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Temperament and sex as moderators of the relationship between maternal smoke exposure during pregnancy and child externalizing behaviors

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TEMPERAMENT AND SEX AS MODERATORS OF THE RELATIONSHIP BETWEEN MATERNAL SMOKE EXPOSURE DURING PREGNANCY AND CHILD EXTERNALIZING BEHAVIORS

by

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DEDICATION

There are several people to whom I would like to dedicate this work. I would like to dedicate this to my loving husband for being incredibly supportive and for putting up with my busyness, my academic clutter (which at one point may have overtaken the entire house) and my constant whines and complaints about graduate school. I would also like to dedicate this to my mentoring committee, who have made themselves incredibly available to me, despite my being a very needy grad student. As well, their combined tutelage has been absolutely essential to my academic success, even when I manage to change my research focus every other week. Last, I would like to dedicate this to my parents, who did a wonderful job of raising me (or at least I would like to think they did).

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CHAPTER 1

TEMPERAMENT AND SEX AS MODERATORS OF THE RELATIONSHIP BETWEEN MATERNAL SMOKE EXPOSURE DURING PREGNANCY AND CHILD EXTERNALIZING BEHAVIORS

In 2007 approximately 31.8% of women who were of childbearing age (15-44 years) smoked cigarettes (USDHHS, 2007). In addition approximately 16.4% of women in this age range smoked cigarettes during their pregnancy. Smoking during pregnancy has been associated with a number of deleterious consequences. The most notable of these consequences is low birth weight, but maternal smoking has also been associated with respiratory infections, asthma, childhood obesity, low Apgar scores, increased rates of still births, neonatal deaths and orofacial clefts (Gilliland, Li & Peters, 2001; Kallen, 2001; Shaw et al., 1996; Taylor & Wadsworth, 1987; Toschke, Koletzko, Slikker, Hermann & von Kries, 2002). Many studies have also found links between maternal smoking during pregnancy and negative child behavioral outcomes (Brook, Brook & Whiteman, 2000; Gaetzke-Kopp & Beauchaine, 2007; Hook, Cederblad & Berg, 2006; Jacobsen, Slotkin, Mencl, Frost & Pugh, 2007; Martin, Dombrowski, Mullis, Wisenbaker & Huttunen, 2006; Naeye & Peters, 1984; Roza et al., 2008; Schmitz et al., 2006; Wakschlag et al., 1997; Weissman, Warner, Wickramaratne & Kandel, 1999; Weitzman, Gortmaker & Sobol, 1992). Some of these studies have looked at general increases in behavior problems, while others have looked for an association of maternal smoking with increased incidence of specific behavior disorders such as Conduct Disorder (CD) and Attention-Deficit Hyperactivity Disorder (ADHD).

Maternal Smoking and Child Behavior

Generally, child problem behaviors can be sorted into one of two categories: externalizing behaviors and internalizing behaviors (Achenbach, 1978). Negative behaviors directed out from the child onto their environment are considered externalizing behaviors. These include aggressive and delinquent behaviors. In contrast, internalizing behaviors are those negative behaviors from the child directed inward. Internalizing behaviors include behaviors derived from social withdrawal, somatic complaints, anxiety, and depression.

Studies investigating the relationship between maternal smoking during pregnancy and externalizing and internalizing behaviors show an association of maternal smoking status with externalizing behaviors, but not with internalizing behaviors. In a longitudinal study, Hook et al. (2005) investigated the relationship between maternal smoking and child behavior as measured by the Child Behavior Checklist (CBCL) at 3 and 5.5 years of age. Their results showed that maternal smoking in pregnancy significantly predicted externalizing, aggressive and destructive/delinquent behaviors, but not internalizing behaviors or attention problems. Hook et al. (2005) also reported finding a dose-response relationship between maternal smoking and child externalizing behaviors, with children of mothers who smoked 11-20 cigarettes per day having significantly higher externalizing behavior scores than children of mothers who smoked 1-10 cigarettes per day. In another longitudinal study, Gatzke-Kopp and Beauchaine (2007) investigated the relationship between maternal smoking and child behavior as measured by the CBCL in children aged 7-15. They found that children of mothers who smoked during pregnancy had significantly higher attention problems and aggression scale scores than children of mothers who did not smoke during pregnancy,

but found no significant differences for the anxious/depressed scale scores. Roza et al. (2008) investigated the relationship between maternal smoking during pregnancy and child behavior in children aged 18 months, as measured by the CBCL. They found maternal smoking to be associated with increased externalizing and internalizing behavior scale scores and also reported finding a dose-response relationship. However, when parental education, family income and parental psychopathology were entered into the model, the relationship between maternal smoking and internalizing scale scores disappeared (odd ratio (OR) 1.02, 95% confidence interval (CI) 0.70-1.47, p = 0.94), but the relationship between maternal smoking and externalizing behavior scale score was still approaching significance (OR 1.28, 95% CI 0.97-1.69, p = 0.08).

Environmental Tobacco Smoke Exposure During Pregnancy

Relatively fewer studies have investigated the potentially dangerous effects of Environmental Tobacco Smoke (ETS) exposure during pregnancy. The few studies that do exist suggest that prenatal ETS exposure to be associated with increased risks of cardiovascular dysfunction and respiratory disease (Hutchison, Glantz, Zhu, Sun, Chou, Chatterjee, et al., 1998; Jedrychowski et al., 2007; Yang et al., 2004).The few studies to focus on the behavioral outcomes associated with prenatal ETS exposure have found results similar to the prenatal smoking literature, with prenatal ETS exposure being associated with externalizing behaviors (Gatze-Kopp & Beauchain, 2007; Roza et al., 2008). The extension of the association of maternal smoking and child behavior outcomes to similar outcomes in women who were only exposed to ETS during their pregnancies seems to suggest a teratogenic effect.

It should be noted that Roza et al. (2008) did not agree with a teratogenic explanation for their findings. In their study, children of mothers who did not smoke but had fathers who smoked indoors during the pregnancy were compared with children of mothers who did not smoke but had fathers who smoked outdoors during the pregnancy. In accordance with their findings involving maternal smoking status in this study, fathers smoking indoors during pregnancy was associated with both externalizing and internalizing behavior scale scores. Rosa et al. reported that the OR for Total Behavior problems was approximately 66% higher in children of fathers who smoked indoors, compared to children of fathers who smoked outdoors. However, again, the association was decreased and no longer significant after the addition of parental education, family income and parental psychopathology to their model. The researchers concluded that parental education, family income and parental psychopathology were confounding factors which “generate the effect of maternal smoking” (Roza et al., 2008, pg. 7). Though factors such as parental education, family income and parental psychopathology can be seen as confounding factors in the relationship between maternal smoke exposure status and child behavior, there is evidence for nicotine being a potential physiological mechanism for these child outcomes.

