Child Activity Level: A Longitudinal Analysis of its Relationship to Prenatal Cigarette Exposure

by

Judith G. Chipperfield

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ABSTRACT

Motor activity level (AL) is a cornerstone dimension of childhood temperament, and thus an understanding of its etiology is important. The present study examined the relationship between maternal smoking and offspring AL using a developmental perspective and a longitudinal design. The major goal of the study was to explore four smoking issues: amount; duration; presence (vs. absence) of prenatal cigarette exposure; and AL differences between the offspring of smokers and nonsmokers that are not the result of the smoking exposure per se. In addition, these same issues were examined using attention span as a dependent measure. A secondary goal was to describe aspects of AL in the developing child. Measures of AL were obtained from birth to eight years of age in the offspring of 25,035 mothers participating in the National Collaborative Perinatal Project, and smoking measures were obtained during the mother's pregnancy. Regression analysis indicated that the amount and duration of maternal smoking were positively related to neonatal AL; however, this relationship was not evident in infancy or childhood. That is, neonatal AL increased with the amount smoked by the mother, and was higher for those neonates whose mothers smoked continually compared to those whose mothers quit early in pregnancy. While neonatal AL was associated with amount and duration of maternal smoking, no relationships were found between maternal smoking and attention span at any age. Maternal smoking may, in part, influence neonatal AL, but processes other than maternal smoking are more important for understanding AL as the child grows. Other processes are implied by

some of the longitudinal findings, such as a decrease in AL from infancy onward, discontinuity in AL from the newborn to childhood times, and a positive to negative change over time in the relationship between AL and attention span. Finally, although a relationship between maternal smoking and neonatal activity is implied by the positive associations between neonatal activity and both the amount and duration of maternal smoking, the comparison of smokers and nonsmokers produced no differences in AL. These seemingly incompatible results may be partially explained by a finding which suggests that pre-existing group differences between smokers and nonsmokers are likely operating to enhance activity in the offspring of nonsmokers. To the extent that neonatal activity is enhanced by characterisitics of nonsmokers, differences in activity may not appear when comparing the offspring of nonsmokers and smokers.

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Introduction

Gross motor activity level (AL) has been defined as an individual's customary level of energy expenditure through movement (Eaton, 1983), and is a cornerstone dimension of childhood temperament. The definition derives from a body of research suggesting that individuals differ in their levels of motor activity (Campbell, Kujek, Lang, Partington, 1971; Hagekull & Bohlin, 1981; Rothbart, 1980). Indeed, many view AL as a basic component of a child's behavioral style or temperament (Buss & Plomin, 1975; Hubert, Wachs, Peters-Martin & Gandour, 1982). Related to the notion that AL is a predominant feature of childhood behaviour, researchers have examined the stability of an individual's AL over time (Buss & Plomin, 1975; Halverson & Waldrop, 1976), and its genetic linkage (Buss & Plomin, 1975; Goldsmith & Gottesman, 1981; Scarr, 1966; Torgersen, 1981; Willerman, 1973). For example, some twin studies indicate that monozygotic twins manifest a more similar level of activity than do dyzygotic twins (e.g., Torgerson, 1981). Environmental influences also appear to be important contributors to childhood AL (Eaton & Keats, 1982; Parke & O'Leary, 1976; Vliestra, 1981), as is implied by the finding that preschool children who had day care experience expressed a higher level of activity than did those without the experience (Schwarz, Strickland & Krolick, 1974).

The expression of activity in the child has been viewed as the result of genetics, environment, or some combination thereof. Until recently however, environmental explanations have focused only on the environment we see around us, and have ignored the intrauterine environment. The intrauterine environment may be an important consideration in the understanding of neonatal and childhood AL, just as the prenatal environment clearly has long-term implications for later childhood development. Maternal alcohol ingestion, for example, can have damaging consequences for later childhood development (Majewski, 1981). Maternal smoking has been linked to variables such as perinatal death (Meyer, Jones, Tonascia, & Buck, 1975; Niswander & Gordon, 1972), prenatal complications (Naeye, 1978a), physical growth parameters (Landesman-Dwyer & Emaneul, 1979; Naeye, 1978b), and childhood behavior or performance (Butler & Goldstein, 1973; Nichols & Chen, 1981; Saxton, 1978). As in the latter case, the present study focused on the relationship between maternal smoking and behavior, the behavior being AL.

The primary goal of this study was to further explore the link between intrauterine cigarette exposure and subsequent postnatal AL. AL was viewed as a continuum with intense activity at one extreme end and passivity at the opposite end. The general prediction was that the continuum of AL would be positively related to maternal smoking, and this prediction led to a number of more specific questions. Does offspring AL increase as the number of cigarettes smoked by the mother goes up? Does offspring AL increase as the duration of maternal smoking is extended? Is AL higher for those offspring who were prenatally exposed to cigarette smoke compared to those not exposed? Finally, if AL is higher for the offspring of smokers, is this due to the smoking per se, or would predisposing mother characteristics produce higher AL regardless of the fetal exposure to cigarette smoke? This final issue is critical in the study of maternal cigarette smoking and offspring measures such as AL because findings that are attributed to maternal smoking may instead by due to predispositional differences or environmental differences between those women who smoke and those who do no smoke. It was hoped that, taken together, the answers to these four smoking questions would enhance our understanding of AL. Similarily, these questions were asked for a second behavioral variable, attention span, because attention span has been consistently related to AL in previous research (e.g., Schaefer & Bailey, 1963), and because one study has found that maternal smoking during pregnancy predicted offspring attention span (Streissguth, Martin, Barr, MacGregor Sandman, Kirchner & Darby, 1984).

A secondary goal of the study was to describe some longitudinal developmental aspects of AL. A description of the development of AL over time may be important in the interpretation of a relationship between offspring AL and maternal smoking. That is, while there may be a link between offspring AL and maternal smoking, developmental phenomena that influence AL may be superimposed upon this relationship. Moreover, a description of AL in the developing child is also valuable in and of itself. An approach which considered both maternal smoking and general development was thus chosen for the examination of AL. Stability and trends in AL were examined within a very large sample of children over the eight-year period. Finally, since the relationship between maternal smoking and attention span was of importance, attention span was also further examined for both stability and its link to AL over time.

The current study differs from previous research in two important ways. First, some of the issues, such as the link between attention span and AL have previously been examined. Most studies however, have only assessed the upper extreme of activity (i.e., hyperactivity). Viewing AL as a continuum, extends our understanding of relationships over the complete range of activity. Utilizing the entire range of AL as it relates to maternal smoking may also provide insights that would not emerge by studying only the extreme upper range of AL.

Second, this study differs from much of the activity level research in its use of a very large sample. The data base consists of mothers and children who participated in a longitudinal project, the National Collaborative Perinatal Project (NCPP). The project was conducted between 1958 and 1965 and involved 12 United States university-affiliated hospitals. The initial mandate of the project was to provide a data base that could be used in the discovery of variables that contribute to perinatal mortality and fetal insult. Therefore, data was compiled both before and after pregnancy, for thousands of variables. Within the data are AL measures obtained from birth to eight years of age, and the mother's smoking behavior as reported at each prenatal visit. The use of this data base provided a number of advantages for the examination of AL and maternal smoking. For example, the prospective data collection avoids some of the problems of retrospective accounts such as inaccuracy in mother reports of smoking behavior. In addition, the longitudinal design is more desirable than a single occasion design since maternal smoking may be related to AL at one occasion, but not at another.

A longitudinal prospective assessment of AL is used in this project to examine the two broad topics: prenatal nicotine exposure, and longitudinal AL issues in the developing child. The questions and issues briefly introduced are presented in detail within each of these topics. While these two areas are presented separately, an attempt to integrate them is made.

Prenatal Nicotine Exposure and Behavior/Performance

It is potentially very difficult to establish a relationship between maternal smoking and a subtle, temporally distinct behavioral outcome because a link with subtle outcomes may not be readily apparent. Nonetheless, such linkages, if they are found, may be valuable for the understanding of general development and for health-related problems. One need look no further than the discovery of the teratogenic effects of rubella to find an example, though these outcomes can vary from cataracts to deafness and can be most unstable.

Recent evidence does indicate that maternal smoking is related to childhood hyperactivity. Denson, Nanson, and McWalters (1975) selected 20 children from 5 to 15 years who were diagnosed as hyperkinetic and who showed improvements with methylephenidate treatment. Each child was then matched for sex, age, and social class with a normal control child. The mothers of all children were interviewed to determine what their smoking behavior had been during the corresponding pregnancy. Denson et al. (1975) found that the mothers of the hyperactive children reported smoking two to three times more than mothers of the control group.

Nichols and Chen (1981) provide stronger evidence of a link between maternal smoking and hyperactive-impulsive behavior in their prospective study of 35,000 mothers and their offspring who participated in the National Collaborative Perinatal Project. Activity was initially rated on 5-point scales from which Nichols and Chen derived a hyperactive-impulsive (HI) factor. They found that the offspring of mothers who smoked during pregnancy were more likely to score high on the hyperactive-impulsive factor at 7 years of age than were the offspring of nonsmoking mothers.

If hyperactivity and maternal smoking are related, and if hyperactivity is viewed as one end of the AL continuum, a relationship between maternal smoking and the AL continuum may also be expected. It must be noted that hyperactivity definitions usually include attentional deficits as well as excessive movement, which could complicate the view that hyperactivity is one end of an AL continuum. The few studies that have investigated this relationship between maternal smoking and the range of AL provide confusing results. First, Landesman-Dwyer, Rogozin and Little (1981) examined AL as one of a number of dimensions of child temperament. They interviewed 4-year-olds in a study where AL was measured as a dimension of child temperament that was theoretically associated with hyperactivity, minimal brain dysfunction and attentional deficit syndrome. While their goal was to examine the link between moderate alcohol exposure and a mild or subclinical form of hyperactivity, their study also examined maternal smoking patterns. Furthermore, AL was assessed using instruments often used in the study of general AL, therefore Landesman-Dwyer et al's. results reflect the continuum of AL. Landsman-Dwyer et al. (1981) interviewed mothers during their pregnancy, and identified them as smokers or nonsmokers, and "moderate drinkers" or "occasional or non-drinkers". Nearly 50 percent of smokers had 10 or fewer cigarettes per day, and less than 25 percent smoked 20 or more per day. Moderate drinkers, on the average, consumed one drink per day, and none had more than four per day. Childrens' behaviors were measured in the home by both the mothers and by a trained observer. Mothers rated their own children on the Chess, Thomas, and Korn Parent Questionnaire on Temperament which involved rating behaviors such as amount of activity, distractibility, persistence, and approach-withdrawal. Additionally, mothers rated their children on the Werry, Weiss and Peters Activity Scale, a 26-item scale measuring restlessness in different situations. The trained observers watched the children for a "minimum of 15 minutes during mealtime, 15 minutes during a play session, and 10 minutes while the mother read one of the child's favorite stories". While observing, raters recorded presence or absence of various pre-defined behaviors including motor activity and attention. Landsman-Dwyer et al. found that mothers who had smoked during their pregnancy (and were occasional or non drinkers), rated their offspring as most active; and nonsmokers (who also were occasional or non drinkers), rated their children as least active on the Chess, Thomas, and Korn Parent questionnaire, on temperament. Smoking however, was not related to activity as measured by mothers' ratings on the Activity Scale, or as rated by the trained observers. While the results of Landesman-Dwyer et al.'s study were mixed, some support was found for enhanced AL in 4-year-old offspring of smokers compared to nonsmokers.

Streissguth, Martin, Barr, McGregor Sandman, Kirchner, and Darby (1984) also examined the link between maternal smoking and 4-year-old activity as measured by a motion detector that detected a child's movement under laboratory conditions. In this longitudinal study, the Pregnancy and Health Study, mothers were interviewed during pregnancy to determine maternal use of alcohol, nicotine, caffeine, drugs, and diet. From this sample, 500 subjects were selected, 250 heavier drinkers and smokers and 250 infrequent drinkers and abstainers. Of these initial 500 subjects, 452 participated in the relevant phase of the study. These offspring were examined at 4 years 3 months to attain a measure of activity. A multiple regression analysis revealed no relationship between maternal smoking and 4-year activity.

Finally, a study by Saxton (1978) examined the behavioral patterns of 32 4-6 day old infants using the Brazelton Assessment Scales. This scale measures a number of behavioral reactions including activity, altertness, and orientation to auditory stimuli. Results from the examination were then recoded on a 1-9 point scale and the offspring of mothers who smoked more than 15 cigarettes per day were compared to a control group consisting of nonsmokers. Saxton found no significant differences between the activity level in the offspring of smoking mothers (M=4.93) compared to the level in offspring of nonsmoking mothers (M=5.18).

