhood since this child was born? [4 - 9: 1; 10 : 2]
- (8) Is your family receiving any financial assistance (General Welfare Assistance, Mother's Allowance, Unemployment Insurance)? [1]

Parent Questions

Please indicate your relationship to the child

Do you work outside the home? Fulltime parttime

- (1) Would you say that your health is
 excellent
 good
 fair [1]
 poor [1]
- (2) Are there times when you can't seem to get going because of lack of energy?
 days [1]
 weeks [1]
 months [2]
- (3) Are there times when you feel isolated or lonely?
 often [1] sometimes never

- (4) When your child was six years or less, was she/he ever separated from you for a period of more than 3 months?
yes [1] how many times _____
no _____
- (5) What language do you speak with your child? [if m. & f. are different: ;
if different from community: 1]
- (6) Do you and your partner agree about how to raise children?
Usually _____
Sometimes [1]
Seldom [1]
- (7) Do you and your partner agree about the way this child behaves?
Usually _____
Sometimes [1]
Seldom [1]
- (8) Beyond the eight-ten hour working day
How much of your time is spent together with your partner and your children? most _____ some [1] a little [1]
How much of your time is spent alone with the children? most [1] some _____ a little [1]
How much of your partner's time is spent alone with the children? most [1] some _____ a little [1]
- (9) How often do you hug/kiss your child?
often _____ sometimes [1] never [1]
- (10) How often over the years, have you punished your child
by taking away privileges? often [1] sometimes [1] never _____
by yelling at him/her? often [1] sometimes [1] never _____
by slapping or spanking? often _____ sometimes _____ never _____
by strapping or hitting with some object? often [1] sometimes [1] never _____
- (11) How consistent are you in your use of punishments or consequences?
usually _____ sometimes [1] seldom [1]
- (12) When your child does something that upsets you, do you yell at her/him? often [1] sometimes [1] never _____
- (13) What activities do you enjoy with your child? _____
- (14) Most couples have some arguments. Do you think you have (or had, if now separated) more arguments than most couples? [1]
the same as most couples? [1]
fewer arguments than most couples _____
- (15) Do you feel that the present situation of high living costs presents a severe strain for your family [1]
a moderate strain [1]
little strain _____

Thank you for your cooperation.

Scoring:

Score for each item checked is given in parentheses.

Items 1-6 are scored from one questionnaire.

Items 1-3 are scored for mother only.

Items 4, 6-7 are scored for both parents.

Item 5 is scored once.

Items 8-12, 14, 15 are scored for both parents. If there is a single parent in the home the score is doubled in order to be compared with other questionnaire scores.

Item 13 has no scoring.

Appendix L

Zeros Task

SET ONE

SET TWO

Instructions:

Two rows of rectangles will appear on the screen. There are 6 rectangles in the top row and 1 rectangle in the bottom row. Your job is to remember where the lower rectangle is. We shall look at seven different sets of rectangles. After we have looked at all seven, we shall go through again. That time I want you to show me on this card where you think the lower rectangle is before we look at the picture. Then push any key and the picture will come up on the screen so you can check yourself.

This is a new set of 6 rectangles. Remember your job is to remember where the lower rectangle is.

Memory Lists

List A

shirt	chicken	Pat	Montreal
trousers	drum	Susan	wood
blouse	Alberta	Kate	lake
skirt	pig	Jenny	Vancouver
jacket	piano	Anna	plastic
corn	Manitoba	bed	sea
peas	hen	chair	Toronto
carrots	trumpet	table	metal
tomatoes	Nova Scotia	sofa	ocean
beans	cow	desk	Calgary
football	guitar	arm	glass
hockey	British Columbia	leg	pond
soccer	horse	body	Winnipeg
baseball	flute	head	cloth
basketball	Quebec	neck	river

List B

apple	hammer	mother	plate
cherries	Canada	uncle	Mike
peaches	mosquito	cousin	tulip
grapes	saw	son	cup
banana	England	sister	David
tiger	fly	church	rose
zebra	drill	house	glass
monkey	Mexico	store	John
elephant	ant	garage	daisy
giraffe	screwdriver	school	saucer
bus	Japan	coffee	Steve
car	spider	tea	lily
truck	pliers	coke	mug
motorcycle	Russia	milk	Ken
bicycle	bee	water	dandelion

Instructions

I am going to say a list of words to you. After I am through I want you to count backwards from 20 to 1 and then say back to me as many words as you remember.

(Before the fourth list)

Have you noticed that it is easier to remember the words when you group them together?