Animal Models of Prenatal Exposure to Nicotine and Brain Development

Though tobacco smoke contains many different chemicals, nicotine has been the most widely studied of these chemicals. Nicotine is a neurotoxin which can cross the placenta and has been found to result in concentrations of nicotine in fetal tissue which are higher than concentrations seen in the pregnant mothers (Luck, Nau, Hansen & Steldinger, 1985). Though studies directly assessing the effects of nicotine have not

been done in humans, there has been a plethora of animal research examining how prenatal nicotine exposure affects the developing brain (Slotkin et al., 2005; Slotkin, 2004; Slotkin, Pinkerton, Auman, Qiao & Seidler, 2002; Slotkin, Orband-Miller, Queen, Whitmore & Seidler, 1987; Slotkin, Orband-Miller & Queen, 1987; Roy, Andrews, Seidler & Slotkin, 1998; Navarro et al., 1989; Roy, Seidler & Slotkin, 2002; Muneoka et al., 1997; Navarro, Seidler, Whitmore & Slotkin, 1987).

In the typically developing foetus, acetylcholine (ACh) and nicotinic acetylcholine receptors (nAChRs) play an important role in neural development. ACh promotes cell division early in development, and later signals the switch from cell division to cellular differentiation in neuronal cells (Hohmann, Brooks & Coyle, 1988, Navarro et al., 1989). nAChRs also play a role in the guidance of nerve growth cones (Zheng, Felder, Connor & Poo, 1994). In the case of prenatal tobacco smoke exposure, nicotinic receptors in the brain are stimulated prematurely (Navarro et al., 1989). This affects development in a negative manner by producing a premature switch from neurogenesis to differentiation, which leads to a decreased number of cortical cells. In addition, prenatal tobacco smoke exposure affects the development of the cholinergic system itself. Studies modeling both direct and passive exposure have found selective upregulation of nAChRs (Slotkin et al., 2002; Slotkin et al., 2005). Upregulation of α-4 β-2 nicotinic receptors was found in the hippocampus, brainstem, frontal cortex and caudate. Cell size is also affected, with cells in the CA3 region and dentate gyrus of the hippocampus having a 30% decrease in cell size, with cells being more densely packed, yet with tissue still being thinner than in the same regions in the non-exposed brain (Roy et al., 2001). Another study, Muneoka et al. (1997) investigated the effects of prenatal nicotine

exposure on the development of dopaminergic and serotonergic systems in rats. Reductions of dihydroxyphenylacetic acid (DOPAC)/dopamine (DA) and homovanilic acid (HVA)/DA ratios were found. Reductions in these ratios are indicative of decreased dopaminergic system functioning. Also, a similar effect of prenatal nicotine exposure was found on the serotonergic system, where the 5-hydroxy-3-indoleacetic acid (5-HIAA)/serotonin (5-HT) ratio was decreased. This suggests that prenatal nicotine exposure leads to either a decrease in 5-HT and DA production, or an increased rate of dissipation of these neurotransmitters from the synaptic cleft coupled with a decrease in reuptake into the terminal button.

The Neurobiological Effects of Nicotine and the Neurobiology of Aggression: A Comparison

In a review of the neurobiology of aggression, Siever (2008) reports that aggression is associated with a decrease in 5-HT levels, an increase in ACh levels and decreased cortical volume. In addition, aggression has also been found to be associated with a decrease in hippocampal volume (Zetzsche et al., 2005). These findings related to the neurobiology of aggression seem to pair up very well with the effects of prenatal nicotine on neural development. Thus, it would seem plausible that prenatal nicotine exposure could lead to an increase in externalizing behaviors, which are a combination of aggressive and delinquent behaviors.

Examining Potential Moderators of the Relationship Between Prenatal Nicotine and Behavior Problems

Though nicotine has been shown in animal studies to have adverse effects on neural development in controlled laboratory settings, and though many studies of humans have associated prenatal nicotine exposure with an increase in behavior problems in humans, these associations do not happen in all cases. That is, not all children exposed prenatally to nicotine have increased behavior problems compared to unexposed children.

Utilizing a developmental systems framework, it becomes clear that to determine which children are most at risk for developing behavior problems after being exposed prenatally to nicotine, we must determine which environmental and internal factors might interact with the prenatal nicotine exposure to bias the developmental trajectory toward the development of behavior problems. Few, if any, studies have examined potential moderating factors of the relationship between maternal smoking and child behavior problems. Though many factors could interact with maternal tobacco smoke exposure, including the confounding factors of parental education, family income and parental psychopathology that were focused on by Roza et al. (2008), the present study focuses on infant temperament and sex as potential moderators of the relationship between maternal tobacco smoke exposure and child behavior problems, while taking maternal depression into account as a control variable.

Temperament.

In 1968, Thomas, Chess and Birch defined temperament as, "...a phenomenologic term used to describe the characteristic tempo, rhythmicity, adaptability, energy expenditure, mood, and focus of attention of a child, independently

of the content of any specific behavior" (Thomas, Chess & Birch, 1968, p. 4). Temperament has been found to remain relatively stable across the lifespan. Though temperament can be measured in terms of relative standing on a number of different dimensions including activity level, biological regularity, adaptability, approach/withdrawal, sensory threshold, quality of mood, intensity of mood, distractability and perseveration, it can also be measured in terms of having an easy or difficult temperament (Thomas, Chess & Birch, 1968; Chess & Thomas, 1991). Difficult temperament has been found by many researchers to be related to the development of behavior problems (Thomas, Chess & Birch, 1968; Fagot & Leve, 1998; Olson, Bates, Sandy & Lanthier, 2000; Keenan, Shaw, Delliquadri, Giovannelli & Walsh, 1998). Chess and Thomas theorized that when a child's temperament and other individual characteristics allowed them to meet the demands of their environment, there was a, "goodness of fit" which fosters healthy development (1991). However, if fit was poor, this would lead to excessive stress which would result in behavior problems. Thus, if a child were measured by a parent report as being more difficult in terms of temperament, their temperament may interact with the increase in externalizing behaviors typically seen in children exposed prenatally to maternal smoking or ETS exposure, and result in higher levels of externalizing behaviors when compared to children with easier temperaments.

Sex.

Few, if any, studies have examined the potential moderating role of sex in the relationship between maternal tobacco smoke exposure and child behavior problems. Hook et al. (2006) reported finding no sex differences in children in their study who were

exposed to tobacco smoke postnatally, but did not report any findings on sex differences in children exposed to tobacco smoke prenatally. However, sex differences have been found to be associated with aggression, with males tending to be more aggressive than females (Maccoby & Jacklin, 1980). Also, it appears that females may be more protected from early insults than males in general. Prenatal and postpartum maternal depressive symptoms have been found to be associated with behavior problems in males, but not females (Carter, Garrity-Rokous, Chazan-Cohen, Little & Briggs-Gowan, 2001). Females born at very low birth weight tend to have a lower mortality rate, higher Apgar scores, better cognitive outcomes, and better language outcomes than males born at very low birthweight (Brothwood, Wolke, Gamsu, Benson & Cooper, 1986).