There are several factors which may account for the failure to find a relationship between maternal smoking and AL in the latter two studies. An explanation for Streissguth et al.'s (1984) failure to find any relationship between smoking and AL may reside in their measure of AL. The researchers developed a motion detector consisting of an ultrasonic intrusion alarm and an automatic timer that recorded the amount of time the child spent in motion. However, details on the validity and reliability were not provided, thus it is difficult to judge the merits of their technique, which may have been insensitive to different levels of activity.

Saxton's failure to find a significant relationship between maternal smoking and AL may be the result of two features of the study. First, the technique used to administer the Brazelton Assessment Scale may have deflated the activity scores for neonates of smoking mothers. If the "infant became irritable or upset, the examiner waited 15 seconds" in an attempt to measure the best performance for each item. Given these instructions, it seems highly likely that neonatal activity could be interpreted as a manifestation of irritability. If a high level of activity was regarded as irritability and the examiner waited 15 seconds before recording behavior, many ratings of high activity could go unrecorded. Compared to the offspring of nonsmokers, those of smokers were rated as more irritable in the "overall impressions" at the end of the session, which implies that more time was spent waiting for these infants to calm down before rating behaviors. This may have deflated the AL ratings for the offspring of smokers, and subsequently attenuated a relationship between maternal smoking and AL. Secondly, the sample size of 15 smokers and 17 nonsmokers in Saxton's study is not large enough to detect any but a very strong relationship.

The failure, in the former two studies, to demonstrate a relationship between maternal smoking and AL is somewhat puzzling when a relationship between smoking and hyperactivity has been uncovered. That is, if hyperactivity is viewed as the upper end of the AL continuum, and a relationship between offspring hyperactivity and intrauterine cigarette exposure exists, a link between maternal smoking and the continuum of AL would also be expected. The prediction of a positive link between maternal smoking and AL also seems plausible given the findings that attention span and maternal smoking are negatively related (Streissguth et at., 1984), and that attention span and AL are negatively related (e.g., Garside, Birch, Scott, Chambers, Kolvin, Tweddle & Barber, 1975) In other words, if attention span and AL are related, and a link exists between offspring attention and maternal smoking, a link between AL and maternal smoking follows conceptually.

The link between maternal smoking and attention span, however, is far from conclusive and requires further study. In Streissguth et al's. study of 4-year-old children, a vigilance paradigm was used to assess sustained attention span and orientation. The child was asked to press a button upon the appearance of a critical stimulus (a cat) during the 13-minute vigilance task. Low attention span and orientation were found to be associated with high levels of maternal smoking. In contrast, Landesman-Dwyer et al.'s (1981) study of the same age group however found that the offspring of smokers did not differ from those of nonsmokers on distractability (mother rating) or on focused attention and interruptions in focused attention (observer rating).

Low attention span, along with high AL, is likely to interfere with performance in school settings, thus further investigation of the link between attention span and maternal smoking seems especially important. The performance of children whose mothers smoked has been found to differ along various related dimensions, when compared to infants of mothers who did not smoke. For example, lower academic skills (Butler & Goldstein, 1973; Dunn, McBurney, Ingram & Hunter, 1977) have been reported for the offspring of smokers. Butler and Goldstein examined the 17,000 children of the British National Child Development Study, comparing the offspring of smokers and nonsmokers. They found that 11-year-old children of smoking mothers performed lower, by three to five months, on general ability, reading, and mathematics than children of mothers who did not smoke during pregnancy, even when statistically adjusting for class, maternal age and height, sex of child, and number of siblings.

Most previous research on maternal smoking and behavior has been of a correlational design, and thus experimental control over extraneous variables has not been possible. Similarily, the present study could not experimentally control for confounding variables. However, it was possible to exercise statistical control over variables known to covary with maternal smoking or AL, and to minimize some competing explanations for an obtained relationship between maternal smoking and behavior. Variables that were controlled for in the regression analysis included neonatal measures (gestational age, birthweight and birth order), prenatal exposure to substances (drugs and alcohol), and parental education. Gestational age was partialled out because Buncher (1969) has reported longer mean gestational periods in nonsmokers compared to smokers, and there is some evidence that increasing gestational age may, in turn, be associated with enhanced fetal AL. In an early study Richards and Newberry (1938) report that fetal AL may be related to development such that the AL can be viewed as an index of overall development. If AL is positively related to gestational age, and gestational periods differ for smokers and nonsmokers, differences in offspring AL could actually reflect a gestational age effect. Likewise, a smoking effect could reflect either a birth-weight or birth-order effect, since both of these variables have been found to covary with maternal smoking. A relationship between maternal smoking and lowered birth weight in newborns has been convincingly demonstrated (e.g., Simpson, 1957), and later borns are more likely to be exposed to cigarette smoke during fetal development than are earlier borns (see Fried & Oxorn, 1980). Similarily, drug and alcohol exposure were partialled out because they were believed to be correlated with smoking behavior. Finally, parental education was controlled for because mother's education has been found to correlate negatively to smoking behavior (Niswander & Gordon, 1972).

While partialling out variables known to covary with maternal smoking and AL, the four smoking questions were addressed; two examining only smokers, and the other two comparing smokers and nonsmokers. For the analyses of each smoking issue, mothers were defined as: nonsmokers (NS), pre-pregnancy quitters (PPQ), during-pregnancy quitters (DPQ), or continual smokers (CS). Additionally, one of the issues required that each pregnancy be identified as a smoking pregnancy (SP) or a nonsmoking pregnancy (NSP). An examination of only those mothers who smoked involved i) assessing a possible dose-response relationship between amount smoked during pregnancy and both AL and attention span in the offspring, and ii) the assessment of a relationship between duration smoked and offspring measures. An examination involving both those mothers who smoked and those who did not was made i) to assess offspring behavior as it relates to prenatal cigarette exposure vs. no exposure and ii) to consider differences in offspring AL that could be related to mothers' smoking status i.e., (pre-pregnancy) quitters vs. nonsmokers. Each of these issues and related hypotheses will now be presented in detail.

Amount of exposure (dose-response relationship). Does AL increase in the offspring of smoking mothers as the amount smoked increases? This question can be addressed by examining dose-response relationship, just as the decreasing birth weight and maternal smoking issue has been examined. In a chapter on fetal growth, birthweight, and prematurity, Fried and Orien (1980) concluded that the demonstration of a dose-response relationship between maternal smoking and birth weight, combined with other evidence, strongly supported the causal role of maternal smoking on reduced birthweight. Similarily, the relationship between maternal smoking and later performance has been examined by associating performance with amount smoked (Steissguth, et al., 1984). The present study used this same approach to examine changes in AL and attention span as maternal smoking varied. Only those mothers who reported smoking on repeat prenatal visits were used in this analysis (i.e., continual smokers). A dose-response relationship was predicted whereby AL in the offspring was expected to increase as the mean amount smoked by the mother during pregnancy increased. Conversely, it was predicted that attention span would decrease as maternal smoking increased.

The predicted link between maternal smoking and the range of AL is consistent with the existing literature on smoking and hyperactivity. The demonstration of a dose-response relationship in the present study would suggest a more general relationship between maternal smoking and the entire range of AL. Moreover, the predicted smoking-attention span outcome would replicate Streissguth et al's. (1984) finding with a large sample, and would thus strengthen the evidence of a link between maternal smoking and childhood attention span. This link may be particularily important in understanding the reported relationships between mother's smoking and poor performance in reading, mathematics, etc. (Butler & Goldstein, 1973).

<u>Duration of exposure</u>. Does AL for those offspring who were prenatally exposed to maternal smoking increase as the duration of exposure is lengthened? If AL is related to maternal smoking and the duration of fetal exposure influences AL, it may be that prolonged, repeated exposure could have powerful effects on AL and/or attention span in the offspring, while shorter exposure may have little effect. The relationship between the duration of cigarette exposure and offspring behavior was examined by comparing the offspring of mothers who quit smoking early in their pregnancy (DPQ) to those of mothers who continued smoking during the entire pregnancy (CS). It was predicted that AL would be higher and attention span lower for the offspring of the mothers who smoked during for their entire pregnancy compared to mothers who quit during their pregnancy (i.e., CS > DPQ). This is consistent with the dose-response prediction that AL increases and attention span decreases with increasing amounts of cigarette exposure. Although the current discussion favours the duration of exposure as an important variable, it must be emphasized that other variables would also explain the predicted findings. A critical period of exposure may be of greater importance than the duration of exposure. The ingestion of maternal cigarette smoke may be most damaging during a particular period of fetal development, just as the ingestion of thalidimide or the mother's contact with rubella is most damaging at particular periods. It is important to note that the duration and critical period explanations are not separable in the present analysis since a long duration is more likely to cover a particular critical period.

One other explanation for the predicted findings (i.e., higher AL and lower attention in the offspring of mothers who continued smoking compared to those whose mother's quit early during their pregnancy), is that the two groups of mothers differ in ways other than their smoking behavior, and that such differences affect the dependent measures. Hook (1976) suggests that mothers who quit smoking during their pregnancy do so because the smoking produces nausea. If nausea is a protective physiological response to harmful substances, as Hook suggests, then those mothers who quit smoking may differ physiologically from mothers who continue. In short, this study may identify offspring differences for the two groups (i.e., DPQ and CS), but it can not definitively isolate the cause or causes for the differences. Nonetheless, duration of exposure to smoking would have to be a primary suspect in the case.

Exposure vs. no exposure. Do the offspring of mothers who smoked during their pregnancies differ in their level of activity and/or attention span from the offspring of mothers who did not smoke at all during the pregnancy? The examination of relationships between prenatal cigarette exposure and AL and/or attention span has thus far involved only those mothers who smoked during pregnancy. To address the question of exposure, the offspring of smoking pregnancies (i.e., during-pregnancy quitters and smokers) were compared to the offspring of nonsmoking pregnancies (i.e., nonsmokers and pre-pregnancy quitters). Consistent with the dose-response prediction, AL was expected to be higher, and attention-span lower for offspring that had been exposed to cigarette smoking in utero compared to those who were not exposed (i.e., SP > NSP). Such a finding, in combination with a dose-response relationship would add evidence to the link between maternal smoking and childhood behavior. Once again interpretative complexities arise because of potential pre-existing group differences between the nonsmokers and the smokers.

Quitters vs. nonsmokers. Do smokers and nonsmokers differ in such ways that would determine offspring AL regardless of fetal exposure to cigarette smoke? If pre-existing group differences do influence offspring AL, the predicted positive relationships between AL and maternal smoking could be due to the mother's characteristics rather than smoking per se. This is a question of causality: Is it the smoker or the smoking that causes higher AL in the offspring of smokers?

Differences between smokers and nonsmokers do exist. Evidence suggests that smokers differ from nonsmokers biologically, in their personality characteristics, and in their behavior. For example, it has been reported that smokers begin menopause earlier than nonsmokers (Bailey, Robinson & Vessey, 1979). Furthermore, smoking may be the result of biological differences according to Hickey, Clelland, and Bowers' (1978) genetic-constitutional hypotheses. Hickey et al. (1978) argued that "cigarette smoking, for many persons, is symptomatic of a physiologic deficiency that nicotine tends to alleviate".

To take another example, Eysenck, Tarrant, Woolf, and England (1960) reported that mean extroversion scores increased as the amount of smoking increased (nonsmokers M=7.02, light smokers, M=7.13, medium smokers, M=7.45, heavy smokers, M=7.36) and concluded that smokers, on the average, are more extroverted than nonsmokers. Coan (1973) replicated this finding, and reported personality differences between smokers and nonsmokers on 19 other factors (e.g., smokers were more distress prone, and spontaneous than nonsmokers). Finally, Fried and Oxorn (1980) summarized some of the social and behavioral ways in which nonsmokers differ from smokers. Smokers, in general, drink more coffee and alcohol than nonsmokers, and differ in work history, education and number of previous pregnancies. There is also evidence that heavy smokers may be undernourished compared to nonsmokers (Naeye, 1978b).

The question remains: Is the smoker or the smoking responsible for differences between offspring of smokers and nonsmokers? This concern has not been examined in the few studies of maternal smoking and AL, but it has been extensively addressed within the well-established relationship between maternal smoking and birthweight. A brief summary of the debate over the causal role of smoking on birthweight will illustrate the concern and the approaches to this problem.

Yerushalmy was a central figure in the debate over smoking as a causal influence on birthweight. He argued that low birth weight in infants of mothers who smoked during their pregnancy may be attributable, not to the smoking, but to the smoker (Yerushalmy, 1974). Silverman (1977) buttressed this position with results from a study of 5000 pregnancies, in which birth weights were examined in each of two subsequent pregnancies for each mother. Some mothers did not begin smoking until after the first pregnancy, thus their second offspring was exposed to smoke during fetal development, while the first was not. The birth weights for the first newborn of the pair, not exposed to smoke, however was low just as often as for the newborn of the second pregnancy during which the mother had smoked. Moreover, "future smokers" had lower birth-weight infants than those of nonsmokers. Silverman concluded that the findings "neither confirm or deny the hypothesis that smokers rather than the smoking per se causes a reduction in birth weight", but that they do "suggest that smokers have a different reproductive history than nonsmokers regardless of whether they smoke during pregnancy".