Appendix N

Single Arithmetic Task

2	5	3	6	7
+3	+3	+1	+3	+6
—	—	—	—	—

5	2	9	8	5
+4	+7	+9	+8	+9
—	—	—	—	—

1	9	4	9	2
+1	+6	+4	+4	+2
—	—	—	—	—

4	2	3	6	3
+8	+4	+9	+5	+9
—	—	—	—	—

4	7	6	8	4
-2	-5	-2	-3	-3
—	—	—	—	—

3	9	7	7	3
-1	-4	-3	-4	-1
—	—	—	—	—

9	4	9	9	8
-7	-2	-5	-2	-3
—	—	—	—	—

Instructions

Complete this sheet as quickly as you can. All the problems above the line are addition. All the ones below the line are take-away.

Appendix O

Equation Arithmetic Task

$$(3 + 2) - (4 - 2) =$$

$$(5 + 4) + (1 + 1) =$$

$$(4 + 8) - (3 - 1) =$$

$$(9 - 7) - (4 - 3) =$$

$$(5 + 3) + (2 + 7) =$$

$$(9 + 6) - (7 - 5) =$$

$$(2 + 4) - (3 + 1) =$$

$$(9 + 9) - (4 + 4) =$$

$$(3 - 3) + (3 + 9) =$$

$$(6 + 3) - (9 - 4) =$$

$$(8 + 8) - (4 + 4) =$$

$$(4 - 2) + (6 + 3) =$$

$$(9 - 7) + (4 - 2) =$$

$$(8 + 2) + (6 + 3) =$$

$$(6 + 5) - (6 + 5) =$$

$$(7 + 1) - (6 - 2) =$$

$$(5 - 5) + (7 - 5) =$$

$$(8 - 7) + (6 - 2) =$$

$$(7 + 2) - (9 - 5) =$$

$$(7 - 3) + (7 - 1) =$$

$$(4 + 5) + (3 + 9) =$$

$$(4 - 2) + (8 - 3) =$$

$$(7 - 5) + (2 + 2) =$$

$$(4 + 9) - (7 - 4) =$$

$$(5 + 9) - (8 - 3) =$$

$$(2 + 7) + (2 + 5) =$$

$$(5 + 3) - (9 - 7) =$$

$$(9 - 2) + (7 + 1) =$$

$$(7 + 6) - (4 - 2) =$$

$$(6 - 2) + (4 - 3) =$$

Instructions

This sheet has the same problems as the last one but they are set up differently. First you solve these two numbers by what it tells you to do here, then you solve these two by what it tells you to do here and then you take your two answers and do what it tells you to do here. The only thing you can write down is the final answer. Do the first two before I start timing.

Good, finish this column and do the next one.

Appendix P

Raven's Standard Progressive Matrices

Instructions: At the top of the page you will see a picture--but one piece is missing. At the bottom of the page there are six pieces, later on there are eight pieces. You are to choose the piece that completes the pattern.

Appendix Q

Object Sorting Task

Items included:SET ONE

red apple
 red artificial apple
 golf ball
 light bulb
 short candle - pink
 long candle - white
 playing card
 core remover - orange handle
 cracker
 Dungeon & Dragons die - red
 domino - orange spots on black
 flashlight - red and black
 fork - metal
 hand-sized pinball game
 (battery operated)
 glue bottle - white
 small hammer - wood handle
 metal knife
 wood knife
 marker - yellow
 match - wooden
 nail
 orange
 padlock - round
 pliers
 hand radio - blue and white
 plastic battery operated
 ruler - yellow
 ski pass - yellow plastic
 stapler - brown plastic
 sugar cube
 cassette tape - black

SET TWO

bell - metal
 bird - straw
 bird - wood
 book - green cover
 toy box - brown plastic
 box - orange plastic
 celery
 cheese
 cup - metal
 dollar - pink (\$2)
 feather - pink
 file folder - beige
 wood game
 paper route collection book
 - orange
 toy hat - red
 ink in glass bottle - green
 jackknife - red
 lipstick - pink
 paint in plastic holder -
 green
 paint brush - red
 paper
 artist's pen - black
 pencil - red
 penny - copper
 pitcher - copper
 plant - green plastic pot
 scissors - green plastic handles
 baby rattle - pink wood with
 silver bell
 block of wood

Instructions:

Put all of the objects that go together in some way together.
 ...I think I have followed why you have grouped the objects the
 way you have, but why don't you tell me just to be sure I have
 it right...Now can you sort them in another way?

Appendix Q cont'd.