Sex may also interact with temperament in the development of behavior problems. Leve, Kim and Pears (2005) found that the temperamental dimension of impulsivity was related to externalizing behaviors in both males and females, while the temperamental dimension fear/shyness was related to externalizing behaviors only in males. It also appears that sex effects temperament in general. A study of children in a French speaking population found that significantly more males than females fell into the extremely difficult temperament category (Maziade, Cote, Boudreault, Thivierge & Caperaa, 1984). In addition, a recent meta-analysis found that females exhibit greater levels of effortful control than males, and that males exhibit greater levels of surgency than females (Else-Quest, Hyde, Goldsmith & Van Hulle, 2006).

Maternal Depression and Smoking

Depressive symptoms have been found to be associated with smoking (Glassman et al., 1990; Anda et al., 1990) . Anda et al. reported that as depression scores increase, the likelihood of quitting smoking decreases (1990). In addition, maternal depression has been found to be associated with the perception of maladjustment in children, such that women who report more depressive symptoms perceive their child as being more maladjusted (Griest, Wells & Forehand, 1979). Since this study uses some maternal report measures of child behavior, and the presence of maternal depression threatens to bias those maternal reports, maternal depression was added to the model as a control.

The Present Study

The present study examines the potential moderating roles of sex and infant temperament at six months on the relationship between maternal tobacco smoke exposure during pregnancy and child externalizing and internalizing behaviors at 2 years, 3 years and in first grade, while statistically controlling for the potential effects of maternal depression. Both direct maternal exposure and maternal ETS exposure are being examined. Also, teacher reports will be utilized in the first grade analyses for comparison with the maternal report measures.

The hypotheses are:

1)Both direct maternal tobacco smoke exposure and maternal ETS exposure during pregnancy will be associated with an increase in child externalizing behaviors. An increase in internalizing behaviors is not expected in either exposure group.

2)Temperament at 6 months will moderate the relationship of maternal tobacco smoke exposure and externalizing behaviors such that having a difficult temperament will

exacerbate the effects of prenatal tobacco smoke exposure on externalizing behaviors. 3) The association between prenatal tobacco exposure and externalizing behavior will be greater in boys than in girls. Also, behavior data are examined at 2 years, 3 years and first grade to determine how stable these relationships may be over time.

CHAPTER 2

METHOD

Participants

The data used in this study are from the National Institute of Child Health and Human Development Study of Early Childcare (NICHD SECC). The NICHD SECC is a longitudinal dataset which has followed 1364 children from their birth in 1991 at hospitals near Boston, MA., Charlottesville, VA., Hickory, NC., Lawrenceville, KA., Little Rock, AR., Madison, WI., Morganton, NC., Philadelphia, PA., Pittsburgh, PA., Orange County, CA., Seattle, WA., and Topeka, KA. Though conditionally random sampling methods were used to ensure that the participating families were reflective of the demographic diversity of the data collection areas, it is of note that families were excluded from the sample under the following conditions: if the mother was under 18 years of age, if the mother did not speak English, if the infant had disabilities that were obvious at birth or stayed in the hospital longer than 7 days postpartum, if the family lived in a dangerous neighborhood as rated by police officers, if the family anticipated moving, or if the mother had known substance abuse problems.

This sample includes 705 males and 659 females. As shown in Table 1, 89.8% of mothers in the sample had at least completed high school, with the average education level of mothers in the sample being 14 years. The average age for mothers in this sample was 28.11 years, with a range from 18-48years. The median total annual family income within the sample at the beginning of the study was $30,000. Only 15.6% of mothers in the sample had scores on the CES-D that were indicative of depression.

Thus, this sample is a low-risk, normative sample that controls for the confounds thought to provide the effect found in Rosa et al. (2008).

Measures

Maternal tobacco smoke exposure

Data on maternal smoke exposure were collected retrospectively at the 24 month interview. Direct maternal smoking was assessed based on response to the question, "What best describes your smoking patterns during the year before your child was born?" with choices as follows: "I did not smoke", "I smoked but stopped before pregnancy began", "I smoked and stopped during the first three months of pregnancy", "I smoked through the first three months of pregnancy but stopped before my child was born" and "I smoked through the year". Passive maternal smoke exposure was assessed based on the response to the question, "During the year before your child was born, how frequently did you come in contact with family, friends or coworkers who smoked?" with the following choices: Never, Sometimes, Always and Often.

Externalizing and internalizing behaviors

Child externalizing and internalizing behaviors were assessed at 24 and 36 months via the Child Behavior Checklist 2-3 (CBCL) (Achenbach, 1992). The CBCL 4-18 was used to obtain the first grade maternal ratings of behavior (Achenbach, 1991). The Child Behavior Checklist Teacher Report Form (TRF), was used to obtain the first grade teacher ratings of behavior (Achenbach, 1991). Both the 2-3 and 4-18 versions of the CBCL are parent/caregiver report measures, while the TRF is a teacher report measure. Each of these measures consists of approximately 100 items describing child

behaviors. These items comprise several narrow band scales including: withdrawn, somatic complaints, anxious/depressed, social problems, thought problems, attention problems, delinquent behavior, and aggressive behavior. There are also two broad band scales: internalizing and externalizing. The internalizing scale is a composite of the withdrawn, somatic complaints and anxious/depressed subscales. The externalizing scale is a composite of the delinquent behavior and aggressive behavior subscales. Parents/caregivers are asked to rate each item on a 3 point scale ranging from “not true of the child” to “very true of the child”. For the subscales of the CBCL 2-3 and CBCL 4-18, test-retest reliability ranges from .71 - .93. The test-retest reliability of the TRF is .89 (as reported in Belsky et al., 2007).

Temperament

Child temperament was assessed at 6 months using the Revised Infant Temperament Questionnaire (Carey & McDevitt, 1978). This 90 item maternal report questionnaire contains items from nine categories of temperament: rhythmicity, approach, threshold, distractability, persistence, intensity, mood, activity, and adaptability. The items are complete statements describing infant behaviors and mothers are asked to rate how often these behaviors occur on a 6 point scale ranging “almost always” to “almost never”. The version used by NICHD SECC only includes items from five of the nine original subscales: activity, adaptability, approach, mood and intensity. This modification brings the total number of items on the scale down to 38. The scores from each item comprise a composite score for difficult temperament, with lower scores representing an easier temperament and higher scores representing a more difficult temperament. The profile for difficult temperament is negative mood, high

intensity, low adaptability, arrhymthic, and withdrawal, while the profile for easy temperament is the opposite. Reliability coefficients for the subscales range from .53 - .71.

