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Temperament as a Predictor of Upper Respiratory Illnesses Following Kindergarten Entry

by

Elizabeth Latouf Chesterman

A dissertation
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Elizabeth Latouf Chesterman

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ABSTRACT

Temperament as a Predictor of Upper Respiratory Illnesses
Following Kindergarten Entry

Elizabeth Latouf Chesterman

A small but growing body of evidence indicates that a child's temperament affects the likelihood of illness and illness-related events. Neither the effect of temperament on upper respiratory illnesses, nor the immune response to stress in children has been previously explored. This study prospectively investigated the effect of temperament on the number of upper respiratory illnesses experienced following Kindergarten entry, and the mediation of this effect by the immune response.

Ninety-seven children gave blood samples before and after Kindergarten entry, and at study entrance parents answered the Behavioral Style Questionnaire (BSQ, McDevitt & Carey, 1978) and global temperament items adapted from Ratekin and Keogh (1992). Blood was assayed for changes in: CD4 and CD8 T cell counts, CD19 B cell counts, pokeweed mitogen response, and antibody response to the Pneumovax vaccine. Parents reported upper respiratory illness occurrences with biweekly illness diaries during the three months after Kindergarten entry.

The results indicate a moderate, but significant effect of the BSQ "index of difficulty" measure of temperament on the number of upper respiratory illnesses following Kindergarten entry. Post-hoc comparisons identified a subgroup of children with more difficult temperaments who experienced significantly more

illnesses than children with easier or intermediate temperaments.

Factor analysis identified four temperament dimensions comprising the BSQ "index of difficulty" measure: mood, adaptability, activity and persistence. Of these, negative mood was the most salient dimension. The study findings also indicate that the global measures of temperament are not acceptable substitutes for the BSQ index of difficulty measure.

The effect of temperament on upper respiratory illnesses is not mediated (or moderated) by the measures of immunological responsivity in this study. While the mechanism of the effect remains unclear, it is speculated that it may have a behavioral base, driven largely by a child's tendency to respond to events with a negative or positive mood.

Finally, a measure of temperament which combines both the BSQ diagnostic cluster rating and the BSQ index of difficulty score similarly divided (into easy, intermediate and difficult) is more effective in predicting total upper respiratory illnesses than either method alone.

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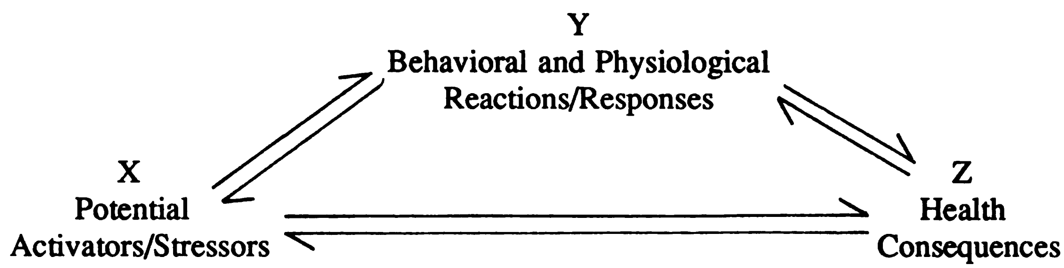
REVIEW OF THE LITERATURE

X-Y-Z Model of Stress and Disease

Conventional wisdom and folklore have long suggested that a person's experience of stress can affect his or her health. Systematic research over the last 30 years has found that a variety of psychosocial stressors and modifiers, such as stressful life events and personality factors, affect a variety of physical and mental illnesses. Such research has also found that behavioral and physiological reactions to stressors, such as avoidant behaviors or changes in immunological measures, can affect physical and mental illness. Elliot and Eisdorfer (1982) have proposed the X-Y-Z model of stress and disease as a framework of reference for categorizing and understanding this growing body of research. In the X-Y-Z model, X refers to potential activators/stressors (e.g., stressful life events), Y to short term behavioral and physiological reactions/responses (e.g., avoidant behaviors, changes in immunological measures), and Z to health consequences (e.g., infectious illness). Elliot and Eisdorfer (1982) maintain that X, Y and Z are all necessary components for understanding the effects of the environment on an individual. First, something in the environment becomes an activator/stressor; second, the individual reacts to that activator; and third, that reaction leads to a consequence. They acknowledge, however, that not all research conforms to this model and studies often examine only pieces of the relationship such as X-Y, X-Z, or Y-Z. Figure 1 presents a schematic of the X-Y-Z model.

FIGURE 1: X-Y-Z Model of Stress and Disease (Elliot & Eisdorfer, 1982)



An important additional component of the X-Y-Z model is Elliot and Eisdorfer's (1982) concept of a "mediator." Not to be confused with a statistical mediator, their "mediator" is a filter or modifier that can act on each stage in the sequence to produce individual variations in the X-Y-Z sequence. Of particular interest to this literature review are individual constitutional differences in emotional and behavioral responsiveness to the environment (i.e., personality factors), that filter or modify a potential activator/stressor (X) to determine the degree of "stress" from which Y and Z result. In fact, a recurring theme emerging from recent stress and health research indicates that a person's experience of stress and the biobehavioral reactions to stress are dependent upon that individual's emotional state and appraisal of the stressor (Boyce & Jemerin, 1990). A way to reconcile this approach with the X-Y-Z model, and to indicate a physical and temporal place in the model for these individual constitutional differences that filter or modify the stressor, is to describe "stress" as a sequence of events. In this revised model X identifies both the potential activator/stressor, and constitutional differences that affect the individual's emotional and behavioral appraisal.

In stress and health research with children, the concept of temperament, defined here as the characteristic style of emotional and behavioral response of an individual in a variety of differing situations, can be understood as the child's filter or modifier of psychosocial stressors. In fact, Boyce, Barr, and Zelzter (1992) propose that temperament be regarded as an organizing principle in children's responses to environmental adversity, and the window through which biobehavioral reactions to stress and their health consequences can be viewed.

Using this revised X-Y-Z model, this literature review focuses on three areas of stress and health research with children. First, the relationships of psychosocial stressors and modifiers with infectious illness (X-Z) are reviewed with an emphasis on personality factors (individual constitutional differences), temperament in particular. Second, the relationships of psychosocial stressors and modifiers with physiological responses (X-Y) and their possible combined role in infectious illness (X-Y-Z) are reviewed, with an emphasis on temperament as the modifier of interest, and immunologic changes as the short term physiological response (Y) of interest. It is the combined role of X and Y on Z that is of particular interest in this second area of the literature review. The third area is a brief review of the operationalization of temperament, focusing on Kindergarten age children. The measurement of psychosocial modifiers is the weakest link in the X-Y-Z chain because of the various theoretical perspectives that affect their operationalization, and the necessarily subjective nature of their assessment.

Throughout this literature review references to adult and animal studies are made only when no research with children on a specific topic is available.

X-Z: Psychosocial Stressors and Modifiers and Infectious Illness

X-Z: Psychosocial Stressors and Infectious Illness

Holmes, Hawkins, Bowerman, Clarke, and Joffe (1957) studied 33 children three to twelve years old, hospitalized for tuberculosis. They found that 89% of the children came from "unstable homes," characterized by marital dissolution, frequent residential changes, and unstable financial conditions. There was no control group with which to compare rates of instability. However, the authors felt that the rate of instability in their sample greatly exceeded the normal population.

Miller, Court, and Walton (1960) followed more than 800 children from birth to five years, recording data on illnesses, family and environmental conditions, and growth and development. They found strong associations between adverse social factors and the risk of, among others, severe respiratory infection. There was a tenfold increase in the incidence of such infections as bronchitis and pneumonia in the psychosocial gradient from professional families to families of unskilled workers.

Meyer and Haggerty (1962) found in a group of 16 families (100 adults and school age children) followed for a year, that 36% of all the streptococcal infections were preceded by a stressful event. They also found that families with a high versus low level of chronic family stress had twice as many strep throats, and were ten times more likely to develop a rise in ASLO titer, which indicates the risk of developing rheumatic fever.

Spivey (1977) reviewed the Indian Health Service charts from birth to three years for the children from 20 American Indian families: 10 with multiple psychosocial problems such as alcoholism, physical abuse, marital dissolution, unemployment, and child behavior problems; and 10 "adequately" functioning matched control families. In the first year of life, the 46 children of the multi-problem families experienced 50% more upper respiratory infections than the 35 children of the control families. The multi-problem children also experienced, in the first year of life, 75% more non-respiratory infections (such as impetigo, scabies, and chicken pox).

For one year, Boyce, Jensen, Cassel, Collior, Smith, and Ramey (1977) followed the respiratory illnesses of 58 children from one to eleven years old. They found that the children with high life change scores were ill 25% longer than children with low life changes. They also found that children with high life change in the context of high family routine scores (more rigid and ritualized patterns of daily family activity) experienced illnesses 22% more severe than children with low life change and low family routine scores.

Beautrais, Fergusson, and Shannon (1982) followed 1,082 children from one to four years and found a strong association between family life events and the risk of, among others, lower respiratory illness. While there were no significant differences in lower respiratory illnesses alone for low versus high life events, there was a twofold increase in medical attendance (hospital, ER, and outpatient) for all categories of morbidity combined (including lower respiratory illness, accidents, poisoning, etc.). There was a sixfold increase in hospitalizations alone for children with the highest versus the lowest number of life events.

The above body of literature on the consequences of environmental stressors/protectors on infectious illness (X-Z) is considerably smaller for children than adults. Yet despite various methodological issues (see critical reviews by Boyce, 1985; Campbell, 1986; and Haggerty, 1980), it consistently demonstrates associations between psychosocial stressors and infectious illness parallel to the adult literature. These associations are always small to modest in magnitude, perhaps because of a lack of examination of the role of individual differences in stressor appraisal. Boyce and Jemerin (1990) state that for research on psychosocial stress (X) to make a useful contribution to understanding patterns of illness, it is necessary to explain why certain individuals are susceptible to the pathogenic effects of psychosocial stressors and why others are more resilient. Yet, the role of these individual differences (stable tendencies, in particular) in behavioral and emotional responsiveness to stressors on physical health has been generally ignored.

X-Z: Personality and Infectious Illness

Very little research has been done on the effects of individual differences in personality on the stress and illness relationship in children. Such concepts as self-esteem, locus of control, sense of permanence and temperament have been examined but mostly in relation to behavioral outcomes. Even less has been done with infectious illness as the outcome.

<u>Behavioral responsiveness</u>. Lewis, Thomas and Worobey (1990) followed the atopic (non-infectious, immune based illnesses such as asthma and allergies) and infectious illnesses of 40 infants from birth to two years. The newborn's behavioral responses to a heel stick at two days old and an inoculation at two months old were recorded and scored. The behavioral response to the heel stick score predicted the behavioral response to the inoculation but did not predict either atopy or infection using a path analysis. In the same path analysis, the behavioral response to the inoculation score did predict both atopy and infectious illness. Infants who were most behaviorally reactive to a "perturbation" at two months, indicating less of an ability to cope with stress (according to the authors), were more likely to have a history a year or more later of atopy and infections.

<u>Sense of Permanence</u>. Boyce, Chesterman, and Winkleby (1991) followed 89 adolescent mothers (14 to 18 years) and their newborn infants from delivery for one year. Stressful life events and social support were assessed at the beginning of the study year, as were individual differences in the adolescent mother's "sense of permanence." This was defined as the "belief or perception that certain central, valued elements of life experience are stable and enduring" (Boyce, Chesterman & Winkleby, 1991, p. 267). Maternal and child illnesses were calculated from biweekly illness diaries which elicited symptoms of upper respiratory illness infection and the number of days ill with these symptoms. A path analysis revealed that the effects of stressful life events and social support on maternal and child illnesses were

via the effect of sense of permanence on illnesses. Subjects with a weaker sense of permanence recorded significantly higher rates of illness for both themselves and their babies.

Temperament. There has been a great deal of speculation recently that temperament, may have an important effect on a variety of health related outcomes (Boyce, Barr & Zeltzer, 1992; Rutter, 1981). This seems to be largely due to a resurgence of theoretical work on the biological origins and physiological nature of temperament (Gunnar, Mangelsdorf, Larson, & Hertsgaard, 1989; Healy, 1989; Kagan, Reznick & Snidman, 1987; Rothbart & Derryberry, 1981). Yet, most studies of the role of temperament have looked at its prediction of adjustment to school, social competence, behavioral problems, and other goodness of fit with the environment indicators. In general, these studies have found a consistent but small to moderate effect of temperament. A much smaller number of studies have found that a child's temperament predicts illness-related outcomes such as colic, accidents and injuries, as well as health care utilization (Carey, 1972; Huttunen & Nyman, 1982; Nyman, 1987; Wertlieb, Weigel & Feldstein, 1988).

Only two studies attempted to predict actual physical illness as a function of a child's temperament. One study by Priel et al. (1990), found in a stepwise regression that rhythmicity of daily and physical routine was the only dimension of temperament to significantly predict the development (a year later) of asthma in 69 infants originally seen for a wheeziness attack (Multiple $R=.39$, $p<.001$). The more arrhythmic the child's daily routine and biological functions, the more likely was the child to develop asthma, an atopic rather than infectious illness. While negative quality of mood also showed a small significant bivariate correlation with the development of asthma ($r=.30$, $p<.05$), it did not add significantly to rhythmicity in predicting asthma in the regression. These limited findings seem to tentatively support the possibility that temperament can affect physical illness.

The other study, by Huttunen and Nyman (1982), followed 1855 six to eight month old infants for five years for pneumonia incidence as well as a variety of non infectious illnesses. While more negative quality of mood and high intensity (the "difficult" ends of two temperament dimensions) predicted colic and accidents, the study failed to find a relationship between any of the nine dimensions of temperament and the occurrence of pneumonia. This study suffered from a number of methodological and statistical difficulties, including the problem of insufficient variance because of the low incidence of pneumonia. A better infectious illness outcome would have been the incidence of common upper respiratory infections (URIs) such as colds, flus and ear infections, which are much higher in the population.

The support for individual differences in temperament (X) as a predictor of infectious illness (Z) is small (only two studies) and tentative (only one positive finding and with atopic illness). This tentative support and the consistent, but small to moderate associations of other psychosocial stressors and modifiers (X) with infectious illness (Z) give added emphasis to Elliot and Eisdorfer's (1982) insistence on the examination of the role of behavioral or physiological responses (Y) in the X-

Z sequence. This is echoed by Boyce and Jemerin (1990) who maintain that individual differences in physiological as well as behavioral responses to stress hold the key to our enhanced understanding of the relationship of psychosocial factors with illness.

Physiological Mediators of the Psychosocial Stressors/Modifiers and Infectious Illness Relationship

In this section, the relationship between psychosocial stressors and modifiers and physiological responses (X-Y) is reviewed first, with an emphasis on temperament as the psychosocial modifier, and immunologic changes as Y. This is accompanied by brief descriptions of the biology of temperament and of basic immunology, as well as a brief discussion of the issue of their possible dissociation with each other. Finally, the combined role of psychosocial stressors and modifiers, (particularly temperament as X), and physiological responses (particularly immunologic changes as Y) on infectious illness (Z) is reviewed as the area of particular interest.

X-Y: Psychosocial Stressors and Modifiers and Physiological Responses

There is a growing body of literature on physiological responses to stress in children, with consistent findings of associations of stressor/protectors (X) with various physiological responses (Y), parallel to the adult and animal literature. Psychosocial stressors ranging from challenging laboratory tasks to stressful life events and family circumstances have been found to elicit neuroendocrine, cardiovascular and immunological responses. Boyce and Jemerin (1990) emphasize that evidence that psychosocial stressors can modify physiologic processes lends biological plausibility to the hypothesis that psychosocial stress may be involved in the genesis of disease. However, the physiological response to stress is dependent upon individual constitutional differences that affect emotional and behavioral appraisal of psychosocial stressors.

X-Y: Temperament and Physiological Responses

Boyce, Barr, and Zeltzer (1992) believe temperament is the psychosocial modifier through which physiologic responses to stress should be viewed. Temperament is the most frequently studied concept of individual behavioral and emotional differences in response to events in children. This relationship of temperament (X) with physiological responses to stress (Y) is the primary focus of this section. However, to better understand its potential connection with physiological responses, the biology of temperament is first briefly reviewed.

The biology of temperament. When they first operationalized the concept, Thomas and Chess and colleagues (Rutter, Birch, Thomas, & Chess, 1964; Thomas, Chess, Birch, Hertzig, & Korn, 1963) stated that temperament is largely determined by the child's physiological makeup and thresholds to stimuli. While they never presented physiological evidence, more recent explorations of the biological origins and physiological nature of temperament have offered more substantive evidence to support and expand Thomas and Chess' original claim.

Neuroanatomical studies indicate that the limbic system is the core of emotion and temperament related structures in the brain (Rothbart, 1986; Steinmetz, 1992). The areas that compose the limbic system are at adult maturity by six months old, unlike other areas of the brain (Nelson, 1992). This evidence is used by Nelson (1992) and others such as Kagan, Reznick, and Snidman (1987) as further argument for the limbic system as the biological origin of temperament, because the differences in behavioral responses to stimuli that compose temperament are evident in research from as early as two months old (Fox, 1992), and in clinical observations from two weeks old (Carey, 1972; Thomas, Chess, & Birch, 1970). It is well documented by human as well as animal studies that the limbic system is responsible for the activation of the neuroendocrine system in response to cognitive, physical and emotional stimuli.

As summarized by Boyce and Jemerin (1990), the initial physiologic response to psychosocial factors involves three major neuroendocrine subsystems: the sympathetic-adrenomedullary, pituitary-adrenocortical, and endogenous opiate systems. These subsystems interact with each other and have extensive effects on other target systems and organs throughout the body. Thus the neuroendocrine system is the first line of physiologic response to psychosocial factors. Since temperament reflects stable individual differences in behavioral and emotional responses to stressors, it is no surprise that the few existing studies have found consistent associations between temperament and neuroendocrine responses to stress. These are briefly reviewed, as the focus of interest of this study is with immunological responses because of their role in infectious illness.

X-Y: Temperament and neuroendocrine responses. Kagan, Reznick, and Snidman (1987) followed 120 children two to three years old, 60 classified as inhibited and 60 as uninhibited. They found that inhibited children (extremely withdrawn and extremely maladaptive--the difficult ends of two temperament dimensions) show very different patterns of physiological response (both adreno-cortical and autonomic nervous system) to novelty than did uninhibited children. The inhibited (more difficult) children had higher salivary cortisol and urinary epinephrine levels than uninhibited (easy) children both at home and during laboratory testing.

Gunnar et al. (1989) tested infants at nine and thirteen months and found that infants whose parental temperament ratings indicated they were more withdrawn and more maladaptive (two important dimensions of classic temperament) experienced greater increases in adrenocortical activity during laboratory testing. Those infants whose temperament scores indicated a greater proneness to distress in new situations, produced significantly higher salivary cortisol levels during a laboratory situation.

Stansbury and Harris (1993) found similar patterns of salivary cortisol production in 62 preschoolers in two laboratory episodes designed to induce negative affect. Children with more difficult temperaments produced higher cortisol levels during the two laboratory episodes.

Neuroendocrine responses have widespread effects on the functioning of the immune system as well as other systems. The above studies are quite relevant, since the effects of corticosteroids on the immune system have been known for decades as a component of the hypothalamic-pituitary adrenal response to environmental stressors and their emotional and behavioral concomitants (Boyce, 1989; Jemmott & Locke, 1984; Schleifer, Scott, Stein, & Keller, 1986).

Y-Z: Immune Response and Infectious Illness

While there is no conclusive evidence that infectious illness follows stress **because** immune function is altered (Palmblad, 1981), there is ample evidence from adult studies (Ader, Felten, & Cohen, 1990; Jemmott & Locke, 1984) to suggest that alteration in the functioning of the immune system (Y) could contribute to **susceptibility** to infectious illness (Z). The very few prospective studies in children seem to corroborate this. For example, Yodfat and Silvian (1977) found an association of secretory immunoglobulin A with acute respiratory tract infections among 48 kibbutz children, ages six months to four years old. Children who developed higher concentrations of secretory IgA during episodes of acute respiratory tract infection showed a lower incidence of infection in the following year.

To better understand the possible connection between temperament, immune response and infectious illness, a brief description of the immune system and its neuroendocrine connections follows.

Basic immunology. The immune system is a surveillance mechanism that protects a person from disease-causing microorganisms (Borysenko, 1987; Jemmott

& Locke, 1984). It regulates susceptibility to among others, infectious illnesses. The white blood cells (leukocytes) and their by-products that perform the surveillance are generated in the bone marrow, differentiated in the lymph nodes, spleen and thymus, and circulate via the lymphatic system.

There are two general but interactive categories of immune function: humoral and cellular. Humoral immunity is characterized by the production of immunoglobulin molecules known as antibodies, which attach to invading microorganisms known as antigens, and either neutralize them or earmark them for phagocytosis by cells such as natural killer cells. Cellular immunity is characterized by the direct action of effector and regulator lymphocytes. For example, effector lymphocytes such as killer T cells release chemicals known as lymphokines which cause lysis (killing) of foreign cells. Regulator lymphocytes such as helper and suppressor T cells augment or suppress humoral reactions by proliferating and releasing types of lymphokines that communicate with the B cells that make antibodies.

Recent research even shows that lymphocytes also produce lymphokines that communicate directly with receptors on cells of the neuroendocrine system, which has direct nerve connections in the lymph nodes, spleen and thymus (Bulloch, 1985; Livnat, Felten, Carlson, Bellinger, & Felten, 1985). Receptors for these "immunohormones" have even been found in the limbic system (Ader, Felten, & Cohen, 1990; Bulloch, 1985), the area of the brain most associated with emotion and temperament (Nelson, 1992; Steinmetz, 1992).

Developmental studies of the immune system have found that acute stressors and traumatic life events in infancy and early childhood may have long-term as well as acute affects on immune responses (Coe, Lubach, & Ershler, 1993). These animal studies found that early life experiences altered the developmental trajectory of the immune system, leading to changes that persisted into adulthood (Coe, Lubach, Ershler, & Klopp, 1989; Schleifer et al., 1986). While it is unclear how susceptible the immune system in human infants is to permanent impairment from early trauma, these studies may in part explain why studies of illness in children have consistently found a subgroup of 15 to 20% that tends to experience a disproportionate share of illness (Boyce & Jemerin, 1990). The effects on immune responses of individual differences in response to these stressors may also offer partial explanation.