Scoring:

Sorts:

Score

2/3 of the objects are placed in groups	1
2/3 of the objects are moved, but groups are formed by switching rather than regrouping	.5
1/2 of the objects are moved and more than 2 groups are formed	.5
1/2 of the objects are moved and 2 groups are formed	.2
less than 1/2 of the objects are moved and 2 or more groups are formed	.1
all objects are moved into 2 groups with 2 attributes named	.6
all objects are moved into 2 groups with 1 attribute named	.3
all objects moved but no new groups created	0

Concepts:

1 point scored for each concept

category or name (toys)
 appearance characteristic (rough)
 use (produces light)
 use characteristic (rolls)
 material made from
 location used in
 origin (man-made)
 colour
 shape
 size
 association (pitcher to water plant)
 other (if a whole sort is based on a concept not listed above)

Appendix R^a: Letter to Parents Explaining Study Procedure
(CCAT scores available at school board)

Carleton University
Ottawa, Canada K1S 5B6

Dear

Enclosed you will find the questionnaires to which I referred during our phone conversation. I would appreciate it if each of you would complete separately one of the family background questionnaires. Only one of you would need to answer the first eight questions.

The diet sheet includes food which can alter the body biochemical levels. Please try to avoid these foods during and on since will be tested during the subsequent should now know the date of the first testing. At the time of the first testing, I shall tell the dates of the other testing session and sample collection.

Since unusual events can cause a change in biochemical levels, I shall phone you the evenings of and to ask if any unusual incidents have occurred for

Please return the questionnaires in a sealed envelope to the school or, if you prefer, call me at 233-8228 and I shall pick them up.

Thank you for your willingness to participate in this study and for your time.

Sincerely,

Appendix R^b: Letter to Parents Explaining Study Procedure
(CCAT scores not available at school board)

Carleton University
Ottawa, Canada K1S 5B6

Dear

Enclosed you will find the questionnaires to which I referred during our phone conversation. I would appreciate it if each of you would complete separately one of the family background questionnaires. Only one of you would need to answer the first eight questions.

The diet sheet includes foods which can alter the body biochemical levels. Please try to avoid these foods during and on, since will be tested during the subsequent should not know the date of the first testing. At the time of the first testing, I shall tell the dates of the other testing session and sample collection.

Since unusual events can cause a change in biochemical levels, I shall phone you the evenings of and to ask if any unusual incidents have occurred for

In the initial letter that was sent to you by the Research Committee, Ottawa Board of Education, it was noted that mental ability test scores, if available, would be obtained from your child's school file. These scores will be used to examine the effect general level of ability may or may not have as a "protector" between specific experiences and alteration in thinking skills. Since such a test has not been administered to your child's class, these scores are not available at present. I am, therefore, requesting permission to administer a portion of the Canadian Cognitive Abilities Test (a group test which is commonly used by the Ottawa Board) to your child. S/he would be tested along with the other children in the school who have participated in the study. The testing will take approximately 50 minutes. I would be most appreciative if you could include the attached permission form when returning the completed questionnaires to your child's school.

Please return the questionnaires in a sealed envelope to the school or, if you prefer, call me at 238-8228 and I shall pick them up. Thank you for your willingness to participate in this study and for your time.

Sincerely,

Appendix S

RECOMMENDED DIET LIST

Please avoid serving your child the foods listed below for the two meals preceding each urine collection.

Beverages: chocolate, chocolate milk, cocoa, cola drinks, coffee, orange juice and tea.

Dairy Products: aged cheese, sour cream, ice cream, ice milk, milk shakes.

Desserts: pudding, baked goods containing chocolate, baked goods containing vanilla, candies containing chocolate or vanilla, chocolate or vanilla flavored cereals, sherbet.

Fruits and Nuts: avocado, banana, pineapple, plums, prunes, oranges, raisins, nuts, tomatoes.

Meats: chicken livers, herring, smoked fish.

Vegetables: broad beans, eggplant.

Appendix T

Determination of Marginal Fluctuation Group for Response Measure Scores

Proportion score limits for marginal fluctuation			
Biochemical	$\bar{x}$	SE	$\frac{\bar{x}}{\sqrt{n}}(\bar{x} + SE)$ $\frac{\bar{x}}{\sqrt{n}}(\bar{x} - SE)$
Adrenalin			
Time I	8.3	.96	.47 .53
Time II	6.0	.64	
Noradrenalin			
Time I	58.6	7.15	.47 .53
Time II	47.1	5.65	
MHPG			
Time I	689.2	105.99	.46 .54
Time II	711.9	105.33	
State Anxiety			
Time I	31.4	.62	
Time II	29.8	.73	.49 .51

Appendix U

ANOVA Results for Biochemical Response under Stressor/
Non-Stressor Conditions.

Variable	Source	F	df	sig.
E (n=35)	time	5.77373	2,32	.007
	I-II	8.01256		*
	II-III	2.28456		ns
	sex	8.80539	1,33	.006
	sex x time	1.09575	1,32	ns
NE (n=35)	time	2.35987	2,32	.1
	sex	4.52944	1,33	.04
	sex x time	2.71450	2,32	.08
	I-II	3.11496		
	II-III	1.89587		
MHPG (n=35)	time	.18128	2,32	ns
	sex	.04968	1,33	ns
	sex x time	.97435	2,32	ns

* Based on a priori contrasts, significant at .005.