Maternal depression

Maternal Depression was assessed six months postpartum with the Center for Epidemiological Studies Depression Scale (CES-D) (Radloff, 1977). The CES-D is a self-report measure designed to assess depression symptoms in non-clinical populations. The scale consists of 20 statements describing a variety of feelings and behaviors. Participants are asked to rate how often they experienced each feeling in the past week. Responses include “rarely or none of the time (less than 1 day)”, “some or a little of the time (1-2 days)”, “occasionally or a moderate amount of the time (3-4 days)”, and “most or all of the time (5-7 days)”. Scores range from 0-60, with scores ≥ 16 indicating depression. The reliability coefficient of the CES-D for use in the general population is .85, and for use in the clinical population is .90.

Maternal Education

Maternal education was added as an additional control variable, as parental education was found by Roza et al. (2008) to be a potential confound. Maternal education was assessed during an interview at one month postpartum. Participants were asked the question, “How much school have you completed?”. Answers to this question were recorded in number of years if less than 12 or coded in the following manner: 12 years if they completed high school, 14 years if they completed some college, 16 years if they completed a bachelor's degree, 18 years if they completed

some graduate school or obtained a master's degree, 19 years if they completed a law degree, or 21 years if they completed more than one master's degree, or a doctoral degree.

Data Analysis

Data were analyzed in PASW version 18 utilizing a series of hierarchical linear regressions. Separate regressions were conducted for externalizing and internalizing behavior data at 24 months, 36 months and first grade, for both direct maternal smoking, and maternal ETS exposure. To determine if temperament moderated the relationship between smoke exposure and child behavior outcomes, an interaction term of smoke exposure X temperament was added into each model. In addition, each of those models were run separately for males and females, to determine if gender moderated those relationships. The testing for sex moderation was done this way, rather than adding sex into the regression, so that it could be determined whether sex moderates the moderation of temperament on the smoke exposure - child behavior relationship.

CHAPTER 3

RESULTS

Preliminary Analysis

As shown in Table 1, 76.5% of women who responded to the smoking questionnaire in the sample did not smoke during pregnancy. As a result, maternal smoking had significant positive skew (skewness value 25.68, $p < .001$). Due to the extreme skew, smoking was analyzed as a dichotomous variable. Only 24.3% of responders answered that during their pregnancy they were never exposed to tobacco smoke. The majority of women reported being exposed to tobacco smoke “sometimes” during their pregnancy, with this category accounting for 45.7% of the sample. Even so, ETS exposure was significantly positively skewed (skewness value 7.65, $p < .001$). As shown in Table 2, the majority of women who did not report smoking during pregnancy still reported being exposed “sometimes” to tobacco smoke during their pregnancy, with this category accounting for 49.3% of responders. To correct for the skew, a log transformation was performed on the ETS exposure variable. This transformation reduced the skew (skewness value 2.86, $p < .01$).

Hierarchical linear regressions were conducted to determine whether temperament moderated the relationship between maternal smoking status and child behavior problems. Maternal depression, infant temperament and maternal education were entered in the first step, maternal smoking status was entered in the second step and the smoke exposure X temperament interaction term was entered in the third step.

Smoke Exposure as a Predictor of Externalizing Behavior

For males, maternal smoking was not found to be a significant predictor of externalizing behavior upon entry in the model. Prenatal ETS exposure was found to be a significant predictor of externalizing behavior at 3 time points: 24 months, 36 months and for the first grade maternal report. At 24 months, prenatal ETS exposure accounted for 1.49% of the variance in externalizing behavior (β =2.69, sr^2 = .01, $p < .01$). At 36 months, prenatal exposure accounted for 1.96% of the variance in externalizing behavior (β =3.14, sr^2 = .02, $p < .01$). At the first grade time point, prenatal ETS exposure accounted for 2.25% of the variance in externalizing behavior (β =3.85, sr^2 = .02, $p < .01$). This suggests that women who reported being exposed to more ETS during pregnancy, also reported significantly higher levels of externalizing behaviors in their sons at 24 months, 36 months and first grade than women who reported being exposed to less ETS during pregnancy.

For females, maternal smoking was only found to be a significant predictor of externalizing behavior upon entry in the model for the 36 month time point, accounting for 1.14% of the variance in externalizing behavior (β =2.44, sr^2 = .01, $p < .01$). This suggests that women who reported smoking for a longer duration of their pregnancy, also reported a significantly higher level of externalizing behavior in their daughters at 36 months, than women who reported smoking for a shorter duration of their pregnancy. Prenatal ETS exposure was found to be a significant predictor of externalizing behavior at 24 months, accounting for 1.42% of the variance in externalizing behavior (β =.46, sr^2 = .01, $p < .01$). This suggests that women who reported being exposed to more ETS during their pregnancy also reported significantly higher levels of externalizing behavior

in their daughters at 24 months, when compared to women who reported being exposed to less ETS.

To determine whether sex moderated the relationship between maternal smoking and child externalizing behavior, Fisher's Zs were calculated for each time point. The results of the Fisher's Zs were not significant, which would suggest that sex does not moderate the relationship between maternal smoking and child externalizing behavior. To determine whether sex moderated the relationship between maternal ETS exposure and child externalizing behavior, Fisher's Zs were calculated for each time point. The results of these analyses were not significant, which would suggest that sex does not moderate the relationship between maternal ETS exposure and child externalizing behavior.

Smoke Exposure as a Predictor of Internalizing Behavior

For males, maternal smoking was found to be a significant predictor of internalizing behavior upon entry in the model for the first grade maternal report, accounting for 1.12% of the variance in internalizing behavior (β =2.74, sr^2 = .01, $p <$ .05). This suggests that mothers who reported smoking for a longer duration of their pregnancy were significantly more likely to report their son as having internalizing problems in first grade than mothers who smoked for shorter durations of their pregnancy. Prenatal ETS exposure was not found to be a significant predictor of internalizing behavior at any time point.

For females, maternal smoking was found to be a significant predictor of internalizing behavior upon entry in the model for the first grade teacher report., accounting for 1.40% of the variance in internalizing behavior (β =3.05, sr^2 = .01, $p <$

.01). This suggests that teachers reported significantly higher levels of internalizing behaviors in girls whose mothers reported smoking for a longer duration of their pregnancy, compared to girls whose mothers reported smoking for a shorter duration of their pregnancy. Prenatal ETS exposure was found to be a significant predictor of internalizing behavior at both 24 months, and the first grade teacher report. At 24 months, prenatal ETS exposure accounted for 0.9% of the variance in internalizing behavior (β =2.13, sr^2 = .01, $p < .05$). At the first grade time point, prenatal ETS exposure accounted for 0.96% of the variance in internalizing behavior (β =2.10, sr^2 = .01, $p < .05$). This suggests that mothers who reported being exposed to more ETS during their pregnancy are more likely to report higher levels of internalizing behavior in their daughters at 24 months and during first grade, than women who reported less ETS exposure.