Although some evidence suggests that smoker characteristics influence birthweight more than smoking per se., there is other evidence that leads to the opposite conclusion. Naeye (1978b) compared birth weights in the newborns of mothers who smoked during one pregnancy but not during another. Results indicated that birth weights were lower for the offspring of the smoking pregnancy irrespective of birth order, and other factors known to affect fetal growth.

The issue of group differences is clearly applicable to the understanding of how maternal smoking may relate to childhood behavior and performance. If, for example, mothers who smoke differ from nonsmoking mothers in ways such that their offspring are likely to be more active, regardless of prenatal smoking exposure, then findings of higher AL in the offspring of smokers would not imply a direct relationship between maternal smoking and AL. Rather, it could be argued that higher AL in the offspring is genetically based, and that a woman who is predisposed to high activity is also more likely to smoke. If this were true, the high AL in the neonate could be viewed as the result of genotype rather than the uterine environment. This genetic explanation of high AL in the smoking mother's offspring is compatible with Eysenck's theory of personality and his finding that smokers are more likely to be extroverts than are nonsmokers. If AL is substantially heritable, and if smokers are predisposed to higher AL, then the offspring of smokers should be more active.

Alternatively, women who smoke may be biologically similar to nonsmoking women but may differ in their behavior. Women who do smoke may be less "health conscious", a situation which would have great implications for their offspring both during pregnancy and during later childhood. If hyperactivity and attention deficits are linked to diet, as some have suggested, parental concern over nutrition could certainly affect AL and/or attention span in the offspring. The effects of different parenting practices, such as emphasis on nutrition, are not obvious. A nutritious diet could lead to more energy, thus more activity, whereas a nutritional deficiency could suppress activity. A suppressing effect for the AL of smokers' offspring would not create concern for the interpretation of the prior prediction that AL will be higher for the offspring of smokers. Suppression of AL in smokers' offspring would, in fact, work against this prediction.

The intent of examining possible pre-existing group differences between smokers and nonsmokers in this study is to consider the possibility that AL may be enhanced for the AL of smokers' offspring. If it is, a simple explanation citing smoking exposure as a cause would not be tenable. It must be remembered though, that the existence of differences between the behavior in the offspring of smokers and nonsmokers does not preclude smoking as a causal factor in childhood AL and/or attention span.

The NCPP data base provides an opportunity to examine group differences between smokers and nonsmokers as they relate to AL and attention span in the offspring. Specifically, both AL and attention span were compared in the offspring of nonsmoking mothers (i.e., NS) and the offspring of mothers who had once smoked, but quit prior to pregnancy (ie., PPQ). It is assumed here that pre-pregnancy quitters share common "smoker characteristics," and thus represent smokers as a whole. Their offspring, however would not have been prenatally exposed to cigarette smoking. Differences in offspring AL and/or attention span between the children of nonsmokers and pre-pregnancy quitters then, could not be the result of fetal exposure to cigarette smoke since neither group of mothers smoked during pregnancy. Rather, to the extent that pre-pregnancy quitters represent smokers as a whole, differences in AL and/or attention span would be attributable to dissimilar characteristics between smokers and nonsmokers.

The assumption that pre-pregnancy quitters represent smokers as a whole may be criticized in view of Hickey's (1978) suggestion that smokers smoke to alleviate a deficiency. In other words, smokers who persist, it could be argued, have a greater deficiency than quitters. Despite the possibility that pre-pregnancy quitters may differ from smokers who persist, it seems reasonable to expect that these two groups of women are more similar to each other than they are compared to nonsmoking women.

Longitudinal Activity Level Issues

A description of the development of AL throughout infancy and childhood may be helpful in the context of this study. In general, understanding of the the stability (or instability) of AL or particular patterns of AL over time may be useful. For example, a curvilinear trend in AL, where AL increases from birth to 3 years, then decreases throughout childhood, could complicate the interpretation of a relationship between maternal smoking and AL such that a relationship would be identifiable while AL is at its highest, but not earlier or later. Describing the general development of

AL throughout childhood is also valuable for the understanding of AL. The literature on correlational stability and mean level AL changes during development will be briefly reviewed as will the research on an important correlate of AL, attention span. The link between AL and attention span is important in view of the suggestion that both may be related to maternal smoking.

Stability and change in AL. Stability in AL research refers to consistency in individual AL difference from one time to another. Researchers have examined stability coefficients based on child AL and have found AL to be a stable feature in childhood, e.g., researchers have found stability in AL from around 2 1/2 to 7 years (Buss et al., 1980; Halverson & Waldrop, 1976). In other words, these data argue that a 2-year-old high on AL at one age will tend to be high on AL at a later age. As for infancy, AL stability has been found in some studies, but only over short periods of time. For example, Korner, Hutchinson, Koperski, Kraemer, and Schneider (1981) using an electronic activity monitor, found AL in 72 neonates to be stable over a period of 3 days. Similarly, Rothbart (1980), using an Infant Behavior Questionnaire and independent home observations found stability in AL from 3 months to 9 months. The present examination of stability in AL examined intercorrelations among the infant period, the preschool period, and early childhood period.

Stability can also be examined in terms of changes in mean level. Quite independently of correlational stability, AL may show an increase or decrease in mean level over time. Eaton (1983b) proposed a possible developmental pattern for AL over the life span, and argued that the focus on correlational stability of AL over time has detracted from the question of a developmental pattern in AL. Using 57 studies where interpretable age-AL relationships existed, a developmental pattern in AL outcomes was found. Specifically, AL traced a curvilinear pattern with AL increases during infancy, a peak between 2 and 5 years, and decreases across the remainder of the life-span. A possible explanation for such a pattern is that physiological or environmental inhibitory mechanism(s) of some kind come into play in early childhood. For example, physiological maturational changes may be occuring between 2 years and 5 years. Alternatively, many environmental changes that could inhibit AL are also occuring during this time period. This study further examined the possibility that AL begins to decline in early childhood, even though stability in individual differences was also expected. Specifically, it was predicted that an individual's AL would show test-retest stability at various times from birth to 8 years of age; but that AL at 4 years would be greater than AL in infancy and at 7 years.

Activity level and attention span. The link between activity and attention span has been extensively examined with extremely active (i.e., hyperactive) samples. This research consistently links childhood hyperactivity and low attention span on vigilance performance Goldberg & Konstantareas, 1979; Nichols & Chen, 1981; Roberts, Milich, Loney & Caputo, 1981). Furthermore, the Diagnostic and Statistical Manual (DSM-III, American Psychiatric Association, 1980) recognizes this linkage by including a diagnosis of attention deficit disorder with hyperactivity. If hyperactivity is one extreme end of the AL continuum, then a general relationship between AL and attention span should be found.

Several studies have found a negative relationship between AL and attention span in a nonclinical sample. Garside et al. (1975) conducted a factor analytic study to examine dimensions of infant temperament. One of the dimensions was AL as measured on a 5-point scale at various times during the day (i.e., at meals, at play, at bed time, and while dressing). Results of the analysis showed AL loaded positively on the same principal components factors as poor attention span and distractability, as well as spontaneous aggression and malleability. Similarly, Schaefer and Bayley (1963) found that active 10-month-old boys were low on attentiveness. The same relationship could be infered for 2-year-olds in a study by Repucci (1970) if the measure of sustained directed activity (SDA) with toys can be viewed as attention span. Children were observed during free play, and activity was rated according to the number of squares the child traversed during the session. Repucci found an inverse relationship between AL and the length of time the child participated in SDA with toys during free play.

The AL and attention span link was examined in the current study using multiple measures on the same child over time. A negative correlation between AL and attention span was expected at 8 months, and in childhood. It was argued that such a correlation, if obtained, would imply a stable inverse relationship between AL and attention span.

Summary

The relationships between maternal smoking and AL, an important childhood characteristic, were assessed in this research project. A broad perspective was used whereby a number of potentially important issues regarding maternal smoking were addressed. Furthermore, the development of AL from the neonate to childhood was explored and the smoking relationships are discussed within this developmental context. In short, the present study used a longitudinal, prospective design to examine the etiology of activity level in children from birth to eight years. To reiterate, the specific hypothesis were:

1. Among smokers, amount of maternal smoking will be positively associated with AL in the offspring, and negatively associated with attention span;
2. Among smokers, duration of maternal smoking will be positively associated with AL in the offspring, and negatively related to attention span;
3. AL will be higher, and attention span lower for the offspring who were exposed to maternal smoking during fetal development, compared to those who had no exposure;
4. AL will be higher and attention span lower for the offspring of mothers who once smoked, but not during their pregnancy, compared to offspring of mothers who never smoked;
5. Individual differences in AL will show longitudinal stability;
6. Preschoolers (4-year-olds) will be more active than both older children (7-year-olds) and infants (8-month-olds);
7. Attention span will be negatively related to AL.

Some of these relationships have emerged as tentative, subsidiary findings in earlier research. The present investigation examined AL issues on a much larger scale and with greater precision than previous work. Moreover, this investigation differed from much previous research in its design, by studying AL within a prospective longitudinal design. Most previous work, e.g., with hyperactives, has been retrospective and open to a host of selection artifacts. Similarily, much research on cigarette smoking during pregnancy has retrospectively collected information on smoking behavior, and thus has relied on the mother's memory. Because AL is a cornerstone dimension of child development, an understanding of it's etiology and development for both normal and clinical populations should prove most useful.

Method

Data Base

Women in this study were interviewed during their pregnancy and examined by their physician at the beginning of their participation in a longitudinal project designed by the National Institute of Neurological Diseases and Blindness (NINDB) [later changed to the National Institute of Neurological and Communicative Disorders and Stroke (NINCDS)]. The intial year of the project, 1958, was a pre-test period during which all study personnel were monitored. The data was collected until December 31, 1965, with continual monitoring throughout. The women involved in the NINCDS Collaborative Perinatal Project were seeking care in various university-affiliated medical centres in the United States (see Appendix A for list of centres). Detailed forms were used to collect data on the mothers and their offspring during the project. These forms and instruction manuals are available through NCPP. A complete summary of the original subject selection can be found elsewhere (e.g., Niswander and Gordon 1972).

Subjects

Subjects for the present study were the children born to women participating in the NCPP longitudinal project. Decisions regarding exclusion of subjects have been derived in part from Nichols and Chen's (1981) exclusion rules. Specifically, they excluded, among others, subjects of multiple births, those with neurological malformations, blindness, or a history of focal-motor seizures. The present study excluded these as well as babies born premature (< 37 weeks), postmature (> 41 weeks) and small for gestational age (i.e., under 2000 grams), and children in a coma at 1 year of age. All of these subjects were excluded because generalizations were sought for a normal population. Finally, for those mothers who participated in the study more than once, only the first child was included, since more than one pregnancy per mother would introduce dependence between data points, a concern also expressed by Niswander and Gordon (1972). These exclusions coupled with missing data on key variables reduced the final sample from the original 54,908 to 25,035. The final sample was comprised of 12,439 males and 12,595 females, and the children were primarily first borns (9,422), second borns (4,797), third borns (4,099), and fourth borns (2,494). Other demographic characteristics for the final NCPP sample are presented in tables 1 and 2, where it can be seen that the typical mother in the study was around 24 years old, had 11 years of education, had been pregnant about 2 times previous to the study pregnancy, and had visited the doctor approximately 9 times during the study pregnancy. The newborns in the study were born around the 39th

TABLE 1

Demographic Characteristics for Parents in the Selected NCPP Sample

	M	S	Range	n
Mother's age	24.06	6.03	12-47	25035
Prior pregnancies	1.93	2.55	0-22	24948
Prenatal visits to doctor	8.95	3.79	1-35	25018
Mother's education	10.87	2.58	0-18	24569
Father's education	11.22	3.10	0-18	19871

gestational week and weighed approximately 3193 grams.

TABLE 2

Demographic Characteristics for Newborns in the Selected NCPP Sample

	M	SD	Range	n
Gestational age (weeks)	39.45	1.22	37-41	25035
Nursery weight (gms)	3192.54	447.20	2013-6804	25035
Body length (cms)	50.03	2.44	20-60	24837
Head circumference (cms)	33.79	1.40	22-46	24925
Birth order	2.65	1.94	1-16	24651

Variables

Various measures were taken: at the birth of the offspring, in the nursery, during infancy (8 months), around 3 years, 4 years, 7 years, and 8 years. Some measures were based on common instruments (i.e., metric ruler or tape, scales and standardized measuring boards), while observational data utilized mothers' self reports, study personnel's direct observation/examination, and summarized reports of information obtained at earlier times. The summarized reports consist of a synthesis of information from all study and hospital records, completed by a senior study pediatrician. The majority of observational data involved 3-point and 5-point descriptive rating scales. Relevant information about procedures and specific instructions for administering forms are presented under the pertinent variable (i.e., AL, attention span, maternal smoking, control variables and other demographic variables), following some comments regarding the reliability of measures.