Appendix V

ANOVA Results for Behavioural Response Under Stressor/Non-Stressor Conditions

Variable	Source	F	df	Sig.
state anxiety (n=38)	time	4.07651	1,34	.05
	sex	1.27958	1,34	ns
	sex x time	.05399	1,34	ns
	group (target/control)	.07832	1,34	ns
	group x time	.92468	1,34	ns
observed tension (n=38)	time	31.61913	1,34	.000
	sex	1.03946	1,34	ns
	sex x time	.35313	1,34	ns
	group (target/control)	6.41771	1,34	.01
	group x time	1.73568	1,34	.2

4 4
OF / DE

Appendix X
Mean and Standard Error Scores for Biochemical Measures by Subgroup and Sex

Groups	Adrenalin						Noradrenalin						MHPG							
	I			II			III			I			II			III				
	X	SE	N	X	SE	N	X	SE	N	X	SE	N	X	SE	N	X	SE	N		
Increase																				
girls	9.3	3.73		2.5	1.16	4.3	1.42		77.7	42.90	8.2	3.97	17.4	6.76	1190	821	244	129	535	107
boys	12.3	1.25		7.1	1.16	11.0	1.57		83.3	10.33	41.0	7.59	69.0	10.25	720	239	303	60	471	96
Marginal Fluctuation																				
girls	4.9	2.78		4.1	2.43	3.8	3.39		12.7	.28	12.0	.01	40.6	11.67	516		454		561	
boys	6.4	1.49		6.2	1.38	12.6	4.05		79.4	24.51	80.0	23.07	115.5	36.66	881	213	874	216	1028	221
Decrease																				
girls	2.8	.78		5.2	.95	7.3	3.14		30.6	11.88	68.2	16.00	56.4	18.60	458	51	855	161	1029	395
boys	4.1	1.14		7.0	1.51	6.2	.74		33.5	6.68	51.0	9.15	69.4	19.20	564	143	1265	145	896	215
Total																				
girls	5.8	1.77		3.9	.75	5.5	1.48		39.4	13.30	43.8	12.57	44.0	11.78	645.8	201.88	659.0	135.46	885.5	267.54
boys	9.5	1.09		6.9	.80	10.3	1.23		67.5	8.03	48.6	6.06	74.9	9.36	709.2	126.38	731.6	142.41	734.3	103.20

Appendix Y

Pearson Product-Moment Correlations between Intellectual Level and Response Measure Scores

		Response Measures									
		Adrenalin		Noradrenalin		MHPG	State Anxiety		Observed Tension		
		I	II	I	II	I	II	I	II	I	II
Intellectual Level		Time									
		I	II	I	II	I	II	I	II	I	II
Verbal scores											
Performance scores											

Appendix AA

Pearson Product-Moment Correlations between Biochemical Change
Scores by A/MHPG Subgroups

Subgroup	n	Biochemical		
		AΔ	NAA	MHPGΔ
A+MHPG+	12	AΔ	.53 (.03)	.33 (.13)
		NAA		-.03 (ns)
		MHPGΔ		
A+MHPG+	12	AΔ	.77 (.002)	-.04 (ns)
		NAA		.18 (ns)
		MHPGΔ		
A+MHPG+	6	AΔ	.63 (.09)	.27 (ns)
		NAA		.16 (ns)
		MHPGΔ		
A+MHPG+	6	AΔ	.85 (.02)	.81 (.03)
		NAA		.64 (.09)
		MHPGΔ		

Appendix BB

Canonical Correlation Results for Biochemical Response Scores
and Behavioural Response Scores

Boys (n=26)

$R_c = .27$ $R_c^2 = .07$ Eigen Value = .07922 $p = .9$

Girls (n=12)

$R_c = .87$ $R_c^2 = .76$ Eigen Value = 3.18713 $p = .13$

Structure coefficients: State anxietyΔ .69022 AΔ .25780

Observed tensionΔ -.30091 NAAΔ -.07800

MHPGAΔ -.41875

Appendix CC

Univariate Multiple Regression for State Anxiety Change
with Biochemical Change

Boys

method: stepwise - no entry

method: enter - no entry

Girls

method: stepwise - no entry

method: enter

	<u>R</u>	<u>R²</u>	<u>F/t</u>	<u>sig</u>
total :	.64	.40	3.06	.1
AA			2.39	.04
NAA			-2.46	.04

Appendix DD

MANOVA Results for Attention Tasks Under Stressor/Non-Stressor Conditions

Variables: CPT-omission, CPT-commission, Zeros-ordered, Zeros-random, Stroop-time

Group designation	Source	Approx. F	df	Sig. (Pillais)
<hr/>				
<u>Cog. Control Study</u>				
n = 9	time	241.98149	5, 4	.000
<hr/>				
<u>Experimental Study</u>				
Identified groups	group	.60432	5, 32	n.s.
target = 28	time	15.38831	5, 32	.000
control = 10	group x time	.75662	5, 32	n.s.
Adrenalin	group	3.07293	5, 32	.02
increasers = 26	time	17.71008	5, 32	.000
decreasers = 12	group x time	1.49588	5, 32	n.s.
Observed tension	group	.90048	5, 32	n.s.
increasers = 26	time	15.27639	5, 32	.000
decreasers = 12	group x time	.52459	5, 32	n.s.
State anxiety	group	1.23485	5, 32	n.s.
increasers = 24	time	15.05943	5, 32	.000
decreasers = 14	group x time	.82903	5, 32	n.s.

