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Effects of fetal tobacco exposure on focused attention in infancy

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ABSTRACT

This study examined the association between fetal tobacco exposure (FTE) and focused attention at 9 months of child age, and the role of child sex and infant behavioral reactivity as potential moderators of this association. Data were obtained from 203 mothers and their infants (105 fetally exposed and 98 non-exposed) on infant focused attention and behavioral reactivity to a frustration task. FTE was ascertained via nicotine metabolites in infant meconium, reflecting primarily third trimester fetal exposure. Results demonstrated a main effect of FTE on focused attention, such that exposed infants exhibited lower levels of focused attention than non-exposed infants. Behavioral reactivity, but not infant sex, moderated the relationship between FTE and focused attention, such that exposed infants who were highly reactive to frustration had the lowest levels of focused attention. Results suggest that smoking interventions, even in the third trimester, may have a positive impact on attentional outcomes for infants.

1. Introduction

Tobacco is one of the most commonly used drugs during pregnancy and is known to deliver significant amounts of chemical toxins to the fetus via the maternal bloodstream. Despite the known health consequences, 16.4% of American women continue to smoke while pregnant (Substance Abuse and Mental Health Services Administration, 2009), making prenatal tobacco exposure one of the largest preventable causes of poor fetal outcomes such as impaired fetal growth, respiratory problems, and infant mortality in the U.S. (Dietz et al., 2010). There is less consensus regarding other aspects of development, especially basic underlying processes of attention and arousal. One key aspect of attention in infancy that ispredictive of both behavioral problems and cognitive abilities in early childhood is focused attention (Lawson & Ruff, 2004).

Focused attention in infancy is a state of attention during which the infant is selectively attending to an object to the exclusion of other things in the environment. Focused attention involves intense concentration, coupled with a quieting of

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vocalizations, social bids, and irrelevant body movements. In a state of focused attention, the infant is devoting their energy and resources to the exploration of the object, and may remain oriented to the object for longer periods of time than they would in a state of casual attention (Lawson & Ruff, 2001; Ruff, Capozzoli, & Saltarelli, 1996). As their primary source of information, measures of focused attention in infancy are an early index of memory and learning (Lamb, Bornstein, & Teti, 2002). This has been evidenced by the tendency of infants to use focused attention when presented with a novel object (Ruff, 1988; Ruff, Saltarelli, Capozzoli, & Dubiner, 1992; Oakes, Madole, & Cohen, 1991). Once information has been gathered, the infant may move on to more casual behaviors such as mouthing, banging, or shaking, which are characteristic of lower levels of attention. This type of active processing of objects during play is predominant from around 6 to 24 months (Lawson & Ruff, 2001). This study examined the association between FTE and focused attention at 9 months of child age.

Although there is a relatively large literature on the association between prenatal tobacco exposure and ADHD risk (Motlagh et al., 2011), few studies examined the attentional system, specifically. These small number of studies span different developmental periods. For instance, in infancy Espy et al. (2011) reported significant effects of prenatal tobacco exposure on attention/orientation at birth and 2 weeks, but not at 4 weeks. Authors attributed results to withdrawal effects (Espy et al., 2011). Willoughby, Greenberg, Blair, Stifter, and T.F.L.I. Group (2007) noted continued effects beyond the neonatal period, finding lower attention among prenatal tobacco exposed boys compared to control boys, but not girls, during developmental testing at 6–8 months of age. In early childhood, trimester specific effects were noted, with second and third trimester prenatal tobacco exposure associated with greater inattention at 6 years of age (Leech, Richardson, Goldschmidt, & Day, 1999). Finally, in adolescence Jacobsen, Slotkin, Menci, Frost, and Pugh (2007) found the lowest auditory and visual selective attention among prenatally exposed adolescent girls who were smokers compared to non-exposed girls or those who were non-smokers. Thus, studies examining the association between prenatal tobacco exposure and attentional processes are few in number and to our knowledge none examined the effects of prenatal tobacco exposure on focused attention specifically.

One explanation of the mixed results for attentional processes in general may be the presence of moderators. One such moderator may be behavioral reactivity or arousal, in light of the robust association between attention and arousal. The attention/arousal system is coordinated and attention is often used to regulate arousal (Lyon & Krasnegor, 1996). Attention, arousal, and the ability to maintain behavioral states reflect central nervous system functioning and work inter-dependently to regulate responses to internal and external stimulation (Karmel, Gardner, & Magnano, 1991). Indeed, this dynamic system of attention and arousal is the interface between the infant and their environment, and allows infants to shift and focus attention effectively to external stimuli (Richards, 2008). In this context, high arousal interferes with responses to external stimulation as attentional efforts may be allocated to facilitating emotion regulation and limiting potential distress, and may not be appropriately shifted to other external stimuli (Gardner, Karmel, & Magnano, 1992; Kopp, 2002). Thus, excessive arousal or reactivity may hamper infants' ability to focus attention effectively, especially among infants who are biologically vulnerable due to prenatal tobacco exposure. Individual differences in reactivity may be indicated by the latency and/or intensity of reactions to frustration. Indeed, Calkins, Dedmon, Gill, Lomax, and Johnson (2002) observed easily frustrated infants as less attentive than their less easily frustrated counterparts. Similarly, more intense reactivity to negative events were found previously in children with ADHD as compared to children without ADHD (Jensen & Rosén, 2004).

Infant sex may also have the potential to moderate the association between prenatal tobacco exposure and focused attention. Girls of all ages have fewer attentional problems than boys of the same age (Arnold, 1996). Boys typically receive higher ratings for symptoms of attentional problems than girls (DuPaul et al., 1998). In addition, the attentional abilities of girls often progress at different rates than boys, with sustained attention developing earlier in girls than in boys (Greenberg & Waldman, 1993). Furthermore, boys are more biologically vulnerable to prenatal insult than girls (Lewis & Kestler, 2012), indicating the possibility of the association between prenatal tobacco exposure and poor focused attention to be stronger for boys compared to girls.

The primary purpose of this study was to examine the relationship between prenatal tobacco exposure and focused attention in infancy in a diverse sample of low-income mothers and infants. Based on the literature presented above, we hypothesized that prenatal tobacco exposure would be associated with poorer focused attention, and that behavioral reactivity and infant sex would moderate this relationship. Specifically, we expected that the association between prenatal tobacco exposure and focused attention in infancy would be stronger for infants with higher behavioral reactivity compared to infants with lower behavioral reactivity, and would also be stronger for boys than for girls.

2. Method

2.1. Participants

The sample included 258 mother/infant dyads, with 181 infants prenatally exposed to tobacco (99 boys and 82 girls), and 77 not exposed (35 boys and 42 girls). Pregnant women were recruited at their first prenatal appointment in a local area hospital and screened for eligibility. Women were eligible if they met the following criteria: greater than 20 weeks gestation, were not having a multiple birth, were at least 18 years old, were not using illicit drugs (other than cannabis), were not heavy alcohol users (defined as 4 or more drinks in one sitting or drinking an average of more than 1 drink/day), were not heavy marijuana users after pregnancy recognition (defined as smoking an average of more than 1 joint/day), and were English speakers. Women using other substances were excluded in order to disentangle the specific effects of tobacco exposure from those that might be caused by other drugs. At the conclusion of each recruitment month, participating smokers