To determine whether sex moderated the relationship between maternal smoking and child internalizing behavior, Fisher's Zs were calculated for each time point. The results of the Fisher's Zs were not significant, which would suggest that sex does not moderate this relationship. In addition, Fisher's Zs were calculated at each time point to determine whether sex moderated the relationship between maternal ETS exposure and child internalizing behavior. The results of the Fisher's Zs were not significant, which would suggest that sex does not moderate the relationship between maternal ETS exposure and child internalizing behavior.

Temperament as a Moderator of the Relationship Between Smoke Exposure and Child Externalizing Behavior

The model for males exposed to ETS prenatally predicting externalizing behaviors at 24 months was significant, $F (6, 589) = 18.32$, $p < .01$. There was a significant change in R^2 with the addition of the ETS exposure X infant temperament interaction term, $\Delta R^2 = .01$, $p < .05$. This would suggest that infant temperament moderates the relationship between ETS exposure and externalizing behavior in males at 24 months such that prenatally exposed males with a more difficult temperament are more likely to have a higher level of externalizing behaviors than prenatally exposed males who have an easier temperament. The interaction between ETS exposure and infant temperament accounted for 0.85% of the variance in externalizing behaviors in males at 24 months ($\beta = .74$, $sr^2 = .01$, $p < .05$). This model was also found to be significant for females ($F (6, 560) = 15.79$, $p < .01$). However, the interaction between ETS exposure and infant temperament was not found to be significant, $\Delta R^2 = .00$, $p = .85$. To determine whether sex moderated the moderation of temperament, Fisher's Z was calculated. The results of this Fisher's Z suggest that child sex moderates the moderation of temperament such that temperament moderates the relationship between prenatal ETS exposure and externalizing behavior problems at 24 months in males, but not in females ($z = 16.96$, $p < .001$).

Regressions were also conducted examining the relationship between prenatal ETS exposure and externalizing behaviors at 36 months and first grade as reported by the mother and first grade as reported by the teacher for both males and females. Temperament was not found to moderate any of these relationships. In addition, regressions were run examining the relationship between maternal smoking and externalizing behaviors at 24 months, 36 months, first grade as reported by the mother

and first grade as reported by the teacher for both females and males. Temperament was not found to moderate any of these relationships.

Temperament as a Moderator of the Relationship Between Smoke Exposure and Child Internalizing Behavior

Regressions were run for internalizing behaviors at 24 months, 36 months, and first grade as reported by the mother and at first grade as reported by the teacher for both males and females. Temperament was not found to moderate any of these relationships. In addition, regressions were run examining the relationship between maternal smoking and internalizing behaviors at 24 months, 36 months,and first grade as reported by the mother and first grade as reported by the teacher for both females and males. Temperament was not found to moderate any of these relationships.

CHAPTER 4

DISCUSSION

This study investigated the complex relationship between maternal smoke exposure, child temperament and child sex. It was hypothesized that both direct maternal smoke exposure and maternal ETS exposure would be associated with externalizing behavior in children. This was found to be the case with maternal ETS exposure in males, but was not the case with females, and the same relationship was not found with direct maternal smoke exposure. It was also hypothesized that child temperament at 6 months would moderate this relationship between maternal smoke exposure and externalizing behaviors. This study found that temperament moderates the relationship between maternal ETS exposure during pregnancy and child externalizing behavior problems at 24 months. Children exposed prenatally to ETS who have a more difficult temperament have a greater number of behavior problems than children exposed prenatally who have an easier temperament. In addition, it was hypothesized that sex would moderate this relationship such that the relationship between prenatal exposure and externalizing behaviors would be greater in boys than in girls. Though this was not found consistently in this study, it was found that the sex of a child further moderates the relationship between temperament, maternal ETS exposure and child externalizing behavior at 24 months, such that the relationship between these variables is stronger in males than in females.

The results of this study are consistent with the findings of previous studies indicating that ETS exposure results in negative consequences on prenatal development. Previous research has linked prenatal ETS exposure with negative

physiological outcomes such as cardiovascular dysfunction and respiratory disease (Hutchison, Glantz, Zhu, Sun, Chou, Chatterjee, et al., 1998; Jedrychowski et al., 2007; Yang et al., 2004). This study added to the literature in this area by confirming a link between prenatal ETS exposure and negative child behavioral outcomes (Gatzke-Kopp & Beauchaine, 2007; Roza et al., 2008), but also by determining how child sex and temperament effect this relationship.

It is important to note that secondhand smoke exposure during pregnancy was found to have an effect on child behavior even in a low-risk sample. Typically, low-risk populations are thought of as being more resilient to developmental insults than high-risk populations. Despite this sample having a higher average family income level; well educated, mentally healthy mothers; and living in safe neighborhoods, these children were still affected negatively by their mother's exposure to ETS during pregnancy.

Interestingly, direct maternal smoking was not a consistent predictor of child behavior across models. This may be due to the way smoking was measured in this study. In previous studies, maternal smoking was measured in terms of how many cigarettes those women were smoking (Gatzke-Kopp & Beauchaine, 2007; Roza et al., 2008; and Hook et al., 2006). In this study, maternal smoking was measured in terms of the length of the pregnancy during which these women smoked. So rather than a measure of quantity, as was used by previous studies, this study relied on a measure of duration of exposure. Unfortunately, by using this method the amount of cigarettes per day that these women were smoking may have masked effects by category, as the possibility exists that women in the category who only smoked during the first trimester

of their pregnancy may have smoked more in terms of quantity than women who continued to smoke throughout the pregnancy.

Also, the shape of the distributions for maternal smoking and maternal ETS exposure may explain the difference in findings between these two exposure groups. Most women did not report smoking during their pregnancy, resulting in a severely positively skewed distribution, which was then analyzed as a dichotomous variable. However, most women reported being exposed to ETS “sometimes”, resulting in a distribution that was less skewed. The scores for ETS were more varied in general, providing more variance which is beneficial for regression-based analyses.

Though some relationships were found between maternal smoke exposure (both direct and ETS), the Fisher's Zs used to determine whether sex moderated these relationships were not found to be significant. It would, however, appear from the regressions that sex has a slight moderating effect, particularly with ETS exposure predicting externalizing behavior, such that males seem to be more affected. Due to the size of the main effect of ETS in these relationships, and the study being overpowered, the Fisher's Zs may not have been able to accurately detect a difference between these two groups.

The reason for the sex differences found in the moderating relationship between temperament, maternal ETS exposure and child externalizing behavior may have to do with the sex differences in temperament uncovered by previous research. Else-Quest et al. (2006) found that generally females tend to score higher on effortful control than males. So it may be that females, potentially due to socialization, have better behavior

regulation and thus, their temperament is less likely to exacerbate externalizing behaviors. It may also be that males and females, due to expected social norms, are perceived as being difficult for different reasons. So it could be that there are sex differences in the subscale scores that comprise difficult temperament. If this were the case, using a temperament measure that allowed for analysis of specific temperament traits, rather than the easy-difficult composite, might garner different results. In addition, the findings of a recent review suggest that levels of testosterone males are exposed to prenatally may lead to slower physical and neural maturation seen in males when compared to females in early development, as well as higher levels of disinhibition typically seen in males (Zahn-Waxler, Shirtcliff & Marceau, 2008). Thus, if the brains of females are more mature, they may result in females having an easier time controlling their behaviors than males.