X-Y: Psychosocial Stressors and Modifiers and Immune Response

A growing body of literature, using a wide array of approaches, has consistently demonstrated associations between psychosocial stressors and immune-mediated diseases, infectious illness in particular, in both adults and children (Boyce & Jemerin, 1990; Dorian & Garfinkel, 1987; Jemmott & Locke, 1984). Associations in adults and animals between psychosocial stressors and laboratory measures of immune function have also been consistently demonstrated (Ader & Cohen, 1993; Palmblad, 1981; Schleifer et al., 1986).

Unfortunately, to date, very little research on psychosocial stressor/protectors (X) and immune responses (Y) has been done with children. Work with infant and juvenile monkeys has shown depressed immune responses in those monkeys separated from their mothers or from their social groups (Coe, Rosenberg, Fischer, & Levine, 1987; Friedman, Coe, & Ershler, 1991). Similar results have been found with infant rats (Schleifer et al., 1986). However, the only known study of human children was on the effects of self-hypnosis on salivary immunoglobulin levels (Olness, Culbert, & Uden, 1989). Children who were specifically directed to increase immune substances in their saliva as part of the self-hypnosis protocol showed significantly increased salivary IgA levels. Children who were not specifically directed or who did not perform self-hypnosis showed no increase from pre-protocol levels.

While this is consistent with adult and animal studies indicating that psychosocial stressors/protectors (X) modify immune responses (Y), there has been even less research on the effects of individual differences in behavioral and emotional response to stressors (X), personality in particular, and immune responses (Y) in adults as well as children.

X-Y: Personality and Immune Responses

In fact, no studies of children exist which examine the role of temperament, or any aspect of personality, in immune responses to stress. The few adult studies of personality and immune response to stress are therefore briefly reviewed here (For a more critical review, see O'Leary, 1990). Studies using psychiatric symptoms and psychological states (such as depressed mood, loneliness and anxiety) rather than traits are not included since the focus here is on stable characteristics of the individual.

Optimistic/pessimistic explanatory style. Kamen-Siegel, Rodin, Seligman, and Dwyer (1991) examined the relationship of pessimistic explanatory style (the belief that negative events are caused by internal, stable and global factors) with immunocompetence in a sample of 26 older adults. They found that T-helper/suppressor count ratios and T-lymphocyte proliferative response to mitogen challenge were lower in individuals with a pessimistic style of explaining/responding to stressful negative events. This effect remained, even after removing the confounding effects of current health, depression, medication, recent weight change, sleep, and alcohol use. The authors found that pessimistic explanatory style was associated with increased T-suppressor cell percentages (explaining lower helper/suppressor ratios). They posited that this may be the mechanism through which explanatory style may influence immune competence because of the negative regulatory role of T-suppressor cells.

Locus of control. Kubitz, Peavey, and Moore (1986) examined the relationship of health locus of control with daily hassles stress and salivary immunoglobulin A (s-IgA) levels. Locus of control is a person's belief about the degree to which outcomes are generally under his or her own control (internal) or that of others or the environment (external). Those subjects with high stress and high internality had lower levels of s-IgA than those with low stress and high internality. The tendency to attribute one's stress to oneself rather than others may exacerbate the effects of stress.

Sieber et al. (1992) measured changes in natural killer (NK) cell activity and proportions of circulating T and NK lymphocyte subsets in adult males immediately after, 21 hours after, and 72 hours after exposure to a controllable or uncontrollable (noise) stressor. Subjects who perceived they had no control over the stressor showed reduced NK activity immediately after the conclusion of the first 20-minute stress session, and the effect was found as long as 72 hours later. Subjects with a greater need for internal control in this uncontrollable stressor group experienced even more reduction in NK activity.

Power/Affiliation Motivation. A small group of studies of motivational dispositions and immune responses to stress have been performed by Jemmott and colleagues and McClelland and colleagues. People whose power motive is strong display a strong need to affect or influence others, a need that is stronger than their need for affiliation with other people. Inhibited power motivation is characterized by a high level of self-restraint.

In a study of dental students by Jemmott, Borysenko, Borysenko, McClelland, Chapman, Meyer, and Benson (1983), those subjects characterized by high affiliation motivation experienced higher salivary immunoglobulin A (s-IgA) levels during the exam and non-exam periods. Students with inhibited power motivation experienced lowered s-IgA levels during exams, and these levels failed to recover after the period of stress. Similarly, McClelland and colleagues found in two separate studies (McClelland, Alexander, & Marks, 1982; McClelland, Floor, Davidson, & Saron,

1980) that subjects characterized by high power motivation and reporting high stress had lower s-IgA levels than the rest of the sample. They also found in another study (McClelland, Ross, & Patel, 1985) that students higher in power motivation had lower s-IgA levels than other subjects shortly after an exam, and lower levels than their own baselines. While there has been some controversy over the use of salivary IgA levels as measures of immune response, the results are consistently positive. Also, in an attempt to replicate the results with another immunologic index, Jemmott, Hellman, Locke, Kraus, Williams, and Valeri (1990) performed three studies of power motivation using serum Natural Killer cell measures. In all three studies, subjects exhibiting higher power motivation and greater stress had lower Natural Killer cell activity than their peers.

Repressive coping. Biondi and colleagues (cited in Biondi & Kotzalidis, 1990) found associations between tendencies to repression-denial (inattention to threatening material) in behavioral responses to stress, and depressed immune responses. Preoperative patients scoring high on repression-denial had lower serum lymphocyte proliferation to PHA mitogen and reduced E-rosette formation of antibodies to an antigen.

Jamner, Schwartz, and Leigh (1988) found repressive coping to be associated with decreased monocyte counts and increased eosinophil counts. The decreased monocyte counts indicate fewer cells available to respond to a potential infectious agent, but the meaning of the increased eosinophil counts is unclear. Also, Brown, O'Leary, and Murasko (as cited in O'Leary, 1990) found that repressive coping was associated with reduced lymphocyte response to mitogens in a geriatric population.

X-Y: Dissociation of Behavioral and Biological Responses to Stressors

Despite evidence of neuroanatomical and physiological connections with temperament and personality, studies have revealed only low to moderate statistical associations with immune responses. The old assumption was that there is a syndrome involving multiple physiological and behavioral events (i.e., a stress response) triggered as a nonspecific reaction to a range of environmental and emotional perturbations (Selye, 1950). This model was used in many studies of psychosocial stressors and modifiers on physiological responses, generating results indicating that a variety of stressors and modifiers are weakly to moderately associated with a variety of physiological responses. The weakness of these results have suggested a seeming dissociation (lack of a pattern) between behavioral and physiological measures. However, theories of specific physiological responses to specific behaviors in specific contexts have been found to be too simplistic (Gunnar, 1987; Kagan, 1992) and are not supported by the data (Lewis, Brooks, & Haviland, 1978). This raises the currently debated issue of whether behavior and biology are truly as closely linked as once thought.

Lewis, Brooks, and Haviland (1978) contend that if all response systems acted together in response to a stimulus, homeostasis would not be possible. Organisms need both to act and to stop acting. Thus in any response-producing situation, there is a competitive system: response synchrony or covariation for more efficient behavior, and response asynchrony for the termination of ongoing behavior (Lewis, Brooks, & Haviland, 1978). The context determines the amount of covariation: a low threat situation would produce less covariance (lower statistical association) between behavioral and physiological response sets, whereas extreme stress, which requires more efficiency of response, might produce more covariance between behavior and physiology.

A variety of studies seem to support this perspective (see reviews by Gunnar, 1987; Lewis, Brooks, and Haviland, 1978). In one of the few studies examining the dissociation issue relevant to **temperament** research, Gunnar (1992) found a larger association between temperament and cortisol levels in the fall than later that winter in a group of children starting preschool. Children scoring high on activity and low on fear (easier temperament) had the highest cortisol levels in the fall, but the lowest in the winter. Children scoring low on activity and high on fear (more difficult temperament) had lower cortisol levels in the fall which increased in the winter. The magnitude of the cortisol levels was smaller and the change in cortisol was much smaller for the more difficult children. Gunnar posits that perhaps this is a function of the amount of risk taking by the two different groups at different times. The high active/low fear group may be risking new contacts and new interactions sooner than the low active/high fear group that waits longer before taking a risk, and takes less of one. Thus the higher risk situation in the fall may have affected the correlation between temperament and cortisol levels.

Kagan (1992) offers a slightly different interpretation of results like Gunnar's

(1992). He contends that it is not that behavior and biology are less related in a given context but that conditions that are optimal for the psychologic phenomena of interest are not always optimal for provoking responsivity in the physiologic targets. He offers as one possible reason the observation that each system, whether behavioral or physiologic, is mediated by excitatory and inhibitory mechanisms that are often unique to that system. As a result, each biologic variable provides, at best, only partial information regarding the psychologic state. In addition, different metrics are applied to behavioral and physiologic measures. For example, the metrics of difficulty of temperament and change in serum cortisol levels are two incommensurable metrics which accentuate the lack of a one to one association.

Thus, Kagan (1992) contends that behavior and biology are not closely yoked outcomes of an abstract psychologic state but are loosely linked systems. As such, one cannot expect large statistical associations between only one measure of behavioral response and one measure of physiological response, but one should expect some relationship. It is too simplistic to expect one physiological measure to provide a certain or sure marker of psychological state (Bronson, 1987; Kagan, 1992). Instead multiple biologic measures from multiple physiologic systems should be assessed in order to more comprehensively document the impact of a psychologic construct such as temperament.

With this issue of dissociation in mind, studies are reviewed addressing all four categories of salient variables in the "causal" pathway between stress and infectious illness: psychosocial stressors and individual differences in behavioral and emotional response to stressors (X), immune responses to stress (Y), and infectious illness (Z).

X-Y-Z: The Effect of Psychosocial Stressors and Modifiers and Immune Response on Infectious Illness

To date there are very few prospective studies that address this causal pathway as a whole. As Boyce and Jemerin (1990) and Elliot and Eisdorfer (1982) maintain, such studies are necessary if the issues raised in this literature review ever hope to be resolved. The Kindergarten Health Project, which provides the data for this dissertation, is the first known study of this kind in children. Because even in adults there are so few applicable X-Y-Z studies, both state and trait measures of emotional and behavioral response to stressors are included in the review.

Glaser, Rice, Sheridan, Fertel, Stout, Speicher, Pinsky, Kotur, Post, Beck, and Kiecolt-Glaser (1987) followed 40 medical students during their first year of school for examination-related changes in both immune parameters and self-reported infectious illnesses. Those subjects who reported more distress (Y) during the examination periods (X) experienced significant declines in immune status (Y) (as measured by gamma interferon production and antibody titers to latent Epstein-Barr virus), and significant increases in the incidence of infections (Z), mostly upper respiratory infections.

Kemeny, Cohen, Zegans, and Conant (1989) followed 36 patients with recurrent genital herpes simplex virus (HSV) for six months. The relationships among stressful life experiences (chronic and acute), negative mood (anxiety, hostility, and depression), T-cell subsets, and subsequent HSV recurrences were examined. Stressful life experience (X) did not predict HSV recurrence but those subjects with more elevated depressive mood scores (X) over the six month study period had lower proportions of helper T and suppressor T cells (Y), and in the absence of other infections, higher rates of HSV recurrence (Z). The intercorellations of depressive mood, suppressor T cell levels and HSV recurrence suggested to the authors that suppressor T cell levels or an associated immunological parameter may mediate the relationship between depressed affect and herpes recurrence.

Cohen, Tyrrell, and Smith (1991), exposed 394 subjects by nasal inoculation to respiratory viruses, and then followed them for the presence of respiratory infections and clinical colds. "Psychological-stress" (X), a combination of the number of stressful life events in the previous year, "perceived stress," and negative affect, was found to predict both respiratory infection and clinical colds, even after a variety of confounders were accounted for. Personality variables, self-esteem, personal control, and introversion-extroversion did not predict illnesses, and did not interact with psychological stress. It is possible that combining stressors, perceived stress and negative affect in the measure of stress suppressed any possible effect of personality traits because differences in emotional response states are likely to be the product of one's personality traits.

White cell counts and total immunoglobulin levels were collected before the viral challenge as possible factors linking psychological stress and susceptibility to illness, but they were not associated with either psychological stress, personality, or virus induced respiratory infections or clinical colds. Cohen, Tyrrell, and Smith (1991) admit that the immune measures used were very general and were not necessarily responses to stress given the timing of their collection. They suggest that measures of "primary" immunity might be found to mediate stress and infection--perhaps T cell proliferation (Kemeny et al., 1989), or specific antibody response to a specific antigen (Glaser et al., 1987).

While the results of the above studies are not consistently clear, there does seem to be some preliminary support for the role of individual differences in emotional and possibly behavioral response to stressors as an important contributor in the path from stressors (X), via immune response to stress (Y), and infectious illness.

The Operationalization of Temperament

Individual differences in temperament have been of interest to writers and philosophers for centuries. Recent attempts to operationalize temperament have been motivated by the desire to identify more difficult children for medical/psychological interventions (Carey, 1972; Rutter et al., 1964). In lay use, temperament has come to mean the characteristic style of emotional and behavioral response of an individual in a variety of differing situations (Prior, 1992). Temperament researchers have been unable to agree on a strict definition of the concept. However their various biological and biosocial theories vary in degree rather than in kind (Prior, 1992). Thus, their lack of agreement on definition has not prevented, but has affected, operationalization of the temperament concept.

A difficulty in assessing the effect of temperament (X) on infectious illnesses (Z) is the fact that since the early operationalization of the temperament concept by Thomas and Chess and colleagues (Rutter et al., 1964; Thomas et al., 1963), how to best measure it has been the object of much debate. A variety of instruments rated by observers, parents or teachers have been developed, based on widely varying concepts of the nature and definition of temperament. It is this inconsistency and often failure to operationalize temperament adequately that may have contributed to the limited and sometimes negative findings of the earlier reviewed temperament and infectious illness studies.

The most common method of temperament measurement has been the administration of questionnaires rated by either parents or teachers. There is a lack of consensus over which rater is less biased and whose rating is more appropriate for specific outcomes such as school adjustment. However, there is some agreement that parents, mothers in particular, are the best informants on their child's behaviors and behavior patterns, since they know them best from repeated observations over long periods of time in natural settings (Prior, 1992).

No less than 12 different temperament scales have been used in research that was meant to be or has been applied to Kindergarten age children (Hubert, Wachs, Peters-Martin, & Gandour, 1982). These instruments vary widely in the degree to which they assess the original 9 components/dimensions of temperament from the New York Longitudinal Study (NYLS): Activity level, Rhythmicity, Approach/Withdrawal, Adaptability, Threshold of Responsiveness, Intensity of Reaction, Quality of Mood, Distractibility, and Persistence/Attention Span (Thomas et al., 1963).

Some of this variance is dependent on the age of the children to be studied and the developmental context of the study (Prior, 1992). Rhythmicity seems to be more applicable to newborns and infants than to preschool or school-age children (Kaiser, in press). Carey (1981) agrees that by three to seven years, rhythmicity has become unimportant, and observes that persistence and activity have assumed greater significance, particularly with teachers. Indeed, in a review of temperament studies of children entering Kindergarten or first grade, Martin (1989) notes that activity, distractibility and persistence are consistently predictive of adjustment to and success in school. Two separate studies by Ballantine and Klein (1989) and Klein (1982) both found approach/withdrawal to be predictive of adjustment to Kindergarten. Another two studies by Carey, Fox, and McDevitt (1977), and Slee (1986) both found adaptability to be predictive of adjustment to Kindergarten. Kyrios and Prior (1990) found that activity, quality of mood, and intensity combined into one factor and distractibility, persistence and rhythmicity combined into a second factor predicted the behavioral adjustment of 3-5 year olds to preschool/prekindergarten.

The other source of variance among the 12 instruments seems to result from differing foci among researchers: the general concept of temperament versus the specific concepts used to describe individual differences in behavior that together comprise temperament (i.e., some or one of the original 9 NYLS temperament

categories, or modified interpretations). However, Bates (1989) notes that negative emotionality (the negative end of quality of mood) is present in all schemes of temperament used to describe children, while the use of the other dimensions in temperament measurement is more dependent on the theoretical approach of the researcher.

Very few of the 12 questionnaires have been used more than once, having been tailored for the specific focus of a given study, and only one has standardized population scores. The Behavioral Style Questionnaire (BSQ) developed by McDevitt and Carey (1978), is unequivocally the most widely used questionnaire measure of temperament for the Kindergarten age child (Bates, 1989)[1].

A specific behavior based measure of temperament. The Behavioral Style Questionnaire (BSQ, McDevitt & Carey, 1978), designed for 3-7 year olds, contains 100 six point parent ratings indicating the frequency of specific behaviors. It yields nine continuous subscale scores for the nine NYLS dimensions of temperament. By asking for ratings of specific everyday behaviors and emotional responses rather than general perceptions of temperament dimensions, some measurement and response bias is avoided (Prior, 1992). However, the instrument has several limitations: it does not fully take into account the parent's social desirability in responding; its normative sample is white middle class and it may therefore may not account for

[1] For detailed, critical reviews of all available questionnaire measures of temperament, see Hubert, Wachs, Peters-Martin, and Gandour (1982), and Bates (1989).

social class and ethnic/cultural influences.

The dimension scores allow for examination of the unique relationships of each temperament dimension with an outcome. There are nine of these scores which would require nine separate variables in representing temperament: the nine scales do not sum to yield an actual temperament score.

The diagnostic cluster rating obtained from the BSQ yields one score representing temperament, rather than nine components of temperament. Using the nine continuous dimension scores, ratings of easy, difficult, slow to warm up, or intermediate temperament[2] are assigned to each child (McDevitt & Carey, 1978). This rating is clinically more expedient, yet it is severely statistically limited because it is categorical and because it is subjectively derived using population standard scores. Because of its statistical limitations and its designation for clinical diagnosis, few studies have employed it. Carey (1972) found that significantly more babies rated as difficult suffered from colic. Difficult infants also sustained more lacerations requiring sutures than easy infants and had more physician visits for illness or injury in the first two years than easy infants (Carey, 1981). Since these studies were of infants and toddlers, the ability of the BSQ diagnostic rating to predict health outcomes, particularly infectious illness, in Kindergarten age children is untested.

In more recent work Thomas and Chess (1982); Thomas, Chess and Korn

[2] The slow to warm up and intermediate categories are often combined into an intermediate category as recommended by Carey (1970, 1972).

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(1982); and Carey, Hegvik and McDevitt (1988) have all developed a continuous "index of difficulty" temperament score based on factor analysis of the nine BSQ dimension scores. A search of the relevant literature found no factor analyses of the BSQ except the one by Thomas, Chess and Korn (1982) and Thomas and Chess (1982), who developed the index of difficulty measure on 5 year olds using their parental interview on which the BSQ is based. This factor analysis yielded as the components of the one factor: Activity, Adaptability, Quality of Mood and Intensity (rather than Persistence as the above literature review indicated might be relevant to this age group). Thomas and Chess (1982) actually added in Rhythmicity "for good measure;" however, there was no appropriate theoretical justification and certainly no statistical justification for this addition.

The predictive validity of the BSQ index of difficulty measure has been tested in only two studies. Carey, Hegvik, and McDevitt (1988) found significant correlations between the index of difficulty score and later weight for height percentile gains (an index of obesity) of .22, .41, and .39 for three subsamples of four to five year olds followed for four years. These average to .34. Thomas and Chess (1982) found correlations between the index of difficulty score taken at five years old and four measures of later child and adult adjustment. The correlations were .11, .23, .19, and .58. These average to .28 and when only the child adjustment correlations of .11 (school) and .58 (home) are used, the average is .35.

The "index of difficulty" score satisfies some of the statistical concerns and desire for clinical expedience. While use of this method of temperament rating from the BSQ has been more limited, it the most promising of the three ratings of temperament derived from the BSQ. Its ability to predict health outcomes, particularly infectious illness, is untested.

Global perception based measures of temperament. The primary justification for attempting to measure temperament with global ratings is the desire for parsimony. If a few or even one question can take the place of a hundred-item questionnaire, then the simpler measure is preferable.

Trends toward simplifying and reducing the size of psychological measures in both the social support and life events literature bolster such a global rating approach toward temperament. Sarason, Sarason, Shearin, and Pierce (1987) found that a simple satisfaction score for social support was more effective in predicting various behavioral and medical outcomes than earlier bulky, complicated scores from larger measures. Skinner and Lei (1980) found that a simple sum of life events was just as predictive of health outcomes as the score weighted by additional distress ratings which requires more items on the questionnaire.

In addition to specific behavior ratings on a temperament questionnaire, Sanson, Prior, Garino, Oberklaid, and Sewell (1987) employed a global rating of temperament. Parents rated their child's temperament on a five point scale in comparison to the "average child." The continuous global rating did not correlate closely with the continuous, psychometrically derived profiles obtained through the complete temperament questionnaire. However, the global rating of temperament

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was at least as good at predicting parentally reported behavioral adjustment or maladjustment (Sanson, Prior, & Oberklaid, cited in Prior, 1992).

Similarly, Ratekin and Keogh (1992) gathered both maternal global perceptions of temperament and overall temperament ratings from quantitative item level ratings of a questionnaire. The two global perception statements--6 point scales of how easy and how difficult was the child--were combined and categorized by their score as difficult, intermediate and easy, in parallel to the diagnostic rating from the questionnaire. The global categorical temperament rating better predicted such outcomes as behavioral adjustment, while the specific behavior based categorical temperament rating better predicted school achievement.

With only two studies on record, the tentative conclusion is that global continuous and categorical measures of temperament may adequately predict parentally reported behavioral outcomes, but not externally assessed outcomes such as school achievement. However, no evidence is available on the prediction of health outcomes, let alone infectious illness, by global temperament measures.

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Rationale for the Study and Statement of the Problem

The first aim of this dissertation was to examine whether temperament predicted upper respiratory illnesses following Kindergarten entry. The second aim was to examine immunological responsivity to the stressor of starting Kindergarten as a possible biological mechanism mediating the effect of temperament on upper respiratory illnesses. The third aim was to compare the predictive validities of two parent reported temperament measures: the McDevitt and Carey (1978) Behavioral Style Questionnaire (BSQ); and global ratings of temperament developed for the study.