Reliability. Although no reliability and validity data are available for the measures, both the original and the present study attempted to enhance reliability. Initially, the NCPP developed a data processing system to minimize errors and provide assurance that unreliability due to coding errors was minimized. The data processing system "included comprehensive reviews and tests at every stage of the processing in order to minimize errors" (Niswander & Gordon, 1972, pp. 18). The system was organized in this manner:

1. When an examination was completed and reviewed at the Center, a copy of the form was sent for data processing to the Perinatal Research Branch.

2. The form was then edited by specially trained nurses for completeness and accuracy, and was then coded.

3. Cards were punched, verified, and sent to the computer facility.

4. The next stage of processing included a screening of every column in every card for invalid codes.

5. The data on the cards were checked to determine whether they fell ouside of range levels established by the medical group responsible for that particular form. For example, the record for a child with a first breath recorded in excess of ten minutes after birth, and who was reported to be liveborn, would be questioned. Similar reviews were made for many other measurements.

6. The cards earmarked for review in this procedure were returned to the appropriate evaluations unit which then examined the original form. If a mistake was found, the card was corrected and returned for processing. If the item was correctly recorded, it was then forwarded to the physician in charge who attempted to ascertain the reason for the unusual reading. He had two options. The first was to accept the recording as legitimate and send the data back to the processing group. The second option was to request a review by the hospital for confirmation or rejection of the observation and a substitution of the correct observation, if known. If the observation was incorrect and no substitution was possible, the item was classed as unknown.

7. After data were processed into the computer file, frequency distributions were tabulated periodically for specific items in the file so that unusual values could be rechecked. The original forms were examined to provide a review of these unusual observations.

The present study attempted to enhance reliability using a method introduced by Epstein (1980) because of his concern with the lack of control in research conducted in natural settings. The concern, and particularly in a longitudinal design, is that many variables will influence human behavior and that observations will be a result of these uncontrollable variables. The technique to cancel out these uncontrollable factors is to aggregate behavior over situations and/or occasions. Eaton (1983a) demonstrated this increase in reliability through aggregating AL scores measured by motion recorders (i.e., actometers). The reliability of differences in preschoolers' AL was measured using a single actometer reading, then compared to the score derived from multiple recordings. While the reliability in the former case was .33, the reliability in the latter rose to approximately .88. The multiple ratings of both AL and attention span for each child in the current study, allowed for the aggregation of measures, which presumably increased reliability, generalizability, and replicability.

Despite these attempts to enhance reliability, the observational measures are crude, and therefore likely to contain a substantial error component. However, for two further reasons, the measures can be considered adequate. First, to the extent these measures are unreliable, correlations should be attenuated. Second, the large sample size in this study provides the advantage of enhanced power for statistical tests.

Activity level. Within the NCPP data are seven previously unanalyzed measures of AL. Two are newborn measures, the first derived from a Nursery History completed:

1. sometime during the first 24 hours of life, and again
2. sometime between 36 and 60 hours of age centering about 48 hours of age, and
3. prior to discharge if the infant remains more than 24 hours after the previous summary, and finally
4. weekly for infants who have a prolonged hospital stay.

A designated person observed and rated the newborn's activity as excessive or diminished, if applicable. The instructions for the activity measures were as follows:

> This term is intended to classify the infant's activity only as to amount. It is difficult to define what a normal amount of activity is, so the decision on this must be left to the judgment of the individuals who see the infants and make the initial records. Only extremes of excessive or diminished activity are desired here. "Excessive" shall include the hyper-active, jittery baby and the baby who seems to be never still. "Diminished" shall include the very quiet baby who moves very little.

Local policy determined the type of person responsible for completing the Nursery History, but a standard procedure within institutions was required. To avoid bias, the rater was to "be unaware of the events of pregnancy including labor and delivery, and of the subsequent course of the mother" and "avoid as much as possible reference to previous recordings."

The following procedure was used to arrive at a single AL score for each child and to adapt these original ratings into a scale compatible with the other scales used in this study. A rating of "diminished activity" with no rating of "excessive" was given a score of 1 on the new scale. Subjects with no rating of "diminished" or "excessive" were given a score of 2, and one or more ratings of "excessive", with no rating of "diminished" resulted in a score of 3.

The second newborn AL measure exists within a report entitled the Newborn Diagnostic Summary (PED-8). A senior pediatrician rated the newborn as hyperactive or hypoactive, also indicating that the diagnosis was suspect or definite. The following instructions indicate how these judgements were made:

> Records to be used in preparation of the Diagnostic Summary include all study and hospital pediatric records, including records of hospital care received when the infant is transferred directly from the nursery to another service or hospital for care. When the infant is finally discharged, that hospital's records should also be used to complete the PED-8 even though study forms may not be completed in that hospital. A review of the mother's records is not be be included in completing PED-8.

A hyperactive rating was given if activity was judged as excessive, while a hypoactive rating reflected a paucity of spontaneous activity as related to maturity. Judgements of AL were made with the following instructions:

> It is recognized that clinical judgment will have to include weighing the relative merits and timing of the various examinations. Differentiation between coding suspect and definite will vary according to the item and category under consideration. In general, all clear cut unquestionable diagnoses, conditions, or states should be coded under definite. Where there is doubt regarding the presence of the condition or its existence in significant degree, the coder will encircle the appropriate code number under suspect.

For purposes of the present study, a 5-point scale was utilized by treating the diagnoses of suspect and definite as levels of behavior. A rating of definite hypoactivity was assigned a value of 1; suspect hypoactivity, a value of 2; no rating of hypoactivity or hyperactivity, a value of 3; suspect hyperactivity, a 4; and definite hyperactivity, a 5.

A third measure of AL (i.e., for the 7 1/2 to 10 month old infant) is found in the 8-month <u>Infant Behavior Profile</u>. The profile is part of a 40-minute examination conducted by a psychologist, and consists of the observation and rating of each child on a number of dimensions. Ratings were on a scale of 1 to 5 with each point representing the degree of manifested behavior, as shown below:

1. Hypoactive: stays quietly in one place and shows no self-initiated movement;
2. Little activity: seldom moves and only for brief periods;
3. Responds appropriately in situations calling for activity;
4. Much activity: in action a good deal of time; and
5. Hyperactive: constantly in motion, cannot be quieted for sedentary tasks.

Instructions for completion of the Behavior Profile were the following:

> "The form provides a summary of the ratings for the major dimensions considered to be of diagnostic value. The aim of this form is to simplify the recording and coding of the behavioral data. The ratings from 1-5 represent degrees of manifestation of specified behavior, not judgment of abnormality or normality. Brain-damaged or "suspect" babies may score frequently on the extremes of some of these categories, but this might not hold for all areas. Conversely some "normal" babies might receive ratings of 1 or 5 on certain categories."

The psychologist was asked to evaluate behavior as it was

> "... observed during sedentary tasks on the mental tests, during motor tasks and free play," and base ratings on frequency of shifts in position, movements of head, trunk and extremities."

Further instructions suggested that the testing room be pleasant without many distracting items, and that testers avoid wearing white lab-coats in an effort to provide a casual setting for the children. The presence of the mother (or surrogate) was also requested during testing.

A fourth rating of activity (i.e., for the 3-year-old) is available in the Speech, Language and Hearing Examination - Additional Observations. The examination occurred sometime between 2 years 11 months and 3 years 2 months, and the Psychologist's "Additional Observations" consisted of checking unusual behaviors observed during the test period. (See Appendix B for list of unusual behaviors). Hyperactivity and hypoactivity were among the unusual behaviors, thus providing a measure similar to the hypoactive/hyperactive rating of the newborn. The 3-year measure differed from the earlier newborn measure by attempting to describe the child only on the day of the examination, rather than as a feature of the child over some time. The examination took place in a quiet 8' x 10' room with attention to selection and placement of furniture.

For the purposes of this study, the ratings for the 3-year measure of AL were dealt with in the same way as the newborn measure (Newborn Diagnostic

Summary). That is, AL was classified as: 1) hypoactive, 2) normal (i.e., no rating), or 3) hyperactive.

The 4-year Psychological Exam-Behavior Profile provides a fifth measure of AL. This exam was administered by a psychologist to children between the ages of 3 years 7 months and 4 years 3 months. The psychologists observed and, as with the 8-month Behavior Profile, rated a number of behavior dimensions on a 5-point scale. Additionally, instructions stated that the purpose was not to differentiate between levels of normal behavior; however, distributions on this variable do approach normality (see Nichols & Chen, 1981). The following AL scale was used to rate the "amount of activity and motor restlessness demonstrated by the child during the test session":

1. Extreme inactivity and passivity; very little or no self-initiated activity;
2. little activity; content to sit still most of the time;
3. normal amount of activity; able to sit quietly when interested; may fidget and become restless at times; may demonstrate a high energy level which is normal for this age;
4. unusual amount of activity and restlessness; very seldom able to sit quietly;
5. extreme overactivity and restlessness; can't sit still; constantly in motion; appears propelled by internal drives; activities may not be in response to external stimulation.

The psychologist was also advised to expect a certain amount of restlessness towards the end of the examination. Further instructions for the rating of dimensions in the Behavior Profile indicated that behavior be rateo relative to other peers and compared to the following description of the characteristics a typical 4-year-old child:

Talkative
Boastful
Refuses to admit inability
Assertive
Self-praise and self-approval
Physically very active
Bossy and critical of others
Extremely curious
Negativistic
Very imaginative
Develops more fears
Supplies alibis:
"My mother does not want me to do this."
"I have no time."
"I said, I don't know, didn't I?"
Cooperative play relationships with peers.

The 4-year-old is becoming self-dependent in the area of self-help with his ability to dress, undress, comb his hair and brush his teeth with minimal assistance. He is becoming very interested in his surroundings; displays a great deal of curiosity about people and the world around him; asks millions of questions; and now enters the "why" stage.

He tries out his abilities; likes to play with words and tries them out; and has many ideas which he is unable to carry out. He no longer naps in the afternoon and parallel play has developed into cooperative play with two or three of his peers. He is becoming a social creature and usually enjoys attending nursery school. He is beginning to become conscious of his overall physical development in relation to his peers and is now aware of sex differences. He is interested in the nature of the differences between the sexes and may be worried about them. He is beginning to differentiate between boys' and girls' roles, and often his play is limited to children of the same sex.

His social interest is developing, and he is beginning to have some guilt about his assertiveness, his boasting and his fears. His imagination is very fertile and intense. This rich inner life manifests itself in many problems which are relevant to this age level. Many fears and excessive daydreaming may be the result of the 4-year-old's world of "make believe" and imaginary playmates. He may evidence fear of the dark, dogs, fires, death, body injuries and castration. Fears may be more intense in children who have been made more tense by forceful feedings, severe toilet training, scary stories and warnings. Children who have not yet developed independence and social awareness and rapport may find refuge in this fantasy life.

The 7-year Psychological Examination Behavior Profile provides the sixth measure of activity, a 5-point rating scale identical to that used in the 4 year test. Children between the ages of 6 years 7 months and 7 years 3 months were rated by a psychologist on various behavioral dimensions. Once more, the purpose was not to differentiate between various levels of normal behavior, but again, as illustrated by Nichols and Chen (1981), the distribution is near normal.

The seventh measure of AL is for the 8-year-old and is found in the Final Speech, Language and Hearing Exam Additional Observations. Hypoactivity and hyperactivity, along with 17 other behaviors, were scored as present or absent during the test period. (See Appendix C for list of "General Behavior Abberations Observed during the Test Period"). Specifications for the examining room indicated the room should be at least 8' x 10' with a table and chairs appropriate for 8-year-olds, and should be away from any main sources of ambient noise and free of distractions. The examiner was to ensure the child was physically comfortable prior to beginning the examination, and was asked to avoid expressing any dissatisfaction with the child during testing. Again ratings of AL will be coded as: 1) hypoactive, 2) normal (i.e., no rating), or 3) hyperactive.