As well, this relationship was found to only occur at 24 months. This may be due to natural fluctuations in the tendency toward externalizing behaviors. In the typically developing child, the incidence of externalizing behaviors increases around the age of 18 months, and decreases around the age of 2 or 3 years (Tremblay, 2000). So it may be that at two years, the prenatal exposure and child temperament exacerbated the already high natural tendency toward externalizing behaviors, and that at subsequent time points, the starting point for behavior problems in the sample was much lower, leading to non-significant results.

It is important to note that the effect sizes of significant findings in this study were relatively small. It is possible that the somewhat rigid exclusion criteria employed by the NICHD SECC during recruitment of their sample may have reduced the variance

in the sample, leading to a decreased possibility of finding a difference if such a difference exists in the true population. Part of this exclusion criteria included excluded infants with obvious disabilities at birth, and children who stayed at the hospital longer than 7 days postpartum. As aforementioned, the most well known teratogenic effect of nicotine is low birth weight. In 1987, just four years before data collection began for the NICHD SECC, the average length of hospital stay for a baby weighing between 2000-2500g who did not require ventilation assistance was 8 days (US Congress Office of Technology Assessment, 1987). The average stay for the same weight range if ventilation assistance was required was 23.2 days. Thus, by excluding infants from the study on the basis of hospital stay length, it is possible that they excluded the children who may have been the most sensitive to prenatal nicotine exposure, which in turn would reduce variance within the sample.

This study had a number of limitations. Though temperament was viewed from the goodness of fit perspective, and thus was theorized to take parenting into account, no true measure of parenting style was employed. As well, the temperament measure used in this study was only able to be a measure of easy vs. difficult temperament. Having a measure of temperament that could account for different facets of temperament might lead to more specific results. For example, behavioral inhibition may be a better moderator than difficult temperament. Future research should further examine the moderating effect of various factors of temperament. Yet another limitation was the method of measuring maternal tobacco smoke exposure. This study relied on retrospective self-report of maternal smoking and ETS exposure. Though retrospective self-reports have been found to be an acceptable method, taking cotinine levels at

regular intervals during pregnancy would be a far more reliable method with much more accurate results. The development of a longitudinal study including cotinine levels during pregnancy and child behavioral assessments would be very helpful in determining the nature of this relationship.

Table 1

Descriptive Statistics

	M	*SD*	*Mdn*
Maternal Age	28.11	5.63	29.00
Total Family Income	37947.77	34102.36	30000.00
Maternal Education	14.23	2.51	14.00
Maternal Depression	8.97	8.34	7.00
CBCL Externalizing Behavior 24 Months	52.32	8.48	52.00
CBCL Externalizing Behavior 36 Months	51.13	8.50	51.00
CBCL Externalizing Behavior First Grade	48.64	9.79	48.00
TRF Externalizing Behavior First Grade	50.67	8.72	50.00
CBCL Internalizing Behavior 24 Months	50.27	9.63	51.00
CBCL Internalizing Behavior 36 Months	51.21	9.50	51.00
CBCL Internalizing Behavior First Grade	48.27	8.94	48.00
TRF Internalizing Behavior First Grade	49.21	9.18	49.00
Child Temperament	3.18	0.40	3.20
Maternal Smoking	1.65	1.32	1.00
Maternal ETS Exposure	2.20	0.96	2.00

Table 2

Summary of Hierarchical Regression Analysis for ETS Predicting Externalizing Behavior in Males

	24 Months			36 Months			1st Grade CBCL			1st Grade TRF		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1												
Maternal Depression	0.20	0.04	0.19**	0.24	0.05	0.22**	0.25	0.05	0.21**	0.07	0.05	0.07
Temperament	4.72	0.84	0.22**	5.03	0.87	0.23**	0.29	1.11	0.01	1.20	1.04	0.05
Mother's Education	-0.33	0.15	-0.09*	-0.34	0.15	-0.10*	-0.45	0.19	-0.11*	-0.41	0.18	0.11*
Maternal Smoking During Pregnancy	0.29	0.26	0.05	0.35	0.27	0.10	0.75	0.34	0.10*	-0.25	0.33	-0.4
Step 2												
Maternal ETS Exposure	2.69	0.84	.14**	3.14	0.85	0.17**	3.85	1.1	0.17**	-0.01	1.04	0.00
Step 3												
ETS x Temperament	4.22	1.74	.74*	2.82	1.78	0.49	2.30	2.31	0.35	-0.85	2.21	-0.15

*Note. At 24 months $R^2 = .13$** for Step 1; $\Delta R^2 = .02$** for Step 2; $\Delta R^2 = .01$* for Step 3. At 36 months $R^2 = .16$** for Step 1; $\Delta R^2 = .02$** for Step 2; $\Delta R^2 = .00$ for Step 3.*

*For 1st grade maternal report $R^2 = .10$** for Step 1; $\Delta R^2 = .02$** for Step 2; $\Delta R^2 = .00$* for Step 3.*

For 1st grade teacher report $R^2 = .03$ for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

* $p < .05$.

** $p < .01$.

Table 3

Summary of Hierarchical Regression Analysis for ETS Predicting Internalizing Behavior in Males

	24 Months			36 Months			1st Grade CBCL			1st Grade TRF		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1												
Maternal Depression	0.24	0.05	0.21**	0.29	0.05	0.25**	0.22	0.05	0.20**	-0.01	0.05	-0.01
Temperament	5.16	0.90	0.22**	4.87	0.92	0.21**	0.05	1.08	0.00	0.75	1.11	0.03
Mother's Education	-0.70	0.16	-0.18**	-0.66	0.16	-0.17**	-0.01	0.19	0.00	-0.17	0.19	-0.04
Maternal Smoking During Pregnancy	0.06	0.28	0.01	0.13	0.28	0.02	0.84	0.34	0.12*	0.00	0.34	0.00
Step 2												
Maternal ETS Exposure	0.86	0.90	0.04	1.54	0.91	0.08	1.96	1.08	0.09	0.05	1.10	0.00
Step 3												
ETS x Temperament	2.50	1.88	0.40	3.66	1.90	0.59	3.44	2.28	0.54	4.46	2.34	0.73

*Note. At 24 months R^2 = .18** for Step 1; ΔR^2 = .00 for Step 2; ΔR^2 = .00 for Step 3. At 36 months R^2 = .19** for Step 1; ΔR^2 = .00 for Step 2; ΔR^2 = .01 for Step 3.*

*For 1st grade maternal report R^2 = .06** for Step 1; ΔR^2 = .01 for Step 2; ΔR^2 = .00 for Step 3.*

For 1st grade teacher report R^2 = .00 for Step 1; ΔR^2 = .00 for Step 2; ΔR^2 = .01 for Step 3.