Aim 1

Entry into Kindergarten presents a child with a variety of psychosocial and microbiological challenges. Even among children previously enrolled in daycare or preschool, kindergarten entry represents an important and often stressful transition to a larger, busier, and more aversive social setting (Boyce, 1989). Also, even among children previously exposed to such infections in daycare, respiratory tract infections constitute the largest proportion of overall childhood morbidity in the primary school years, with a slight drop from 32% to 30% at six years (Boyce, 1989).

Thus, Kindergarten entry represents a significant environmental challenge to a child: a psychological challenge in the form of a new, and sometimes overwhelming, social milieu, and a biological challenge in the form of new pathogens and the diseases they produce, particularly respiratory infections. The work reviewed above indicates that experiences of psychosocial stressors (X) may undermine host

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resistance and, during a period of increased exposure to infectious pathogen, allow the emergence of biological disease processes (Z). The same review also indicates that this process is affected by individual differences in behavioral and emotional response to stressors (X).

Since Kindergarten entry is a normative stressor (X) common to every child, individual differences in emotional and behavioral responses to Kindergarten entry (X) become all the more important to examine in the relationship between stress and illness. The above literature review indicates that a child's temperament, his/her characteristic style of emotional and behavioral response in a variety of differing situations, is a likely candidate. In fact, studies have consistently demonstrated an association of some component of temperament with adjustment and achievement following Kindergarten entry (Carey, Fox, & McDevitt, 1977; Klein, 1982; Martin, 1989; Slee, 1986).

To date, there have been no studies of the effect of temperament on illness following Kindergarten entry. However, the above review does tentatively indicate an effect of temperament on illness in other contexts. The time lost to absence from illness disrupts the child's transition to Kindergarten and places the child at a disadvantage relative to the other children, both socially and academically. Determining whether a child's temperament affects the amount of infectious illness experienced during the period following Kindergarten entry may provide useful information for both parents and teachers. It may also contribute to our understanding of the consistent observations (discussed in the literature review) of a

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subgroup of children which bears the brunt of illness burden. Finally, it may also elucidate our understanding of the role of individual differences in behavioral and emotional response to stressors on the effect of stressors on illness incidence in children.

Aim 2

A major shortcoming in the previously reviewed studies of temperament on illness is that the authors failed to consider the possibility that the effects of temperament on physical illness, rather than being direct, may be mediated (accounted for) by biological mechanisms. For several reasons, physiological mechanisms need to be considered in any study of the effects of temperament on illness outcome. First, there is a growing consensus that the pattern of past behavioral research consistently finding only small relationships of personality factors to illness outcome is due to the neglect of individual biological differences in vulnerability to illness (Boyce, 1989; Boyce & Jemerin, 1990). In particular, a person's tendency to react to stressors/challenges in certain ways (e.g., temperament) may affect and/or be affected by his or her unique physiological ability to respond not only to external challenges but also to internal demands.

Second, since upper respiratory illnesses (e.g., colds, flus, ear infections) were the outcome of interest, the immune system is likely to be germane to the effects of temperament. Extrapolating from the previously reviewed adult studies on the effects of personality on immune response to stress, there is reason to believe that a child's temperament (X) may influence his/her immune response (Y) to stressors (X). Also,

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as indicated in the above review, when immune response (Y) is depressed by psychosocial stressors and modifiers, resistance to infection (Z) may be compromised.

Specifically, temperament may directly affect upper respiratory illnesses (URIs), but may also indirectly affect URIs via the immune system. Studying both in a model may give a more complete picture of temperament's role. Since asthma and pneumonia are illnesses (atopic and infectious) also connected with the immune system, it is entirely possible that had the studies reviewed above included measures of immune competence in their models of temperament and physical illness, their results could have been more positive.

In such a model of an indirect effect of temperament via the immune system, the total effect of temperament on URIs does not change from the model which simply examines the effect of temperament alone, but could now be more accurately shown to have both direct and indirect components. The direct effect of temperament on the outcome is lessened when the indirect effect via the mediator is also accounted for in a regression (Baron & Kenny, 1986). Specifically, temperament alone may have an effect on upper respiratory illnesses, but immune response, when added to the regression as the mediator, may show that temperament's effect on upper respiratory illnesses has both direct and indirect components. These add up to the effect seen when temperament alone is in the regression.

To measure a short term physiological response to stress (Y), immune

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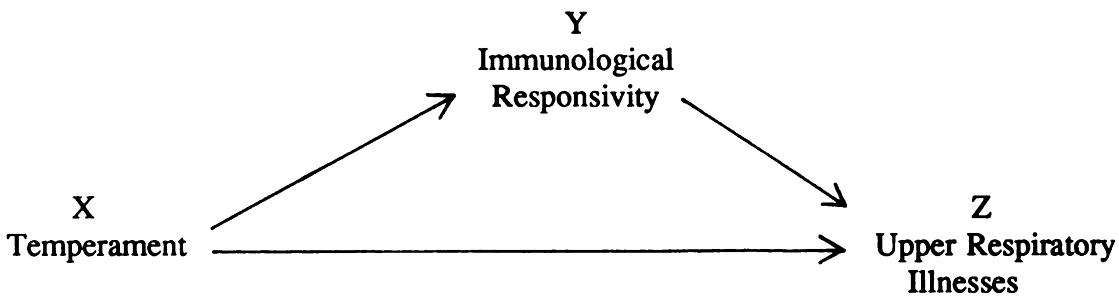
parameters from both before and after a stressor, in this case entering Kindergarten, were examined. This immunological responsivity[3] to the stress of Kindergarten entry was to be tested as a possible biological mechanism mediating the effect of temperament on upper respiratory illnesses (Figure 2).

FIGURE 2: Model of the Effects of Temperament and Immunological Responsivity on Upper Respiratory Illnesses



The possibility exists that it is not only the immunological responsivity of the individual but also the amount or frequency of exposure to new pathogens that mediates the effect of temperament on URIs. It follows that children who are more socially outgoing would be more likely to be exposed to new pathogens. Children who are more socially outgoing are also more likely to possess easier temperaments (Thomas & Chess, 1977). Thus, individual differences in social activity,[4] by being related to both temperament and URIs, may be an additional mediator of the effect of

[3] To be defined in methods section

[4] To be defined in methods section

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temperament on URIs. Since social activity may increase the chances of URIs and immunological responsivity may decrease the chances of URIs it is important to examine their potentially opposing effects together in the same model. This was to be pursued in corollary analyses.

Given the debate reviewed above over the dissociation of behavioral and biological responses to stressors, whether or not immunological mediation of the effects of temperament on URIs occurs is an important issue in temperament research. This needed to be examined as this issue has not been previously addressed in the temperament literature.

Aim 3

Since how temperament is measured affects how well one can statistically assess the effect of temperament on upper respiratory illnesses, it was important to compare some of the different temperament measures available that can be used with the Kindergarten-age child.

The "index of difficulty" score from the Behavioral Style Questionnaire (McDevitt & Carey, 1978) was to be used in this study for comparison with a global index of temperament, in testing which measures of temperament best predict upper respiratory illnesses. For completeness and comparison with previous literature, corollary analyses were to be performed using the diagnostic cluster score and the dimension scores from the BSQ, but they were not expected to be as useful.

Using the concept of global temperament ratings as employed by Sanson et al. (1987) and especially by Ratekin and Keogh (1992) in the above review, parental

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global perception temperament ratings were to be created for this study. Since starting Kindergarten is a change requiring adaptive behaviors, a global rating of the adaptability dimension of temperament would be obtained from parents. Parents would also be asked to make a global diagnostic rating (categorical) of their child's overall temperament ranging from easier to more difficult. A continuous global index of difficulty of temperament was also to be derived from parental global dimension responses. Thus, three global ratings parallel to the BSQ derived scores were to be created. As with the BSQ derived scores, the individual dimension and the overall diagnostic global ratings were less likely to be useful and were therefore to be examined only in corollary analyses.

By comparing the predictive validities of the global temperament ratings to the BSQ derived temperament scores, the study would address the issue of simplifying temperament measurement. Based on Ratekin and Keogh's (1992) findings, from whose measures these were developed, the continuous global rating of temperament may be almost as effective as the BSQ derived "index of difficulty" score in certain behavioral circumstances, but there is no evidence as to its ability to predict upper respiratory illnesses. These two different ways of measuring temperament may vary in their effectiveness in predicting illness outcomes, and this possibility needed to be examined.

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Hypotheses

Hypothesis I: Children with more "difficult"[5] temperaments will contract more upper respiratory illnesses in the three months following Kindergarten entry than children with "easier"[6] temperaments.

Hypothesis II: Immunological responsivity to the stress of starting Kindergarten will account for (mediate) the effect of temperament on upper respiratory illnesses.

Hypothesis III: The global index of temperament score developed for this study will predict upper respiratory illnesses as well as the "index of difficulty" score of the Behavioral Style Questionnaire.

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[5] To be defined in methods section

[6] To be defined in methods section.

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METHODS

Sample

Subjects were the 109 children (54 males and 55 females) who completed participation in the Kindergarten Health Project study (W. Thomas Boyce, P.I.) in three cohorts from 1989-1991. The final sample, after elimination of subjects with missing data, consisted of 97 children. These subjects were between age 4 years 8 months and 6 years 0 months, starting Kindergarten for the first time, all with previous daycare experience, and with no developmental disabilities or chronic illnesses. Recruitment was accomplished by television and newspaper community notices and by bulletins posted at the UCSF outpatient pediatric clinics. Both child and parent had to speak and comprehend English to participate.

Design and Procedure

Data collection occurred at three points: Time 1, approximately one week before starting Kindergarten; Time 2, approximately one week after starting Kindergarten; and during the three months after Kindergarten entry (when illness diaries were filled out biweekly). At Time 1 each child and parent came to the UCSF Division of Behavioral and Developmental Pediatrics research laboratory, where a blood sample was drawn from each child by venipuncture. Each child was also immunized with a .5 ml subcutaneous dose of 23-valent pneumococcal vaccine (Pneumovax), containing 25 micrograms of each type of pneumococcal polysaccharide (PPS). At Time 2, at least two weeks following Time 1 and within

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two weeks of starting Kindergarten, each child returned for a second, follow-up, blood sample by venipuncture. Blood samples totalling 7 mls were collected at both visits in vacuum tubes: 5 ml in the preservative ACD, 1 ml in the preservative EDTA, and 1 ml in silicon as a serum separator. These were kept at room temperature on a mixing rack, and were analyzed within 12 hours by the UCSF Pediatric Immunology Laboratory.

Table 1 identifies the measures examined in this study. All measures of temperament, social activity and demographics were obtained from questionnaires answered at Time 1 by parents while their children participated in a school readiness evaluation. Immunological responsivity was assessed based on the two blood samples taken at Time 1 and Time 2. Prior upper respiratory illnesses occurring in the four weeks preceding the study were reported by parents at Time 1. Post Kindergarten entry upper respiratory illnesses were monitored using illness diaries mailed biweekly, covering the period starting right after Time 2 and continuing through the third month after Kindergarten entry (5 diaries over 10 weeks).

Of the 109 subjects who originally enrolled, 12 had to be dropped: 11 were missing 3 or more of the illness diaries, and 1 was missing all measures of temperament. Based on this final sample size of 97, power calculations were carried out as described in Appendix F.

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TABLE 1: Study Design

	Time 1 (1 week prior to school entry)	Time 2 (1 week post school entry)	Time 3 (3 months post school entry)
1)Predictor Variables			
A)Temperament			
1)BSQ*	X		
2)global ratings	X		
2)Mediator/Mechanism Variables			
A)Immune Status			
1)T cell subsets (percentage CD4 CD8 & CD19 cells**)	X	X	
2)Lymphocyte response to mitogen stimulation (pokeweed [PWM])	X	X	
3)Serum antibody response to immunization by Pneumovax injection (PPS)	X(immunization)	X(serum IgG reaction) IgA IgM	
B)Social Activity	X		
3)Outcome			
A)Upper Respiratory Illness Incidence (from biweekly diaries)			X---X---X---X---X
4)Confounder Variables			
A)Prior Upper Respiratory Illnesses	X		

* BSQ = Behavioral Style Questionnaire

** CD4 = helper/inducer T cells, CD8 = suppressor/cytotoxic T cells
CD19 = T cell induced B cells

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Measurement of Variables

Temperament: Behavioral Style Questionnaire[7]

Temperament instruments tend to be targeted at specific age groups because of large developmental differences in the attentional and behavioral patterns that are characteristic of a child's temperament. The Behavioral Style Questionnaire (BSQ) by McDevitt and Carey (1978) for ages 3-7 is considered the most reliable and well tested questionnaire measure of parent-rated temperament for this age group (Bates, 1989; Hubert, Wachs, Peters-Martin, & Gandour, 1982). Teacher ratings of temperament were not possible because children had just started school and teachers need considerable familiarity with their students in order to make these ratings. Observer ratings were not possible because of their expensive, time consuming nature and because they might have been confounded by adjustment reactions to the stress of starting Kindergarten.

The test-retest reliability and internal consistency of the BSQ appear to be adequate (r = .89 and alpha = .84) and the questionnaire appears to show face validity with the measurement of temperament used in the New York Longitudinal Study from which Chess and Thomas developed the original operationalization of temperament (Thomas, Chess, & Birch, 1970). Also, the BSQ is the only temperament instrument for the Kindergarten age group to have standardized scores and to have been used unmodified in more than one study.

Parents responded to 100 6-point Likert scale statements in the BSQ about

[7] see Appendix A

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how often the child's recent and current behavior had been like the behavior described by each item. Certain questions were reverse scored and then items belonging to a given subscale were added together and divided by the number of items rated, producing nine subscale scores[8] for the BSQ (see McDevitt & Carey, 1978). The higher the subscale score, the more difficult was the child's behavior on that dimension. The BSQ subscale scores were then used to obtain two temperament indices: a continuous "index of difficulty" score and a categorical diagnostic cluster rating.

BSQ "index of difficulty". In this study, a modified version of Thomas and Chess' "index of difficulty"[9] score was used. There are actually two different statistical methods of obtaining a continuous index of difficulty score based on the nine subscale scores of the BSQ. Thomas, Chess and Korn (1982) and Thomas and Chess (1982) obtained their "index of difficulty" score by first factor analyzing all nine dimensions and simply summing or averaging together (statistically, the same) those dimension scores which loaded together on one factor. The higher the index score, the more difficult the child's overall temperament.

Carey, Hegvik and McDevitt (1988) used a different method. For six of the dimensions, they allotted 1 point to each dimension score on the difficult side of the mean and 2 points for each dimension score that was more than one standard

[8] To be used in corollary analyses

[9] To be used in primary analyses

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deviation beyond the difficult side of the mean. These points were then added together for their "index of difficulty" score.

The first method for creating the "index of difficulty" score is preferable because it equally weights each dimension identified by factor analysis. There seems to be no justification for differentially weighting different dimensions based on how far they are from the mean.

Our method paralleled the Thomas, Chess, and Korn (1982) method in that the nine subscale scores were factor analyzed using the Principal Components technique. However, instead of using raw scores, all subscale scores that loaded onto the obtained factor were standardized to create a uniform metric (an improvement over just using the raw scores). Those standardized subscale scores were then summed for the "index of difficulty" score.

BSQ diagnostic cluster rating. To determine whether the child was difficult, easy or slow to warm up, the diagnostic cluster rating[10] was calculated from six of the nine subscale scores by using the guidelines and standard sample means and standard deviations provided in the BSQ profile sheet[11]. Using these guidelines, subjects' subscale scores for six dimensions were compared to the standardized means and standard deviations. How often the child's subscale scores fell to the difficult or easy sides of the mean plus one standard deviation determined their diagnostic rating.

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[10] To be used in corollary analyses

[11] see Appendix B

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The major detraction is the categorical, rather than continuous nature of the rating. Statistically this is more limited because of the loss of variance. This can attenuate association with other variables as Kaiser (1993) found. There is also the issue of the usefulness and accuracy of the slow to warm up category which Ratekin and Keogh (1992) recommend be collapsed in with the Intermediate Low and Intermediate High categories (see BSQ profile sheet) to form an Intermediate category as suggested by Carey (1970, 1972). They found that numerically, there was little difference between these groupings on various outcomes. There is little in the literature to indicate the use or theoretical differentiation of these intermediate categories (only a mention in McDevitt and Carey (1978)), as the focus is on the easy versus difficult groupings.

Temperament: Global Ratings[12]

Three global ratings were used in this study: a rating of adaptability, ratings on eight global temperament dimensions to be combined for an index score, and an overall diagnostic rating. The ratings were developed by Ratekin and Keogh (1992) and have been used only in that study. No data are available on test-retest reliability. Comparison to the above three BSQ-derived measures indicates face validity, but with one important difference. The global ratings are based on the parent's overall impressions while the BSQ measures are based on the parent's ratings of specific behaviors. Preliminary evidence (Keogh, personal communication, 1992) indicates

[12] see Appendix C & D

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that when parents view their children globally, they tend to rate them "easier" than when rating their children based on specific behaviors. This is supported by Carey's (1970) clinical observations that mothers presented general impressions that markedly minimized the amount of difficulty they reported by questionnaire. Thus the global ratings may not correlate highly with the BSQ measures.

The global rating of adaptability[13] was the response on a 5 point Likert scale to the question, "How flexible is your child in new situations?" At face value, this seems to tap the same concept as the score derived from the twelve 6-point Likert items that compose the adaptability subscale of the BSQ.

A continuous global index of temperament[14] was developed for this study in order to create a global measure parallel to the BSQ index of difficulty. Parents rated their child, relative to children of equivalent age, on eight of the original temperament dimensions defined in lay terms by eight 8-point Likert scale items. For example, to the statement, "Adaptability--How easily initial reactions are modified in desired direction", parents responded in a range from 1 "Low in adaptability" to 8 "High in adaptability" (see appendix for the other seven). There are only 8 global dimension ratings because rhythmicity is excluded since in previous temperament research on preschool and young school age groups it consistently has the lowest reliability. It is often dropped in current temperament research because it is considered different from the other dimensions in that it taps the biological

[13] For use in corollary analyses

[14] For use in primary analyses

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rhythmicity of infancy rather than patterns of behavioral response and because it often drops out in a factor analysis.

The eight global dimension ratings were factor analyzed using the Principal Components technique, in parallel to Thomas, Chess, and Korn (1982), and in the same manner as the BSQ index of difficulty measure. All global dimension ratings that loaded onto the obtained factor were standardized to create a uniform metric. Those standardized global dimension ratings were then summed for the global index of temperament score in parallel with the BSQ index of difficulty score.

The last global rating was the parental response to "In general, the temperament of your child is:". This three-category global diagnostic rating[15] (easier than average, about average, or more difficult than average) has the same limited variability attributed to categorical variables as the diagnostic cluster rating derived from the BSQ. The advantage of this categorization is that children are ranked on a continuum from easier to more difficult (rather than assigning one of three unconnected diagnoses of easy, slow to warm up or difficult).

Immunological Responsivity

Immunological responsivity to the stress of starting Kindergarten was measured as change in immune parameters from Time 1 to Time 2. A variety of immune assays were performed as part of the larger Kindergarten Health project, and this study chose four indexes of cellular immunity and one index of humoral

[15] For use in corollary analyses

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immunity to examine immunological responsivity.

Immune parameters. The choice of which immune parameters to use was dictated by several criteria. Immunologists consider T and B cell counts to be reliable measures of cellular immunity and the change from one time period to another to be more easily attributable to intervening events (e.g., Kindergarten entry), because T and B cell counts are less susceptible to a number of spurious factors such as climbing a flight of stairs just before the blood draw. Lymphocyte proliferation response to mitogen stimulation is not as reliable and more likely to be affected by spurious factors. However, since it is a measure of T and B cell function rather than count, and it was already collected, it was thought useful to analyze it as an alternative aspect of cellular immunity in an exploratory corollary analysis.

Serum antibody response to immunization by Pneumovax injection was used an index of humoral immunity. This specific response to an immunization is considered a more reliable measure of humoral immune competence than general measures of antibody levels because a specific antibody response to a specific immunologic challenge yields more information about the influence of intervening events than non specific antibody levels. For example, simply measuring the change in Immunoglobulin class G antibodies over the two weeks between Time 1 and Time 2 would be less meaningful as an index of immunological responsivity because any one of a number of antigens or some combination of antigens acquired in a variety of manners could have triggered a production of this class of antibodies. Only the pneumococcal polysaccharides (PPS) present in the Pneumovax vaccine could have

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triggered the production of the antibodies specifically made to attach to the PPS antigens.

Assay methods. T and B cells were assayed at the UCSF Pediatric Immunology Laboratory by centrifuging a blood sample, then immunofluorescent staining the mononuclear cell fraction with T or B cell specific markers. The FACSAN cell sorter then counted the helper/inducer T cells (CD4), suppressor/cytotoxic T cells (CD8), and T cell induced B cells (CD19) as a percentage of all lymphocytes. The ratio of the helper/inducer count to the suppressor/cytotoxic count is often used to combine the CD4 and CD8 counts into one measure, but since a ratio is difficult to interpret and the change in a ratio even more difficult to interpret, the CD4 and CD8 counts were kept separate.

Lymphocyte proliferation response to mitogen stimulation reflects B cell function. The proliferation response was assayed by culturing the lymphocytes separated by centrifuge onto nutrient plates and then introducing the pokeweed (PWM) mitogens. The cultures were then labelled with tritiated Thymidine and harvested. Enumeration of lymphocytes was performed on the FACSCAN cell sorter. The response was measured by subtracting the original number cultured from the harvested number.

The antibody response to the Pneumovax antigen at Time 2 was measured from the production of pneumococcal polysaccharide (PPS) specific antibodies. Nutrient plates were coated with the PPS3 and PPS4 antigens and incubated. A 1:200 dilution of pre- and post-immunization serum samples was then added to the

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plates and incubated. The plates were then washed and incubated with goat anti-human IgG, IgA, or IgM markers. Optical density was read using the Biorad ELISA (Enzyme Linked ImmunoSorbent Assay) technique and mechanical reader, and the results were expressed as change in optical density between pre- and post-immunization samples. Any increase in optical density greater than .25 was considered a positive response, and antibody response scores were expressed as the number of positive responses out of six antibody assays (IgG, IgA, and IgM antibody to PPS3 and PPS4). PPS3 and PPS4 were selected because of type 3's ability to elicit a strong antibody response and because of type 4's ability to elicit a weaker antibody response. This combination provides a broad assay of type-specific antibody responses to the Pneumovax vaccine. The Pneumovax was chosen as the immunization because few children had already received this vaccine. (It is an expensive vaccine, normally reserved for children with chronic illnesses and other conditions that leave them at high risk from the pneumococcus bacteria. No child who had previously received this vaccine was accepted in the study.)