Appendix EE

MANOVA Results for Recall Memory Tasks under Stressor/Non-

Stressor Conditions

Variables(5): recall-#-cl, recall-#-n/cl, recall-order-cl,
recall-order-n/cl, digit span

Group designation	source	F	df	sig (Pillais)
<u>Control study</u>				
n=9	time	5.79330	4	.06
<u>Experimental study</u>				
n=38 target/control	group	2.79138	5,28	.04
	time	.55341	5,28	ns
	group x time	1.62408	5,28	.18
adrenalin	group	1.27191	5,26	ns
	time	.53875	5,26	ns
	group x time	.21794	5,26	ns
observed tension	group	.85174	5,28	ns
	time	.53310	5,28	ns
	group x time	.28291	5,28	ns
state anxiety	group	3.40207	5,28	.02
	time	.54461	5,28	ns
	group x time	1.22744	5,28	ns

Appendix FF

MANOVA Results for Recognition Memory Tasks Under Stressor/
Non-Stressor ConditionsVariables(4): misses-cl list; misses-n/cl list; false-cl list;
false pos-n/cl list

Group designation	Source	Approx. F	df	Sig. (Pillais)
<hr/>				
<u>Cog. Control Study</u>				
n = 9	time	.30820	4,5	n.s.
<hr/>				
<u>Experimental Study</u>				
Identified groups target = 26 control = 9	group	1.12548	4,30	n.s.
	time	4.32818	4,30	.007
	group x time	4.32816	4,30	.007
Adrenalin increasers = 23 decreasers = 12	group	.49496	4,30	n.s.
	time	4.89750	4,30	.004
	group x time	2.63179	4,30	.05
Observed tension increasers = 26 decreasers = 9	group	1.36336	4,30	n.s.
	time	4.10500	4,30	.009
	group x time	.60603	4,30	n.s.
State anxiety increasers = 22 decreasers = 13	group	1.53760	4,30	n.s.
	time	4.05004	4,30	.01
	group x time	.79833	4,30	n.s.

MANOVA Results for Processing Tasks under Stressor/Non-Stressor Conditions

Variables (6): arithmetic-time, arithmetic-errors, Ravens-time, Ravens-errors, Object Sorting-sorts, Object-Sorting-concepts

Group designation	Source	Approx. F	df	Sig. (Pillais)
<u>Cog. Control Study</u>				
n = 9	time	3.64691	6,3	.2
<u>Experimental Study</u>				
Identified groups target = 38 control = 10	group	1.87379	6,31	.12
	time	4.11519	6,31	.004
	group x time	.75994	6,31	n.s.
Adrenalin increasers = 26 decreasers = 12	group	1.80786	6,31	.13
	time	4.09910	6,31	.004
	group x time	1.44981	6,31	n.s.
Observed tension increasers = 27 decreasers = 11	group	2.04137	6,31	.09
	time	4.10337	6,31	.004
	group x time	.19614	6,31	n.s.
State anxiety increasers = 24 decreasers = 14	group	1.38738	6,31	n.s.
	time	4.45257	6,31	.002
	group x time	1.75182	6,31	.14

Appendix HH

Canonical Correlation Results for Attention Task and Biochemical Response Measures

Attention tasks with AA NAA MHPGA

$R_c = .62$ $R_c^2 = .39$ Eigen Value = .63834 $p = .12$

Structure coefficients:	CPT-om	-.16822	AA	.76927
	CPT-com	-.66598*	NAA	.19271
	Zeros-or	-.44600*	MHPGA	-.11860
	Zeros-ran	.34004		
	Stroop	-.18548		

Attention tasks with AP NAA MHPGP

$R_c = .56$ $R_c^2 = .32$ Eigen Value = .46757 $p = .20$

Attention tasks with AA NAA MHPG

$R_c = .68$ $R_c^2 = .46$ Eigen Value = .86255 $p = .15$

Structure coefficients:	CPT-om	-.18159	AA	.69403
	CPT-com	-.69814*	NA Δ	.15817
	Zeros-or	-.40930*	MHPGA	.45619
	Zeros-ran	.33953		
	Stroop	-.13302		

Attention tasks with AA+, AA+, NAA+, AA+, MHPGA

$R_c = .66$ $R_c^2 = .44$ Eigen Value = .78057 $p = .16$

Structure coefficients:	CPT-om	.37572	AA+	.06461
	CPT-com	.62596*	AA+	-.67537
	Zeros-or	.37905	NAA+	-.57472
	Zeros-ran	.40652*	NAA+	-.25351
	Stroop	.32685	MHPGA	-.15068

*to be examined by univariate multiple regression.