Attention Span. Measures for attention span were taken from forms described previously, and the reader is referred back to these discussions for the relevant instructions/details pertaining to the particular form used. Measures of attention span are available at 8-months, 4 years, 7 years and 8 years. The 8-month measure is found in the Infant Behavior Profile in the form of a 5-point scale. Infants are presented with objects, and evaluated on the following scale as to how much time is spent with the object:

1. Attends to objects only very briefly; fleeting, momentary interest;
2. spends short time with objects; is easily distracted;
3. spends moderate amount of time with objects; is soon ready for another toy or activity;
4. spends fairly long time with objects; turns eventually to new toy or activity;

spends very long time with objects; does not turn to new toy or activity unless examiner intervenes. Although attention span may be difficult to measure during infancy, "duration of response" as measured by this scale should provide some indication, albeit a crude indication, of attentional style.

The second attention Span measure was a 4-years measure taken from the <u>4-Year Psychological Exam-Behavior Profile</u>. Each child was rated relative to the average 4-year-old (as outlined under the 4-year AL measure) on the following 5-point scale:

1. Attends to tasks very briefly; highly distractable; fleeting and sporadic attention; lack of concentration interferes significantly with test performance;
2. spends short time with tasks; easily distractable; frequently needs help in maintaining attention; brief attention may interfere somewhat with test performance;
3. spends adequate amount of time on tasks; able to concentrate until successful or until failure is clear;
4. spends more than average time on tasks; eventually is able to turn to new activity;

5. highly perseverative; unable to shift attention; fixated at one task; requires examiner's intervention in order to change activity.

The identical 5-point scale was also used the 7-year measure of attention span found in the 7-year Psychological Exam-Behavior Profile.

The third and were fourth 8-year measures of attention found in the Final Speech, Language and Hearing Exam-Additional Observation and differ from the former 5-point measures. Short attention span was coded on this exam as either being present or absent, and distractibility as being present or absent.

Maternal smoking. Smoking measures were obtained during the initial interview with the mother in early pregnancy (i.e., History Since Last Menstrual Period), and similar questions were asked during Repeat Visits. Among the questions, the interviewer asked the mother:

1. If she had ever smoked;
2. how many years in total she had smoked;
3. how many cigarettes per day she was smoking at the time;
4. the age at which she had started smoking;
5. if she had quit smoking, the age at which she quit.

From these questions it was determined if a mother: i) ever began smoking; ii) began smoking, but had quit; iii) still smoked; and, iv) the number of cigarettes she smoked per day. From this information, mothers smoking status was broken down into four groups. Mothers were defined as nonsmokers, pre-pregnancy quitters, during-pregnancy quitters, or continual smokers. Nonsmokers were those mothers who had responded that they had never begun smoking and who reported not smoking at all repeat visits. Pre-pregnancy quitters were mothers who had reported having smoked at one time, but not at the initial prenatal visit to the doctor and not at any repeat visits. During-pregnancy quitters were mothers who reported smoking at the initial visit, but not at any repeat visits. Continual smokers reported smoking at the initial and at one or more repeat visits to the doctor. Finally, pregnancies were also classified as smoking or nonsmoking pregnancies so that the offspring could be identified as having been prenatally exposed to cigarette smoke or not exposed. A smoking pregnancy included pregnancies in which mothers' smoking was present for part or all of the pregnancy (i.e., DPQ plus CS), and a nonsmoking pregnancy involved those in which no smoking occurred during the pregnancy (NS plus PPQ). Table 3 indicates the percentage of mothers falling into each of these categories. Finally, a mean number of cigarettes per day was calculated for each women who reported smoking at repeat prenatal visits (i.e., CS only). The overall mean cigarettes smoked per day for this group of women was 12.17 and the medium was 10. Over half of these women (54%) smoked 10 or fewer cigarettes per day, and about a fourth (26%) smoked 20 or more per day.

Control variables. The variables controlled for in the analysis of the four smoking issues included: birthweight, gestational age, birth order, parental education, and maternal alcohol use and drug exposure. Birth weight was the newborn's official weight recorded usings the following instructions:

> "Record the child's official birth weight. It is desirable that a metric system scale be used and the weight be recorded in grams. However, if an English system scale is used, report the weight in pounds rather than converting to grams. Report ounces as fractions (--1/16) of a pound thus: seven pounds, six ounces is recorded as 7 and 6/16."

TABLE 3

Percentage of Mothers in each Smoking Category

Category	Percentage	n
Nonsmoking Pregnancies		
Nonsmokers	41.58	9586
Pre-pregnancy quitters	11.23	2589
	50.82	12175
Smoking Pregnancies		
During-pregnancy quitters	3.30	761
Continual smokers	43.88	10116
	47.18	10877

Gestational age was noted by an interviewer on a form entitled Reproductive History. Instructions for determining gestational age follow:

> "The length of gestation should be given in weeks from the Last Menstrual Period (LMP) to the termination of pregnancy (corrected to the nearest whole week). The average as determined in this manner is 40 weeks. If the gravida reports a duration in months,

> multiply the number of months by 4 1/3 to get the number of weeks. Thus, a 4 month gestation is equal to 17 1/3 weeks, which should be recorded as 17. If, however, the gravida reports "9 months," she probably means term, or 40 weeks). If the gravida reports a delivery as "three weeks early" or "2 weeks late," add or subtract this number of weeks from 40."

Birth order was determined by subtracting the number of prior lost pregnancies from the total number of prior pregnancies as reported by the gravida during the Reproduction History. Parental education was also obtained by the mother's report during the initial interview.

The measure for maternal alcohol use is found on the Obstetric Diagnostic Summary. This instrument was sometimes completed by non-physician personnel (nurses, code clerks, lay editors, etc.) at the preliminary summarization stage, but was edited as soon as possible under the immediate supervision of the Obstetric Coordinator. The coordinator attempted to secure any missing information or clarify inadequate data at the time. The presence or absence of alcoholism was noted on the summary form, with instruction that absence should only be indicated if the condition was definitely absent.

Maternal drug use was also classified as present or absent. Three measures of drug use are available, two including drugs taken during pregnancy (Drugs in Pregnancy) and the other, including anesthetics administered prior to and during delivery (Anesthetic Agents). Mothers were classified as having been exposed or not exposed to drugs and/or anesthetics.

Other demographic variables. These variables included: number of prior pregnancies and prenatal visits to the doctor, newborn body length and head circumference. Except for the latter two newborn measures, demographic data was collected during the interviews with the mother in early pregnancy. The newborn measures (i.e., body length and head circumference) are available from the Delivery Report and the Neonatal Examination respectively. Body length and head circumference were measured by a pediatrician somewhere between zero and 24 hours subsequent to birth. Body length was "measured with the child in supine position on a flat surface" to the closest centimeter. Head circumference was recorded to the closest centimeter using a flexible measuring tape "applied firmly over the glabella and supraorbital ridges anteriorly and that part of the occiput posteriorly which gives the maximum circumference".

Hypothesis Restatement

Each hypothesis is restated below:

1. Amount of maternal smoking (MS) and offspring AL will be positively associated, while amount of maternal smoking and attention span (AS) will negatively associated.

   $r\ (MS, AL) > 0.$

   $r\ (MS, AS) < 0.$

2. AL will be higher and AS will be lower for offspring of mothers who continued to smoke during the entire pregnancy (CS) compared to those of mothers who quit during their pregnancy (DPQ).

   $AL(CS) > AL(DPQ).$

   $AS(CS) < AS(DPQ).$

3. AL will be higher and AS will be lower for children who were prenatally exposed to cigarette smoking during pregnancy (SP) compared to those not exposed to maternal smoking or non-smoking pregnancies (NSP).

   AL(SP) > AL(NSP).

   AS(SP) < AS(NSP).

4. AL will be higher and attention span lower for the offspring of pre-pregnancy quitters (PPQ) compared to the offspring of mothers who had never smoked (NS).

   AL(PPQ) > AL(NS).

   AS(PPQ) < AS(NS).

   Note: Maternal alcohol use and drug exposure, parents' education, gestational age, birth weight, and birth order was partialed out in each of these this analyses.

5. Four-year-old children will be more active than both 7-year-old children and 8-month-old children.

   AL(4 yr) > AL(7 yr).

   AL(4 yr) > AL(8 month).

6. Individual differences in AL will show test-retest stability.

   r (longitudinal AL pairings) > 0.

7. Attention span (AS) and AL will be negatively related.

   r (AS,AL) < 0.

Results

Preliminary data manipulation

Two tapes consisting of NCPP data were obtained from the Developmental Neurology Branch Neurological Disorders Program. One tape consisted of variables that had previously been extracted from the raw data and conveniently stored on a summary tape. It was also necessary to work from the raw data tape since some of the activity level measures and smoking measures were not on the summarized tape. The Developmental Neurology Branch created this raw data tape by extracting the requested information from the 21 tapes comprising the entire data set. Data from the two sources was linked by identification number, which identified both the mother and the child for a particular pregnancy. The linking of the data was accomplished using the SAS computer package, as was all other data manipulation.

Prior to hypothesis testing, a computer programme was written to modify the data for the examination of the hypotheses. Many of the variables were recoded since the initial coding was inappropriate for analyses. The number of cigarettes smoked per day was calculated by obtaining a mean for each mother who reported smoking after the initial prenatal visit. Also the four activity scales (i.e., the two newborn, the 3-year, and the 8-year scales) were created. To create these scales, two-way frequency tables were examined to determine if any subjects had been rated both hypoactive and hyperactive on the same measure. For the newborn measure involving multiple ratings of AL over time, 0.27% of the neonates were rated at least once as diminished, while also being rated at least once as excessive. These contradictory ratings were not used in the creation of the first newborn measure, since such inconsistency could reflect coding errors. Similarily the second newborn measure did not include neonates who were recorded as both hypoactive and hyperactive (0.03%) in the calculation of the 5-point newborn measure. Recording errors were assumed in these cases, where ratings on both dimensions were given at the same time. Finally, for the same reason, any 8-year old, who was rated as both hypoactive and hyperactive, (.02%), was not given a score on the 8-year activity rating. No subjects were rated both hyperactive and hypoactive simultaneously on the 3-year measure.

In an indirect way, the very low incidence of a subject being rated both hypoactive and hyperactive can be used as evidence of reliability. In the first case, where subjects were observed at different times in the nursery, the very few inconsistent ratings suggest that the neonate's AL remained stable over ratings. In the latter two measures, where the incidence of a simultaneous rating of hypoactive and hyperactive behavior was low, reliability in coding is implied. A simultaneous rating of hypoactivity and hyperactivity would clearly suggest some sort of unreliability in the rating procedure, and the low percentage of such ratings is reassuring.

Following the modification of variables and the creation of AL scales, each of the outlined hypotheses were tested. Results from the basic longitudinal AL hypotheses will be addressed before the smoking results for purposes of organization. The longitudinal AL hypotheses included an examination of the longitudinal trend in AL (i.e., curvilinear hypothesis); the stability of AL over time; and the relationship of AL to attention span.

Longitudinal AL hypotheses

Longitudinal trend. The curvilinear AL hypothesis was examined by way of a pair of t tests, and was supported only in part. The test for the difference between 8-month AL and 4-year AL was significant, t (15566) = 17.30, $p < .0001$. However, in contrast to the prediction, the mean was higher for 8-month activity (3.12), than for 4-year activity (3.02). The difference for the 4-year to 7-year comparison was again significant, t (15833) = 12.24, $p < .0001$, and was in the predicted direction, the 4-year-olds being more active (M = 3.02) than 7-year-olds (M = 2.95). It is important to note that the measurement of AL at different ages may be based on different metrics. In other words, a score of 5 for the 8-month old may reflect a different measure of activity than the same score for the 4-year or 7-year measure. This is particularily true in comparing the 8-month and 4-year scales since a variable value of "4" at 8 months meant "much activity", as defined in the instrutions, while a value of "4" at 4 years meant "unusual amount of activity and restlessness". To the extent that AL measures at different ages are based on different metrics, trends in AL over time would be difficult to assess.

Stability in AL. The hypothesis that individual pairings of longitudinal AL measures would be positively associated was considered next. Since the pairwise correlations were not independent of one another, some method of controlling for type 1 error was advisable. A likelihood ratio statistic (see Morrison, 1976) was used to reduce the possibility of finding significant correlations by chance. This calculation involves testing the null hypothesis that the entire matrix of correlations is an identity matrix (i.e., that all off-diagonal correlations are equal to zero). The calculation of this likelihood ratio requires that a subject has a value on every AL measure, which resulted in a sample size of 5999 for this particular analysis. The null hypothesis was rejected implying that it was meaningful to further discuss the bivariate relationships within the matrix, $\underline{X}^2$ (21) = 700.9, $p < .001$. All correlations are found in table 4 where it can be seen that 12 out of the 21 correlations between

TABLE 4

Longitudinal Activity Level Correlations

	neo 2	8 mo	3 yr	4 yr	7 yr	8 yr
neonate 1	.19 ***	.02	-.01	.01	.02	-.01
neonate 2		.02	-.03 *	.01	-.01	.00
8 month			.03 *	.06 ***	.05 **	.05**
3 year				.14 ***	.07 ***	.05 **
4 year					.18 ***	.08***
7 year						.10***

$\underline{n}$=5999.