Residualized immunological responsivity scores. Since change scores are statistically unstable and difficult to interpret, residualized scores were used as the immunological responsivity measures of the T and B cell and mitogen assays. The Time 2 CD4 T cell count was regressed onto the Time 1 CD4 T cell count to yield a continuous residual CD4 count score. This was repeated for the Time 2 and Time 1 CD8 T cell counts, for the Time 2 and Time 1 CD19 B cell counts, and for the Time 2 and Time 1 PWM mitogen responses. These yielded residual CD8 and CD19

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count scores, and a residual PWM response score.

A residual score is the difference between the expected and the observed count at Time 2 (T2) as predicted by the count at Time 1 (T1). In mathematical terms the residual score is Time 2, minus the slope or regression coefficient (B_{21}) of the Time 2 on Time 1 regression line, times Time 1: $T2 - B_{21} X T1$. A simple change score is merely T2 - T1 where the slope or regression coefficient is incorrectly assumed to be 1. While it seems similar to a simple change score, the residual score does not make this faulty assumption, and therefore avoids the risk of spurious or attenuated correlations, lower reliability, and restriction of range often found with simple change scores (Cohen & Cohen, 1983).

The residual of the Time 2 on Time 1 T helper cell count (CD4) was chosen as the measure for primary analysis of immunological responsivity in the path model. The CD4 residual was chosen because a review of the psychoimmunology literature indicated that T helper cells are immune parameters frequently shown to be associated with psychosocial factors (Jemmot & Locke, 1984; Kiecolt-Glaser & Glaser, 1992). However, the use of one measure to reflect the immune system's responsivity may be too narrow a focus. An exploratory corollary analysis will also simultaneously examine in a path model several indices of cellular count (CD4, CD8, & CD19 residuals) and cellular function (PWM residual) and one index of humoral immunity (PPS response). This simultaneous use of immunological responsivity measures will provide a broader reflection of the role of immunological responsivity as a mediator of the effects of temperament on upper respiratory illnesses.

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Social Activity[16]

The social activity measure was obtained by adding the standardized scores from the parents' responses to two questions:[17] one, about the child's number of close friends and the other, about how often he/she sees them a week. This continuous variable is a reflection of the frequency of contacts with other children and therefore how much exposure to new pathogens the child may have received in Kindergarten.

Upper Respiratory Illnesses[18]

The incidence, duration and severity of upper respiratory illnesses (URIs) was obtained from a biweekly illness diary developed from the diaries and interviews used by Gold, Weiss, Tager, Segal, and Speizer (1989) and Tager and Speizer (1976). The diary documented the occurrences of a variety of respiratory symptoms, the duration of these symptoms, and the presence or absence of fever. While it was tailored for the Kindergarten Health Project, the diary seems to share face validity with other illness diaries (Boyce et al., 1977; Boyce, Chesterman, & Winkleby, 1990). These two referenced studies also had very high compliance levels with the biweekly, mailed questionnaire format.

Two upper respiratory illness measures were obtained from the diaries: the number of discrete upper respiratory illnesses for each child as reported by parents in

[16] For use in corollary analyses

[17] see Appendix D

[18] see Appendix E

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ten weeks worth of illness diaries (5 diaries); and the number of days sick with upper respiratory illness symptoms during the ten weeks. Using the Tecumseh Study of Illness guidelines (Monto, Napier, & Metzner, 1971), an upper respiratory illness incidence in a diary period was defined as the presence of one or more upper respiratory symptoms (nasal congestion, sore throat, hoarseness, ear pain, wheezing, cough, etc.) lasting for one or more days. The number of upper respiratory illnesses was then the sum of illness incidences for the five diaries over the ten weeks.

The number of days the above symptoms were present in each diary was summed over the five diaries to create the number of days sick with upper respiratory illnesses. The number of days sick has successfully been used in other research (Boyce, Chesterman, & Winkleby, 1990) and is appealing because it incorporates incidence and duration. However, it may not provide as accurate a measure as the number of discrete illnesses which only require the parent to remember whether or not the child was sick in the two week diary period, not for how many days. Therefore, whether or not to use the number of days sick as a measure of upper respiratory illness in the hypothesis testing analyses would be determined by preliminary frequency and correlation analyses.

The period between Time 1 and Time 2 was not included in the measurement of post Kindergarten upper respiratory illnesses. Respiratory illnesses occurring during this time could have confounded the immunological responsivity measures. That is, the illnesses experienced in the period between Time 1 and Time 2 could in effect have created the immune changes between Time 1 and Time 2. This possible

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confound was removed by using only the five illness diaries that started the day after Time 2, which occurred about one week after starting Kindergarten.

It is also possible that the immune changes from Time 1 to Time 2 could be correlated with the next illness diary as well, by incubating the illnesses which then occurred in the next diary period. This seemed likely to be a smaller, more indirect effect and there was a need to balance the concern over possible confounding with the loss of two weeks of outcome data, which could compromise variance. To evaluate this potential confound, a corollary analysis was planned which would utilize only the 4 illness diaries that started two weeks after Time 2. Thus only 8 rather than 10 weeks of illness diaries would be used in these corollary analyses.

Prior upper respiratory illnesses could have affected children's experiences of post Kindergarten URIs. This potential confound of the outcome was measured using the same illness diary format parents filled out starting after Time 2, but the instructions were altered to cover the 4 weeks preceding Time 1. As with the outcome variable, prior URIs were quantified both as the incidence of upper respiratory illness and the number of days sick.

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Data Analysis Plan

Hypothesis I: Children with more "difficult" temperaments will contract more upper respiratory illnesses in the three months following Kindergarten entry than children with "easier" temperaments.

Primary analysis. To test Hypothesis I, upper respiratory illnesses (URIs) were to be regressed onto temperament, with the effects of previous URIs and other potential confounders partialled out. This was to be accomplished by a hierarchical multiple regression where the first step would include previous URIs and any other variables, such as age and sex, identified by preliminary correlation analysis as significantly correlated with the outcome of upper respiratory illnesses. The second step would include the Behavioral Style Questionnaire (BSQ) "index of difficulty" score as the measure of temperament (the predictor).

In the primary analysis, the total number of upper respiratory illnesses over 10 weeks worth of diaries was to be the outcome variable. A power analysis found that the sample size of 97 was adequate to test this hierarchical regression (see Appendix F). In an exploratory corollary analysis, total URIs for 8 weeks would be substituted as the outcome.

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Hypothesis II: Immunological responsivity to the stress of starting Kindergarten will account for (mediate) the effect of temperament on upper respiratory illnesses.

Primary analysis. In testing the second hypothesis, one must first have decided how to properly examine the possible mediating effect of immunological responsivity. It seems to be a question of a simple hierarchical regression versus a path model. However, a path model is better suited for temporal and causal ordering of the independent variables and for the delineation of the mediation of the effects of temperament on respiratory illness by immunological responsivity (see Baron & Kenny, 1986).

A path model would be created by a series of multiple regressions. Step One of the path would include previous URIs (dependent), temperament, and demographic confounders (predictors). Previous URIs would be regressed onto the BSQ "index of difficulty" and demographic confounders such as age or sex all in one set. Step Two would include immunological responsivity [IR] (dependent), previous URIs, temperament, and demographic confounders (predictors). The T helper (CD4) residual would be regressed onto previous URIs, the BSQ "index of difficulty", and confounders such as age or sex all in one set. Step Three would include post Kindergarten URIs (dependent), immunological responsivity, previous URIs, temperament, and demographic confounders (predictors). The number of upper respiratory illnesses over 10 weeks of illness diaries would be regressed onto both the CD4 residual and the BSQ index, as well as previous URIs and confounders such

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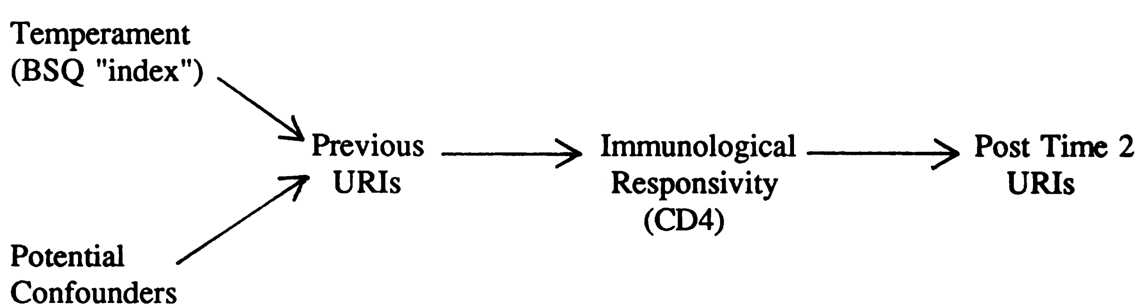
as age or sex all in one set. In this sequential path model the unique contribution of temperament as well as the potential mediating paths of immunological responsivity via temperament on respiratory illness would be elucidated (Figure 3). A power analysis found that the sample size of 97 was adequate to test this path model (see Appendix F).

FIGURE 3: Proposed Path Model of Temperament, Immunological Responsivity (IR) and Upper Respiratory Illnesses (URIs)



In this model, one would expect that adding immunological responsivity as a mediator would not increase the variance accounted for by the simple effect of temperament on URIs. If immunological responsivity did mediate the effect of temperament on URIs, the direct correlation of temperament to URIs would decrease by the amount of the indirect correlation via IR (Baron & Kenny, 1986). Thus the test of Hypothesis II would be whether the direct path of temperament to URIs decreases when the indirect path of temperament via immunological responsivity is included in the model.

Corollary analyses. A corollary analysis was to be performed to examine the usefulness of a more extensive approach to the question of immunological responsivity as a mediator of the effects of temperament. This would be done by examining simultaneously in one path model the CD4, CD8, CD19 and PWM residual scores and the antibody response to PPS, as a broader measure of immunological responsivity. The results of this corollary analysis would be discussed as exploratory in nature.

Another corollary analysis was to be performed exploring the possibility that social activity may also mediate the effect of temperament on URIs. This would be done by performing a parallel path analysis where social activity is substituted in the same step as immunological responsivity in the model. The results of this corollary analysis would be discussed as exploratory in nature.

Hypothesis III: The global index of temperament score developed for this study will predict upper respiratory illnesses as well as the "index of difficulty" score of the Behavioral Style Questionnaire.

Primary analysis. To test Hypothesis III, parallel analyses would be performed in which the global index of temperament score would be substituted for the "index of difficulty" score in the hierarchical regression used in Hypothesis I and in the path model used in Hypothesis II. The results of these two analyses would be compared with the two above to determine which continuous measure of temperament better predicted URIs.

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Corollary analyses. A set of corollary analyses would be performed exploring the discriminant validity of all six temperament measures by examining their bivariate relationships. Of particular interest is how the global ratings did or did not parallel the BSQ-derived measures. Finally, the predictive validity of the BSQ-derived "index of difficulty" score was to be compared with the BSQ-derived diagnostic cluster rating. This would be accomplished by partiling the continuous index measure into segments that parallel the distribution of easy, difficult and intermediate categories in the population. The standardized sample distributions identified by McDevitt and Carey (1978) and the sample distributions found by Ratekin and Keogh (1992) were used as guides: the upper sextile of the index score (17%) would become the difficult group; the middle halftile (50%) would become the intermediate group; and the lowest tertile (33%) would become the easy group. Of particular interest was whether the same children were identified as easy or difficult by the two different scoring techniques for the same questionnaire. The results of these corollary analyses would be discussed as exploratory in nature.

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RESULTS: FINAL SAMPLE AND OPERATIONALIZATION OF VARIABLES

Final Sample Characteristics

The average age for the final sample was 5 years 3 months, of whom 50 were male and 47 were female. The ethnic distribution of the sample was 66% Caucasian, 15.5% African American, 14.5% Asian, and 4% Hispanic. This distribution is not very representative of the Bay Area ethnic distribution, which is closer to 30% Caucasian, 30% Asian, and 20% Hispanic (but still about 20% African American). The requirement that parents and children be able to speak and comprehend English in order to answer the battery of questionnaires (parents) and participate in the school readiness evaluation paradigm (children) is probably the most salient reason for the underrepresentation in the sample by Asian and Hispanic groups. The sample distribution of health insurance coverage (used as a proxy for SES) was 50.5% in an HMO, 26% in Private Group insurance, 16.5% in MediCAL, and 7% with No coverage.

The following section describes the final operationalization of the temperament, immune and upper respiratory illness variables. This included the examination of frequency distributions of all variables in the study to determine normality and linearity and determine if transformations were necessary.

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TABLE 2

BSQ and GLOBAL Dimension (Subscale) Scores

BSQ N = 97	mean	s.d.	Range
ACTIVITY	3.54	.54	2.23 to 4.85
RHYTHMICITY	2.98	.56	1.78 to 4.56
APPROACH/WITHDRAW	3.06	.70	1.10 to 5.46
ADAPTABILITY	2.72	.58	1.17 to 4.58
INTENSITY	4.38	.63	2.33 to 5.58
QUALITY OF MOOD	3.33	.65	1.08 to 5.08
PERSISTENCE	2.84	.57	1.40 to 4.44
DISTRACTIBILITY	3.73	.64	2.40 to 5.50
SENSORY THRESHOLD	3.78	.53	2.46 to 5.00

GLOBAL N = 73	mean	s.d.	Range
ACTIVITY	6.04	1.23	1.00 to 8.00
APPROACH/WITHDRAW	3.99	1.52	1.00 to 8.00
ADAPTABILITY	3.14	1.32	1.00 to 8.00
INTENSITY	6.18	1.17	1.00 to 8.00
QUALITY OF MOOD	2.64	1.28	1.00 to 6.00
PERSISTENCE	2.89	1.32	1.00 to 7.00
DISTRACTIBILITY	3.78	1.39	1.00 to 7.00
SENSORY THRESHOLD	6.01	1.21	1.00 to 8.00

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Final Operationalization of Variables

Temperament: Behavioral Style Questionnaire[19]

The nine subscale scores[20] were normally distributed with the means and standard deviations in Table 2 very similar to those of the standard sample provided by McDevitt and Carey in their profile sheet[21] (1975).

As described in the methods section, to obtain the "index of difficulty"[22] score, a factor analysis using the Principal Components technique was conducted on the nine subscale scores. Their loadings onto one unrotated factor are displayed below in Table 3.

TABLE 3

Factor Loadings: 9 BSQ Dimensions on One Unrotated Factor

ACTIVITY	.64
RHYTHMICITY	.30
APPROACH/WITHDRAWAL	.36
ADAPTABILITY	.82
INTENSITY	.41
QUALITY OF MOOD	.82
PERSISTENCE	.46
DISTRACTIBILITY	-.15
SENSORY THRESHOLD	.07

[19] see Appendix

[20] To be used in corollary analyses

[21] see Appendix

[22] To be used in primary analyses

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Activity (.64), Adaptability (.82), Quality of Mood (.81), and Persistence (.46) were the four subscales to meet the criteria of .45 as the minimum factor loading for inclusion in the index of difficulty. This factor solution was confirmed with a Varimax rotation which yielded these same four subscales as the components of Factor I.

Our index of difficulty measure used only those four subscales identified above by factor analysis. The standardized item Chronbach's alpha for the scale was .69. For a principal components factor analysis, this just meets the .70 standard of acceptability. The four subscale scores were standardized and added together. The sum was then standardized again and converted to a T-score with a mean of 50 and a standard deviation of 10 in order to make the values more interpretable for the reader[23]. The values for this index of difficulty score are normally distributed, and range from 19 (least difficult) to 74 (most difficult).

The distribution of categories for the diagnostic cluster rating[24] was 34% Easy, 10.5% Slow to Warm Up (STWU), 17.5% Difficult, 27% Intermediate Low (IL) [inbetween easy and slow to warm up], and 11% Intermediate High (IH) [inbetween slow to warm up and difficult]. This distribution roughly matches that given by McDevitt and Carey (1975) as derived from their standard sample population: 34.3% Easy, 5.7% Slow to Warm Up, 12.6% Difficult, 34.5%

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[23] This technique, called T scoring, merely shifts the mean and standard deviation into a positive range, more easily interpretable, and does not affect the relationships between subjects for the variable.

[24] To be used in corollary analyses

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Intermediate Low, and 12.9% Intermediate High. When the intermediate and slow to warm up categories were collapsed together as Ratekin and Keogh (1992) advocate and as was discussed in the methods section, the distribution for our sample was 34% Easy, 48.5% Intermediate, and 17.5% Difficult. This compares favorably to Ratekin and Keogh's (1992) distribution, 39% Easy, 50% Intermediate (STWU, IL & IH), and 11% Difficult, using a modified version of the BSQ with normal early school age children.

Temperament: Global Ratings[25]

The global rating of adaptability[26] showed a maximum flexibility of 1 and a minimum flexibility of 5 (reverse scored to parallel the direction of the BSQ adaptability dimension). The Likert type item had a mean of 2 (moderately flexible) with a standard deviation of .9 and was normally distributed.

Because the following two global temperament measures were not collected in the first year of data collection, only 76 of the 97 subject's parents responded to the relevant questionnaire items.

As discussed in the methods section, the continuous global index of temperament[27] was created as a global measure parallel to the BSQ index of difficulty. Table 2 displays the means and standard deviations for the

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[25] see Appendix

[26] For use in corollary analyses

[27] For use in primary analyses

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response/dimension scores which were normally distributed. These scores were available for 73 of the 76 subjects, due to missing data for 3 subjects. The eight global dimension scores were factor analyzed using the Principal Components technique. Their loadings onto one unrotated factor are displayed below in Table 4.

TABLE 4

Factor Loadings: 8 Global Dimensions on One Unrotated Factor

ACTIVITY	-.52
APPROACH/WITHDRAWAL	.69
ADAPTABILITY	.41
INTENSITY	-.69
QUALITY OF MOOD	.52
PERSISTENCE	.48
DISTRACTIBILITY	-.06
SENSORY THRESHOLD	-.57

Six of the 8 dimensions loaded above .45 on the one unrotated factor: Activity (-.52), Approach/Withdrawal (.69), Intensity (-.69), Quality of Mood (.52), Persistence (.48), and Sensory Threshold (-.57), with only Distractibility and Adaptability dropping out. This was not confirmed with a Varimax rotation which yielded only Sensory Threshold, Approach/Withdrawal, Adaptability (which had not even loaded above .45 on the unrotated factor), and Quality of Mood as the components of Factor I. The unrotated factor loadings were still used as the criteria for the global index because it was imperative that the global measure be created in the same manner as the BSQ index in order to be as comparable as possible. The standardized item Chronbach's alpha for the six component scale was .63, which is

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lower than the BSQ index of difficulty alpha coefficient. The components were standardized and summed. The sum was then standardized again and converted to a T-score. The values of this global temperament rating are normally distributed with a range of 27 to 78.

The three category global diagnostic rating[28] was available for 74 of the 76 subjects due to missing data for 2 subjects. The distribution of global category ratings was 40% Easier than Average, 42% About Average, and 18% More Difficult than Average. This compares favorably to Ratekin and Keogh's (1992) findings using the same global categorical rating with normal early school age children (43% Easy, 45% Intermediate {Average}, and 12% Difficult).

Immunological Responsivity to the Stress of Starting Kindergarten

Because of laboratory problems, some blood samples were not assayed for all immune parameters. The following numbers of subjects were available for the different assays: 89 for helper/inducer T cell (CD4) counts, 89 for suppressor/cytotoxic T cell (CD8) counts, 88 for T dependent B cell (CD19) counts, 83 for pokeweed mitogen lymphocyte proliferation (PWM) response, and 89 for Pneumovax (PPS) response.

T and B cell counts were normally distributed for Time 1 CD4 and CD19 and Time 2 CD19 assays. Time 1 CD8 and Time 2 CD4 and CD8 counts were positively skewed in their distributions, with the means almost equal to the standard

[28] For use in corollary analyses

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deviations. This poisson like distribution must be transformed in order to meet assumptions of normality and linearity with other variables. Cohen and Cohen (1983) recommend square root transformations. After transformation, all Time 1 and Time 2 CD4, CD8 and CD19 counts were normally distributed.

The values for the T-scored CD4, CD8 and CD19 count residuals of Time 2 on Time 1 are normally distributed. The CD4 residual ranged from 24 to 93, the CD8 residual ranged from 30 to 113, and the CD19 residual ranged from 30 to 82 (Table 2).

Lymphocyte proliferation response to mitogen stimulation (PWM) for Time 1 was normally distributed. PWM response for Time 2 was positively skewed and was therefore square root transformed (Cohen & Cohen, 1983). The value for the T-scored PWM response residual of Time 2 on Time 1 is normally distributed and ranges from 35 to 86.

Serum antibody response to an immunization (the sum of positive responses by six Pneumovax specific antibody subclasses) was normally distributed with a mean number of positive responses of 3.5, ranging from 0 to 6.

Social Activity[29]

The two components of social activity, the child's number of close friends and how often a week he/she sees them, were both normally distributed. The mean score for number of friends was 2 (two or three close friends) ranging from 0 (none) to 3 (four or more). The mean score for how often he/she sees them was 1 (one or

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two times a week) ranging from 0 (less than 1) to 2 (three or more). Since the first component was missing for 2 subjects and the second component was missing for 5 subjects, the composite variable was only available for 92 of the 97 subjects. The T-scored social activity measure is normally distributed and ranges from 22 to 64.

Upper Respiratory Illnesses[30]

The total number of discrete upper respiratory illnesses (Total URIs) for ten and eight weeks were normally distributed. Total URIs for ten weeks had a mean number of 2.5 illnesses, a standard deviation of 1.4, and a range of 0 to 5. Total URIs for eight weeks had a mean number of 2 illnesses, a standard deviation of 1.3, and a range of 0 to 4.

The total number of days sick (Total Days Ill) with upper respiratory illness symptoms for both ten and eight weeks were positively skewed in their distributions. Cohen and Cohen (1983) note that time based variables, particularly those measuring a rare event in a restricted time frame, are more prone to give rise to non-linear relationships with other variables and recommend square root transformations. After square root transformation, Total Days Ill was also normally distributed. Total Days Ill for ten weeks had a mean of 3 days ill, a standard deviation of 1.8, and a range of 0 to 7. Total Days Ill for eight weeks had a mean of 2.6 days ill, a standard deviation of 1.7, and a range of 0 to 7.