Appendix II

Canonical Correlation Results for Processing Task and Biochemical
Response Measures

Processing tasks with AD NAD MHPGD

$R_C = .66$ $R_C^2 = .43$ Eigen Value = .76107 $p = .28$

Processing tasks with AP NAP MHPGP

$R_C = .54$ $R_C^2 = .29$ Eigen Value = .41201 $p = .47$

Processing tasks with AD NAD MHPG

$R_C = .66$ $R_C^2 = .44$ Eigen Value = .77552 $p = .06$

Structure coefficients:	Arith-time	-.35592	AA	-.19867
	Arith-error	-.00998	NAA	.44394
	Ravens-time	-.21402	MHPG	-.10161
	Ravens-error	-.35864		
	Obj.Sort-sort	-.61842*		
	Obj.Sort-con	-.20493		

Processing tasks with AD1, ADD, NAD1, NADD, MHPG

$R_C = .75$ $R_C^2 = .57$ Eigen Value = 1.31066 $p = .01$

Structure coefficients:	Arith-time	-.68961*	AA+	.20351
	Arith-error	.24216	AA+	-.10847
	Ravens-time	.29588	NAΔ+	-.44906
	Ravens-error	-.13889	NAΔ+	.53514
	Obj.Sort-sort	-.36473*	MHPG	-.37607
	Obj.Sort-con	.20581		

Processing tasks with OTD OT1

$R_C = .66$ $R_C^2 = .44$ Eigen Value = .78 $p = .09$

Structure coefficients:	Arith-time	-.01572	OTΔ	.37162
	Arith-error	.26077	OT1	.77415
	Ravens-time	-.03294		
	Ravens-error	-.22424		
	Obj.Sort-sort	-.67847*		
	Obj.Sort-con	-.87924*		

*to be examined by univariate multiple regression

Appendix JJ

Univariate Multiple Regression Results for Attention Task

Scores with Response Measure Scores

Regression Analysis: CPT Commission with AA, NAA, MHPGA

method = stepwise - no entry

method = enter -

	<u>R</u>	<u>R²</u>	<u>F/t</u>	<u>sig.</u>
total	.44	.20	2.77	.06
MHPGA:			-.074	.94
AA:			-2.861	.007
NAA:			2.351	.02

Regression Analysis: Zeros-ordered with AA, NAA, MHPGA

method: stepwise

	<u>R</u>	<u>R²</u>	<u>F</u>	<u>sig.</u>
step 1: MHPGA:	.32	.09	3.97	.05
step 2: AA: (-) ^a addition:	.3	.20	total 4.43	.02
	.45			

Regression Analysis: Zeros-randomized with AA, NAA, MHPGA

method: stepwise - no entry

method: enter - no entry

^a Notation in parentheses indicates negative correlation for that variable.

Appendix KK

Univariate Multiple Regression Results for Processing Task
Scores with Response Measure Scores

Regression Analysis: combined arithmetic time AA^a, AA^b,
NAA^a, NAA^b, MHPG

method: stepwise

	<u>R</u>	<u>R²</u>	<u>F</u>	<u>sig</u>
Step 1: NAA ^a :	.35	.12	4.91	.03
Step 2: AA ^a :	addition: .13	total: .23	5.27	.01
Step 3: NAA ^b :	addition: .06	total: .30	4.79	.007
	.54			

Regression Analysis: simple arithmetic time with AA^a, AA^b,
NAA^a, NAA^b, MHPG

method: stepwise - no entry

method: enter - (NAA^a, AA^a)

	<u>R</u>	<u>R²</u>	<u>F/t</u>	<u>sig</u>
total:	.39	.15	3.11	.06
AA ^a :			2.18	
NAA ^a :			-2.38	

Regression Analysis: equation arithmetic time with AA^a, AA^b,
NAA^a, NAA^b, MHPG

method: stepwise

	<u>R</u>	<u>R²</u>	<u>F</u>	<u>sig</u>
Step 1: NAA ^a :	.33	.11	4.51	.04
Step 2: NAA ^b :	addition: .14	total: .22	5.00	.01
	.47			