* p < .05.

** p < .01.

Table 4

Summary of Hierarchical Regression Analysis for ETS Predicting Externalizing Behavior in Females

	24 Months			36 Months			1st Grade CBCL			1st Grade TRF		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1												
Maternal Depression	0.19	0.04	0.20**	0.16	0.04	0.16**	0.15	0.05	0.13**	0.08	0.05	0.08
Temperament	3.42	0.84	0.17**	2.74	0.86	0.13**	2.81	1.08	.12**	-0.46	0.96	-0.02
Mother's Education	-0.45	0.14	-0.13**	-0.44	0.15	-0.13**	-0.46	0.18	-0.11*	-0.74	0.16	-0.21**
Maternal Smoking During Pregnancy	0.54	0.27	0.08*	0.63	0.28	0.10*	0.74	0.36	0.10*	0.14	0.32	0.02
Step 2												
Maternal ETS Exposure	2.46	0.80	0.14**	1.09	0.85	0.06	1.45	1.07	0.07	-0.18	0.95	-0.01
Step 3												
ETS x Temperament	-0.35	1.76	-0.06	-1.78	1.82	-0.33	-2.63	2.32	-0.41	2.79	2.06	0.5

*Note. At 24 months $R^2 = .13$** for Step 1; $\Delta R^2 = .01$** for Step 2; $\Delta R^2 = .00$ for Step 3. At 36 months $R^2 = .10$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

*For 1st grade maternal report $R^2 = .08$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

*For 1st grade teacher report $R^2 = .06$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

* $p < .05$.

** $p < .01$.

Table 5

Summary of Hierarchical Regression Analysis for ETS Predicting Internalizing Behavior in Females

	24 Months			36 Months			1st Grade CBCL			1st Grade TRF		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1												
Maternal Depression	0.22	0.04	0.20**	0.23	0.05	0.20**	0.15	0.05	0.15**	-0.02	0.05	-0.02
Temperament	4.03	0.90	0.18**	4.05	0.97	0.17**	2.97	0.95	0.14**	1.19	1.06	-0.05
Mother's Education	-0.72	0.15	-0.20*	-0.74	0.17	-0.19**	0.11	0.16	0.03	-0.37	0.18	-0.10*
Maternal Smoking During Pregnancy	0.18	0.29	0.02	0.19	0.32	0.03	0.57	0.32	0.08	0.77	0.35	0.10*
Step 2												
Maternal ETS Exposure	2.13	0.87	0.11*	0.84	0.95	0.04	2.09	0.94	0.11	-0.51	1.00	-0.03
Step 3												
ETS x Temperament	1.01	1.89	0.17	-1.84	2.05	-0.30	-2.27	2.04	-0.41	-1.13	2.27	-0.19

*Note. At 24 months $R^2 = .16$** for Step 1; $\Delta R^2 = .01$* for Step 2; $\Delta R^2 = .00$ for Step 3. At 36 months $R^2 = .14$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

*For 1st grade maternal report $R^2 = .06$** for Step 1; $\Delta R^2 = .01$* for Step 2; $\Delta R^2 = .00$ for Step 3.*

For 1st grade teacher report $R^2 = .03$ for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

* $p < .05$.

** $p < .01$.

Table 6

Summary of Hierarchical Regression Analysis for Maternal Smoking Predicting Externalizing Behavior in Males

	24 Months			36 Months			1st Grade CBCL			1st Grade TRF		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1												
Maternal Depression	0.20	0.04	0.19**	0.24	0.05	0.22**	0.25	0.05	0.21**	0.07	0.05	0.07
Temperament	4.69	0.84	0.22**	4.98	0.87	0.23**	0.23	1.11	0.01	1.22	1.04	0.06
Mother's Education	-0.38	0.14	-0.11**	-0.42	0.14	-0.12**	-0.60	0.18	-0.15**	-0.36	0.17	-0.10*
Step 2												
Maternal Smoking	1.26	0.88	0.06	1.37	0.91	0.06	2.53	1.15	.10*	-0.48	1.09	-0.02
Step 3												
Smoke x Temperament	3.70	2.01	0.59	2.63	2.07	0.41	-4.22	2.63	-0.59	-2.19	2.53	-0.34

*Note. At 24 months $R^2 = .13$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .01$ for Step 3. At 36 months $R^2 = .16$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

*For 1st grade maternal report $R^2 = .09$** for Step 1; $\Delta R^2 = .01$* for Step 2; $\Delta R^2 = .01$ for Step 3.*

*For 1st grade teacher report $R^2 = .03$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

* $p < .05$.

** $p < .01$.

Table 7

Summary of Hierarchical Regression Analysis for Maternal Smoking Predicting Internalizing Behavior in Males

	24 Months			36 Months			1st Grade CBCL			1st Grade TRF		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1												
Maternal Depression	0.24	0.04	0.21**	0.29	0.05	0.25**	0.23	0.05	0.20**	-0.01	0.05	-0.01
Temperament	5.15	0.90	0.22**	4.86	0.92	0.20**	-0.02	1.08	0.00	0.75	1.11	0.03
Mother's Education	-0.71	0.15	-0.19**	-0.69	0.15	-0.18**	-0.19	0.18	-0.05	-0.16	0.18	-0.04
Step 2												
Maternal Smoking	0.33	0.94	0.01	0.59	0.96	0.03	2.74	1.13	0.12*	-0.23	1.16	-0.10
Step 3												
Smoke x Temperament	3.72	2.16	0.54	3.01	2.19	0.43	-0.20	2.58	-0.03	0.45	2.70	0.07

*Note. At 24 months $R^2 = .18$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3. At 36 months $R^2 = .19$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

*For 1st grade maternal report $R^2 = .05$** for Step 1; $\Delta R^2 = .01$* for Step 2; $\Delta R^2 = .00$ for Step 3.*

For 1st grade teacher report $R^2 = .00$ for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.

* $p < .05$.

** $p < .01$.

Table 8

Summary of Hierarchical Regression Analysis for Maternal Smoking Predicting Externalizing Behavior in Females

	24 Months			36 Months			1st Grade CBCL			1st Grade TRF		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1												
Maternal Depression	0.20	0.04	0.20**	0.17	0.04	0.17**	0.16	0.05	0.14**	0.08	0.05	0.08
Temperament	3.52	0.84	0.17**	2.84	0.86	0.14**	2.93	1.08	0.12**	-0.43	0.96	-0.20
Mother's Education	-0.52	0.14	-0.16**	-0.52	0.14	-0.15**	-0.55	0.18	-0.14**	-0.76	0.16	-0.22**
Step 2												
Maternal Smoking	2.24	0.90	0.10	2.44	0.93	0.11**	2.18	1.20	0.08	1.07	1.05	0.05
Step 3												
Smoke x Temperament	-0.85	2.29	-0.14	-0.01	2.38	0.00	0.46	3.16	0.06	0.63	2.82	0.10

*Note. At 24 months $R^2 = .12$** for Step 1; $\Delta R^2 = .01$* for Step 2; $\Delta R^2 = .00$ for Step 3. At 36 months $R^2 = .09$** for Step 1; $\Delta R^2 = .01$** for Step 2; $\Delta R^2 = .00$ for Step 3.*

*For 1st grade maternal report $R^2 = .07$** for Step 1; $\Delta R^2 = .01$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

*For 1st grade teacher report $R^2 = .06$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

* $p < .05$.