* $p < .05$. ** $p < .0005$. *** $p < .0001$.

AL at different ages are significant. Because some of the AL measures were correlated with others, they were combined for further analysis. The rationale for aggregating this data follows Epstein's (1980) recommendation, and presumably enhances the reliability of the measures. The two newborn measures were significantly correlated with each other but did not, with one exception, relate to the later measures. For this reason, the two newborn measures for each baby were summed to create a single newborn or neonate scale. It is also apparent from table 4 that the 3-year to 8-year measures were intercorrelated, and were therefore aggregated into a single childhood measure. While all of the childhood measures were significantly correlated, the highest magnitude correlations were between the 4-year and 7-year measure. A partial explanation for this is that the 3-year and 8-year intercorrelations are attenuated due to the less than ideal distributional properties of these 3-point measures. The 8-month score was significantly related to the later childhood measures, but for three reasons was kept distinct. First, the magnitude of the 8-month intercorrelations were not as strong as the intercorrelations at later ages. Second, there was the suspicion that perceptions of AL at 8 months would be very strongly influenced by whether the infant was walking or not. Thus, the 8-month AL ratings would reflect individual differences in maturational timing rather than in customary energy expenditure. Finally, as previously described, the discontinuity between newborn and childhood AL may indicate that some kind of development transition occurs between infancy and early childhood. To consider the possibility of such discontinuity, the 8-month measure was maintained.

AL and attention span. Prior to examining the relationships between AL and attention span, the four attention span measures were also assessed using the likelihood ratio test. This again required that each subject have a value on every attention measure, and resulted in a sample size of 8311. The matrix was found to be significantly different from the identity matrix, $\underline{X}^2$ (10) = 2792.65, p < .0001, i.e., off-diagonal correlations differed from zero. The individual correlations between the attention span

TABLE 5

Longitudinal Attention Span Correlations

	Age			
	4 yr	7 yr	8 yr (1)	8 yr (2)
8 mo	.01	.02	.00	-.01
4 yr		.08***	.07***	.06***
7 yr			.12***	.09***
8 yr (1)				.52***

n=8311.

*** p < .0001.

(AS) measures can be seen in table 5.

Two attention span measures were derived and used for all the following analyses. The 4-year, 7-year, and two 8-year measures were significantly related to each other, and were combined to create a childhood attention span measure. It should be noted that the very high correlation between the two 8-year measures is probably inflated due to these measures being recorded by the same rater in the same situation and at the same time. Once again, the 8-month measure was unrelated to the same construct at later ages, so the 8-month attention span variable remained separate. The discontinuity between the 8-month and later childhood attention span measures is consistent with the pattern in AL, and provides further reason to suspect that some kind of developmental transition may be occurring at this time.

The examination of relationships between AL and measures of attention span involved 5 correlations, thus the control of Type 1 error again became necessary. The multistage Bonferroni procedure, introduced by Lazelere and Mulaik (1977), was used to reduce the probability of making at least one Type 1 error to .05. This involved adjusting the alpha level by dividing the nominal alpha of .05 by the number of a priori tests. With this adjusted alpha of .01, it was determined that 2 of the 5 correlations were significant. During the next step of the multistage procedure, the 3 nonsignificant correlations were retested, again readjusting the alpha. This involved dividing the previously established alpha (.01) by the number of a priori tests (5) minus the number of nonsignificant correlations (3). Since all nonsignificant correlations remained nonsignificant at the new .005 alpha, the stage procedure terminated.

The results regarding the AL and attention span correlates (see table 6) indicated that the predicted negative correlation for 8-month AL and AS was not supported. In contrast, AL and attention span were significantly positively related in infancy. The expected negative relationship, where

TABLE 6

Activity Level by Attention Span Correlates

		Attention Span	
		infant	child
	neonate		
Activity	infant	.27***	
	child		-.35***

n=not less than 3021.

*** $p < .0001$.

Note. Only significant correlations as determined by Lazelere and Mulaik (1977) procedure are tabled.

AS is associated with high AL, was however, strongly supported in childhood, r (6864) = -.35, $p < .0001$.

<u>Maternal smoking and AL/attention span hypotheses</u>

<u>Variables</u>. The examination of smoking behavior as a predictor of both AL and attention span involved the multiple regression technique, which allowed for the statistical control over prenatal exposure to drugs and medication taken during pregnancy, anesthetics administered prior to and during delivery, and severe alcohol usage. The percentages of newborns who had been prenatally exposed to drugs and alcohol are presented for each smoking category in table 7. Nursery weight, fathers' and mothers' education, gestational age, and birth order were also partialled out of the analysis. The means and standard deviations for these continuous

TABLE 7

Percentage of Prenatal Exposure to Drugs and Alcohol by Mothers Smoking Status

	Non-smoking pregnancies		Smoking pregnancies	
	NS	PPQ	DPQ	CS
Drugs during Pregnancy	94.31	95.75	94.72	95.60
Medication during pregnancy	76.05	83.94	77.75	80.03
Anesthetics during delivery	82.98	86.92	82.51	86.17
Alcoholism during pregnancy	.01	.00	.00	.09

predictors are found for each smoking group in table 8. Intercorrelations among all predictor variables are found in table 9. The variables of

TABLE 8

Means and Standard Deviations for Continuous Predictor Variables by Mothers Smoking Status

	Nonsmoking Pregnancies			
	NS		PPQ	
	M	SD	M	SD
Father's education	11.13	3.35	11.98	3.22
Mother's education	10.74	2.79	11.45	2.59
Gestational age	39.43	1.22	39.53	1.20
Nursery weight	3241.18	446.27	3286.55	446.10
Birth order	2.64	1.98	2.48	1.90
	Smoking Pregnancies			
	DPQ		CS	
	M	SD	M	SD
Father's education	11.20	3.02	11.09	2.79
Mother's education	10.72	2.69	10.68	2.33
Gestational age	39.50	1.21	39.50	1.25
Nursery weight	3243.98	440.13	3116.32	433.34
Birth order	2.60	1.86	2.71	1.90

interest for the testing of the smoking hypotheses included the mean number of cigarettes smoked per day, and three orthogonal contrasts regarding the mothers smoking status. The three a priori contrasts were: i) short vs. long exposure (DPQ vs. CS) ii) exposure vs. no exposure, (NSP vs. SP) and iii) quitters vs. nonsmokers (PPQ vs. NS).

As well as controlling for these variables, adjustments were made to three of the variables. First, newborns with weight under 2000 grams were excluded because these babies were small for gestational age, and it was thought this could independently influence AL and/or AS. Second, the birth

TABLE 9

Intercorrelations Among Predictor Variables in Regression Analyses

	2	3	4	5	6	7	8	9	10	11	12	13
1 Drugs in preg	31 ***	04 ***	03 ***	07 ***	07 ***	-01 *	04 ***	00	02 **	02 **	03 ***	02 **
2 Medication		07 ***	06 ***	11 ***	11 ***	00 ***	07 ***	00	03 ***	03 ***	06 ***	03 **
3 Anaesthetics			05 ***	20 ***	17 ***	-34 ***	04 ***	-01	03 ***	03 ***	04 ***	05 ***
4 Nursery weight				05 ***	06 ***	12 ***	28 ***	-01 *	-14 ***	-14 ***	-03 ***	-08 ***
5 Father's educ					64 ***	-30 ***	06 ***	00	-03 ***	-03 ***	06 ***	-01
6 Mother's educ						-27 ***	07 ***	00	-03 ***	-04 ***	06 ***	03 *
7 Birth order							-03 ***	01	04 ***	04 ***	-01	12 ***
8 Gestational age								00	00	01	02 **	03 *
9 Alcoholism									02 **	02 **	01	03 *
10 Duration										77 ***	34 **	00
11 Exposure											43 ***	00
12 Predisposing factors												00
13 Amount												

* $p < .05$. ** $p < .0005$. *** $p < .0001$.

order variable included a very small percentage (.0005) of negative values, which were assumed to be recording errors and thus discarded. In addition, the birth order distribution was highly skewed so a transformation using the natural logarithm was applied. Although this did not normalize the distribution, it did reduced the variance and the effect of outliers. Third, the mean number of cigarettes smoked per day was highly skewed, and therefore transformed using a logarithmetic transformation.

Regression models. Two separate regression models were established to address the four smoking questions. The first model included only those mothers who continued to smoke during their entire pregnancy (i.e., CS). This model was used in two separate analyses to examine the dose-response relationship between maternal smoking amount and measures of activity and attention span in the offspring. The second prediction equation was used to examine specific relationships between smoking status and both AL and attention span, thus both smokers and nonsmokers were included. Both models tested the appropriate hypothesis, while partialling out the control variables. The specific hypotheses for each of the smoking questions were evaluated by the significance of the beta weight for the smoking variables. In other words, the predictive value of all control variables was established, and then the additional predictive value of the maternal smoking variable was considered. The smoking variable consisted of the mean number of cigarettes smoked per day (for model 1), and the contrast of interest (for model 2).

Dose-response relationship. The hypothesized dose-response relationship between the number of cigarettes smoked per day and AL [i.e., (MS, AL) > 0] was supported, but only partially, because the number of cigarettes smoked per day was predictive of AL increases only for neonatal AL (see table 10).

TABLE 10

Predictive Success for Amount of Smoking on Activity Level and Attention Span

	Neonate		Infant		Child	
	t	n	t	n	t	n
Activity	2.75 *	8507	-.32	6793	1.15	2148
Attention Span			-.53	6785	.03	3203

* $p < .0006$.

The amount of smoking during pregnancy was not, however, associated with increased levels of AL at 8 months or in childhood, and similarly, the expected association between smoking and reduced attention span was not supported at 8 months or in childhood. The complete set of predictors was significant at all ages in accounting for both AL and attention span variance, which can be seen in table 11. The correlations and beta weights for each of the predictor variables and the dependent measures are found in table 12, and the t values for all control variables in this regression model are presented in table 13.

Duration of exposure. As with the test of the dose-response relationship, the hypothesis regarding long vs. short duration of exposure [i.e., AL(CS) > AL(DPQ)] involved only the offspring of smoking mothers, however, one group of smokers quit during pregnancy (DPQ) and the other continued to smoke for the entire pregnancy (CS). As indicated in table 14, significant differences in AL were found in the neonate, $t(14133) =$

TABLE 11

Predictive Success for the Full Model in Regressions where Amount of Smoking is Used to Predict Activity or Attention Span

	Neonate			Infant			Child		
	r^2	F	n	r^2	F	n	r^2	F	n
Activity level	.003	2.43**	8507	.010	9.61**	6793	.020	3.67**	2148
Attention Span				.009	6.37**	6785	.020	6.76**	3203

* $p < .01$. ** $p < .0001$.

2.24, $p < .03$ with higher AL for newborns whose mothers had smoked during the entire pregnancy. Whether a smoker quit during pregnancy or continued throughout did not significantly contribute to AL at other ages or to AS in infancy or childhood. The r^2 and F values for the overall set of predictors are found in table 15, where it can be seen that the set of predictor was significant for all ages for both AL and attention span. The correlations for each of the predictor variables with AL or attention span are found in table 16, and the t values for control variables in this regression model are found in table 17.

Exposure vs. no exposure. The next hypothesis compared mothers who smoked during pregnancy to those who did not, and predicted higher AL for children who had been exposed to cigarette smoke in utero [i.e. AL(SP) > AL(NSP)]. Recall that smoking pregnancies (SP) included mothers identified as continual smokers (CS), as well as those who smoked for only part of their pregnancy (DPQ), and nonsmoking pregnancies (NSP) included mothers

TABLE 12

Correlations and Beta Weights for Predictor Variables and Dependent Measures in Regression where Amount Smoked is Used to Predict AL or Attention Span

Predictor	Neonate		8 months		Childhood	
Activity Level						
	(n=8507)		(n=6793)		(n=2148)	
	r	b	r	b	r	b
Drugs	.01	.022	.00	.034	.00	.09
Medication	-.01	.017	-.04**	-.071***	.07**	.169
Anesthetics	.00	-.005	.02	-.027	.05*	.035
Nursery weight	.02*	.000	.04**	.000	-.01	.000
Father's education	.03*	.004*	.02*	.001	.07**	.014
Mother's education	.01	-.001	.02	-.001	.04*	-.007
Birth order	.00	.003	-.09***	-.082	-.10***	-.115
Gestational age	.02*	.003	.05***	.015	-.01	-.017
Alcohol	.00	.029	-.01	-.129	.00	-.103
Cigarettes per day	.03	.023*	-.02	-.005	.02	.052
Attention Span						
			(n=6785)		(n=3203)	
Drugs			.01	.08	.02	.08
Medication			-.03*	.05	-.02	-.08
Anesthetics			-.02	.04	.01	.01
Nursery weight			.04***	.00	.00	.00
Father's education			-.03*	.01	.11***	.02
Mother's education			-.02*	.00	.10***	.02
Birth order			-.01	-.03	.02	.07
Gestational age			.05***	.02	.04*	.03
Alcohol			.04***	.10	-.01	-.40
Cigarettes per day			-.01	-.01	.00	.00

* *p* < .05. ** *p* < .005. *** *p* < .0005.

