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Parental bad habits breed bad behaviors in youth: Exposure to gestational smoke and child impulsivity

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ABSTRACT

In utero exposure to cigarette smoke has been shown to have an adverse effect on healthy brain development in childhood. In the present study, we examine whether fetal exposure to mild and heavy smoking is associated with lower levels of impulsivity and cognitive control at age 10. Using a sample of 2120 children from the Québec Longitudinal Study of Child Development, we examine the association between gestational cigarette smoke exposure and fourth grade teacher reports of impulsivity and classroom engagement which represent behavioral indicators of executive functions. When compared to children of non-smokers, children of mothers who reported smoking heavily during pregnancy (10 or more cigarettes per day) were rated by their fourth grade teachers as displaying higher levels of impulsive behavior, scoring.112 standard deviation units higher than children of non-smokers. Children of mothers who smoked heavily were also less engaged in the classroom, scoring.057 standard deviation units lower than children of women who did not smoke. These analyses were adjusted for many potentially confounding child and family variables. Exposure to perinatal nicotine may compromise subsequent brain development. In particular, fetal nicotine may be associated with impairment in areas recruited for the effortful control of behavior in later childhood, a time when task-orientation and industriousness are imperative for academic success.

1. Introduction

Unfavorable fetal environments can impede subsequent child development and increase individual susceptibility to disease throughout the lifespan (Barker, 1998). In industrialized countries, as many as 25% of children are exposed to nicotine during gestation (Beck et al., 2002). Because nicotine crosses the placental barrier, it can interfere with healthy fetal development. Randomized experimental designs with animals confirm a causal relationship whereby direct prenatal exposure to nicotine evokes mutations in neural brain cell proliferation and subsequent differentiation. These processes can in turn compromise cortical functioning and development (Slotkin et al., 2011). It is reasonable to expect similar epigenetic sequelae in humans exposed to nicotine. If disruptions in the development of prefrontal brain areas persist through later developmental stages, they are likely to foster enduring risk for poor executive control in later childhood.

Epidemiological studies suggest that maternal gestational smoking is related to serious long-term risks for the development of children. These include neurocognitive deficits that affect child cognitive and behavioral functioning (Brennan et al., 2002; Ekblad et al., 2010; Gilman et al., 2008; Linnet et al., 2003). Gestational smoking is also associated with ADHD and reduced general intellectual ability (Brennan et al., 2002; Button et al., 2005; Fergusson and Lloyd, 1991; Gilman et al., 2008; Linnet et al., 2003).

Exposure to maternal smoking may disrupt early brain growth because it can interfere with the flow of oxygen and nutrients to the developing fetus and lead to increases in toxic carbon monoxide in the gestational environment (Slotkin et al., 2002). In addition, cigarette smoke increases activation of nicotine receptors in the developing fetus. Repeated activation of nicotine receptors can eventually disrupt the neurotransmitter systems involving adrenaline, noradrenaline, and dopamine (Brennan and Arnsten, 2008). The regulation and maintenance of optimal levels of these neurotransmitters are essential for the proper functioning of the prefrontal cortex, which plays an important role in the willful control of behavior.

In childhood, one of the core symptoms of ADHD is impulsivity, which reflects poor behavioral inhibition, inattentiveness, and restlessness in social and academic domains (Barkley, 1997). Children who meet the clinical criteria for ADHD are likely to experience severe impairments in their academic and social functioning (Barkley, 2002). Nevertheless, even children who present non-clinical levels of impulsivity are at risk of facing challenges with successful lifelong adjustment (Currie and Stabile, 2006). As early as kindergarten, impulsive

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children have more difficulty with academic achievement and adjustment in the classroom and are more likely to be held back a grade (Duncan et al., 2007; Pagani et al., 2001, 2010a). Within typically developing populations, children who are more impulsive are also at greater risk of early involvement in addictive behaviors such as gambling and substance abuse (Pagani et al., 2009; Vitaro et al., 2001). Further contributing to its social and individual burden, impulsivity that persists into adulthood is associated with poor occupational performance, adverse health outcomes, and impaired interpersonal functioning (Barkley, 2002).

Although studies have shown a link between exposure to gestational tobacco and child ADHD diagnosis (Mick et al., 2002; Milberger et al., 1996), research has yet to use a population-based sample to assess whether exposure is prospectively associated with impulsivity and applied measures of cognitive control in the classroom. Because prefrontal brain areas play a key role in helping children complete goal-directed behavior, follow procedures, and remain on-task, it is likely that children exposed to gestational tobacco smoke might show less engagement in the elementary level classroom. Academic trajectories tend to stabilize by the middle of elementary school, thus setting the course for high school achievement and academic persistence (Entwisle et al., 2005). Moreover, goal-directed classroom behavior is a precursor to later adult workplace behavior (Farkas, 2003). As such, examining productive behavior in the fourth grade classroom provides a useful indicator of children's eventual academic attainment and personal success (Duncan et al., 2007). Furthermore, a putative test of long-term negative influence becomes more compelling if the prospective associations endure over the long-term. For these reasons, our outcomes are assessed in the fourth grade.