Regression Analysis: object sorting - sorts with AA^a, AA^b,
NAA^a, NAA^b, MHPG

method: stepwise

	<u>R</u>	<u>R²</u>	<u>F</u>	<u>sig</u>
Step 1: NAA ^a :	.30	.09	3.59	.07

Regression Analysis: object sorting - sorts with OT-Time I, OT-Δ

method: stepwise - no entry

method: enter

	<u>F</u>	<u>R²</u>	<u>F/t</u>	<u>sig</u>
total:	.45	.20	4.43	.02
OT-Time I:			-2.97	.02
OT-Δ:			2.54	.005

Regression Analysis: object sorting - concepts with OT-Time I, OT-Δ

method: stepwise

	<u>R</u>	<u>R²</u>	<u>F</u>	<u>sig</u>
Step 1: OT-Time I:	.41	.16	7.10	.01
Step 2: OT-Δ:	addition: .17	total: .34	8.83	.0008
	.58			

^a = increasers
^b = decreasers

Appendix LL

Score System for Cumulative Factor (On-Going Stressor level)

Variables	Range				
	below $\bar{X}$	$\bar{X} - \frac{1}{2}sd$	$\frac{1}{2}sd - 1sd$	$1sd - 1\frac{1}{2}sd$	$1\frac{1}{2}sd - \text{above}$
	Score				
	0	1	2	3	4
Family background	- 7.9	8.0-9.6	9.7-11.4	11.5-13.2	13.3 -
6-month life change events	- 56	57-90	91-124	125-159	160 -
12-month life change events	- 92	93-124	125-156	157-190	191 -
Trait anxiety	- 36	37-38	39-41	42-44	45 -

Background factor-6 = (family background) + (6 mo. life change events) + (trait anxiety)

Background factor-12 = (family background) + (12 mo. life change events) + (trait anxiety)

Appendix MM

Canonical Correlation Results for Antecedent Factors and Bio-
chemical Response Measures

Situation factors(12) with AA, NAA, MHPGA

$R_c = .49$ $R_c^2 = .24$ Eigen Value = .32414 $p = .10$

Structure coefficients:	AA	-.00931	LCE(12)	-.51302
	NAA	.36910	Fam.Back.	-.67208
	MHPGA	-.74886*	Cum.Fac.	-.13172

Personal factors with SAA, OTA

$R_c = .74$ $R_c^2 = .54$ Eigen Value = 1.19121 $p = .02$

Structure coefficients:	SAA	.26657	TA	-.56036
	OTA	-.87921*	L of C	.04692
			Intel	.86704

*To be examined by univariate multiple regression.

Appendix NN

Antecedent Factor Group Divisions for Chi-Square Analyses

Factor	No. of groups	Group divisions	
		designation	score
cumulative factor(6) (12)	3	$\pm 1/2$ sd	1,4
		low v + p(-100)	2,4
intellectual level	5	low	
		average	
		average v+p(100-120)	
		average high	
		high v+p.(120-)	
family background	2	medium	8
life change events(6) (12)	2	medium	38.8
			132
locus of control	2	mean	13
trait anxiety	3	$\pm 1/2$ sd	33,40

Appendix OO

Summary Table for Chi-Square Tests of Association between Antecedent Factors and

		Response Measures					
Variables	Antecedent Response factor	Association		if indep.	Results		
		Antecedent group	Response group	for sample	χ^2	df	Sig.
Locus of control	MHPG	external	marg.fluc.	86%	45%	6.74	2 .03
		internal	increase	73%	55%		
Locus of control	SA	external	decrease	71%	45%	8.63	2 .01
		internal	marg.fluc.	86%	55%		
Cumulative factor	NA	moderate	marg.fluc.	60%	29%	7.82	4 .09
		low	increase	67%	48%		
Cumulative factor	A	moderate	marg.fluc.	36%	16%	7.33	4 .1
		low	increase	73%	55%		

Appendix IV
Mean and Standard Error Scores for Attention Tasks by Study Samples and Response Measure Groups