As discussed in the methods section, preliminary frequency and correlation

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comparisons of Total Days Ill with Total URIs were performed. The results indicate that Total URIs may be the more reliable measure of upper respiratory illnesses for the analyses to follow. For Total URIs, 50 subjects are above or below one standard deviation from the mean, while for Total Days Ill only 30 subjects are above or below one standard deviation from the mean. This narrower distribution of values indicates that Total Days Ill suffers from more limited variance. This may have resulted in the attenuated correlation in comparison to Total URIs with the BSQ index of difficulty and the global index of temperament. As a result of these preliminary analyses, Total Days Ill was not used as a measure of upper respiratory illness in the hypothesis testing analyses.

Prior Upper Respiratory Illnesses[31].

The presence of prior upper respiratory illnesses (Previous URIs) in the four weeks prior to Time 1 was binomially distributed with a range of 0 to 1. However, the total number of days sick (Previous Days Ill) with upper respiratory illness symptoms was severely positively skewed in its distribution. Unfortunately, even after square root transformation, Previous Days Ill was still severely skewed in its distribution. So for this reason and the higher chance of recall error, Previous Days Ill was considered less reliable as a variable than Previous URIs.

Table 5 gives the frequency distributions for the final versions of all variables to be used in primary and corollary analyses of Hypotheses I, II, and III.

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[31] see Appendix

TABLE 5

Frequency Distributions for Independent and Dependent Variables used in Primary and Corollary Analyses of Hypotheses I, II , and III

Independent Variables	mean ± s.d.	Range
Child's Age in months	63.11 ± 4.09	56.00 to 72.00
Previous URIs	.40 ± .49	0 to 1
BSQ Adaptability Dimension	2.72 ± .58	1.17 to 4.58
BSQ Index of Difficulty	50.00 ± 10.00	19.02 to 74.14
Global Adaptability	2.08 ± .87	1 to 5
Global Index of Temperament (N=73)	50.00 ± 10.00	27.11 to 77.55
Immunological Responsivity:		
CD4 residual (N=89)	50.00 ± 10.00	24.41 to 93.05
CD8 residual (N=89)	50.00 ± 10.00	29.57 to 112.76
CD19 residual (N=88)	50.00 ± 10.00	29.72 to 82.31
PWM residual (N=83)	50.00 ± 10.00	34.95 to 86.00
PPS response (N=89) (Pneumovax)	3.46 ± 1.96	0 to 6
Social Activity	50.00 ± 10.00	21.82 to 63.96
Dependent Variables		
Total URIs over 10 weeks	2.49 ± 1.41	0.00 to 5.00
Total URIs over 8 weeks	1.97 ± 1.26	0.00 to 4.00

N = 97 unless otherwise noted.

RESULTS: DATA ANALYSIS

Hypothesis I: Children with more "difficult" temperaments will contract more upper respiratory illnesses in the three months following Kindergarten entry than children with "easier" temperaments.

Table 6 shows the bivariate associations of all potential confounder and predictor variables with outcome variables to be used in primary and corollary analyses of Hypotheses I. The preliminary correlations of potentially confounding demographic variables (see Table 6) revealed that only the child's age correlated with the outcome of total upper respiratory illnesses (Total URIs) in the 10 weeks after starting kindergarten ($r = -.21$, $p < .05$). Interestingly, previous upper respiratory illnesses (Previous URIs) did not correlate strongly enough to be significant ($r = .17$, $p = .11$), but because of its theoretical importance, it was included in the regression as the other confounder.

TABLE 6

Bivariate Relationships of Independent Variables with Dependent Variable, Total Number of Upper Respiratory Illnesses in 10 weeks (Total URIs), for Primary and Corollary Analyses of Hypotheses I and III

		Dependent Variable Total URIs
Potentially Confounding Independent Variables		
	Child's Age in months	**-.21***
	Child's Sex	.04
@	Child's Race	.13
@	Child's Health Insurance	.18
	Previous URIs	.17
Potentially Predicting Independent Variables		
Primary Analyses		
	BSQ Index of Difficulty	**.26****
	Global Index of Temperament (N=73)	.10
Corollary Analyses		
	BSQ Adaptability Dimension	.16
	Global Adaptability	.13
@	BSQ Diagnostic Cluster	.21
@	Global Diagnostic Rating (N=74)	.18

** $p < .01$; * $p < .05$. N = 97 unless otherwise noted.

@ The measure of association for the categorical variables with total URIs is eta, rather than the Pearson r used for the rest of the table.

Age and Previous URIs did not correlate with each other, so they could be entered together in Step 1 of the hierarchical regression for the removal of confounding variance from the outcome. The BSQ "index of difficulty" factor analysis derived score which was not correlated with age or Previous URIs, was correlated with Total URIs ($r = .26$, $p < .01$) and was entered in Step 2 of the hierarchical regression. The results of this regression are displayed in Table 7. The BSQ index of difficulty beta coefficient was .24, which was significant at $p < .05$, such that 6 percent of the variance in Total URIs was accounted for by the BSQ index measure. From these regression results, we can accept Hypothesis I that children with more difficult temperaments contracted more upper respiratory illnesses in the 10 weeks following Kindergarten entry[32].

[32] A corollary hierarchical regression was performed using as the outcome total upper respiratory illnesses from the last 8 rather than 10 weeks worth of diaries following kindergarten entry. The regression results were reduced in magnitude although still significant. An evaluation of the 8 week Total URIs variable suggested that this reduction in the regression was due to the reduced variance of a more restricted range and larger standard deviation. All further analyses will therefore use only the 10 week Total URIs measure.

TABLE 7

Primary Hypothesis I Hierarchical Multiple Regression
Predictor: BSQ "Index of Difficulty" Score
Dependent Variable: Total Number Upper Respiratory Illnesses

Regression Step	r	Beta	R^2 and F
Step 1			
Child's Age in months	-.21*	-.21*	
Previous URIs	.17	.17	
R^2 increment			.07
F			3.65*
Step 2			
BSQ Index of Difficulty	.26**	.24*	
R^2 increment			**.06**
F			**6.17***
Total R^2			**.13**
F			**4.62****
regression df			3
residual df			93

** $p < .01$; * $p < .05$. N = 97

In order to determine if the effect of the index of difficulty score on the number of upper respiratory illnesses was on a graded continuum or different for a difficult subgroup, the sample was divided into three index of difficulty score partiles: easy (lowest 33% of scores), intermediate (middle 50% of scores), and difficult (highest 17% of scores). This mimics the distribution found with the diagnostic cluster for this sample and in the literature (see above operationalization section, BSQ diagnostic cluster). A oneway analysis of variance using the least-significant difference test of multiple means comparisons found the following: the difficult group was significantly different ($p<.05$) in the mean number of URIs from both the easy (3.3 versus 2.2), and intermediate (3.3 versus 2.4) groups (Table 15). This indicates that a subgroup of more difficult children contracted more URIs.

<u>Post-Hoc Analysis</u>

As a post-hoc analysis, the four dimensions identified by the factor analysis as the components of the "index of difficulty" factor were examined individually. It was thought that their separate correlations with total upper respiratory illnesses might aid in understanding the behavioral mechanisms of the temperament with Total URIs relationship. The correlations with Total URIs for each dimension were: Activity, $\underline{r} = .20$ ($p = .05$); Adaptability, $\underline{r} = .16$ ($p = .13$); Quality of Mood, $\underline{r} = .26$ ($p = .01$); Persistence, $\underline{r} = .15$ ($p = .14$). The high factor loading of the Quality of Mood dimension (Table 3) and a correlation with Total URIs equal to the entire "index of difficulty" measure indicate a dominant role of Quality of Mood in the effect of temperament on Total URIs for this sample. To determine how much of the effect was due to Quality of Mood, it was substituted for the "index of difficulty" in the Hypothesis I hierarchical regression. The results were very similar to those in Table 7: beta for Quality of Mood was .25 ($p < .05$); R^2 change = .06 ($F = 6.67$, $p < .05$).

Hypothesis II: Immunological responsivity to the stress of starting Kindergarten will account for (mediate) the effect of temperament on upper respiratory illnesses.

As Table 8 demonstrates, no significant association (Pearson r) was found between any of the immunological responsivity (IR) variables and total upper respiratory illnesses (Total URIs).

TABLE 8

Bivariate Relationships of Independent Variables with Dependent Variable, Total Number of Upper Respiratory Illnesses in 10 weeks (Total URIs), for Primary and Corollary Analyses of Hypotheses II and III

Potentially Mediating Independent Variables	
Primary Analyses	Total URIs
Immunological Responsivity:	
CD4 residual (N=89)	-.01
CD8 residual (N=89)	-.09
CD19 residual (N=88)	-.06
PWM residual (N=83)	.07
PPS response (N=89) (Pneumovax)	-.06
Corollary Analyses	
Social Activity (N=85)	-.08

Also, no significant association (Pearson r) was found between the BSQ index of difficulty score and any of the Immunological Responsivity variables as Table 9 demonstrates.

TABLE 9

Bivariate Relationships of BSQ and Global Indexes with Immunological Responsivity (IR)

Individual IR Variables	BSQ Index of Difficulty	Global Index of Temperament
CD4 residual	-.11 (N=89)	.10 (N=66)
CD8 residual	-.07 (N=89)	-.17 (N=66)
CD19 residual	-.12 (N=88)	-.11 (N=65)
PWM residual	-.04 (N=83)	.07 (N=60)
PPS response (Pneumovax)	-.08 (N=89)	.08 (N=67)

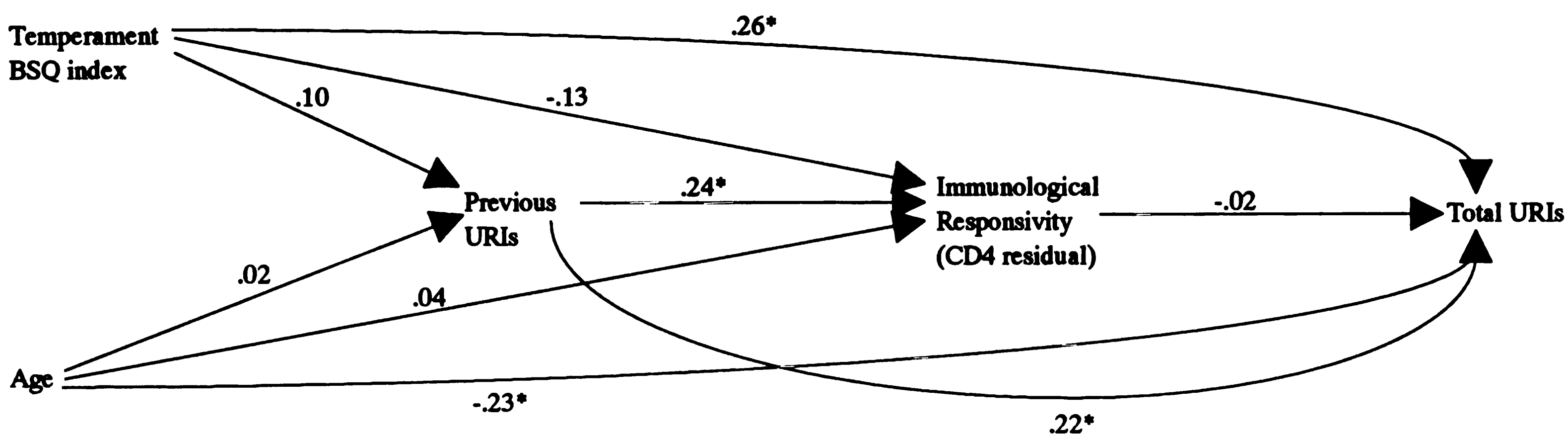
Despite the lack of significant association between the IR variables and either the temperament or URI variables, the path analysis was performed as planned in order to determine if the presence of the immunological responsivity variables in the model altered the effect of temperament on URIs. In the first step, Previous URIs was regressed onto both the BSQ index of difficulty score and the child's age. In the second step the chosen immunological responsivity (IR) variable, the helper/suppressor T cell (CD4) count residual, was regressed onto age, Previous URIs, and the BSQ index of difficulty. In the final step the number of total upper respiratory illnesses over 10 weeks of diaries (Total URIs) was regressed onto age, Previous URIs, the BSQ index of difficulty, and the CD4 IR. These three sequential multiple regressions, in the order as discussed in the methods section, provided the standardized regression coefficients (beta) that describe the strength of the paths between variables in the model.

Figure 4 displays the path model and the beta value paths. Four paths were significant and three of them were direct paths to total upper respiratory infections: the effect of age on Total URIs (beta = -.23, $p < .05$); the effect of the BSQ index of difficulty on Total URIs (beta = .26, $p < .05$); the effect of Previous URIs on CD4 immune responsivity (beta = .24, $p < .05$); and the effect of Previous URIs on Total URIs (beta = .22, $p < .05$).

Since the test of Hypothesis II is whether the direct path of temperament to upper respiratory illnesses decreases when the indirect path of temperament via immunological responsivity is included in the model, this path coefficient of .26 must be compared to the beta from Hypothesis I. Referring again to Table 7 in which the beta for BSQ index of difficulty with Total URIs is .24, there can be no claim of a decrease in the path of temperament with URIs when IR is included in the model. From these path analysis results, we <u>cannot</u> accept Hypothesis II. Immunological responsivity to the stress of starting Kindergarten <u>does not account for</u> (mediate) the effects of temperament on upper respiratory illnesses.

<u>FIGURE 4</u>

Primary Hypothesis II Path Model
The Effects of Temperament {BSQ Index}
and Immunological Responsivity {CD4 Residual}
on Total Upper Respiratory Illnesses {Total URIs}



** $p < .01$, * $p < .05$. Numbers represent standardized regression coefficients.

R^2 total = .19 ($F = 4.89$, $p < .01$) $N = 89$

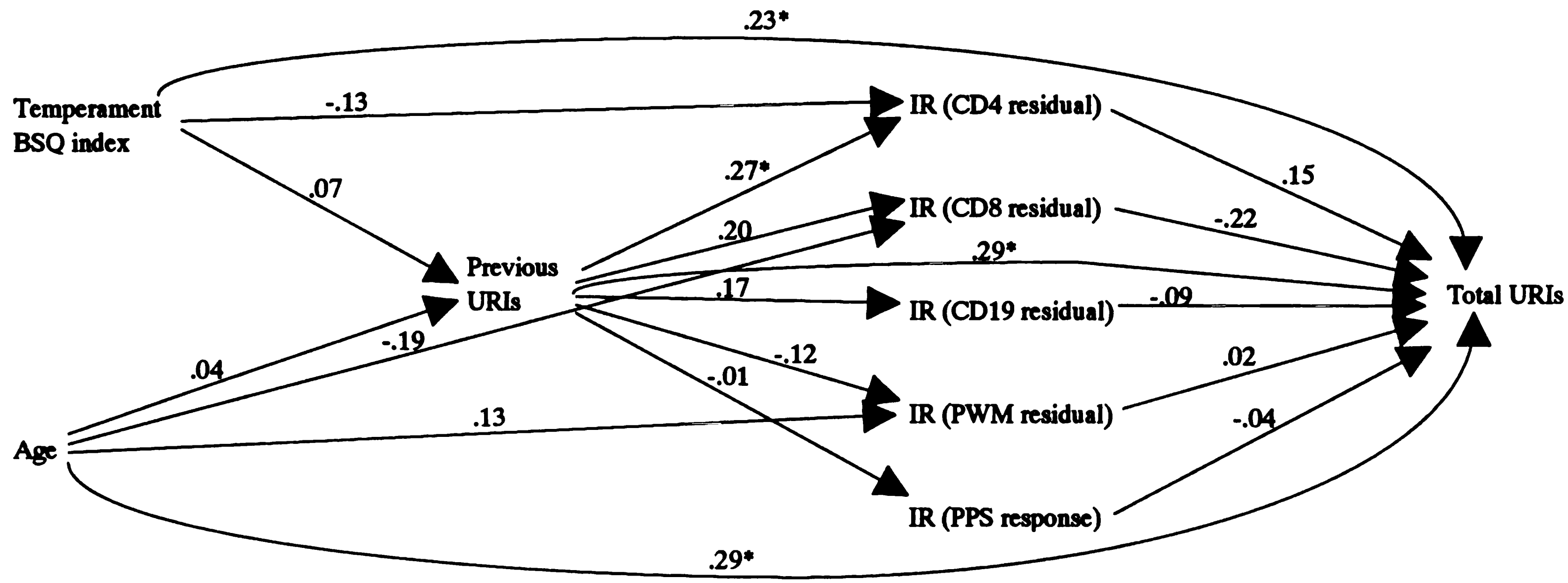
Corollary Analyses to Hypothesis II

All 5 immunological responsivity measures

It was clear from their correlations with Total URIs (Table 8) and from their correlations with BSQ index of difficulty (Table 9) that the remaining measures of immunological responsivity would not improve the path model if substituted individually for the CD4 residual. Instead, the path analysis was repeated substituting all 5 immunological responsivity measures for the single CD4 residual, in attempt to see if a broader representation of immunological responsivity (as discussed in the methods section) would improve the path model. As Figure 5 indicates, the total R^2 improved from .19 to .23 but the lack of mediation by the IR persisted as the direct effect of the BSQ index on URIs did not decrease (beta = .23). Referring again to Table 7 in which the beta for BSQ index of difficulty with Total URIs is .24, there can be no claim of a decrease in the path of temperament with URIs even when several indicators of immunological responsivity are included in the model. Immunological responsivity to the stress of starting Kindergarten does not account for (mediate) the effects of temperament on upper respiratory illnesses.

FIGURE 5

Corollary Hypothesis II Path Model
The Effects of Temperament {BSQ Index} and
Immunological Responsivity (IR) {CD4, CD8, CD19, PWM Residuals, & PPS Response}
on Total Upper Respiratory Illnesses {Total URIs}



** p < .01, * p < .05. Numbers represent standardized regression coefficients.

R^2 total = .23 (F = 2.60, p < .05) N = 77

Time 1 immune measures versus residuals

The focus of this study was on immunological responsivity as the mediator of the temperament-URI relationship. However, since results showed no relationship, an alternate conceptualization would suggest evaluating whether the immunological resting state (Time 1 assay) might be the measure to demonstrate a mediation effect. The Time 1 measure would be more reflective of the person's general immune status. Therefore, a corollary analysis investigated if the helper/suppressor T cell (CD4) count at Time 1 served as the mediator. However this possibility was not borne out. The correlation of CD4 Time 1 count with Total URIs was not much larger ($r = .10$, $p = .35$) than that of the CD4 residual ($r = -.01$, $p = .96$), and the correlation of CD4 Time 1 with BSQ index of difficulty was also not much larger ($r = .11$, $p = .28$) than that of the CD4 residual ($r = -.11$, $p = .30$). Because this lack of significant relationship was sufficient evidence that CD4 Time 1 was not a better mediator than CD4 IR, the path analysis was not repeated using the CD4 Time 1 measure.

Social activity

An additional corollary hypothesis was that social activity instead of immunological responsivity might mediate the effect of temperament on URIs. This is unlikely, as the low correlations of social activity with Total URIs ($r = -.08$, $p = .48$) in Table 8 and with the BSQ index of difficulty ($r = -.06$, $p = .54$) suggest. Because this lack of relationship was sufficient evidence that social activity does not mediate the effect of temperament on URIs, the path analysis was not repeated using social activity instead of immunological responsivity.

Post-Hoc Analysis: Moderation versus mediation

Since the hypothesis that immunological responsivity **mediates** the effects of temperament on upper respiratory illnesses was not substantiated in the primary analysis, and the possibility that other measures might be substituted as mediators was not substantiated in corollary analyses, the possibility of another mechanism needed to be explored. The possibility existed that immunological responsivity **moderates** the effects of temperament on upper respiratory illnesses. This would mean that the effect of temperament on Total URIs depends on the value of the IR measure (Cohen & Cohen, 1983). This is in contrast to a mediation effect where the total variance accounted for by the effect of temperament on URIs would not be increased by including IR in the model. The interaction of temperament and immunological responsivity would be a third variable that contributes to the variance accounted for in upper respiratory illnesses over and above any additive combination of their separate effects (Baron & Kenny, 1986). While this did not seem as biologically plausible as a mediation hypothesis, the possibility could not be overlooked.

Therefore a single hierarchical regression was performed, using the same variables as the primary path analysis. Age and Previous URIs were entered in the first step as confounders, BSQ index of difficulty in the second step as a potential main effect, and CD4 immunological responsivity in the third step also as a potential main effect. Then, in the fourth step of the same regression an interaction term was added which is the product of the BSQ index of difficulty and CD4 IR. The interaction term added less than 1% variance to the model (F = .61, p = .44). Because the interaction term did not significantly add to the model, the effect of temperament on Total URIs does not depend on the value of the IR measure. Immunological responsivity does not moderate the effect of temperament on upper respiratory illnesses.

Hypothesis III: The global index of temperament score developed for this study will predict upper respiratory illnesses as well as the "index of difficulty" score of the Behavioral Style Questionnaire.

Table 10 demonstrates a small, non-significant correlation of the BSQ index of difficulty score with the global index of temperament score (r = .20, p = .08), indicating an overlap of only 4 percent. It is therefore unlikely that the global measure will predict as well.

TABLE 10

Bivariate Relationships of BSQ with Global Temperament Measures

	BSQ Adaptability	BSQ Diagnostic Cluster	BSQ Index of Difficulty
Global Adaptability (N=97)	.31**	.24* (Eta)	.31**
Global Diagnostic Rating (N=74)	.42** (Eta)	.28* (Cramer's V)	.48** (Eta)
Global Index of Temperament (N=73)	.18	.28*	.20 (Eta)

** $p < .01$; * $p < .05$. Note that unless otherwise stated, the associations are measured by Pearson r correlations.

In fact, as Table 6 demonstrates, no significant association was found between the global index of temperament and total upper respiratory illnesses (Total URIs) ($r = .10$, $p = .38$). Also no significant association was found between the global index of temperament score and any of the Immunological Responsivity (IR) variables as Table 9 demonstrates. This lack of significant correlation made it unnecessary to substitute the global index of temperament for the BSQ "index of difficulty" in the regression used in Hypothesis I or in the path model used in Hypothesis II. It is clear from the correlations alone that the global index of temperament does not predict URIs as well as the BSQ index of difficulty, and is not mediated by immunological responsivity, so we cannot accept Hypothesis III.