Using a representative birth cohort of children born in the province of Quebec, we examine the hypothesis that exposure to gestational tobacco smoke is associated with higher impulsivity and lower levels of classroom engagement by age 10. In the present study, we are interested in estimating the independent contribution of perinatal tobacco exposure on later cognitive control skills. Because a number of studies have shown that the relationship between perinatal smoking and cognitive outcomes is reduced when perinatal and family environmental characteristics are taken into account (Maughan et al., 2004), we control for known risk factors in our study.

2. Methods

2.1. Participants

Analyses were conducted using data from the Québec Longitudinal Study of Child Development (QLSCD). This sample originates from a randomly selected stratified sample of 2837 infants born between 1997 and 1998 in Quebec, Canada. At the inception of the study 93 children were deemed ineligible and 172 were untraceable due to incorrect coordinates. Of the 2572 remaining children, 14 were unreachable and 438 refused participation. Beginning at 5-months, 2120 infants were followed up annually for the early childhood phase representing 91% of the eligible target population. Of these, 39% were firstborn. Baseline measures were taken when children were 5 months old. Follow-up of children occurred at 122 months. For each data collection wave, informed consent was obtained from parents. During the school-age phase, teachers and children also gave consent. As in all longitudinal studies there was incomplete data on some of the measures at each data collection wave. Participants were included in the analytical sample if they had complete data on maternal reports of perinatal smoking ($n = 2110$ from the original sample at 5-months).

2.2. Outcome measures (end of fourth grade)

2.2.1. Impulsivity

Teachers rated 9 items reflecting inattentiveness, restlessness, and poor behavioral inhibition. These included: Could not sit still, Was restless and hyperactive; Has trouble sticking to any activity; Could not stop fidgeting; Was impulsive, acted without thinking; Had difficulty waiting for his or her turn; Could not settle down to do anything for more than a few moments; Was easily distracted; Was inattentive; and Was unable to concentrate, could not pay attention for long ($\alpha = .91$).

2.2.2. Classroom engagement

Teachers rated 11 items related to cognitive control, task-orientation, effort in the classroom: Follows directions; Follows rules; Follows instructions; Completes work on time; Works independently; Listens Attentively; Works cooperatively with other children; Works neatly and carefully; Puts a lot of effort into work; Participates in class; and Ask questions when he/she does not understand ($\alpha = .94$) (Pagani et al., 2010a, 2010b). Items were rated on a Likert scale with response options from: 1 (never); 2 (rarely); 3 (sometimes); 4 (often); to 5 (always).

2.3. Predictors

When children were 5 months, mothers self-reported their smoking behavior during pregnancy. Mothers responded to two questions “Did you smoke during pregnancy?” and “How many cigarettes did you smoke while pregnant?”. These questions have been validated in this population previously (Huijbregts et al., 2006, 2007). Based on their responses, mothers were classified into one of three groups: 0 perinatal smoking, 1–9 cigarettes per day, or more than 10 cigarettes per day. The same or similar groupings have been used in the previous studies (Button et al., 2005; Huijbregts et al., 2006; Maughan et al., 2004) Approximately 25% of mothers reported smoking during pregnancy which is consistent with the prevalence rates found in other studies (Breslau et al., 2005; Maughan et al., 2004).

2.4. Control variables

Data on potential child, family, and socio-economic confounders were obtained from parents and through direct observation. Mothers self-reported alcohol consumption (coded as 0 = no alcohol consumption or 1 = alcohol consumption) and illicit drugs (coded as 0 = no drug consumption or 1 = drug consumption). Weight for gestational age was derived from birth records and was standardized by gender and week of gestation using Canadian norms (Kramer et al., 2001). Children were coded as either 0 (normal weight) or 1 (below the 10th percentile). Child sex was also derived from birth records.

Parental history of antisocial behavior during adolescence and adulthood was assessed at baseline when children were 5 months. Five questionnaire items were derived from the NIMH-Diagnostic Interview Schedule. Adolescent items included: Starting fights; Theft, Involvement with youth protection or police; Expulsion or suspension from school; Truancy; and Running away from home. Adult items included: Arrests; Being fired from a job; Trouble at work, with family, or with the police due to drug or alcohol abuse; Starting fights (fathers only); and Hitting or throwing things at the spouse or partner (mothers only).

Parental and family characteristics were measured when children were 5 months.

Maternal involvement and responsiveness were measured using the Home Observation for Measurement of the Environment (HOME) — Infant version (Caldwell and Bradley, 1994). Trained examiners made assessments after observing mother–child interactions for a period of 3 h. Involvement was measured using 5 items: Provides toys that challenge child to develop new skills; Structures child's play periods; Interacts with her child while engaged in other tasks; Encourages her child's progress; and Values educational toys (<alpha> = .85). Responsiveness was also measured using 5 items: Responds verbally to child vocalizations or verbalizations; Vocalizes spontaneously (words or sounds) to the child; Speaks to baby in a distinct, clear, and audible manner; Tells child name of object or

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