** $p < .01$.

Table 9

Summary of Hierarchical Regression Analysis for Maternal Smoking Predicting Internalizing Behavior in Females

	24 Months			36 Months			1st Grade CBCL			1st Grade TRF		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1												
Maternal Depression	0.22	0.04	0.20**	0.23	0.05	0.20**	0.16	0.05	0.16**	-0.01	0.05	-0.01
Temperament	4.07	0.90	0.18**	4.08	0.96	0.17**	3.06	0.95	0.14**	-1.02	1.06	-0.04
Mother's Education	-0.70	0.15	-0.20**	-0.76	0.16	-0.19	0.04	0.16	0.01	-0.49	0.18	-0.12**
Step 2												
Maternal Smoking	1.27	0.97	0.05	1.35	1.05	0.05	1.36	1.06	0.06	3.05	1.16	0.12**
Step 3												
Smoke x Temperament	-1.61	2.46	-0.24	-2.66	2.68	-0.37	-1.48	2.78	-0.23	0.02	3.09	0.00

*Note. At 24 months $R^2 = .16$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3. At 36 months $R^2 = .14$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

*For 1st grade maternal report $R^2 = .05$** for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3.*

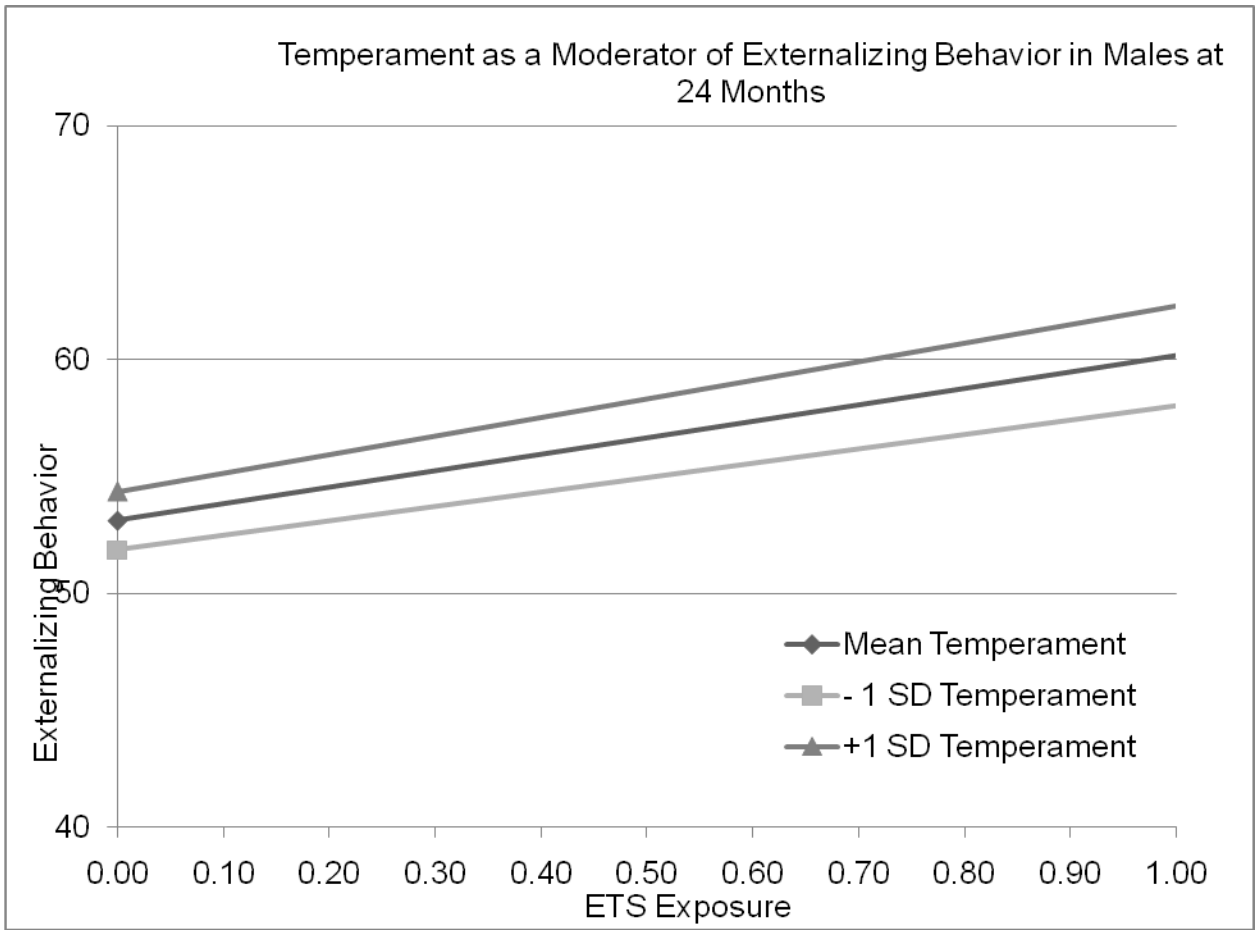
*For 1st grade teacher report $R^2 = .02$ for Step 1; $\Delta R^2 = .01$** for Step 2; $\Delta R^2 = .00$ for Step 3.*

* $p < .05$.

** $p < .01$.

Figure 1

Note the temperament-dependent differential increase in externalizing behavior level as a function of ETS exposure level.



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ABSTRACT

TEMPERAMENT AND SEX AS MODERATORS OF THE RELATIONSHIP OF MATERNAL SMOKING DURING PREGNANCY AND CHILD EXTERNALIZING BEHAVIORS

by

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Cigarette smoking during pregnancy has been associated with negative child behavioral outcomes. Though many studies have found links between maternal smoking during pregnancy and behavior problems in children, few if any have looked into potential moderating factors of that relationship and few have examined the effects of second-hand smoking. This study examined child temperament at 6 months and sex as potential moderators of the relationship between maternal smoke exposure and both internalizing and externalizing behaviors at 24 month, 36 months and first grade. Both maternal smoking and maternal exposure to environmental tobacco smoke (ETS) were examined. Data for this study came from the NICHD Study of Early Child Care. Results indicate that temperament moderates the relationship between maternal ETS exposure during pregnancy and child externalizing behaviors in males at 24 months. Further research is needed to determine what other factors may moderate these relationships.

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