Post-Hoc Analysis

The global index of temperament may not predict URIs as well as the BSQ index of difficulty because of a global rating bias. Preliminary evidence (Keogh, personal communication, 1992) indicates that parents view their children globally as "easier" than when they rate them based on specific behaviors. However, when the frequency distribution of the global index is compared to that of the BSQ index, 55% versus 52% of the sample (global versus BSQ) scored on the easy side of the mean, and 11% versus 19% (global versus BSQ) scored more than 1 standard deviation from the mean on the easy side. Also, when the global index is compared by crosstabulation to the BSQ index where both are broken into easy, intermediate, and difficult partiles (Table 11), the lack of agreement is confirmed (Cramer's $V = .17$, $p = .41$). However, the pattern of disagreement indicates no tendency for the global index to rate the child easier more often than the BSQ index. There is therefore no support for the claim that the parents are rating the children easier on the global index than on the BSQ index, just differently.

TABLE 11

Crosstabulation of BSQ Partiled Index of Difficulty Rating with Global Partiled Index of Temperament Rating

	Count Row pct Col pct	BSQ partiled index of difficulty easy tertile	intermediate halftile	difficult sextile	Row Total
Global partiled index	easy tertile	**8** **33.3** **34.8**	15 62.5 38.5	1 4.2 9.1	24 32.9
	inter-mediate halftile	12 32.4 52.2	**17** **45.9** **43.6**	8 21.6 72.7	37 50.7
	difficult sextile	3 25.0 13.0	7 58.3 17.9	**2** **16.7** **18.2**	12 16.4
	Column Total	23 31.5	39 53.4	11 15.1	73 100.0

Corollary Analyses to Hypothesis III

Discriminant validity of global and BSQ measures

Of particular interest is how the global ratings do or do not parallel the BSQ-derived measures, i.e., their discriminant validity. Table 10 gives the bivariate relationships of the BSQ ratings with the global ratings.

Especially noteworthy is the fact that the factor analysis derived global index of temperament associated only weakly to moderately with any of the BSQ measures, in particular the BSQ index of difficulty with which it was supposed to be parallel. Indeed, the global index of temperament also associated very weakly with the global diagnostic rating (eta = .02, $p = .99$). This was in marked contrast to association of the BSQ index of difficulty with the BSQ diagnostic cluster (eta = .65, $p < .001$).

Also noteworthy is the low association of the global and BSQ diagnostic ratings (Cramer's V = .28, $p < .05$). Despite a slightly higher association than that of the global and BSQ index scores, the kappa statistic of interrater agreement is only -.10. As Table 6 demonstrates, only one of the four remaining temperament measures approaches significance in its correlation with total respiratory illnesses, the BSQ-derived diagnostic cluster (eta = .21, $p = .13$). Also, Table 12 demonstrates that of the four remaining temperament measures only the BSQ diagnostic cluster rating has a significant association with one of the immunological responsivity variables, PPS response (eta = .41, $p < .001$). It is clear from these correlations alone that the other three temperament measures will not improve the regression used in Hypothesis I or the path model used in Hypothesis II.

TABLE 12

Bivariate Relationships of Corollary BSQ and Global Measures with Immunological Responsivity (IR)

Individual IR Variables	BSQ Adaptability	Global Adaptability	BSQ Diagnostic Cluster	Global Diagnostic Rating
CD4 residual	-.17 (N=89)	-.18 (N=89)	.20 (N=89)	.21 (N=67)
CD8 residual	-.14 (N=89)	-.15 (N=89)	.08 (N=89)	.26 (N=67)
CD19 residual	-.19 (N=88)	-.04 (N=88)	.16 (N=89)	.13 (N=66)
PWM residual	.01 (N=83)	-.05 (N=83)	.14 (N=83)	.14 (N=63)
PPS response (Pneumovax)	-.08 (N=89)	-.10 (N=89)	.41**(N=89)	.19 (N=68)

** $p < .01$; * $p < .05$.

Note that the first two columns are Pearson r correlations and the second two columns are eta. Eta does not give the direction of a relationship but only the degree to which the mean IR scores for each category vary from each other.

The BSQ diagnostic cluster rating had a moderate and significant correlation with the Pneumovax immunological responsivity measure (eta = .41, $p < .001$), a large correlation with the BSQ index measure (eta = .65, $p < .001$), and a small but not quite significant correlation with Total URIs (eta = .21, $p = .13$). To determine if the BSQ diagnostic cluster rating is as effective in predicting URIs as the BSQ index of difficulty score, corollary analyses substituted the BSQ diagnostic cluster rating for the BSQ index in both the Hypothesis I regression and the Hypothesis II path analysis.

Substitution of BSQ diagnostic in Hypothesis I

In order to accomplish this substitution of a categorical for a continuous variable in MRC, two contrast coded variables were created, representing the three categories of the BSQ diagnostic cluster. The first contrasted the intermediate group with the easy and difficult groups combined. The second (and the contrast of interest) contrasted the difficult group with the easy group. This set of two contrast coded variables represented the BSQ diagnostic cluster rating in the following regression analyses.

When the BSQ diagnostic cluster contrast set was substituted for the BSQ index of difficulty in the hierarchical step regression of Hypothesis I, it did not compare as favorably, as Table 13 demonstrates. Contrary to the results of Table 7, the diagnostic cluster contrasts both had non-significant beta coefficients of .03 ($p = .80$) for contrast 1 and .18 ($p = .08$) for contrast 2 and an R^2 increment = .03 ($F = 1.75$ $p = .18$). So, as had been posited in the methods section, the relationship with Total URIs was attenuated by the BSQ diagnostic cluster technique of temperament measurement.[33]

[33] Because the BSQ diagnostic cluster rating did not improve the Hypothesis I hierarchical regression, it was not substituted in the Hypothesis II path analysis. It was unlikely that the path model would be improved or changed in any way.

TABLE 13

Corollary Hypothesis I Hierarchical Multiple Regression
Predictor: BSQ Diagnostic Cluster Contrast Set
Dependent Variable: Total Number Upper Respiratory Illnesses

Regression Step	r	Beta	R^2 and F	
Step 1				
Child's Age in months	-.21*	-.21*		
Previous URIs	.17	.17		
R^2 increment			.07	
F			3.65*	
Step 2				
BSQ Diagnostic Cluster Set				
Contrast 1 (intermediate vs. easy/difficult)	.09	.03		
Contrast 2 (difficult vs. easy)	.20*	.18		
R^2 increment			**.03**	
F			**1.75**	
Total R^2			**.11**	
F			**2.73***	
regression df				4
residual df				92

** $p < .01$; * $p < .05$. N = 97

It also is interesting to note in Table 13 that the bivariate correlation of the difficult versus easy contrast with the outcome carries the bulk of the relationship of the diagnostic cluster with upper respiratory illnesses. This indicates that the effect of the diagnostic cluster rating on the number of URIs was largely via the difference between the difficult and easy groups.

In fact, a oneway analysis of variance using the least-significant difference test of multiple means comparisons found the following: the difficult group was different in the mean number of URIs from both the easy (2.9 versus 2.1), and intermediate (2.9 versus 2.6) subsets, but not significantly so. The BSQ diagnostic cluster identifies a subgroup of difficult children who contracted more URIs than the rest of the sample. However, the difference between the difficult and easy groups is not as dramatic as with the BSQ index of difficulty (see Table 15).

In light of the above comparison of the predictive validities of BSQ index of difficulty versus the BSQ diagnostic cluster, it would be particularly useful to understand how the two agree and disagree on the rating of difficult versus easy. When the association of the continuous BSQ index of difficulty with the categorical BSQ diagnostic cluster was calculated, eta = .65 ($eta^2 = .43$, $p < .001$), indicating some but not complete overlap. In order to make a more effective comparison, the BSQ index of difficulty was broken as before into the partiles which parallel the distribution as the BSQ diagnostic cluster: the top 17% of the scores denoting highest difficulty were categorized as difficult; the middle 50% of the scores denoting intermediate difficulty were categorized as intermediate; and the lowest 33% of the scores denoting least difficulty were categorized as easy. As the crosstabulation in Table 14 indicates, there is about 60 agreement on who is difficult and who is easy. In fact, the kappa statistic of interrater agreement is only .45, and the Cramer's V statistic of association between the two measures is only .50. The cells of the crosstabulation table indicate that most of the lack of agreement between the two BSQ scoring methods is between the easy and intermediate and the intermediate and difficulty ratings, with almost twice as many disputes between the easy and intermediate (20) as between the intermediate and difficult ratings (12). A case by case review of the two measures reveals no tendency for the BSQ diagnostic cluster to rate the child easier or difficult more often than the partiled BSQ index.

TABLE 14

Crosstabulation of BSQ Partiled Index of Difficulty Rating with BSQ Diagnostic Cluster Rating

BSQ diagnostic cluster	Count Row pct Col pct	BSQ partiled index of difficulty easy tertile	intermediate halftile	difficult sextile	Row Total
	easy	**22** **66.7** **68.8**	11 33.3 22.4		33 34.0
	inter-mediate	9 19.1 28.1	**32** **68.1** **65.3**	6 12.8 37.5	47 48.5
	difficult	1 5.9 3.1	6 35.3 12.2	**10** **58.8** **62.5**	17 17.5
	Column Total	32 33.0	49 50.5	16 16.5	97 100.0

Post-Hoc Analysis: Combined BSQ measure

The possibility arose from these comparisons of the BSQ diagnostic cluster rating with the BSQ index of difficulty score, that combining these two techniques from the same questionnaire might increase the accuracy of the measurement of temperament. Using more than one technique to identify the easy, intermediate, and especially the difficult subgroups might improve the relationship of the BSQ with upper respiratory illnesses, and therefore improve the ability to identify those truly difficult children at higher risk for upper respiratory illness after starting Kindergarten. From the crosstabulation in Table 14, a combined BSQ partiled index of difficulty and diagnostic cluster rating was created which identified as "truly" easy the 22 (22.7%) subjects identified as "easy" by the two separate measures. In the same manner, 10 (10.3%) subjects were identified as "truly" difficult, and 32 (33%) subjects were identified as "truly" intermediate. The four unmatched intermediate groups were combined along with the 1 disputed difficult/easy subject into an unmatched intermediate group of 33 (34%) subjects. Since there were 20 disputed "easy" subjects as opposed to 12 disputed "difficult" subjects, the unmatched intermediate group ranks somewhere between easy and truly intermediate. The mean URI counts for "truly" easy versus unmatched intermediate versus "truly" intermediate (2.0 versus 2.3 versus 2.7) seem to confirm this ranking.

As proposed, the correlation of this combined BSQ partiled index and diagnostic rating with the number of URIs improved from eta = .21 (n.s) for the diagnostic rating alone, and eta = .28 ($p < .05$) for the partiled index alone to eta = .36 ($p < .01$) for the four category combined measure. A oneway analysis of variance using the least-significant difference test of multiple means comparisons found the following. The difficult group was significantly different in the mean number of URIs from the easy (3.8 versus 2.0), intermediate (3.8 versus 2.7), and unmatched intermediate (3.8 versus 2.3) subsets. These results using the combined BSQ partiled index and diagnostic cluster rating even more clearly indicate the presence of a subgroup of truly difficult children who contracted more URIs than the rest of the sample. Rather than only 1 illness separating the easy and difficult groups as with the diagnostic cluster (2.1 vs 2.9) or partiled index (2.2 vs 3.3) alone, almost 2 illnesses separate the easy and difficult groups as identified by the combined measure (2.0 vs 3.8) as shown in Table 15. This translates into twice the risk of upper respiratory illness for the children with the most difficult versus the most easy temperaments.

Before substituting this combined BSQ partiled index and diagnostic rating in the Hypothesis I hierarchical regression and the Hypothesis II path analysis, the intermediate and unmatched intermediate groups were collapsed into one group of intermediates. This was done because the mean URIs for the two groups were so similar (2.7 vs 2.3), and because the group of interest was the difficult group rather than the intermediate or easy groups. The now three category combined BSQ rating identified 65 (67%) subjects as intermediate, 22 (22.7%) as easy, and 10 (10.3%) as difficult in temperament. The correlation with number of upper respiratory illnesses dropped only slightly from eta = .36 to eta = .34 ($p < .01$). As Table 15 demonstrates, this is still an improvement over the partiled index rating alone or the diagnostic cluster rating alone.

TABLE 15

Comparison of Three BSQ Temperament Rating Techniques
by Group Means and Correlations
with Number of Upper Respiratory Illnesses (Total URIs)

BSQ diagnostic cluster rating

Group	Mean Total URIs
1 "easy"	2.1
2 "intermediate"	2.6
3 "difficult"	2.9

Eta = .21 ($p = .13$)

BSQ partiled "index of difficulty" rating

Group	Mean Total URIs
1 "easy"	2.2*
2 "intermediate"	2.4*
3 "difficult"	3.3

Eta = .28 ($p < .05$)

Combined BSQ partiled "index" and diagnostic cluster rating

Group	Mean Total URIs
1 "easy"	2.0*
2 "intermediate"	2.5*
3 "difficult"	3.8

Eta = .34 ($p < .01$)

* Denotes Group mean significantly different from Group 3 mean at $p < .05$.

As with the BSQ diagnostic cluster rating, it was necessary to create two contrast coded variables representing the three categories of the combined BSQ index and diagnostic rating. The set of two contrast coded variables, intermediate versus easy and difficult, and difficult versus easy, represented the combined BSQ rating in the following regression analyses.

When the combined BSQ rating set was substituted for either the BSQ index of difficulty score or the BSQ diagnostic cluster rating in the hierarchical step regression of Hypothesis I, it compared quite favorably, as Table 16 demonstrates. The combined BSQ index and diagnostic contrast set had a non-significant beta coefficient of -.16 ($p = .10$) for contrast 1 and .34 ($p < .001$) for contrast 2, and a set R^2 increment = .11 ($F = 5.07$ $p < .01$). So, the relationship with Total URIs was improved by this method of temperament measurement and the variance in Total URIs accounted for by the combined BSQ partiled index and diagnostic cluster rating increased from .06 for the index alone (Table 7) and .03 for the diagnostic cluster alone (Table 13).

TABLE 16

Corollary Hypothesis I Hierarchical Multiple Regression
Predictor: Combined BSQ Index and Diagnostic Contrast Set
Dependent Variable: Total Number Upper Respiratory Illnesses

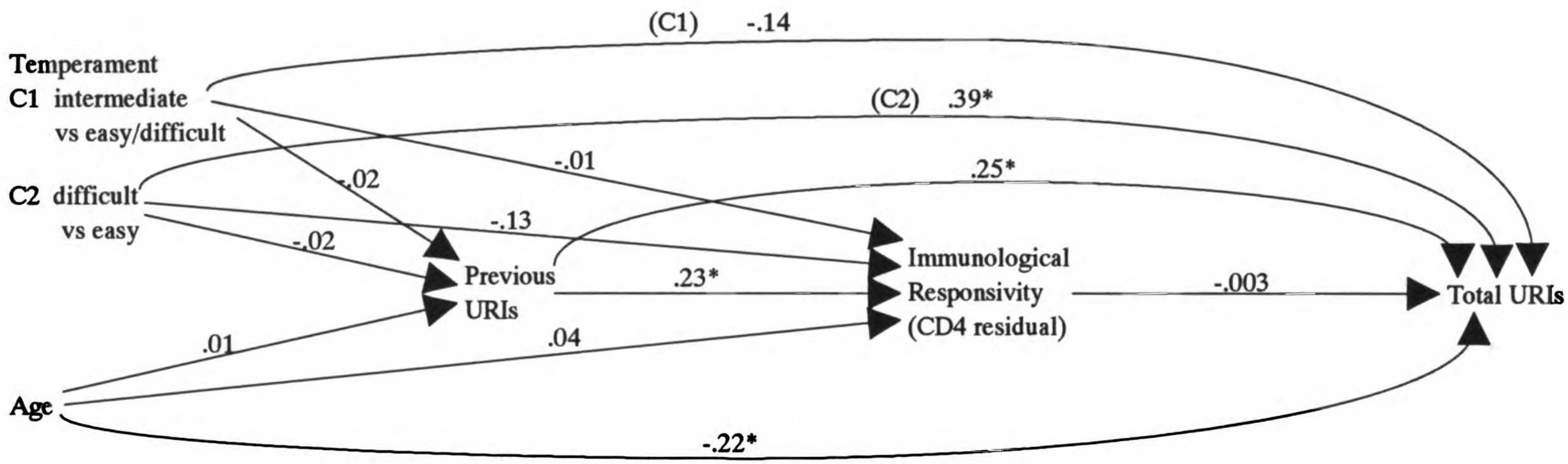
Regression Step	r	Beta	R^2 and F
Step 1			
Child's Age in months	-.21*	-.21*	
Previous URIs	.17	.17	
R^2 increment			.07
F			3.65*
Step 2			
combined BSQ index and diagnostic set			
Contrast 1 (intermediate vs. easy/difficult)	-.04	-.16	
Contrast 2 (difficult vs. easy)	.31**	.34**	
R^2 increment			**.11**
F			**6.11****
Total R^2			**.18**
F			**5.07****
regression df			4
residual df			92

** $p < .01$; * $p < .05$. N = 97

Because the combined BSQ partiled index and diagnostic cluster rating set did improve the Hypothesis I hierarchical regression, it was also substituted in the Hypothesis II path analysis. The total R^2 for both the path models using the CD4 IR measure alone and all 5 IR measures increased from .19 (BSQ index, Figure 4) to .26 and from .23 (BSQ index, Figure 5) to .28, because of the increased effect of the combined BSQ rating on Total URIs. However, as Figures 6 and 7 demonstrate, the lack of mediation by the immunological responsivity measures persisted. The temperament to URIs path coefficients for the model using only the CD4 IR measure were -.14 for Contrast 1 and .39 for Contrast 2 (Figure 6). These were compared to the betas from the corollary Hypothesis I analysis in Table 16 which were -.16 and .34 respectively. The temperament to URIs path coefficients for the model using all 5 IR measures were -.09 for Contrast 1 and .34 for Contrast 2 (Figure 7). These were also compared to the betas of -.16 and .34 respectively. Both path models make it clear that there can still be no claim of a decrease in the path of temperament with URIs when IR is included in the model. Even when using the more effective combined BSQ rating, immunological responsivity does not mediate the effect of temperament on upper respiratory illnesses.

FIGURE 6

Corollary Hypothesis II Path Model
The Effects of Temperament {Combined BSQ Index and Diagnostic Rating}
and Immunological Responsivity {CD4 Residual}
on Total Upper Respiratory Illnesses {Total URIs}

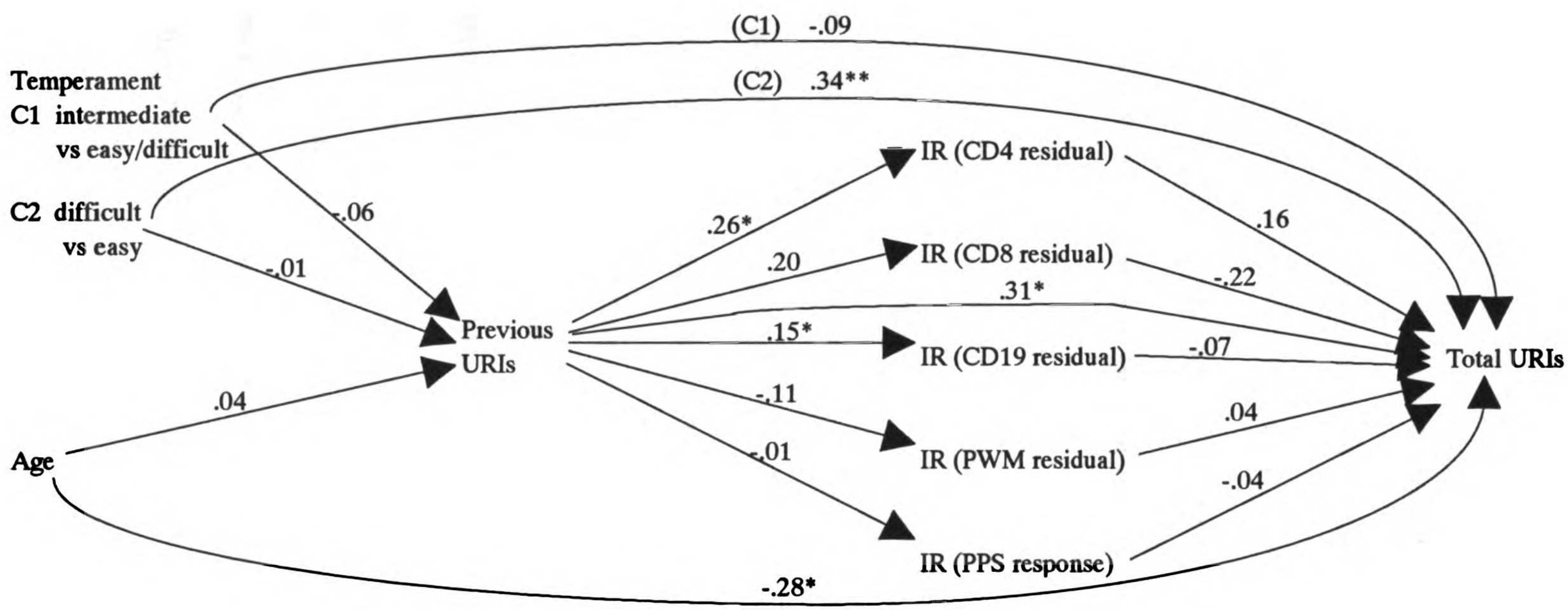


**** $p < .01$, * $p < .05$. Numbers represent standardized regression coefficients.**

R^2 total = .26 ($F = 5.92, p < .01$) N = 89

FIGURE 7

Corollary Hypothesis II Path Model
The Effects of Temperament {Combined BSQ Index and Diagnostic Rating}
Immunological Responsivity (IR) {CD4, CD8, CD19, PWM Residuals, & PPS Response}
on Total Upper Respiratory Illnesses {Total URIs}



** $p < .01$, * $p < .05$. Numbers represent standardized regression coefficients.

R^2 total = .28 ($F = 2.87, p < .01$) N = 77

DISCUSSION

Summary

The results indicate a moderate, but significant effect of temperament (as measured by the Behavioral Style Questionnaire [BSQ]) on the number of upper respiratory illnesses in the period following Kindergarten entry. Of the four dimensions of temperament found by factor analysis to comprise the BSQ "index of difficulty" measure (mood, adaptability, activity and persistence), negative mood is the most salient dimension in the effect of the measure on upper respiratory illnesses. Post-hoc comparisons reveal an identifiable subgroup of children with more difficult temperaments who experience significantly more illnesses than children with easier or intermediate temperaments. This effect is not mediated (or moderated) by this study's measures of immunological response to the stress of Kindergarten entry (changes in: CD4 and CD8 T cell counts, CD19 B cell counts, pokeweed mitogen induced lymphocyte proliferation response, and antibody response to the Pneumovax vaccine).