TABLE 13

t Values for Control Variables in Regression where Amount of Smoking is Used to Predict Activity Level and Attention Span

Predictor	Neonate (n=8507)	8 months (n=6793)	Childhood (n=2148)
Activity Level			
Drugs	1.17	0.85	-0.92
Medication	-1.91	-3.83***	2.98**
Anesthetics	-0.48	-1.27	0.57
Nursery weight	1.79	3.25 **	.00
Father's education	2.35*	0.40	1.69
Mother's education	-0.32	-0.24***	-0.70
Birth order	0.51	-7.34*	-3.61***
Gestational age	1.17	2.52	-1.01
Alcohol	0.25	-0.52	-0.12
Attention Span			
		(n=6785)	(n=3203)
Drugs		1.87	1.24*
Medication		-2.44*	-2.40*
Anesthetics		-1.71	0.15
Nursery weight		2.72*	-1.40
Father's education		-2.19*	3.70***
Mother's education		-0.69	3.12***
Birth order		-2.42*	3.52***
Gestational age		3.57***	2.51*
Alcohol		3.61***	-0.82

* $p < .05$. ** $p < .005$. *** $p < .0005$.

who had never smoked (NS) along with those who had smoked but quit prior to

TABLE 14

Predictive Success of Smoking Status on AL or Attention Span

Contrast	Neonate	8-months	Child
	Activity		
	(n=17654)	(n=14173)	(n=4873)
Long vs. short duration	2.24*	.77	.18
Exposure vs. no exposure	1.61	1.36	1.50
Quitters vs. nonsmokers	-.50	-2.48*	-.72
	Attention Span		
		(n=14146)	(n=6780)
Long vs. short duration		.05	.01
Exposure vs. no exposure		-1.33	-1.91
Quitters vs. nonsmokers		.05	1.66

* $p < .05$.

Note. Quitters refer to pre-pregnancy quitters.

pregnancy (i.e., PPQ). As shown in table 14, the comparison of smoking vs.

TABLE 15

Predictive Success of the Full Regression Model where Mothers Smoking Status predicts Activity Level or Attention Span

	neonate			infant			childhood		
	r^2	F	n	r^2	F	n	r^2	F	n
Activity Level	.005	6.95*	17654	.010	16.81*	14173	.020	8.02*	4873
Attention Span				.009	10.94*	14146	.020	11.58*	6780

* $p < .0001$

no smoking during pregnancy did not significantly increase AL at any age. Similarily, the smoking vs. no smoking comparison was not predictive of attention span.

Quitters vs. nonsmokers. The final prediction was based upon the expectation that AL may be higher for the offspring of smokers as compared to nonsmokers due to characteristics of the mother, rather than as a result of fetal exposure to cigarette smoking [i.e., AL(PPQ) > AL(NS)]. Activity level was examined for children whose mothers had always been nonsmokers and compared to those whose mothers had once smoked, but had quit prior to pregnancy. Activity level was higher for infants (i.e., 8-month-olds) of mothers who had never smoked, as compared to AL of infants whose mothers

TABLE 16

Correlations and Beta Weights for Predictor Variables and Dependent Measures in the Regression where Mothers Smoking Status is Used to Predict AL or Attention Span

Predictor	Neonate		8 months		Childhood	
	Activity Level					
	(n=17654)		(n=14173)		(n=4873)	
	r	b	r	b	r	b
Drugs	.01	.01	.02	.09	.00	-.12
Medication	-.01	-.02	-.04***	-.08	.04**	.11
Anesthetics	-.01	-.02	.01	-.03	.06***	.03
Nursery weight	.02**	.00	.04***	.00	-.01	.00
Father's education	.04***	.00	.01	.00	.08***	-.14
Mother's education	.04***	.00	.00	.00	.06***	.00
Birth order	-.01	.00	-.08	.08	-.12***	.07
Gestational age	.02**	.00	.04***	.01	.01	.03
Alcohol	.00	.04	.00	.09	.00	.01
Long vs short duration	.03***	.01	.01	.01	.03*	.03
Exposure vs no exposure	.01	.00	-.02	.02	.01	.01
Quitter vs nonsmoker	.03***	.02	.01	.01	.02	.01
	Attention Span					
			(n=14146)		(n=6780)	
Drugs			.01	.06	.02	.05
Medication			.04***	-.07	.00	.04
Anesthetics			-.03**	-.06	.02	.01
Nursery weight			.06****	.00	.03*	.00
Father's education			-.02*	.00	.11***	.02
Mother's education			-.02*	.00	.11***	.02
Birth order			-.01	-.04	.02	.06
Gestational age			.04***	.01	.03	.01
Alcohol			.02*	.62	-.01	.39
Long vs short duration			-.03**	.01	-.01	.03
Exposure vs. no exposure			-.01	.00	.01	.00
quitters vs. nonsmokers			-.02	.00	.00	.04

* $p < .05$. ** $p < .005$. *** $p < .0005$.

TABLE 17

t Values for Control Variables in Regression where Smoking Status Contrasts Predict Activity level or Attention Span

Predictor	Neonate	8 months	Child
Activity Level			
	(n=17564)	(n=14173)	(n=4873)
Drugs	1.023	3.40**	-1.86
Medication	-3.14**	-6.08***	3.02**
Anesthetics	-2.42*	-2.33*	0.87
Nursery weight	2.90**	5.37****	0.12
Father's education	2.43*	0.09	1.75
Mother's education	2.58*	1.87	0.44
Birth order	-0.38	-10.28***	-6.63***
Gestational age	1.81	3.61***	-0.41
Alcohol	0.28	.36	-0.08
Attention Span			
		(n=14146)	(n=6780)
Drugs		2.23*	1.15
Medication		-4.94***	-1.83
Anesthetics		-3.62***	0.48
Nursery weight		6.25***	0.66
Father's education		-1.90	5.65**
Mother's education		-1.22	4.44***
Birth order		-4.31***	4.66***
Gestational age		3.13**	1.40
Alcohol		2.25*	-0.79

* $p < .05$. ** $p < .005$. *** $p < .0005$.

quit prior to pregnancy t (12) = -2.48, $p < .013$. This comparison however, was not significant at other ages for AL or for attention span.

The results for the AL-smoking hypotheses are summarized in table 18, where it is evident that the smoking-AL relationship at younger ages disappears during childhood. The values for the smoking-attention span hypotheses are not tabled since none of them were significant.

TABLE 18

Significance of Hypothesis Tests by Age

	Age		
Hypotheses	Neonate	8 months	Childhood
AL increases with amount smoked	.0001	ns	ns
AL increases with duration of smoking	.03	ns	ns
AL is higher for offspring of smoking pregnancies vs nonsmoking pregnancies	ns	ns	ns
AL differs for offspring of nonsmokers and pre-pregnancy quitters	ns	.01	ns

Discussion

Considered in their entirety, the present study finds that neonatal AL is influenced by variation in fetal exposure to cigarette smoke. Soon after birth however, other factors become more important for the etiology of AL. From the longitudinal analysis, it was found that AL decreased from infancy onward, that discontinuity occurred between newborn and childhood

AL, and that the relationship between AL and attention span changed from infancy to childhood. These findings suggest that factors other than maternal smoking are critical for the understanding of AL over time. Furthermore, the relationship between maternal smoking and AL was evident only in the newborn, and replication of this finding is necessary. Each of the results for the maternal smoking and longitudinal issues are discussed below.

Maternal smoking and behavior in the offspring

Although the pattern of results for the maternal smoking issues is complex, it provides some evidence for a relationship between maternal smoking and AL in young offspring. Generally, the examination of AL in the offspring of smokers suggests that maternal smoking may be related to AL in the very young, and that this relationship is either nonexistent or obscured by other factors at later ages. Newborn AL does not, however, differ for the offspring of smokers and nonsmokers. While this latter seemingly incompatible finding implies that there is no relationship between maternal smoking and neonatal AL, the finding can also be explained by other characteristics of smokers and nonsmokers.

Neonatal AL in offspring of smokers. The predictions regarding neonatal AL for the offspring of smokers were supported. That is, AL increased as the amount (i.e., MSamt > 0) and the duration (i.e., CS > DPQ) of maternal smoking increased, even when birthweight, gestational age, birth order, parental education, and maternal alcohol use and drug exposure were partialled out of the analysis. While an association between hyperactivity (i.e., the upper end of the continuum) and maternal smoking has been reported, the findings here suggest that maternal smoking may be related to the entire continuum of AL in the very young, though it should be noted that the continuum was created from reports of excessive, diminished, and normal AL. The demonstration of a dose-response relationship does support the notion of a causal link between the amount smoked and newborn behavior, as does the finding that AL is lower in newborns of mothers who quit smoking early in their pregnancy compared to newborns who were exposed to cigarette smoke throughout fetal development.

Neonatal AL in offspring of smokers vs. nonsmokers. If maternal smoking is related to AL in the offspring, and this is implied by the finding that neonatal AL increased with amount and duration of maternal smoking, it would follow that AL should also be higher for offspring who had been prenatally exposed to cigarette smoke compared to those who had not been exposed. Such differences however, were not found. This absence of a difference is consistent with Saxton's (1978) finding that AL did not differ between the newborns of smokers and nonsmokers. In contrast to the results regarding neonatal AL in the offspring of smokers, the failure to find differences when comparing smokers and nonsmokers implies there is no relationship between neonatal AL and maternal smoking. This paradox may be explained by considering the final smoking issue, pre-existing mother characteristics.

The purpose of comparing AL in the offspring of smokers and nonsmokers was to address a possible criticism that higher AL in offspring of smokers could be due to predisposing mother characteristics rather than to smoking per se. To examine this possibility, AL in the offspring of mothers who had never smoked was compared to the AL in those whose mothers had once smoked, but who quit prior to pregnancy. Pre-pregnancy quitters were assumed to possess the "smoking characteristics" that would contribute to higher offspring AL, yet their offspring would not have been exposed to cigarette smoke during fetal development. In contrast to the prediction, this comparison of nonsmokers' and pre-pregnancy quitters' offspring revealed that AL was lower for the infants of women who had once been smokers. In other words, differences between these two groups of mothers appear to contribute to AL such that offspring AL is suppressed for the infants of women who once smoked. If pre-pregnancy quitter do represent smokers in general, it is not surprising that the comparison of smokers and nonsmokers in this study failed to uncover AL differences consistent with those found in the dose-response and duration analysis. That is, if predisposing or environmental variables associated with being a smoker, lead to lower offspring AL, and prenatal smoking exposure leads to higher offspring AL, then these two sets of variables may cancel each other out. Moreover, this possibility could explain why Saxton (1978) failed to find a difference between AL in the newborns of smokers and nonsmokers.

The implications of an association between characteristics of smoking mothers and low infant AL are critical for researchers examining the link between AL and maternal smoking. First, there are obvious methodological implications for future research. For example, comparisons of smokers and nonsmokers may be meaningless without identifying, and perhaps controlling for, characteristics associated with the smoking mother that may reduce offspring AL. Past examinations of maternal smoking and AL have not directly examined the issue of such mother characteristics, although attempts have been made to control for variables that are known to covary with maternal smoking.

Second, suppressed AL for the offspring of smokers is of interest from a theoretical viewpoint, since it is in opposition to the Eysenckian genetic explanation, which would predict higher AL for these offspring. Smokers are presumably more likely to be extroverted and active, thereby passing on the predisposition for high activity to their children. Although the low AL in offspring of pre-pregnancy quitters (compared to the offspring of nonsmokers) does not support the Eysenckian hypothesis, it can still be consistent with a genetic hypothesis. For example, if smoking women tend to marry introverts, the AL of their offspring would reflect the father's genetic contribution to lower AL.

Finally, the finding that infants of nonsmokers and quitter differ in AL, emphasizes the presence of other factors that influence AL. Different causal processes are likely operating in the link between low infant AL and mother characteristics, and in the positive link between neonatal AL and fetal cigarette exposure (i.e., increasing AL with increasing amount and duration of exposure). For example, women who smoke may be less conscious of health-related issues than their nonsmoking counterparts. It would follow that such an attitude could lead to minimal parental attention to nutrition and general health in their offspring. Such behavior could have an observable impact by inhibiting overall development within the infant, thus slowing motor development. There is reason to believe that lower activity in the infant is associated with overall level of maturation (Richards & Newberry, 1938). Low infant AL in the offspring of pre-pregnancy quitters then, could be due to prenatal behaviors that lead to slow maturation, while heightened AL with increasing amount and duration of maternal smoking could be due to smoking exposure.