Task	Time	Study Samples				Response Measures											
		Experimental Control				Adrenalin				MIPC				Observed Tension			
		$\bar{X}$	SE	$\bar{X}$	SE	Increase $\bar{X}$ SE	Decrease $\bar{X}$ SE	Increase $\bar{X}$ SE	Decrease $\bar{X}$ SE	Increase $\bar{X}$ SE	Decrease $\bar{X}$ SE	Increase $\bar{X}$ SE	Decrease $\bar{X}$ SE	Increase $\bar{X}$ SE	Decrease $\bar{X}$ SE	Increase $\bar{X}$ SE	Decrease $\bar{X}$ SE
PTT-OH	I	2.6	.42	.8	.36	2.3	.51	3.3	.72	2.5	.59	2.6	.63	2.8	.53	2.2	.67
	II	1.4	.24	1.0	.41	1.4	.33	1.3	.33	1.3	.33	1.6	.38	1.5	.28	1.3	.51
CPT-CUM	I	3.4	.61	2.7	.88	3.4	.73	3.6	1.16	4.4	1.06	2.4	.51	1.7	.69	2.9	1.29
	II	1.3	.34	1.4	.56	1.5	.48	.9	.36	1.7	.62	1.0	.27	1.3	.27	1.5	.99
Zeros-OR	I	5.7	1.05	6.7	2.41	4.9	1.05	7.5	2.50	7.4	1.69	3.9	1.22	6.1	1.28	4.8	1.89
	II	3.1	.59	5.1	2.10	3.2	.66	2.9	1.27	3.7	.93	2.6	.76	2.7	.75	3.9	.91
Zeros-RAN	I	19.5	1.63	24.6	2.94	16.0	1.92	27.5	1.15	20.0	2.20	18.3	2.51	20.3	1.91	17.6	3.17
	II	11.6	1.60	12.0	2.91	10.7	1.91	13.5	3.00	12.0	2.46	11.8	2.15	12.8	2.05	8.6	2.32
Persever- ation	I	4.0	.49	4.4	.69	3.2	.53	5.7	.85	3.8	.68	3.9	.66	4.0	.57	4.0	.96
	II	2.3	.46	1.9	.63	2.2	.57	2.5	.78	2.6	.71	2.2	.61	2.7	.58	1.5	.65
Stroop-time	I	77.3	2.74	73.0	5.81	77.4	3.52	76.5	4.36	78.0	3.29	77.7	4.04	79.4	2.00	71.8	5.79
	II	66.8	2.35	61.0	4.63	68.6	2.85	63.0	4.10	68.6	3.14	65.6	3.7	68.2	3.01	63.4	3.36

Appendix QQ
Mean and Standard Error Scores for Memory Recall Tasks By Study Samples and Response Measure Groups

		Study Samples				Response Measures															
Task	Time	Experimental		Control		Adrenalin			MIPG			Observed Tension			State Anxiety						
		X	SE	X	SE	Increase	decrease	SE	Increase	decrease	SE	Increase	decrease	SE	Increase	decrease	SE				
Clustered	I	10.1	.25	11.6	.44	10.2	.36	9.9	.27	10.3	.36	10.0	.38	10.1	.31	10.2	.43	10.5	.29	9.5	.44
	II	9.9	.26	11.0	.56	10.0	.34	9.7	.43	9.6	.41	10.2	.36	9.9	.31	9.9	.53	10.5	.24	8.8	.45
Non-Cl	I	7.8	.31	10.2	.68	7.7	.36	8.0	.59	8.0	.45	7.7	.45	8.1	.33	7.0	.65	8.2	.35	7.2	.55
	II	7.7	.42	9.9	.70	8.1	.51	6.8	.69	7.4	.61	7.8	.61	7.7	.52	7.8	.68	8.1	.55	7.0	.62
Non-Cl + Comment	I	7.3	.36	11.1	.63	5.0	.51	6.2	.39	7.8	.60	6.9	.50	7.1	.45	8.0	.68	7.2	.42	7.5	.57
	II	7.4	.42	11.0	.65	7.9	.52	6.5	.65	7.2	.50	7.9	.64	7.6	.47	6.9	.90	7.6	.60	7.2	.53
Orbit																					
Clustered	I	9.02	.9	9.03	.9	9.03	.9	9.04	.9	8.04	.9	9.03	.9	9.03	.9	8.05	.9	9.02	.9	8.05	.9
	II	9.03	.9	9.07	.9	9.04	.9	9.06	.9	8.06	.9	9.03	.9	9.04	.9	9.06	.9	9.02	.9	8.08	.9
Non-Cl	I	4.06	.4	4.12	.4	4.08	.4	4.11	.4	4.09	.4	5.09	.4	4.07	.4	4.13	.4	3.07	.4	5.10	.4
	II	5.07	.7	7.15	.6	6.08	.5	5.13	.5	5.11	.6	6.10	.5	5.09	.5	7.09	.7	6.09	.5	5.12	.5
Non-Cl + Comment	I	6.07	.8	8.12	.7	7.07	.5	5.13	.5	7.08	.5	5.11	.6	6.08	.7	7.10	.5	5.09	.7	7.09	.7
	II	6.08	.9	9.06	.7	7.09	.4	4.13	.5	5.11	.6	6.11	.5	5.09	.7	7.13	.6	6.09	.5	5.13	.5
Inlet Span	I	5.9	.24	5.8	.43	6.0	.27	5.8	.46	5.8	.36	6.1	.33	6.0	.12	5.9	.25	6.2	.28	5.6	.42
	II	6.1	.20	5.9	.31	6.1	.27	6.0	.28	5.9	.28	6.2	.31	6.1	.27	5.9	.25	6.4	.21	5.6	.40

END

3	1	H	1	0	H	8	5
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FIN