Post-hoc analyses also indicate that a measure of temperament which combines both the BSQ diagnostic cluster rating and the BSQ "index of difficulty" score similarly divided (into easy, intermediate and difficult) is more effective in predicting total upper respiratory illnesses than either method alone. The global measures of temperament were not found to be acceptable substitutes for the Behavioral Style Questionnaire measures. These findings have important implications for temperament research, the issue of the dissociation of behavioral

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responses and physiological responses, and temperament measurement.

Temperament Predicts Upper Respiratory Illnesses

This study presents the first known positive finding of an association of temperament with upper respiratory illnesses. Also, this is the first study of temperament and infectious illness following a normative stressor, and only the second study of temperament and infectious illness for any age group. This finding adds useful information to the very small group of studies examining the role of temperament in the etiology of physical illness outcomes. Individual differences in a child's characteristic temperamental style of behavioral and emotional response to the challenge of Kindergarten entry affect his/her incidence of upper respiratory illnesses during the first 10 weeks of the transition, even after the effects of age and previous upper respiratory illnesses are removed.

Although age has a significant effect on upper respiratory illnesses (URIs), age is neither correlated with the BSQ index of difficulty temperament measure, nor with recent patterns of exposure in social activity, nor with previous upper respiratory illness experience. Perhaps the effect of age is simply reflective of the fact that national statistics identify a decrease in the number of respiratory illnesses at 6 years. Given the linear association of age with URIs, this effect may constitute a gradient in which the 6 year old simply has had more chance to build immunological memory and is therefore susceptible to fewer of the pathogens encountered upon starting Kindergarten.

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Most importantly, despite the small effect size (7% of the variance in URIs), the results are clinically meaningful, with one illness separating the easiest and most difficult index of difficulty scores. Even one more illness sets a child behind the others, during a transition period when he/she can ill afford the lost time, and potentially exaggerates the effects of his/her temperamental disadvantage.

BSQ Index of Difficulty

The four dimensions that compose this sample's BSQ index of difficulty measure of temperament create a picture of emotions and behaviors consistent with those previously found to be associated with Kindergarten adjustment, thus supporting the construct validity of the measure. In this continuum of "difficulty," negative mood and adaptability figure most prominently (based on factor loading scores), together with high activity and nonpersistence. The more difficult child has more unfocused energy and activity, is more resistant to change and less comfortable in new situations, is more likely to become annoyed, angry or upset in a given situation, and is more easily frustrated at tasks or bored with play. The easier child (least difficult on the index continuum) presents behaviors which are not so much opposite those of the more difficult child, but rather are more moderate in their expression. The easier child is not necessarily less active but demonstrates less unfocused energy and activity, is more flexible in the face of change and more comfortable in new situations, and perhaps because of this flexibility and tolerance, is less likely to become annoyed, angry, or upset. The easier child is also less likely

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to become frustrated or bored because he/she tends to be more likely to stick with a task and to be able to occupy himself/herself for longer periods. This description of temperament seems developmentally appropriate for the age range of this sample and quite relevant to the task of adjusting to the Kindergarten environment.

There is only one difference between this study's factor analysis result and that of Thomas, Chess and Korn (1982). Their factor analysis identified Intensity rather than Persistence as the fourth dimension. As Table 3 demonstrates, the factor loading scores for Persistence and Intensity were .46 and .41 respectively, indicating that a small change in the sample could have shifted the loadings in favor of intensity. Given the proximate magnitude of the two loadings, this difference in factor analysis results seems minor and barely detracts from the apparent convergent validity of this study's "index of difficulty."

Most previous studies did not use factor analysis as a technique for identifying the salient aspects of the original temperament concept, and this may offer at least a partial explanation for the lack of consistency between temperament studies. Factor analysis is more objective than deciding post hoc which temperament dimensions/aspects are relevant to the sample based on their individual correlations with the outcome. An a priori choice of dimensions would have been preferable to a post-hoc decision. However, to produce the index of difficulty measure, it was necessary to employ a method similar to that of Thomas, Chess and Korn (1982). While their sample was the same age, the instrument from which the nine dimensions were drawn for factor analysis was the New York Longitudinal Study parental

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interview (Thomas, Chess, & Birch, 1968). Since this study used the Behavioral Style Questionnaire, it was necessary to repeat the factor analysis for this sample.

The four dimensions designated by this study's factor analysis are supported by previous studies and are almost identical to the Thomas, Chess and Korn (1982) factor analysis results. Nonetheless, it would be useful to use this study's factor analysis derived index of difficulty measure in another Kindergarten age sample to determine replicability. Use of this factor analysis derived index may lead to more uniform use of temperament measures and a more consistent developmental portrait of the combined pattern of the different temperament dimensions.

The finding that the Quality of Mood dimension accounts for most of the effect of the BSQ index measure of temperament on infectious illness is supported by the observation that "negative emotionality" is the only aspect of temperament that is consistently a component of all temperament measures (Bates, 1989). Individual differences in quality of mood (negative versus positive style of emotional response) affect the risk of infectious illness during adjustment to kindergarten. The mechanism by which this may occur was in part addressed by the test of immune mediation.

Immunological Responsivity Does Not Mediate the Effect of Temperament on Upper Respiratory Illnesses

The lack of mediation by the immune responsivity measures was the result of a lack of significant association with either temperament or upper respiratory illnesses. A reexamination of power using the reduced sample size available when

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immune measures were included, determined that sufficient power was still available to detect these bivariate associations. This study's immune responsivity measures were simply not associated with the index of difficulty measure of temperament and did not predict the number of upper respiratory illnesses. With insufficient power ruled out, several possible explanations remain for the lack of significant association between immune responsivity and either upper respiratory illnesses or temperament. These explanations will be discussed in two parts: 1) immune responsivity and upper respiratory illnesses; and 2) immune responsivity and temperament.

Immune responsivity and upper respiratory illnesses (Y-Z)

One explanation may be that a measure of "pre-stress" or steady state immune function is more predictive of upper respiratory illnesses than a measure of immune responsivity. Time 1 immune measures were taken pre-Kindergarten entry, presumedly at a time when the child's family situation and life event experiences were similar to those of the previous few months of the summer. However, the Time 1 immune measures were no more correlated with the number of post Kindergarten entry upper respiratory illnesses than were the immune responsivity measures.

Second, the immune responsivity measures reflect immune parameter change between Time 1 and Time 2, two weeks apart. Kindergarten entry occurred halfway through this interval. Was the one week following Kindergarten entry the optimal time period for measuring immunological response? Unfortunately, there is no consensus among immunologists on what time frame most effectively captures the

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immune response to stress. Previous studies have used widely differing time periods, depending on the experimental design. We simply do not know if the time between Kindergarten entry and measurement of Time 2 immune parameters was too long or not long enough. However, given that the stressors associated with Kindergarten entry persist over the first few weeks of school (i.e., meeting and forming new relationships with new children, learning to adjust to the structure and demands of the Kindergarten setting), it seems less likely that the time period was too long. Future studies, similar to ours, in which multiple measures are taken at a number of time points following a stressor may help to determine the optimal timing of the second measure.

Another possible explanation is that the child's anxiety about venipuncture affected the immune measures. That is, fear of venipuncture may have produced short-term immune changes at Time 1 and at Time 2, obscuring the actual immune values at those times. However, this argument is weakened by the fact that Time 1 measures were no more correlated with URIs than the Time 1 to Time 2 responsivity measures, and the Time 1 measures were less likely to have been affected by anxiety. For most children, the Time 1 venipuncture was their first venipuncture experience[34], reducing the likelihood that children experienced anticipatory anxiety at the Time 1 visit. Also, children were distracted with interesting tasks until the moment of venipuncture at the Time 1 visit. It is possible, however, that the Time 2

[34] In young children, blood samples are usually obtained by finger stick, applying a glass capillary tube to the site to siphon off a few drops of blood.

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immune measures were more influenced by anxiety about venipuncture, since children would have a recent memory of the experience, and could therefore be more anxious at the Time 2 visit.

It is also possible that the immune parameters chosen for this study were not the most appropriate ones to reflect susceptibility to upper respiratory illnesses. The immune parameters were chosen based on their use in previous studies and on an understanding of the typical immune system response to infectious agents (pathogens). However, virologists and immunologists cannot pinpoint the immune parameters most relevant to the prediction of infectious illness. The immune parameters utilized in this study represent a small slice of the immune system. Future studies using a broad spectrum of immune parameters may have a better chance at detecting whether there is a mediating effect of the immune response to stress on upper respiratory illnesses.

Finally, it is possible that the lack of an effect by immune responsivity measures on upper respiratory illnesses is due to a direct physiological effect of temperament on upper respiratory illness susceptibility that does not include the immune response. We know that patterns of autonomic nervous system (ANS) activation are different for "difficult" children (Healy, 1989; Kagan, Reznick, & Snidman, 1987). These differences in ANS activation in response to stressors may be the direct physiological mechanism by which temperament operates. There is no evidence to date on how such differences in ANS activation affect illness susceptibility. Future studies of temperament and illness should include autonomic

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nervous system measures in an attempt to explore and explain this possible mechanism.

Immune responsivity and temperament (X-Y)

The second part of the discussion of the lack of mediation by immune responsivity explores explanations for the lack of a significant association of immune responsivity with temperament. First, children who are more frequently ill may be rated as more difficult by their parents because of their illness related behaviors. This bias may create an artifactual relationship between temperament and URIs in which immune response is irrelevant. This has been and will probably always be an issue in research using parental reports of temperament. Several facts diminish this as a possibility in this study, the most important being that the effect of temperament on URIs persists even after previous URIs have been removed from the regression. Also, there is no significant association of the index of difficulty measure with previous URIs (r=.06, p=.54), both of which were assessed before post Kindergarten entry illnesses occurred. It is therefore unlikely that the lack of immune mediation of the temperament with upper respiratory illness association is an artifact of parental reporting bias on the Behavioral Style Questionnaire.

A second explanation is the possibility that the immune mediation exists, but is a subtle effect, difficult to measure because it is a step removed in the chain of physiological response to stress. Any response of the immune system to stress is the product of the primary neuroendocrine response to stress. For example, children

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with more difficult temperaments have demonstrated consistently higher cortisol levels, and chronic stress hormone release (adrenocortical hormones) may wear down the immune system's defenses against infection. It is possible that this study's measures of immune responsivity were not able to effectively capture the subtlety of the secondary nature of the immune mediation of the effect of temperament on URIs.

From Kagan's perspective (1992), this is because each immune response measure provides, at best, only partial information regarding the impact of temperament. Because biology and behavior are not closely yoked and because different metrics are applied to behavioral and physiologic measures, it is too simplistic to expect one immune measure to provide a certain or sure index of the effects of temperament. Thus, the small, non-significant correlation of the BSQ index with the CD4 T cell immune response ($r = -.15$, $p = .14$) may merely reflect the fact that only one immune parameter was used in the model, rather than indicating that there is no immune mediation. Kagan would claim (1992) that multiple measures of immune response are necessary to map the mediation effect by the immune system. However, this argument is weakened by the fact that all five immune responsivity measures together still did not improve the path model or indicate a mediation effect. If each immune response measure alone was an insufficient indicator of immune mediation, then the five together should have at least altered the direct effect of the BSQ index on URIs more than the one immune responsivity measure alone did, even if the alteration was not significant. This was not the case, as the direct path from the BSQ index to upper respiratory illnesses

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decreased by the same tiny, non-significant amount when all five immune response measures together were added to the model as when just one immune response measure was added.

However, these five immune response measures still represent a very narrow slice of the immune system, as immune researchers continue to develop assays of components and products of the immune system not commonly examined a few years before. Thus, it is possible that the addition of other immune measures not employed in this study (e.g., lymphokines, natural killer cells, neurohormonal binding to lymphocytes, and other functional measures) could have provided a broader representation of the immune system and could have better mapped its potential mediation effects.

A third explanation, from Lewis, Brooks, and Haviland's (1978) perspective, is that the lack of mediation means that the context of Kindergarten entry was not sufficiently stressful to engage both the behavioral mechanisms of temperament and the immune system, and to cause them to respond together (covary). Physiological homeostasis requires that response systems maintain only loose connections as part of a competitive biopsychosocial system which uses response synchrony or covariation for more efficient behavior, and response asynchrony for the termination of ongoing behavior. When there are low threat perturbations of the biopsychosocial system, all components may not respond in synchrony. Thus, only extreme stress which requires more efficiency of response, might produce more covariance between temperament and immune effects. Kindergarten entry may not have presented a

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great enough threat to the biopsychosocial system to produce extreme stress and greatly alter physiological homeostasis .

This is supported by the fact that Time 1 (pre-Kindergarten entry, supposedly a time of less stress) immune measures were even less correlated with temperament, and contributed even less to the path model than the Time 1 to Time 2 immune responsivity measures. From Lewis, Brooks, and Haviland's (1978) perspective, the less threatening the context, the less the immune response is associated with temperament. Thus the context of Kindergarten entry may not be sufficiently threatening to cause covariance in two loosely linked response systems. If the immune response does not covary with the behavioral mechanisms of temperament, it cannot mediate their effect on upper respiratory illnesses. This explanation is the only one that is in some way supported by the results.

Since temperament alone predicts upper respiratory illnesses, it is important to explore the potential mechanisms of the effect of the BSQ index of difficulty measure on upper respiratory illnesses. As discussed above, temperament may have a direct physiological effect as a result of differences in autonomic nervous system response patterns, or it may be mediated by components of the immune system not examined in this study. While this study did not collect data pertinent to these explanations, the data do indicate an additional or possibly alternative explanation of a behavioral mechanism of temperament. The dominant role of quality of mood in the index of difficulty composite may lie behind a behavioral mechanism. Children whose style of emotional response is more negative are more easily distraught, more

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easily angered, and more emotionally fragile when sick, tired, or confronted. It follows that these children may find the socially and developmentally challenging transition of kindergarten entry more overwhelming, and would be more driven to seek comfort and/or contact with others, both teachers and classmates. This pattern of behavior in which the more difficult child makes more frequent, and sometimes more physically aggressive contact with others during Kindergarten would greatly increase pathogen exposure. This would in turn increase the risk of infectious illness by simply increasing the chance of encountering a pathogen to which the immune system has not been previously exposed. While these behaviors were not examined in this study, other studies of temperament and adjustment to Kindergarten have found a higher frequency of maladjusted behaviors in more difficult children, including disruptive, attention getting behaviors.

The focus in stress and health research on biobehavioral mechanisms makes it important to replicate the negative finding of no immune mediation of the effect of temperament on upper respiratory illnesses. First, it is important to substantiate the conclusion that the context of Kindergarten entry is insufficiently stressful to cause covariance of immune responses with temperament. Second, the possible behavioral mechanism of temperament's effect on upper respiratory illnesses needs to be elucidated by observing behaviors <u>in Kindergarten</u> during the post entry period that might increase exposure to pathogens. Third, the possible physiological mechanism of temperament via differential autonomic nervous system response patterns needs to be examined at the same time as the behavioral mechanism, in order to evaluate not

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only whether the physiological mechanism exists but also whether it co-exists with a behavioral mechanism. Fourth, examination of the effect of immune response and temperament on upper respiratory illnesses should be attempted in several stressor contexts. For example, children and their families affected by natural disaster or family crises might be followed for their illness experience. Fifth, the possibility must be explored, in further research, that a broader spectrum of immune measures, assessed at several rather than just one post-stressor point, may yet indicate immune mediation of the effect of temperament.

Global Index of Temperament Versus BSQ Index of Difficulty

There are a variety of possible explanations for the fact that the global index of temperament is clearly not as predictive as the BSQ index of difficulty score. For one, the global index is composed of global perceptions of aspects of the child's personality/behavior patterns rather than items recalling specific component behaviors. While this did not affect Ratekin and Keogh's (1992) ability to predict behavioral adjustment, it may have affected our ability to predict upper respiratory illnesses. Also, the BSQ index is not correlated with previous illness but the global index is ($r = -.23$, $p < .05$), suggesting that the global perceptions of temperament were more colored by recent events and less reflective of the consistency and patterns in the child's temperament.

These differences may contribute to or are reflected in the differences between the BSQ and global index factor analyses. Visibly absent from the global

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index is Adaptability, which only loaded .40 in that factor analysis yet shares the highest loading with the mood dimension on the BSQ index, and which is theoretically and clinically considered a relevant dimension of temperament both developmentally and chronologically (age of Kindergarten entry). Also, the inability of a factor rotation to confirm the dimensions of the global index temperament score indicates that it is less clearly defined and structured. Finally, the lower factor loadings and lower internal consistency score indicate that the global index is not as reliable a measure as the BSQ index.

Of the six global dimensions which make up the global index factor, three had negative loadings, unlike the BSQ index on which all four were positive. This indicates that in global ratings parents do not place the same emphasis as they do in specific behavior responses on three of the original temperament dimensions: activity level, threshold for stimulus response, and intensity of response to stimulus. They do, however, share with the BSQ index concerns over quality of mood and persistence, dimensions relevant to parental concerns over behavioral adjustment.

It also appears that on the diagnostic ratings of temperament, "difficult" means something different for parents than for clinicians. This is evident in the lack of agreement between the global diagnostic rating and the BSQ diagnostic cluster rating. There was no tendency for the global diagnostic rating to designate a child as "easy" more frequently than the BSQ diagnostic cluster rating, indicating that the global measure at least does not demonstrate any more social desirability bias than the BSQ derived measure.

In conclusion, the global index measure of temperament, in comparison to the BSQ index of difficulty, seems to suffer from lack of convergent validity, and lower reliability. Neither the global index score nor the global diagnostic rating categorize a greater a number of children as "easy" than their BSQ counterparts, but they suffer from poor construct validity and are far less useful in their prediction of upper respiratory illnesses. Global perceptions of temperament are likely to be less effective in predicting any illness or illness-related outcome.

BSQ: Index of Difficulty Versus Diagnostic Cluster Rating

These two measures' lack of agreement on who is difficult and who is easy presents a dilemma, because in all other respects the diagnostic cluster is simply a lesser but still parallel measure to the index of difficulty. Yet, by using more than one measure to identify the difficult, easy and intermediate child, we have created an even more effective measure. Since measurement error is unique to each method, identifying as "truly" difficult only those children rated as difficult by both methods may reduce measurement error. In fact, for children categorized as difficult by both methods, the risk of upper respiratory illness increases from 1.5 to 2.0. The "truly" difficult children averaged 2 more illnesses than the easy children (as opposed to only 1 more illness with just the index of difficulty measure). This makes all the more dramatic the effect of temperament on upper respiratory illnesses in the 10 weeks following Kindergarten entry. Two more illnesses is an even more devastating setback during a challenging transition, where lost time potentially exaggerates the effects of his/her temperamental disadvantage.

This two pronged approach to identifying those children whose temperament places them most at risk for upper respiratory illnesses is appealing because of its increased effectiveness. Since this technique has not been previously used with the Behavioral Style Questionnaire or with any questionnaire measure of temperament, the results need to be replicated. However, the prospect of being able to more accurately assess temperament and more effectively identify those children at risk for physical illness is likely to interest both clinicians and researchers.

Conclusion

The temptation to draw conclusions from this study's results for purposes of intervention is a compelling one. This is due partly to the knowledge that the original operationalization of temperament was for purposes of clinical intervention with both parents and child. It is also due to the very clinically meaningful differences in risk of upper respiratory illness following Kindergarten entry between those children identified as difficult and those identified as easy and intermediate. However, interventions are difficult to design, expensive to undertake, and tend to have only limited success, particularly when the focus is on changing stable, characteristic patterns of behavior.

The common conclusion by most temperament researchers that more research is needed before interventions can be developed must unfortunately be echoed here. This does not diminish the importance of this study's findings and conclusions, and their contribution to our understanding of the role of temperament in stress and health. A child's temperament has a clinically and statistically meaningful impact on his/her risk of upper respiratory illnesses in the 10 weeks following Kindergarten entry. While the mechanism of this effect remains unclear, it is possible that it may have a behavioral base, driven largely by a child's tendency to respond to events with a negative or positive mood. Without attempting to resolve the hotly debated issue of the genetic versus environmental basis of temperament, these results indicate a need for careful research on how negative mood can be accommodated and/or channeled in the classroom. If it is possible to reduce a child's need to respond negatively to an event, it may be possible to temper the difficult child's risk of upper respiratory illnesses. Such research may eventually lead to constructive interventions. It is our hope that this study will add significantly to the body of temperament literature which may someday be able to provide clinicians and researchers with reliable, proven tools to identify and aid those children whose characteristic style of emotional and behavioral response to events places them at greater risk for illness.

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APPENDIX A

BEHAVIORAL STYLE QUESTIONNAIRE

INSTRUCTIONS:

1. Please base your rating on the child's behavior over the last four to six weeks.
2. Consider only your own impressions and observations of the child.
3. Rate each question independently. Do not purposely attempt to present a consistent picture of the child.
4. Please feel free to use the full range of the scale choices. Avoid rating only near the middle of the scale.
5. Rate each item quickly. If you cannot decide, skip the item and come back to it later.
6. Circle the number of any item that you are unable to answer due to lack of information or any item that does not apply to your child.

PLEASE CIRCLE THE NUMBER UNDER THE COLUMN HEADING THAT TELLS HOW OFTEN THE CHILD'S RECENT AND CURRENT BEHAVIOR HAS BEEN LIKE THE BEHAVIOR DESCRIBED BY EACH ITEM.