Extensive examination of fetal measures during maternal smoking will be required to understand how maternal smoking contributes to neonatal behavior such as AL. Physiological and behavioral changes related to maternal smoking have been noted in the fetus. These include reduced breathing, heart rates (Manning & Fegeraberd, 1976), and fetal movements (Thaler, Goodman & Dawes, 1980). Cole, Hawkins, and Roberts (1972) found a striking result when they measured carboxyhaemoglobin levels in pregnant mothers and their fetuses. Carboxyhaemoglobin forms when carbon monoxide combines with hemoglobin in the blood, and results in displacement of oxygen from the hemoglobin. The highest fetal levels were twice that of the mothers' level. While there is some evidence of physiological effects of prenatal cigarette exposure during fetal development, the effects of smoking on the offspring after birth are much less clear. Fried and Oxorn (1980) suggest that immediate neonatal effects of intrauterine cigarette exposure may occur due to withdrawl and/or the phenomenon of tolerance (pp. 28). Further systematic experimental study of the effects of cigarette smoke on fetal development will be necessary to understand how it is that behavior may be related to intrauterine cigarette exposure. The present correlational work helps to highlight the need for doing such experimental studies.

Infant/Child AL and maternal smoking. While the discussion has focused on the relationship between maternal smoking and AL in the neonate and the infant, some comments must be made regarding the failure to find an association between maternal smoking and AL in childhood. This finding is consistent with Streissguth et al's (1984) finding for 4-year olds, where AL was measured with a motion detector. It should, however, be noted that the present study differed from theirs by examining only smokers in the dose-response relationship and by using subjective ratings of AL. Likewise the lack of a relationship between maternal smoking and activity in the current study was found by Landsman-Dwyer, Ragozin and Little(1981), whose measure of AL (i.e., the Werry, Weiss, and Peters Activity scale) was more similar to the present measure. In contrast to these results however, a relationship between maternal smoking and activity was reported using mothers' ratings of their children's activity (Landsman-Dwyer, Ragozin, & Little, 1981). In their study, the differences may be due to differences in ratings by smokers and nonsmokers rather than real AL differences. Although further research is required to examine the relationship between maternal smoking and the continuum of childhood AL, such a relationship may not exist. This would be somewhat surprising given that a relationship has been reported between maternal smoking and hyperactivity in children. Studies that report a relationship between maternal smoking and hyperactivity however, may be measuring something more than activity, and maternal smoking may be related to a pattern of behavior including, but not limited to, pure activity. Clearly, for example, when Nichols and Chen (1981) established a link between maternal smoking and hyperactivity, their hyperactive-impulsive factor (HI) was a measure of more than pure activity.

Attention span and maternal smoking. Some comments should also be made regarding the failure to find an association between maternal smoking and attention span in the offspring at any age. The examination of the association between maternal smoking and attention span involved the same analyses as those used in the maternal smoking-AL assessments. That is, attention span was examined in the offspring of smokers only, and as well, in the offspring of smokers compared to nonsmokers. No differences in attention span were found as the amount or duration of maternal smoking increased, and similarly, no differences were found when comparing offspring who had been prenatally exposed to cigarette smoke and those who had not, although the latter prediction (i.e., those exposed would have lower attention span) approached significance. Landsman-Dwyer, Ragozin and Little (1981) also found no association between maternal smoking and attention span when comparing 4-year-olds who were not prenatally exposed to cigarette smoke with those who were. In contrast, however, Streissguth et al. (1984) found a dose-response relationship such that attention span in 4-year-olds declined as amount of maternal smoking increased.

The present study differed from Streissguth et al.'s study in several ways that could explain these inconsistent findings. First, measurements of attention span differed in that Streissguth et al. used a vigilance task, while the present study relied on a subjective ratings of attention span during an interview. Second, Streissguth et al. included nonsmokers in their analysis of a dose-response relationship, while the current study used only smokers in the dose-response measurement of attention and maternal smoking. The latter approach may be a better test of the relationship since the inclusion of nonsmokers may introduce the influence of factors other than attention. It should however, be noted that to the extent that pre-pregnancy quitters represent smokers as a whole, the results of the present study suggest that smokers do <u>not</u> seem to differ from nonsmokers in ways that influence attention span. Further research, however, would be required to conclude that pre-existing group differences do not influence attention span, and further studies should carefully select a sensitive measure of attention span. The results of the few studies that have addressed this issue are mixed, and it is too early to draw firm conclusions. Attention span as measured in this study does not appear to be related to maternal smoking.

This analysis of the NCPP data base indicates that maternal smoking is related to newborn AL but not to later activity, a finding that would only appear using a longitudinal approach. It may simply be that maternal smoking affects newborn AL in a temporary way. For example, reduced neonatal AL may be due to an oxygen shortage experienced just prior to birth, and given the adequate oxygen suppy following birth, AL may increase. Alternatively, a link between maternal smoking and childhood AL may persist but be obcured by other factors as the child grows. Considering the results from the longitudinal AL issues, it is argued that AL is initially related to maternal smoking, but later comes under the influence of other factors. This point will be further elaborated following a discussion of the major findings for the longitudinal issues.

<u>Longitudinal AL issues</u>

Overall, the results of the longitudinal issues indicate that AL decreases from infancy to childhood, and that during childhood, AL is stable and negatively related to AL. In infancy however, AL is unrelated to childhood AL, and positively related to attention span. The childhood AL findings were expected and will therefore be discussed prior to the more unexpected infant findings.

Childhood AL. The results regarding childhood AL are consistent with much previous research. For example, stability in childhood AL has been demonstrated (e.g., Halverson & Waldrop, 1976), and the present study adds further support to the idea that AL is a stable childhood dimension. A predicted decrease in AL from 4 years to 7 years was also supported and may suggest that some kind of inhibitory factors are operating to reduce AL over time. In contrast to the predicted increase in AL from infancy to 4 years, AL decreased from infancy onward. To the extent that the AL measures at various times are based on similar metrics, the AL pattern can be viewed as one of decline, which may suggest that inhibitory factors begin to operate earlier than would be expected by the curvilinear hypothesis.

The negative relationship between childhood AL and attention span is consistent with the well-established hyperactivity-attention link (e.g., Roberts, Milich, Loney & Caputo, 1981), and with a study that directly examined the link between AL and attention in 2-year-olds (Repucci, 1970). It follows from the present results that childhood attention span is related not just to the upper end of the AL continuum (i.e., hyperactivity), but more generally to the entire continuum. This conclusion implies that children with high levels of activity are likely to be less attentive, which has numerous implications. For example, those children who have high levels of activity are surely to be at a disadvantage in some learning situations.

Neonatal and infant AL. Unlike the clear relationships found in childhood, results for the younger periods are more complicated. Some of the findings are consistent with previous research, while others are not.

As with previous research (Korner et al., 1981), this study did find stability in neonatal AL when measured from day to day. Newborn AL however, was not related to AL at 8 months or to later childhood measures of AL (with the exception of the three-year measure). The 8-month measure of AL was related to later childhood measures, but the relationships were not as potent as those between the 3-year, 4-year, 7-year, and 8-year measures. This relationship between infant AL and both earlier and later AL is complex. Infant AL (8 months), when rated by parents, has been found to relate to AL at 3 months (Rothbart, 1980), which may mean that 8-month AL is related to earlier AL but not to neonatal AL. The relationship found between 8 month and 3 month AL in Rothbart's study could be due also to the continuity in the raters at the two measurement times.

Inconsistency in behavior during the infant period has been observed by other researchers as well. Schaefer and Bayley (1963) reported inconsistency in their analyses of many behaviors in the Berkely Growth Study. They found "consistency of behavior through time reveals rapid changes for earlier ratings, more consistency for latency periods, and some evidence of rapid changes during the period of adolescence." A transition occurring during infancy that affects customary energy expenditure may, in part, explain the discontinuity in the pattern of AL over time. Such a transition may involve some form of physiological or environmental inhibitory process, or both, and may result in great variability for AL across infants. More specifically, these factors could become operative earlier for some infants than for others, causing differential reductions in AL.

While an explanation for the discontinuity in AL across time is not obvious, the finding is itself important for infant researchers. Depending on the goals of the researcher, these results suggest that the use of an 8-month measurement point may reduce the chances of finding relationships that may exist at earlier or later times. An 18-month measurement point, at which time most children have presumably settled into a more stable pattern of AL, could be more useful for the examination of the relationship between AL and variables of interest. Alternatively, and preferably, a longitudinal approach would clarify changes in patterns and relationships that may be age-dependent.

The finding of a positive relationship between infant AL and attention span is also perplexing and is not consistent with previous infant studies (Bayley & Schaefer, 1963; Garside et al., 1975) that report a negative relationship. These studies, however, used somewhat older infants (i.e., 10 months and older), which could account for the discrepant results. An explanation for the unexpected findings in the current study may be due to possible problems with the 8-month measures. Only one measure of AL and attention span are available for the infancy measures, which suggests that these measures are lower in reliability than the childhood measures. In addition, the difficulty in judging infant attention span could contribute to invalid measures of attention span at this measurement time. Attention span is clearly easier to judge in the child where observation can take place during their responses to a task. A second explanation for the unexpected relationship is that a transition, such as that described earlier, is influencing the relationshp of AL to other variables.

<u>Conclusions</u>

While many variables influence AL, a relationship between maternal smoking and newborn AL is apparent in this study. This relationship may be of a temporary nature or it could be more permanent, but obscured by other factors as they become operative. If, for example, AL is reduced sufficiently by mechanisms that come into play in infancy, a link between AL and maternal smoking that would otherwise appear could be obscured. Maternal smoking may have the potential to influence childhood AL, but other factors that inhibit AL in the developing child may be of overriding importance. If, in some cases, such commonly overriding factors fail to become operative, then the link between childhood hyperactivity and maternal smoking may be evident. In other words, those who are exposed to maternal smoking and who are slow to develop inhibitory mechanisms may be at risk for hyperactivity.

In conclusion, the most critical observation to be made from this study is that an understanding of the etiology of AL requires a multi-causal model taking into account genetic, biological, and environmental influences, including factors in the prenatal environment such as maternal smoking. This multi-causal model is implied in a number of the findings from this longitudinal analysis. Further, this study demonstrates an association between maternal smoking and AL in the very young, though the results do not provide causal evidence that maternal smoking affects AL. As emphasized by Hickey, Clelland, and Bowers (1978), researchers have too often fallaciously infered causality from pure association in smoking-infant measures. Nevertheless, establishing an association between AL and maternal smoking is important, especially after controlling for variables known to covary with maternal smoking. Such covariance anayses help to rule out competing hypotheses in explaining the AL-smoking connection.

Future examinations of the maternal smoking-AL link should consider those differences between smokers and nonsmokers which may influence AL. Comparisons of the offspring of mothers who quit prior to pregnancy, who quit during pregnancy, and who have not quit would also provide clarity in the interpretation of results on maternal smoking and offspring behavior. Longitudinal designs are useful for the study of this link since, as this study suggests, prenatal cigarette exposure may be related to AL in a temporary way, or only at certain periods of development. The research on maternal smoking and offspring AL has to date provided inconsistent results. This inconsistency is undoubtably due to the complexity of the issue, and it is the identification of such complexities that will add futher clarity to the results of further research.

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Appendix A

COLLABORATING INSTITUTIONS

Boston Lying-In Hospital

Providence Lying-In Hospital

Children's Hospital Buffalo

Columbia-Presbyterian Medical Center

New York Medical College

Pennsylvania Lying-In Hospital

John Hopkins Hospital

Medical College of Virginia

University of Tennessee College of Medicine

Charity Hospital, New Orleans

University of Minnesota Hospital

Univerisity of Oregon Medical School

Appendix B

UNUSUAL BEHAVIOR OBSERVED DURING TEST PERIOD

(3 year old)

None

Purposeless hand motions

Excessive crying

Excessive laughing

Hyperactivity

Hypoactivity

Withdrawn

Perseveration

Echolalia

Spontaneous communication, limited or lacking

Other (Describe)

Appendix C

GENERAL BEHAVIOR ABERRATIONS OBSERVED DURING TEST PERIOD

(8 year old)

Purposeless hand motions

Unusual Posturing

Excessive Crying

Excessive Laughing

Hyperactivity

Hypoactivity

Lack of Spontaneous Communication

Withdrawal

Distractability

Negativism

Perseveration

Echolalia

Impulsivity

Echopraxia

Motor Disinhibition

Short Attention Span

Tics

Tremors

Other (describe)