	Almost never	Rarely	Usually does not	Usually	Frequently	Almost always
1. The child is moody for more than a few minutes when corrected or disciplined.	1	2	3	4	5	6
2. The child seems not to hear when involved in a favorite activity.	1	2	3	4	5	6
3. The child can be coaxed out of a forbidden activity.	1	2	3	4	5	6
4. The child runs ahead when walking with the parent.	1	2	3	4	5	6
5. The child laughs or smiles while playing.	1	2	3	4	5	6
6. The child moves slowly when working on a project or activity. ..	1	2	3	4	5	6
7. The child responds intensely to disapproval.	1	2	3	4	5	6
8. The child needs a period of adjustment to get used to changes in school or at home.	1	2	3	4	5	6

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	Almost never	Rarely	Usually does not	Usually	Frequently	Almost always
9. The child enjoys games that involve running or jumping.	1	2	3	4	5	6
10. The child is slow to adjust to changes in household rules.	1	2	3	4	5	6
11. The child has bowel movements at about the same time each day.	1	2	3	4	5	6
12. The child is willing to try new things.	1	2	3	4	5	6
13. The child sits calmly while watching TV or listening to music.	1	2	3	4	5	6
14. The child leaves or wants to leave the table during meals.	1	2	3	4	5	6
15. Changes in plans bother the child.	1	2	3	4	5	6
16. The child notices minor changes in mother's dress or appearance (clothing, hairstyle, etc.).	1	2	3	4	5	6
17. The child does not acknowledge a call to come in if involved in something.	1	2	3	4	5	6
18. The child responds to mild disapproval by the parent (a frown or shake of the head).	1	2	3	4	5	6
19. The child settles arguments with playmates within a few minutes. ..	1	2	3	4	5	6
20. The child shows strong reaction to things, both positive and negative.	1	2	3	4	5	6
21. The child had trouble leaving the mother the first three days when he/she entered school.	1	2	3	4	5	6
22. The child picks up the nuances or subtleties of parental explanations (example: implies meanings).	1	2	3	4	5	6
23. The child falls asleep as soon as he/she is put to bed.	1	2	3	4	5	6

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		Almost never	Rarely	Usually does not	Usually	Frequently	Almost always
24.	The child moves about actively when he/she explores new places.	1	2	3	4	5	6
25.	The child likes to go to new places rather than familiar ones.	1	2	3	4	5	6
26.	The child sits quietly while waiting.	1	2	3	4	5	6
27.	The child spends over an hour reading a book or looking at the pictures.	1	2	3	4	5	6
28.	The child learns new things <u>at his/her level</u> quickly and easily. ...	1	2	3	4	5	6
29.	The child smiles or laughs when he/she meets new visitors at home.	1	2	3	4	5	6
30.	The child is easily excited by people.	1	2	3	4	5	6
31.	The child is outgoing with strangers.	1	2	3	4	5	6
32.	The child fidgets when he/she has to.	1	2	3	4	5	6
33.	The child says that he/she is "bored" with his/her toys and games.	1	2	3	4	5	6
34.	The child is annoyed at interrupting play to comply with a parental request.	1	2	3	4	5	6
35.	The child practices an activity until he/she masters it.	1	2	3	4	5	6
36.	The child eats about the same amount at supper from day to day.	1	2	3	4	5	6
37.	Unusual noises (sirens, thunder, etc.) interrupt the child's behavior.	1	2	3	4	5	6
38.	The child complains when tired. ..	1	2	3	4	5	6
39.	The child loses interest in a new toy or game the same day.	1	2	3	4	5	6

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		Almost never	Rarely	Usually does not	Usually	Frequently	Almost always
40.	The child becomes engrossed in an interesting activity for one half hour or more.	1	2	3	4	5	6
41.	The child cries intensely when hurt.	1	2	3	4	5	6
42.	The child reacts strongly to kidding or light-hearted comments.	1	2	3	4	5	6
43.	The child approaches children his/her age that he/she doesn't know.	1	2	3	4	5	6
44.	The child plays quietly with his/her toys and games.	1	2	3	4	5	6
45.	The child is outwardly expressive of his/her emotions.	1	2	3	4	5	6
46.	The child is enthusiastic when he/she masters an activity and wants to show everyone.	1	2	3	4	5	6
47.	The child is sleepy at his/her bedtime.	1	2	3	4	5	6
48.	The child stops an activity because something else catches his/her attention.	1	2	3	4	5	6
49.	The child is hungry at dinner time.	1	2	3	4	5	6
50.	The child holds back until sure of himself/herself.	1	2	3	4	5	6
51.	The child looks up when someone walks past the doorway.	1	2	3	4	5	6
52.	The child becomes upset if he/she misses a regular television program.	1	2	3	4	5	6
53.	The child reacts strongly (cries or complains) to a disappointment or failure.	1	2	3	4	5	6
54.	The child accepts new foods within one or two tries.	1	2	3	4	5	6

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		Almost never	Rarely	Usually does not	Usually	Frequently	Almost always
55.	The child has difficulty getting used to new situations.	1	2	3	4	5	6
56.	The child will avoid misbehavior if punished firmly one or twice. ...	1	2	3	4	5	6
57.	The child is sensitive to noises (telephone, doorbell) and looks up right away.	1	2	3	4	5	6
58.	The child prefers active outdoor play to quiet play inside.	1	2	3	4	5	6
59.	The child dislikes milk or other drinks if not ice-cold.	1	2	3	4	5	6
60.	The child notices differences or changes in the consistency of food.	1	2	3	4	5	6
61.	The child adjusts easily to changes in his/her routine.	1	2	3	4	5	6
62.	The child eats about the same amount at breakfast from day to day.	1	2	3	4	5	6
63.	The child seems to take setbacks in stride.	1	2	3	4	5	6
64.	The child cries or whines when frustrated.	1	2	3	4	5	6
65.	The child repeats behavior for which he/she has previously been punished.	1	2	3	4	5	6
66.	The child looks up from playing when the telephone rings.	1	2	3	4	5	6
67.	The child is willing to try new foods.	1	2	3	4	5	6
68.	The child needs encouragement before he/she will try new things.	1	2	3	4	5	6
69.	The child cries or whines when ill with a cold or upset stomach.	1	2	3	4	5	6
70.	The child runs to get where he/she wants to go.	1	2	3	4	5	6

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	Almost never	Rarely	Usually does not	Usually	Frequently	Almost always
71. The child's attention drifts away or lapses when listening to parental instructions.	1	2	3	4	5	6
72. The child becomes angry with one of his/her playmates.	1	2	3	4	5	6
73. The child is reluctant to give up when trying to do a difficult task.	1	2	3	4	5	6
74. The child reacts to mild approval from the parent (a nod or smile).	1	2	3	4	5	6
75. The child requests "something to eat" between meals and regular snacks.	1	2	3	4	5	6
76. The child rushes to greet the parent or greets loudly after absence during the day.	1	2	3	4	5	6
77. The child looks up when he/she hears voices in the next room.	1	2	3	4	5	6
78. The child protests when denied a request by the parent.	1	2	3	4	5	6
79. The child ignores loud noises when reading or looking at pictures in a book.	1	2	3	4	5	6
80. The child dislikes a food that he/she had previously seemed to accept.	1	2	3	4	5	6
81. The child stops what he/she is doing and looks up when the parent enters the room.	1	2	3	4	5	6
82. The child cries for more than a few minutes when hurt.	1	2	3	4	5	6
83. The child watches a long (1 hour or more) TV program without getting up to do something else. ..	1	2	3	4	5	6
84. The child spontaneously wakes up at the usual time on weekends and holidays.	1	2	3	4	5	6
85. The child responds to sounds or noises unrelated to his/her activity.	1	2	3	4	5	6

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	Almost never	Rarely	Usually does not	Usually	Frequently	Almost always
86. The child avoids new guests or visitors.	1	2	3	4	5	6
87. The child fidgets when a story is being read to him/her.	1	2	3	4	5	6
88. The child becomes upset or cries over minor falls or bumps.	1	2	3	4	5	6
90. The child is unwilling to leave a play activity that he/she has not completed.	1	2	3	4	5	6
91. The child is able to fall asleep when there is conversation in a nearby room.	1	2	3	4	5	6
92. The child becomes highly excited when presented with a new toy or game.	1	2	3	4	5	6
93. The child pays attention from start to finish when the parent tries to explain something to him/her.	1	2	3	4	5	6
94. The child speaks so quickly that it is sometimes difficult to understand him/her.	1	2	3	4	5	6
95. The child wants to leave the table during meals to answer the doorbell or phone.	1	2	3	4	5	6
96. The child complains of events in school or with playmates that day.	1	2	3	4	5	6
97. The child frowns when asked to do a chore by the parent.	1	2	3	4	5	6
98. The child tends to hold back in new situations.	1	2	3	4	5	6
99. The child laughs hard while watching television cartoons or comedy.	1	2	3	4	5	6
100 The child has "off" days when he/she is moody or cranky.	1	2	3	4	5	6

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APPENDIX B

BEHAVIORAL STYLE QUESTIONNAIRE - PROFILE SHEET

for 3 to 7 year old children

Developed (1975) by Sean C. McDevitt, Ph.D. & William B. Carey, M.D.

Child's Name ______________________________ **Date of Rating** ____________

Age at rating: ____ **years,** ____ **months,** **Sex** ________

Category score from Scoring Sheet:

Profile: Place mark in appropriate box below:

	Activity	Rhythm.	App/With	Adapt.	Intens.	Mood	Persist.	Distract	Thresh.
6	high	arrhyth	withdr.	slowly	intense	negative	nonpers	distrac.	low
+1 SD	4.31	3.43	3.93	3.27	5.17	3.99	3.56	4.70	4.58
mean	3.56	2.75	2.99	2.55	4.52	3.31	2.87	3.89	3.98
-1 SD	2.81	2.07	2.05	1.83	3.87	2.63	2.18	3.08	3.38
1	low	very rhyth.	app.	very adapt.	mild	positive	high per	non-distrac.	high

Diagnostic Clusters

Easy	low$<\bar{X}$	rhyhm.$<\bar{X}$	app.$<\bar{X}$	adapt.$<\bar{X}$	mild$<\bar{X}$	positive$<\bar{X}$
Diff.	high	arrythm.	withdr.	slowly adapt.	intense	negative
STWU	low$<\bar{X}$	rhthm.$<\bar{X}$	withdr.	slowly adapt.	mild$<\bar{X}$	negative

Definition of diagnostic clusters used for individual scoring:

Easy - Scores greater than mean in no more than two of difficult/easy categories (activity, chythmicity, approach, adaptability, intensity & mood) and neither greater than one standard deviation.

Difficult - 4 or 5 scores greater than mean in difficult/easy categories (as above). This must include intensity and two scores greater than one standard deviation.

Slow to warm up - as defined above, except activity intensity and rhythm need to be $<\bar{X}$, but if either withdrawal or slow adaptability is greater than one standard deviation, activity may vary up to 3.93 and month may vary down to 2.97.

Intermediate - all others. Intermediate high - 4 or 5 diff/easy categories above mean with one >1 standard deviation, or 2 or 3 above mean with 2 or 3 >1 standard deviation. Intermediate low - all other intermediates.

This child's diagnostic cluster ______________________________ **Date of scoring** __________

Comment: **Scored by** ______________

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APPENDIX C

KINDERGARTEN HEALTH PROJECT GLOBAL RATING OF ADAPTABILITY

How flexible is your child in new situations? Check one:

______ not flexible at all

______ moderately inflexible

______ inbetween flexible and inflexible

______ moderately flexible

______ very flexible

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APPENDIX D

KINDERGARTEN HEALTH PROJECT

GLOBAL DIMENSIONS AND

DIAGNOSTIC RATING, AND

SOCIAL ACTIVITY

Global Dimensions, items 1-8

Global Diagnostic Rating, item 10

Social Activity, items 11 & 12

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We are interested in describing children's temperament or behavioral style. Temperament refers to how children do things, rather than what they do or why they do them. Please circle the appropriate number to describe your child relative to children of a comparable age.

1. Activity level - Level, tempo, and frequency of motor activity

   1 2 3 4 5 6 7 8

   Low in activity — High in activity

2. Approach/Withdrawal - Nature of the initial spontaneous reaction to a new stimulus, situation, or person

   1 2 3 4 5 6 7 8

   Withdrawing — Approaching

3. Adaptability - How easily initial reactions are modified in desired direction

   1 2 3 4 5 6 7 8

   Low in adaptability — High in adaptability

4. Sensitivity - Sensitivity to sensory stimuli

   1 2 3 4 5 6 7 8

   Low in sensitivity — High in sensitivity

5. Intensity of reaction - Engery level, vigor or strength of response

   1 2 3 4 5 6 7 8

   Low in intensity — High in intensity

6. Quality of mood - Pleasant and cheerful as contrasted with unpleasant and unhappy

   1 2 3 4 5 6 7 8

   Negative — Positive

7. Distractivility - How easily child is drawn away from activities

   1 2 3 4 5 6 7 8

   Low in distractibility — High in distractibility

8. Attention Span and Persistence - Ability to continue and sustain activity

   1 2 3 4 5 6 7 8

   Low in persistence — High in persistence

9. Currently, how well does your child "fit" into his/her child care center?

   1 2 3 4 5 6 7 8

   Low in persistence — High in persistence

10. In general, the temperament of your child is:

    a. about average b. more difficult than average c. easier than average

11. How many close friends does your child have?

    None 1 2 or 3 4 or more

12. About how many times a week does your child do things with these friends?

    less than 1 1 or 2 3 or more

13. Compared to other children of his/her age, how well does your child:

	Worse	About the same	Better
a. Get along with his/her brothers and sisters?	1	2	3
b. Get along with other children?	1	2	3
c. Behave with his/her parents?	1	2	3
d. Play and work by himself/herself?	1	2	3

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APPENDIX E

KINDERGARTEN HEALTH PROJECT ILLNESS DIARY

Your Child's Name________________________________

Please answer the following set of questions on your child's health in the past two weeks (since the last time you filled out the questionnaire). Please check only one answer, except when directed otherwise. Thank you very much!

1. What is today's date: Month______ Day______ Year______

2. What is your relationship to this child?

_____Mother/Step-Mother
_____Father/Step-Father
_____Grandparent
_____Aunt/Uncle
_____Sibling
_____Other: specify __________________________

3. During the past 2 weeks has your child had a (check all that apply):

Cough?	___Yes	___No	Ear pain or discharge?	___Yes	___No
Runny or stuffed nose?	___Yes	___No	Hoarseness?	___Yes	___No
Sore throat?	___Yes	___No	Headache or muscle aches?	___Yes	___No
Fever?	___Yes	___No	Rash?	___Yes	___No

Other? specify________________________________ _____Yes _____No

4. Does your child currently have a (check all that apply):

Cough?	___Yes	___No	Ear pain or discharge?	___Yes	___No
Runny or stuffed nose?	___Yes	___No	Hoarseness?	___Yes	___No
Sore throat?	___Yes	___No	Headache or muscle aches?	___Yes	___No
Fever?	___Yes	___No	Rash?	___Yes	___No

Other? specify__________________________________ _____Yes _____No

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5. During the past 2 weeks was your child out of school because of a (check all that apply):

Cough?	___Yes	___No	Ear pain or discharge?	___Yes	___No
Runny or stuffed nose?	___Yes	___No	Hoarseness?	___Yes	___No
Sore throat?	___Yes	___No	Headache or muscle aches?	___Yes	___No
Fever?	___Yes	___No	Rash?	___Yes	___No

Other? specify________________________________ ____Yes ____No

If you said YES to any of the items in questions 3, 4 or 5, please go on to the following questions about your child's illness(es). If you said NO to all of the items in questions 3, 4 or 5, then you are done with this questionnaire.

1. Is you child now back to his/her usual state of health? ___Yes ___No

   If YES: For how many days was your child ill? ______days

   If NO: For how many days has your child been ill? ______days

2. At any time during this illness did (has your child have (had) a cough? ___Yes ___No

   If NO, skip to question 3.
   If YES, answer the following:
      Does he/she still have a cough? ___Yes ___No

      For how many days did (has he/she have (had this cough? ______days

3. At any time did (has) your child bring (brought) up phlegm from his/her chest during this illness?
   ___Yes ___No ___Don't Know

   If NO or Don't Know skip to question 4.
   If YES, answer the following:
      Is he/she still bringing up phlegm from his/her chest? ___Yes ___No

4. At any time during this illness did (has) your child have (had) any wheezing or whistling in his/her chest?
   ___Yes ___No ___Don't Know

   If NO or Don't Know skip to question 5.
   If YES, answer the following:
      Did (has) he/she complain(ed) of being short of breath? ___Yes ___No ___Don't Know

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5. At any time during this illness did (has) your child complain(ed) of pain in his/her chest?
   ___Yes ___No ___Don't Know

   If NO or Don't Know skip to question 6.
   If YES, answer the following:
      Did (has) he/she say (said) the pain was sharp? ___Yes ___No

      Did (does) taking a deep breath or coughing make the pain worse?
      ___Yes ___No ___Don't Know

6. At any time during this illness did (has) your child have (had) a fever? ___Yes ___No

   If NO or Don't Know skip to question 7.
   If YES, answer the following:
      Did (have) you take(n) your child's temperature with a thermometer? ___Yes ___No

      How high did (has) the fever get (gotten)? (nearest degree)

      _____99 or less

      _____99.1 to 100

      _____100.1 to 102

      _____higher than 102

      _____don't know

7. During this illness did (has) your child have (had) any of the following symptoms or complaints? (check all that apply)

Runny or stuffed nose?	___Yes	___No	Fatigue or less activity?	___Yes	___No
Post nasal drip?	___Yes	___No	Ear drainage?	___Yes	___No
Sore throat?	___Yes	___No	Rash?	___Yes	___No
Swollen or tender glands?	___Yes	___No	Upset stomach?	___Yes	___No
Hoarseness?	___Yes	___No	Diarrhea?	___Yes	___No
Headache?	___Yes	___No	Vomiting?	___Yes	___No
Muscle aches?	___Yes	___No	Other?:	___Yes	___No

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8. Did (has) your child see (seen) or did you call a doctor during this illness? ___Yes ___No

If NO or Don't Know skip to question 9.
If YES, answer the following:

Doctor's Name ____

Address ____

a. What did the doctor say was (is) wrong with your child?

specify:____

b. Did the doctor prescribe any medication? ___Yes ___No

If NO or Don't Know skip to question 8d.
If YES, answer the following:

c. What is the name of the medicine?
specify:____

d. Was (has) a chest x-ray (been) done on your child? ___Yes ___No

If NO or Don't Know skip to question 9.
If YES, answer the following:

Where was the x-ray done?
specify:____

9. In the week before your child got sick did any member of your household have: (check all that apply)

A cold with just a runny nose or sore throat?	___Yes ___No
A chest cold with a cough or bronchitis?	___Yes ___No
Pneumonia?	___Yes ___No
Pleurisy (Inflammation of lung sack, painful)?	___Yes ___No
Laryngitis?	___Yes ___No
Ear Infection?	___Yes ___No
Other?: specify______________________________	___Yes ___No

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10. In the week since your child first became sick has any member of your household developed: (check all that apply)

A cold with just a runny nose or sore throat?	___Yes ___No
A chest cold with a cough or bronchitis?	___Yes ___No
Pneumonia?	___Yes ___No
Pleurisy (Inflammation of lung sack, painful)?	___Yes ___No
Laryngitis?	___Yes ___No
Ear Infection?	___Yes ___No
Other?: specify________________________________	___Yes ___No

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APPENDIX F

POWER CALCULATIONS

Hypothesis I: Children with more "difficult" temperaments will contract more upper respiratory illnesses in the three months following Kindergarten entry than children with "easier" temperaments.

A power analysis was carried out to determine the appropriate effect size of temperament using the "index of difficulty" score derived from the Behavioral Style Questionnaire (McDevitt & Carey, 1978) as the measure of temperament. This analysis utilized the averages calculated from the two studies using the "index of difficulty" measure (Thomas & Chess, 1982; Thomas, Chess, & Korn, 1982). These two (.34 and .35) averaged to .35. Setting alpha at .05, with an n of 97 and k (number of predictors) equal to 1, it was found that the lowest correlation of temperament with upper respiratory illnesses (URIs) to provide a large enough effect size for power at .80 was r = .27. This yields a temperament and model R squared of .07, which becomes a temperament effect size of f squared = .08.

When the confounder variable of previous URIs was included in the model, increasing k to 2, it was found that the lowest correlation of temperament with upper respiratory illnesses to provide a large enough effect size for power at .80 was r = .29. This is using the conservative and unlikely estimate that the confounder will not add to the overall model and therefore yields a temperament and model R squared of .08, which becomes a temperament effect size of f squared=.09. If however, a modest r squared contribution of .12 (r = .35) of previous URIs to the outcome is

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included in the power analysis, the lowest correlation of temperament with URIs to provide a large enough effect size for power at .80 returns to r = .27. This yields a temperament R squared of .07, but a model R squared of .19, which becomes an effect size for temperament of f squared = .09. It is not at all uncommon that previous URIs be this highly correlated with post Kindergarten URIs. In fact the estimate of r = .35 is quite conservative, because pre-event biological parameters can be as highly correlated as .80 with post-event biological parameters (Boyce & Jemerin, 1990). Even with the most conservative power analysis the necessary correlation of .29 is still less than the literature derived average of .35 and indicates that sufficient power was available to test Hypothesis I.

Hypothesis II: Immunological responsivity to the stress of starting Kindergarten will account for (mediate) the effect of temperament on upper respiratory illnesses.

A power analysis of this path model to test Hypothesis II was performed, using k = 3 (temperament, previous URIs, and IR) , alpha = .05, n = 97, r = .35 of previous URIs with the outcome (as in Hypothesis I). The lowest correlation of temperament together with temperament via immunological responsivity (IR) with upper respiratory illnesses (URIs) to provide a large enough effect size for power at .80 is r = .29. This yields a temperament/temperament via IR R squared of .08, but a model R squared of .20, which becomes an effect size for temperament/temperament via IR of f squared = .11.

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Hypothesis III: The global index of temperament score developed for this study will predict upper respiratory illnesses as well as the "index of difficulty" score of the Behavioral Style Questionnaire.

Parallel analyses to the hierarchical regression used in Hypothesis I and in the path model used in Hypothesis II, substituting the global index of temperament for the BSQ index of difficulty would have caused a total of four regression/path analyses to be performed in testing the three hypotheses of this study. Therefore, a Bonferroni correction for these four primary analyses was to be applied, requiring a critical alpha of .0125 (rather than .05).

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